EXECUTIVE SUMMARY

Integrated Natural Resources Appraisal, Monitoring and Desertification

Assessment and mapping of natural resources in Dhanera and Deesa tehsils of Banaskantha district (229966 ha), Gujarat, reveal that despite being located in the wetter fringe of the desert, the tehsils still suffer from drought (>30% years) and floods (25% years). The area is dominated by the alluvial plains of the Banas, Sukal and Bargaon Rivers, all of which are ephemeral, but have deep sediments, with variable aeolian cover. In the six soil series, loamy sand soils cover 78% area, while sandy loam soils cover 15% area and fine sand soils the rest 7% area. About 33% rangelands are severely degraded, and the rest are moderately degraded, herbaceous component being most degraded. Some trees, shrubs and grasses have been identified for range restoration. Agro-forestry can be promoted in the croplands. The tehsils have >800 ponds that can store ~35 mcm water, but are currently used mostly for the brick kiln industry. Scope exists for developing at least 13 potential watersheds. Groundwater, though of good quality, is highly exploited for irrigation, so that the current depletion is @ 4.5 m $year^{-1}$. Both the tehsils have ~33% area under double crops due to irrigation, ~45% area under rainfed crops alone, and 8% area under grazing. Castor, pearl millet and mung bean are the major kharif crops, and mustard and wheat are the major rabi crops. Land degradation due to aeolian activities is almost nil, but that due to water erosion is significant. Simulation studies showed that ~35% area of Dhanera tehsil and 54% of Deesa tehsil had high to very high erosion potential.

Soil fertility assessment in Pali district revealed <0.7% organic carbon. Among the mocro-nutrients, Cu and Mn was sufficient, Fe was most deficient followed by Zn in all the land use systems (rainfed, irrigated and grazing).

At Agolai, in order to quantify the transported bedloads, a sediment catcher was designed and fixed in the channel bed. Analysis of sediments (rhyolite and carbonate nodules) showed higher accumulation of greater weight, larger-size gravels even during a lower flow event.

At RRS, Kukma, an experiment was carried out to see the effects of tillage practices and soil amendments on soil properties. Deep tillage reduced higher percentage of dehydrogenase and alkaline phosphatase activities than the shallow tillage over the control. Tillage did not influence the acid phosphatase activities.

Application of seasonal forecasts for crop planning and livestock management in arid Rajasthan: Agro-advisory on crop planning and livestock management based on Extended Range Weather Forecasts received from IMD/IIT-D, New Delhi, for monsoon 2010 was tested in Jodhpur. District-level rainfall forecast was lower than the actual in June, but closer to observed in July and August. Advisories on cool temperatures favouring downy mildew, white rust in mustard and Isabgol, blight and powdery mildew in cumin were also given.

Biodiversity Conservation and Improvement of Annuals and Perennials

In multilocation trial of *C. ciliaris,* IMTCC-10-4 had maximum green fodder (16083 kg ha^{-1}) at Jodhpur, IMTCC-10-6 (5889 kg ha^{-1}) at Bikaner and IMTCC-10-1 (16867 kg ha^{-1}) at Pali. During second year CAZRI 541 showed maximum green forage (25067 kg ha^{-1}) and dry matter (6439 kg ha^{-1}) productivity. After seed collection among fifty-eight accessions, CAZRI 2221 showed maximum green fodder (25167 kg ha^{-1}). Entry CE-08-3 showed maximum green and dry fodder production and per day productivity in coordinated varietal trial. In IVT of *L. sindicus,* IVTS-2 (1023 kg ha^{-1}) had maximum dry matter yield at Jodhpur and IVTS-6 (630 kg ha^{-1}) at Chandan. In sweet sorghum for fodder at Pali, SPV 422 showed maximum green fodder yield (65300 kg ha^{-1}) with 45 x 10 cm spacing and SPV 913 (62040 kg ha^{-1}) with 30x 10 cm spacing after 70 days of sowing.

Gamma rays created significant variation in morphological traits and nodulation in seedlings *of A. senegal.* Variation in shape, colour and size of nodules, and rhizobial colonies was observed in *A. senegal* and *P. cineraria.* Rajasthan and Sudan genotypes of *A. senegal* produced seeds and maximum seed yield per tree was in case of Sudan material (1931.1 g) followed by Rajasthan (742.0 g).

After six years of establishment of 24 accessions of *S. oleoides,* survival % varied from 40.0 to 100.0 and maximum height was for Acc 214 (2.35 m). Barmer, Jalor, Sirohi, Pali and Nagaur districts were surveyed for Guggul distribution and it was present in 26% of the sampled sites. At Jaisalmer, Dantiwara and Mangaliawas provenances (ten-year-old plantation), and Kailana provenance (four-year-old) showed better suitability for extreme arid conditions. Eight accessions (five-year-old) of *Haloxylon salicornicum* were evaluated at Bikaner and CZBHS-42 had maximum biomass (1785.0 g $plant^{-1}$).

Germplasm of Cactus, Fig, Karonda, Gonda and Ivy gourd is maintained and evaluated. In date palm at Chandan (Jaisalmer), maximum acidity was in Umshok cultivar followed by Halawi and the lowest for Migraf at doka stage.

In pearl millet, sixteen new inbred lines from the advanced breeding material were identified and named CZI 2010/1 to CZI 2010/16. In different hybrid trials, highest grain yielders were ICMA 88004 x CZI 2008/8 (3009 kg ha^{-1}) in HT I, ICMA 92777 x CZI 2004/7 (2964 kg ha^{-1}) in HT-II, ICMA 94555 x CZI 2007/1 (2884 kg ha^{-1}) in HT -III, ICMA 97333 x CZI 2000/13 (3010 kg ha^{-1}) in HT–IV and ICMA 97444 x CZI 2000/22 (2881 kg ha^{-1}) in HT–V; and CZMS 14A x CZI 2005/21 (2877 kg ha^{-1}) in L x T hybrid trial. In coordinated trials the maximum seed yielders were IHT 106 (3092 kg ha^{-1} at Jodhpur and 615 kg ha^{-1} at Bikaner) in IHT; and AHPT 810(2792 kg ha^{-1} at Jodhpur and 1235 kg ha^{-1} at Bikaner) in advance hybrid and population trial.

In clusterbean mutants from HGS-365 performed better (seed 361 kg to 494 kg ha^{-1}, maturing in 82-84 days) than the parent. In germplasm, selection line No. 10, 24 and 29 were high yielders (323-391 kg ha^{-1}) maturing in 90-96 days. GR-1 and RG-8 were significantly better than the others with seed yield of 310-355 kg ha^{-1}, maturing in 86-87 days in IVT; GR-103 and GR-108 (305-354 kg ha^{-1}) maturing in 86-87 days in AVT-I and AVT-II. In mung bean mutants

CZM-24, CZM-25, CZM-26, CZM-41, CZM-47 and CZM-48 were higher yielders (1042-1427 kg ha^{-1}) than the check parent varieties, S-8 and K-851 (850-906 kg ha^{-1}).

Among 17 varieties of sesame at Bhuj, Murg-1 (570 kg ha^{-1}) was the highest seed yielder and matured in 82 days. 179 accessions differed significantly for seed yield and related traits. Highest seed yielder was NIC 17432 (21.6 g plant^{-1}). In watermelon at Jaisalmer DRB 677 among 122 accessions showed maximum number of fruits, fruit and seed yield per plant.

Six lines of cumin, 22 of coriander, 13 of fennel and 17 of fenugreek, 44 genotypes of mung bean and 12 different strains from mushroom fruiting bodies associated with the stem base of diseased trees were molecularly characterized.

In cumin, pre-sowing seed treatment with priming, ethephon (800 ppm) and *T. harzianum* (4 g per kg seed) showed significant positive effect on seed yield, whereas, *T. harzianum*, *A. versicolar*, bavistin and captan showed low incidence of wilt, blight and powdery mildew.

Forty kg breeder seed of pearl millet of open pollinated variety CZ-IC 923; 9.9 kg nucleus seed and 391 kg breeder seed of moth bean var. CAZRI Moth 2, and 184 kg seed of pasture grasses were produced. In addition to this, 4986 kg truthfully labelled (TFL) seed of various crops and 1.35 lakh seedlings of horticultural, forestry and medicinal plants were also produced.

Five *Pleurotus* species viz., *P. sajor-caju, P. citrinopilatus, P. flabbilatus, P. florida* and *P. sapidus* colonized faster on pearl millet and groundnut substrates, however, the maximum yield was on wheat substrate. Maximum yield was in case of *P. sapidus* on wheat straw.

Integrated Arid Land Farming Systems Research

Continuous cropping of pearl millet without fertilizer application produced 291 kg grain ha^{-1}, while application of 20 and 40 kg N ha^{-1} produced 445 and 522 kg grain ha^{-1}. The maximum grain yield (1058 kg ha^{-1}) was obtained with the application of 5 t FYM along with 40 kg N ha^{-1}.

Clusterbean variety HG-100 was best yielder at Bikaner (1175 kg ha^{-1}), while variety RGC 936 gave maximum yield (880 kg ha^{-1}) at Jaisalmer. Row spacing of 45 cm was better than 30 cm spacing at both the lacations. Skip row planting of clusterbean gave 31% higher seed yield compared to normal planting (1298 kg ha^{-1}). Integrated application of 50% N through FYM and 50% N through urea resulted in 11.62, 9.47 and 36.24% increase in seed yield of clusterbean over the application of 100% N through FYM, 100% N through urea and control, respectively. Pod yield of vegetable clusterbean was maximum when irrigation was given at 0.8 CPE (7.8 t ha^{-1}). Incorporation of vermicompost in the preceding crop had beneficial effect on clusterbean yield. Grain yield of sesame increased by 1.76 to 1.91 times with the application of 2.5 and 5.0 t manure ha^{-1}, while, the increase was only 0.019 to 0.61 times in clusterbean.

Sole pearl millet gave 133% higher grain yield compared to 1:1 crop colocynth ratio (391 kg ha^{-1}). Highest clusterbean seed yield (718 kg ha^{-1}) was recorded in 4:1 crop colocynth ratio. Significantly lower number of weeds and weed dry weight m^2 were recorded in 2:1 crop colocynth ratio.

Out of 51 genotypes of mustard tested, 11 genotypes viz. CS 56, CS 54, CS 52, BM 201, DRMR 09-423-1, DRMR-09-517-4, DRMR 09-668-4, BM 199, DRMR 09-664-4 and GM3, showed less reduction in germination (12-21%) at high (15.7 dS m^{-1}) and medium (5.4 dS m^{-1}) salinity levels. Seed treatment of cumin with GA 250 ppm gave maximum seed yield (304 kg ha^{-1}) in 7 DAS irrigation treatment which was at par with yields obtained with GA 100, Thio 250 and Thio 500 ppm seed treatments.

Drip irrigation in cotton at 0.8 ETc gave 27.5% higher seed cotton yield compared to yield with furrow irrigation (1801 kg ha^{-1}). Decrease in seed cotton yield was 6.3% at 0.8 ETc and 25.5% at 0.6 ETc irrigation levels compared to full irrigation (1.0 ETc). Mulching gave 17.9-48.5% higher yield of okra compared to no mulch. Yield was highest with plastic mulch followed by hessian cloth and indigenous material mulch. Fruit yield of ladyfinger was maximum at 20x20 cm spacing (4.5 t ha^{-1} in drip and 3.4 t ha^{-1} in check-basin). Muskmelon cv. Kajri gave 19% higher yield under drip irrigation compared to the yield under check-basin. Tomato hybrid Calyx 248 produced 67.8 t tomato ha^{-1} while the other two varieties produced 38.9 and 15.0 t ha^{-1}. Gladiolus variety snow princess (white coloured) was found best with respect to spike length (45-50 cm), total number of florets per spike (15-19), floret size (6.5 cm) and duration of flowering (14 days) followed by variety Aldebaran.

Among twenty accessions of clitoria tested at Kukma, Bhuj accessions IL 468, CAZRI 752, IGFRI 94 and JHC 94 yielded more than 5.5 t ha^{-1}, whereas the local strain (4.4 t ha^{-1}) and CAZRI 466 (4.6 t ha^{-1}) gave the least dry forage yield. Seed treatment of clitoria with phosphorus solubilizing microbes and plant growth promoting rhizobacteria increased dry forage yield by 11.65 and 11.7%, respectively over control. Combined application of Zn, Mn and B @ 3.0, 3.0 and 0.6 kg ha^{-1}, respectively at the time of sowing increased dry forage yield by 23.75% over control.

The green fodder yield was maximum in oat – pearl millet sequence (64.4 t ha^{-1}), while dry matter yield was highest in *Cenchrus ciliaris* + lucerne intercropping system.

Application of sulphydryl compounds i.e. thioglycollic acid and thiourea in moth bean and clusterbean increased their chlorophyll content, net photosynthetic rate and stomatal conductance. Exposure to high temperature (3-5°C higher than ambient), particularly at reproductive stage, adversely affected total dry matter production and grain yield of clusterbean and pearl millet. The deleterious effect of high temperature was more in clusterbean with respect to nitrate reductase activity and starch accumulation.

Net returns were maximum in ber based production system (Rs. 61,520) and minimum in arable farming system (Rs. 22,460). From seven year old plantation of Henna at Pali, maximum henna dry leaf yield (335.8 kg ha^{-1}) was recorded under sole henna and henna-clusterbean intercropping significantly reduced its leaf yield. At 10 x 10 m spacing of *Ailanthus excelsa*, pearl millet grain yield was 9.4% and 15.5% higher than the yield at 8 x 8 m and 6 x 6 m tree spacing. Similarly, *Cenchrus ciliaris* grass production was 19.5 and 16.2% higher in 10 x 10 m tree spacing compared to yield in 8 x 8 m and 6 x 6 m tree spacing. Yield of fuel wood and fodder was 1667.2 and 524.5 kg ha^{-1} in *Z. rotundifolia* compared to 1170.3 and 179.5 kg ha^{-1} in *A. indica*.

Treating the mustard residues with 10N concentration of H_3PO_4 and H_2SO_4 increased their decomposability by 60%, while treatment with 1N HCl had no effect on decomposability. Decomposition rate of leaf litter of MPTs was lowest in *C. mopane* followed by *Dalbergia sissoo*. Among the fruit trees, the lowest decay rate coefficient was observed in *Cordia myxa*.

Inoculation of pearl millet with *P. purpurogenum* significantly improved plant biomass (30%), root length (21%), P uptake (6%), seed (19%) and straw yield (30%), and P concentration of shoot (15%), root (6%) and seed (33%). Significant improvement in nodule number (50%), pods per plant (27%) and seed yield (23%) of clusterbean was observed when 40 ppm P was applied as nano-P than normal particle. Foliar application of bio-synthesized Zn (10 ppm) and Fe (30 ppm) nanoparticles resulted in significant improvement in growth of clusterbean and moth bean. Ten polysaccharide producing organisms were isolated from arid soils and their polysaccharide production was enhanced by 4 to 9 times through the application of Fe and Zn nanoparticles.

Integrated Land and Water Resources Management

Cumulative soil loss through wind erosion in suspension mode (0.25 to 2 m above surface) during the middle of June to the end of September 2009 was 1.36 t ha^{-1}. In comparison, the soil loss in suspension mode during the middle of April to the middle of June 2010 was 1.76 t ha^{-1}. Extrapolation showed an average soil loss @ 17 kg ha^{-1} min^{-1} during dust storm events and @ 25 kg ha^{-1} day^{-1} during periodical observations. The average contents of C and N in eroded soils from the experimental site were 4 g kg^{-1} and 0.77 g kg^{-1}, respectively. Green & Ampt model and Horton model best fitted the infiltration characteristics of soils of Jaisalmer region. The steady state infiltration rate was very high (12.60 mm min^{-1}) in sand dunes, whereas it was as low as 0.39 mm min^{-1} in cultivated areas of *khadin*.

The physical properties of grazing land in Bikaner district varied significantly with depth. The bulk density increased with depth. The average porosity of soil was 36.95%, being highest in 16-40 cm soil depth. The organic carbon content was highest in surface soil (0.16%) and lowest in deepest soil layer (0.08%). Available N and K_2O content decreased with increase in soil depth. A community surface water reservoir of 3200 m^3 capacity was constructed under SUMAMAD project for irrigation in the run-off farm lands in Jaisalmer district. Four grass species were planted at the rocky stony site of Bhopalgarh. *C. ciliaris* produced 1272.7 kg ha^{-1} dry fodder yield, followed by *D. annulatum* (944.4 kg ha^{-1}).

The total runoff generated from Block-I of Beriganga Research Farm was 78206.91 m^3, out of which 9401.0 m^3 was retained by the four masonary check-dams. The number of species along the banks was 31-37 in contrast to 11-25 recorded 50 m away. Natural regeneration was noted in *Acacia senegal, Rhus mysorensis, Commiphora wightii, Grewia tenax, Calotropis procera, Cocculus pendulus* and *Lycium barbarum*. Rainwater was harvested by transforming sand dunes into catchment areas in Bikaner district. The maximum water was collected in asbestos sheet treatment followed by bricks with cement and use of Kolayat clay.

Annual evapotranspiration (ET), based on Penman-Monteith model, showed wide inter-station variability (e.g., 1623 mm at Jaisalmer to 2177 mm at Barmer). The minimum increase in

ET with each 1°C rise in temperature was at Churu (2.07%), while the maximum was noticed at Hanumangarh (2.27%). The highest change was in winter season, followed by monsoon and summer. Spatial correlation between gridded monsoon rainfall and pearl millet productivity in western Rajasthan (1960-2005) suggested a broad decadal pattern of relationship between the annual summaries of the two till the 1980s when the plotted data mostly fitted well ($r>0.5$), such that the 1960s and 1980s had better relationship and the 1970s had poorer one ($r<0.5$).

Improvement of Animal Production and Management

A herd of Tharparkar cattle was maintained on *Cenchrus* dominated pasture along with concentrate supplementation for research and demonstration to the farmers and distribution of males to villagers for its conservation. In goats, 82% Marwari and 73% Parbatsari does had kidding, whereas, twinning was more in Parbatsari goats (47%) than in Marwari (37%). Milk production in Parbatsari goats was higher than Marwari breed. The body weight of dams at kidding in Parbatsari breed (37.6 kg) was higher than Marwari (32.3 kg).

Milk samples of Tharparker cows maintained at Institute Central Research Farm, Jodhpur and at the farmers' field of Jhanwar village were analyzed. Milk density, solids-not-fat, total solids, and fat contents were higher, specific gravity was similar and hexane extractable total lipids was lower, in the farm managed than the farmers' cows. Low SNF and fat contents in milk of farmers' cows shows the poor nutritional status of the cows, and suggests supplementation of vitamin A and other critical nutrients to farmers' cows. Camels fed with *Lana* seeds replacing 25% of pelleted cattle feed on iso-nitrogenous basis maintained biochemical and mineral profile of blood and were in sound health.

Effect of climate stress on physiological and blood parameters of goats was studied in open and closed housing systems. Temperature humidity index indicated that November to February was most comfortable. The cold stress (November to third week of February) was more severe with the increase in air velocity from north direction. The higher rectal temperature of Marwari goats in afternoon hours in winter was due to the black colour of Marwari goat that absorbs the heat from the sun to keep their body warm. Microclimates of both types of housing systems were similar to macro-climate in morning hours but in afternoon the microclimate of closed-type was better than open-type due to the complete shade in closed area. During summer blood glucose, urea, creatinine and cholesterol were more in open-housing; whereas, heamoglobin, protein and albumin in closed-type housing system. The temperature in the east-west orientation animal shelter, with dimensions of 9 m long, 4.8 m wide with 3 m height from centre and 2.1 m from sides, was 2 to 3°C higher than the macro environment in winter.

Plant and Animal Products and Value Addition

Two aloe products, aloe hair conditioner and aloe soap were prepared using aloe juice as the main active ingredient. The hair conditioner is in the cream form while soaps are either semi-transparent bar or soap cream. Similarly, fruit pulp extracted from seeds of *Salvadora oleoides* was used for preparation of instant *Peelu* squash. 15 kg good-quality fruits (*Peelu*) from Araba in Barmer district showed 40% seed fat. A refinement study of *Prosopis* coffee showed that the 50:50

combinations of *P. juliflora* and raw coffee were accepted. In another effort, coffee powder was prepared by pre-heating and roasting the *P. juliflora* powder at 225°C for two hours. This powder was mixed with original chicory powder and/or original coffee in various ratios and was evaluated. The 70:10:20 (*P. juliflora*: chicory: raw coffee) combination was found to be the best. Three *P. juliflora* pods based milling products (fibrous epicarp, fibrous endocarp, and amorphous mesocarp) were used to prepare multi-nutrient blocks and multi-nutrient mixture. These three types are being tried to replace wheat bran, which is used as fibrous fraction in standard feed blocks. Nutritional evaluation of *C. melo* and *C. callosus* was carried out and value chain for *C. melo* was developed by using the pulp of *C. melo* fruit in the preparation of squash, jam, cussar, *laddoo* and melo sip.

Integrated Pest Management

Application of *Glomus fasciculatum* in nursery soil with and without nematode caused a progressive increase in the growth of chilli seedlings with the increase in the inoculum of arbuscular mycorrhizae fungus from 25 to 100 spores/100 g soil. All levels of the fungus enhanced N, P and K uptake by plants and maximum uptake was in the absence of nematodes. Combined application of *P. chlamydosporium* and *G. fasciculatum* caused significant reduction in gall and egg mass number and nematode population, and increased uptake of N, P and K.

Basidiocarps of *G. lucidum* developed on diseased trees of *A. tortilis* and *P. cineraria* were found infected with fungal hyperparasites, and *Rhizopus* and *Aspergillus* were more common. Under laboratory conditions, maximum growth and number of colonies were in case of *Trichoderma pseudokoningii* followed by *A. flavus* (LY). *Trichoderma* strain GTP4 showed the highest sporulation (7.3×10^7 cfu ml^{-1}) and strain GTP7 maximum colonies ($6/cm^2$) after 25 days. New strains of *Metarhizum*, isolated from *Achaea janata* larvae and white grubs, were highly effective against *A. janata* (70-80% mortality), *Catopsilia* sp. (70-90% mortality) and white grubs (50-60% mortality). Neem formulations (neem pellets and neem seed powder @ 800 kg, 600 kg and 400 kg ha^{-1}, and two neem oil sprays) in mung bean crop gave total protection from termite attack till harvest. There was significant reduction in populations of leafhopper, whitefly and both black and grey weevils. Two sprays of neem oil at 10 days interval was most effective for management of green peach aphid (*Myzus persicae*) in cumin.

B. firmus (biocontrol agent) survived equally well on 2% and 4% residues of cruciferous crops amended soil. Radish residues maintained its superiority over mustard and cauliflower and *B. firmus* had maximum survival in this after 60 days, whereas, for *T. harzianum, P. juliflora* compost was the best food substrate. Among seven combinations of promising food substrates, *P. juliflora* compost + radish + talc + lignite showed their compatibility in promoting individual bio-control agents in a new consortium product, where shelf life of *Bacillus* and *T. harzianum* could be maintained up to 180 days. In laboratory, survival of antagonistic actinomycetes against *Macrophomina phaseolina* was maximum in combination of mustard and weed residue compost. In all other composts there was enhancement in the population of antagonistic actinomycetes (16.5-28.1%) compared to non-amended control (9.3%).

Among forty-eight male sterile lines of pearl millet, 18 lines were free from DM, only one line (8B) showed smut incidence of 16.6% and all were free from blast disease. Seeds of pearl millet cv. 7042S treated with raw cow milk (1:9 dilution), amino acid mixture in 4 concentrations of 1:10, 1:50, 1:100 and 1:200 followed by *Gliocladium virens* (0.6%) reduced the incidence of DM. Seed treatment with RCM (1:9) and AA (1:200) with *G. virens* (0.6%) had the lowest DM incidence.

For management of bait shyness behavior in desert rodents, effect of coconut oil, and groundnut oil + salt as additives at two temperature levels i.e., 21°C and 31.1°C, was studied. In *Rattus rattus*, coconut oil (2%) reduced the shyness period by 15 days at low temperature, and 25 days at high temperature; and groundnut oil (2%) + salt (1%) reduced shyness period by 3 days at low temperature, and by 5 days at high temperature.

In *Funambulus pennanti*, groundnut oil (2%) + salt (1%). reduced shyness by two days at low temperature and by three days at high temperature.

Evaluation of Brodifacoum wax cake formulation showed that its single day exposure registered cent per cent mortality. This intake resulted in 100% kill of test house rats within 3-11 days under no choice test. But this formulation, in presence of an alternate food, registered decreased mortality of 80%.

Evaluation of a plant origin compound, 'Bio' in form of non sticky noodle formulation for its field efficacy as a male sterilant, showed no reduction in rodent population in the study area. However, when the trapped male rats from the treated area were paired with normal females, only two out of 7 pairs registered successful breeding with 2 and 5 young ones, respectively.

Rodent survey in Jhunjhunun district showed predominance of *Meriones hurrianae* and *Tatera indica* in the district. In the forest area, burrows of *Nesokia indica* were also recorded, besides those of *M. hurrianae and T. indica* - commensal rodents.

Bimonthly trapping data of lesser bandicoot rats in Jodhpur revealed no change in trap index. The sex ratio was in favour of females this year also (1:1.28). All the males showed scrotal testes, whereas females included pregnant, females with perforate and non-perforate vagina indicating presence of sub adults and adults. Pregnancy was noticed round the year.

Non-Conventional Energy Sources, Farm Machinery and Power

A solar water purifier with a capacity to purify 30 litres of nadi water per day was designed and fabricated. The maximum stagnation temperature inside chamber of solar water purifier was 147.5°C when ambient temperature was 37.5°C. The average output of solar desalination unit was 8.76 litre distilled water per day when water having 2500, 5000 and 7500 ppm dissolved salt was filled in it.

The maximum stagnation temperatures were 93.4°C, 92.5°C, 98.9°C, 84.8°C and 78.5°C in solar cooker made of clay, vermiculite, vermiculite with reflector, brick and stone slab, respectively when average ambient temperature was 36.7°C. The maximum stagnation temperatures inside cooking chamber were 114.1°C, 119.1°C, and 120.0°C in single hot box solar cooker, double reflector hot box solar cooker and non-tracking solar cooker, respectively when average ambient

temperature was 36.7°C. The stagnation temperatures were 66.2°C and 62.8°C inside solar dryer direct type and solar dryer in-direct type, respectively, when average ambient temperature was 35.0°C. The hot water temperatures were 55.5°C and 63.3°C in integrated collector storage solar water heater and natural circulation type solar water heater, respectively when average tap water temperature was 23.8°C.

The PV mobile unit was improved and tested to run *Aloe vera* gel extractor (350 W AC) and PV blower (75 W DC motor). The PV duster was improved further and its dusting capacity varies from 30 to 120g min^{-1} depending on the size of the holes in the hopper. Performance of thin film hydrogenated amorphous Si modules (12 Wp) was increased by adding two mirror boosters to increase the energy gains. Two small PV systems based on 60 Wp polycrystalline silicon modules were fabricated to charge a battery for illumination and operating AC/DC devices. Some PV modules of PV pump have become yellowish after exposure to irradiance for more than sixteen years and the adverse effect on the PV output was obvious with 40% reduction in Jsc values. A solar heating unit was fabricated for testing the performance of PEM fuel cell.

Seed yield of green gram and clusterbean increased by 29-30% when sown with tractor drawn three furrow (six row) multi-crop seed drill compared to conventional method of sowing. A tractor drawn weeder, with field capacity of 0.35 ha h^{-1}, was developed. It has provision of adjustment on the frame and length of the blade can be selected depending upon row to row spacing of crops. Similarly, an improved seed drill (0.60 ha h^{-1} field capacity) was developed, which comprises a tractor drawn cultivator, seed distribution system with drive wheel and press wheel for each furrow.

A pearl millet pearler was developed to peel and strip various layers of bran before making the flour. The shelf life of pearl millet flour derived from pearled grain improved appreciably. The grit fraction was found to be a good source of dietary energy. An experimental unit (batch type) for preparing biodiesel from tumba (*Citrullus colocynthes*) was fabricated. The recovery of biodiesel from raw tumba oil was 98%. The design of passive cool chamber was improved and holes were provided in outer and inner chambers for better circulation of air. Gravity fed (tank's height, 2.2 m), low-pressure drip irrigation system was developed for small applications. The drippers provided a discharge of 2 lph even at a pressure of 2.0 m height of water column.

Socio-economic Investigation and Evaluation

Survey of gum producing trees (*Acacia senegal*) continued in different habitats in Barmer and Nagaur districts. The period between February and June was most suitable for obtaining maximum gum using gum inducer. Using this technology, farmers have produced 1.8 to 8 t gum arabic.

The MGNREGA programme conducted in Luni tehsil of Jodhpur district provided employment to nearly 45% landless and marginal farmers. Maximum amount was spent for labour employment. Rural to urban migration reduced slightly, agricultural operation was affected and there was hike in wage rate.

Economic assessment of technology transfer in Pali district showed higher income generation from kharif and rabi crops using improved technology. Improved varieties of pearl millet, clusterbean and mung bean provided additional employment.

Economic analysis of camel production system showed camel carting is the main occupation in Bikaner district. Clusterbean, moth bean, chickpea and groundnut straw were the most preferred fodder and feed was the major item of total cost. Higher cost of dry fodder and lower rate of carting charges were the major constraints. On an average, fixed investment per household for animals alone accounted for 53%. In case of tourism, camel safari was the main occupation in and around Jaisalmer city, followed by farming and labour. Feed involved about 52% of total expenditure. About 76% of household investment was spent for animals.

In a study on marketing efficiency of horticultural commodities in Sriganganagar and Jaipur, important marketing channels were identified for kinnow, carrot, aonla and tomato crop. The marketing efficiency index in the supply channels was 0.5 in *kinnow*, 0.3 in carrot, 0.4 in aonla and 0.7 in tomato, respectively.

Technology Assessment and Transfer

Agro-advisory bi-weekly bulletins for monsoon 2010 were issued for Barmer, Churu, Jalor, Jodhpur and Pali districts. The success of rainfall forecast was 83% during summer and 57% during monsoon. A model Good Weather Code (2010) was developed for arid Rajasthan.

Improved technologies of kharif and rabi crops, popularization of high yielding varieties, technology for rodent control, compost making by farm women, livestock feeding system, de-worming with broad-spectrum anthelmentric were demonstrated in Osian tehsil.

Lack of education and less desire were the constraints in the dissemination of technologies among the farm women. Participation in training programmes was very low. Utilization of mass media sources was very less, only few of them subscribed newspaper. Majority of farmers were not aware of compost and vermi-compost. None of the respondents was aware about the disease control method.

High yielding varieties of kharif and rabi crops produced higher seed yield with higher economic returns Adoption of improved package of practices in pearl millet-wheat, clusterbean–wheat and mung bean-wheat enhanced wheat equivalent yield by 22.1, 35 and 27.7%, respectively. Among all the cropping systems highest net return was realized with mung bean-wheat cropping system.

Mung bean-wheat cropping system had 2.0-8.6% higher yield than farmer preferred groundnut-wheat system. Substitution of groundnut-wheat by mung bean-wheat and groundnut-chickpea saved 13 and 4 irrigations, respectively. Averaged across all the irrigation and nutrient management treatments cultivar HNG-10 of groundnut gave the highest yield. Results show that decreasing the irrigation frequency caused no appreciable reduction in yield. Among the long duration varieties, HNG-10 and in short duration varieties TG-39 performed better.

Empowerment of Women and Mainstreaming of Gender Issues

For enhancing knowledge and skills of farm women, they were given crop demonstrations on improved technologies viz: new varieties of mungbean (K-851), moth bean (CAZRI Moth-2), clusterbean (RGM-112) and dual-purpose variety of pearl millet (HHB-67). Farm women were encouraged and helped in establishing kitchen gardens, making compost pits and neem-based bio-pesticides. In the selected villages, women were imparted training regarding balanced feeding, health management and de-worming for increasing milk yield of livestock and income of farm families. Need based vocational trainings were given to more than 1000 farm women on crop production, low cost diet, value addition in fruits, vegetables, cereals, pulses, oilseeds, milk and mushroom etc. under different programs. Women's day in agriculture was celebrated in village Lunawas Charna (Panchayat Samiti Luni) on 4 December 2010.

कार्यकारी सारांश

समन्वित प्राकृतिक संसाधन मूल्यांकन प्रबोधन एवं मरूस्थलीकरण

बनासकांठा (229966 हे.) जिला, गुजरात की धानेरा और डीसा तहसील के प्राकृतिक संसाधनों का मूल्यांकन और मानचित्रण किया गया जिसमें यह प्रकट हुआ कि रेगिस्तान के आर्द किनारों पर स्थित होने के बावजूद तहसील में सूखा प्रभावित क्षेत्र (> 30 प्रतिशत वर्ष) और बाढ़ (25 प्रतिशत वर्ष) में रहे। क्षेत्र में बनास, सूकल और बड़गाव नदी के जलोढ़ मैदानी भाग प्रमुखतः हैं जिसमें सभी अस्थायी है परन्तु गहरे अवसाद के साथ विभिन्न वातज मृदा आवरण से युक्त है। छः मृदा श्रृंखलाओं में संमृदामय मृदा 78 प्रतिशत क्षेत्र में है जबकि सिकता संमृदामय मृदा 15 प्रतिशत और बारीक मृदा शेष 7 प्रतिशत क्षेत्र में है। करीब 30 प्रतिशत चारागाह क्षेत्र गंभीरतः अवह्रासित है और शेष मध्यमतः अवह्रासित है जिसका वानस्पतिक घटक सर्वाधिक अवह्रासित है। कुछ पेड़, झाड़ियाँ और घास का चयन क्षेत्र सुधार हेतु किया गया । फसल भूमि में कृषि वानिकी को बढ़ावा दिया जा सकता है। तहसील में लगभग 800 तालाब हैं जिनमें ~ 35 एमसीएम पानी संग्रहीत किया जा सकता है परन्तु अभी उनका प्रयोग ईंट भट्टा उद्योग में किया जा रहा है। 13 संभावित जल संग्रहकों के विकास की संभावनाएँ मौजूद है। यद्यपि भू जल अच्छी गुणवता का है परन्तु सिंचाई के लिए अति दोहित किया जा रहा है इसलिए अभी भू जलक्षरण की दर 4.5 मी. प्रति वर्ष है। दोनों तहसीलों में सिंचाई के कारण 33 प्रतिशत से अधिक द्विफसलीय क्षेत्र, 45 प्रतिशत बारानी फसल और 8 प्रतिशत क्षेत्र चारागाह के अन्तर्गत है। अरण्डी, बाजरा और मूंग प्रमुख खरीफ फसलें है और सरसों एवं गेहूँ मुख्य रबी फसले है। वायुवीय प्रक्रिया के कारण भूमि अवह्रास नगण्य है परन्तु भूमि अवह्रास के लिए जल कटाव प्रमुख कारण है। अध्ययन बताते है कि धानेरा तहसील का 35 प्रतिशत और डीसा तहसील का 54 प्रतिशत क्षेत्र उच्च कटाव से ग्रसित है।

पाली जिले में मृदा उर्वरता मूल्यांकन से ज्ञात हुआ कि सभी भू उपयोग पद्धतियों (बारानी, सिंचित और चारागाह) में > 0.7 प्रतिशत जैव कार्बन है। सूक्ष्म पौषक तत्वों में ताम्र और मैगनीज पर्याप्त है, जबकि लौह तथा जिंक की सर्वाधिक अल्पता है।

आगोलाई में तलीय मृदा के स्थानान्तरण की मात्रा नापने हेतु सेडीमेंट कैचर का निर्माण करके नहर की तल में लगाया गया। तलछटों के विश्लेषण (रीयोलाइट और कार्बोनेट नोड्यूल) से ज्ञात हुआ कि कम बहाव के समय भी अधिक भारी तथा बड़े आकार के ढ़ेलों का जमाव अधिक रहा।

क्षेत्रीय अनुसंधान केन्द्र, (कुक्मा) भुज में जुताई प्रक्रिया एवं मृदा सुधार का मृदा गुणों पर पड़ने वाले प्रभाव का प्रयोगिक अध्ययन किया गया। छिछली जुताई के बजाय गहरी जुताई में डिहायड्रोजिनेज और अम्लीय फॉस्फेटेज गतिविधियों में की देखी गयी। जुताई का अम्लीय फॉस्फटेज की गतिविधियों पर प्रभाव नहीं पड़ा।

शुष्क राजस्थान में ऋतु आधारित पूर्वानुमान का फसल निर्धारण और पशु प्रबन्धन में प्रयोगः मानसून 2010 हेतु आईएमडी/आईआईटी, नई दिल्ली से प्राप्त विस्तारित क्षेत्रीय मौसम पूर्वानुमान आंकड़ों के आधार पर फसल निर्धारण और पशु प्रबन्धन हेतु कृषि सलाह का जोधपुर में परीक्षण किया गया। वर्षा का पूर्वानुमान जून माह में वास्तविक से कम रहा। जबकि जुलाई, अगस्त का पूर्वानुमान अधिक सफल रहा। इसबगोल एवं सरसों में कम तापमान के समय तुलाषिता तथा सफेद मक्खी तथा जीरे में तुलाषिता और ब्लाइट के नियन्त्रण हेतु भी सलाह दी गई।

जैव विविधता संरक्षण, वार्षिक एवं बहुवार्षिक पादप सुधार

सेन्क्रस सीलीयरिस आईएमटीसीसी–10–4 के बहुस्थानिक परीक्षण में सर्वाधिक हरा चारा (16083 कि.ग्रा./हे.) जोधपुर, में आईएमटीसीसी 10–6 (5889 कि.ग्रा./हे.) बीकानेर में और तत्पश्चात् आईएमटीसीसी 10–1 (16867 कि. ग्रा./हे.) पाली में प्राप्त हुआ। दूसरे वर्ष में काजरी 541 से सर्वाधिक हरा चारा (25067 कि.ग्रा./हे.) और सूखा चारा (6439 कि.ग्रा./हे.) प्राप्त हुआ। 58 एसेसन्स से किये गये बीज संग्रहण से काजरी 2221 से सर्वाधिक हरा चारा (25167 कि.ग्रा./हे.) प्राप्त हुआ। समन्वित किस्म परीक्षण के अन्तर्गत सीई–08–3 ने सर्वाधिक हरा और सूखा चारा

और प्रति दिवस उत्पादकता प्रदान की। *लेज्यूरस सिंडीकस* के आईवीटी परीक्षण में आईवीटी–2 (1023 कि.ग्रा./हे.) से सर्वाधिक सूखा चारा उत्पादन जोधपुर में प्राप्त हुआ और आईवीटीएस–6 से (630 कि.ग्रा./हे.) चांदन में प्राप्त हुआ। चारे के लिए मीठे ज्वार के परीक्षण में पाली में एसपीवी–913 (62040 कि.ग्रा./हे.) उत्पादन 30 x 10 से.मी. अन्तराल में बुवाई से 70 दिन पश्चात् प्राप्त हुआ।

गामा किरणों की खुराक से *ए. सेनेगल* (कुमट) बीजांकुरों में पर्याप्त विभिन्नता पौध आकारिक व गॉठ निर्माण में रही। *ए. सेनेगल* व *पी. सीनेरारिया* में गांठो के आकार और रंग एवं राइजोंबियम मण्डलीय में विभिन्नता पाई गई। *ए. सेनेगल* के राजस्थान एवं सूडान जैव टाइप में प्रति पेड़ सर्वाधिक बीज उपज दर सूडान पैतृक (1931.1 ग्रा.) तत्पश्चात् राजस्थान (742.0 ग्रा.) जैव टाइप की रही।

एस. ऑलियोडिस (जाल) के 24 उत्परिवर्ती के स्थापन के 6 वर्ष पश्चात् जीवितता प्रतिशत 40.0 से 100.0 तक रही और एसीसी–214 में सर्वाधिक ऊॅचाई 2.35 मी. रही। बाड़मेर, जालोर, सिरोही, पाली और नागौर जिलों में गूगल वितरण का सर्वेक्षण किया गया और पाया गया कि यह चिन्हित स्थानों में 26 प्रतिशत तक स्थित है। शुष्क परिस्थितियों में जैसलमेर, दांतीवाड़ा और मांगलियावास क्षेत्रों में (दस वर्ष पुराने पौधरोपण) और कायलाना क्षेत्र (चार वर्ष पुराने) में इसकी अच्छी स्वीकार्यता पाई गई। *हॉलोक्सिलोन सलीकोर्निकम* के आठ उत्परिवर्ती का बीकानेर में परीक्षण किया गया और सी जेड बी एच एस–42 से सर्वाधिक जैविक भार उत्पादन (1785.0 ग्रा.) प्राप्त हुआ।

कैक्टस, अंजीर, करोंदा गोंदा, और कुन्दरू, के जर्मप्लाज्म का परीक्षण किया गया। जैसलमेर (चांदन) में परीक्षित खजूर के सात किस्मों में से *उमसॉक* में सर्वाधिक अम्लीयता तत्पश्चात् हलावी में और सबसे कम मीगराफ में डोका अवस्था में पायी गयी।

बाजरा के संकर परीक्षण में 16 नये अर्न्तजनित एसेसन्स की पहचान अग्रिम प्रजनक पैतृक से की गई और सीजेडआई–2010/1 से सीजेडआई–2010/16 तक नामित की गई। विभिन्न प्रसंकर परीक्षणों में सर्वाधिक अन्न उपज वाले आईसीएमए–88004 x सीजेडआई–2008/8 (3009 कि.ग्रा./हे.) में एचटी–I में, आईसीएमए–92777 x सीजेडआई–2004/7 (2964 कि.ग्रा./हे.) एचटी–II में, आईसीएमए–94555 x सीजेडआई–2007/1 (2884 कि.ग्रा./हे.), एचटी–III में, आईसीएम–97333 x सीजेडआई–2000/13 (3010 कि.ग्रा. हे.) एचटी–IV में और आईसीएमए–97444 x सीजेडआई–2000/22 (2881 कि.ग्रा./हे.) एचटी–V में और सीजेडएमएस–14 ए x सीजेडआई–2005/21 (2877 कि.ग्रा./हे.) एल x टी प्रंसकर परीक्षण में पाई गई। समन्वित परीक्षणों में सर्वाधिक बीज उत्पादक आईएचटी–106 (3092 कि.ग्रा./हे) जोधपुर में और (615 कि.ग्रा./हे.) बीकानेर में, आईएचटी और एएचपीटी–810 (2792 कि.ग्रा./हे.) जोधपुर और (1235 कि.ग्रा./हे.) बीकानेर में अग्रिम प्रंसकर और संख्या परीक्षण में रही।

ग्वार के पैतृक जर्मप्लाज्म की अपेक्षा एचजीएस–365 के उत्परिवर्ती किस्में (बीज उत्पादनः 361 कि.ग्रा. से 494 कि.ग्रा./हे. तथा पकने की अवधिः 82–84 दिन) निष्पादन में अच्छी रही। जर्मप्लाज्म चयन में पंक्ति नं. 10, 24 और 29 उच्च उत्पादक (323–391 कि.ग्रा./हे.) रहे तथा उनके पकने का समय 90–96 दिन था। आईवीटी पीरक्षणों में अन्य किस्मों की अपक्षा जीआर–1 तथा आरजी–8 सर्वाधिक बीज उत्पाक (310–355 कि.ग्रा./हे.) पायी गयी जिनकी परिपक्वता अवधि 86–87 दिन रही। इसी प्रकार एवीटी–। तथा एवीटी–।। परीक्षणों में जीआर–103 तथा जीआर–108, अधिक बीज उत्पादन (305–354 कि.ग्रा./हे.) एवं 86–87 दिन की परिपक्वता काल के अनुसार श्रेष्ठ पायी गयी। मूंग उत्परिवर्ती में सीजेडएम–24, सीजेडएम–25, सीजेडएम–26, सीजेडएम–41, सीजेडएम–47 और सीजेडएम–48 उच्च उत्पादक (1042–1427 कि.ग्रा./हे.) रहीं, जबकि इनकी चैक पैतृक किस्मों एस–8 और के–851 का उत्पादन 850–906 कि.ग्रा./हे. के बीज रहा।

भुज में तिल की 17 किस्मों में से मुरग–1 (570 कि.ग्रा.) सर्वाधिक बीज उत्पादक रही और इसकी परिपक्वास्था 82 दिन रही। 179 एसेसन्स बीज उत्पादन और सम्बन्धित परीक्षणों में प्रमुखतः विभिन्न रहे। सर्वाधिक बीज उत्पादन एनआईसी–17432 (21.6 ग्राम/पौध) से रही। जैसलमेर में तरबूज के 122 एक्सेशनों पर किये अध्ययन में डीआरबी–677 में सर्वाधिक फल संख्या और फल व बीज उत्पादन प्रति पौधा रहा।

जीरा की 6, धनिया की 22, सौंफ की 13 और मैथी की 17 लाईनों तथा मूंग के 44 जीनो टाइप और रोग ग्रसित वृक्षों के तनों के आधार से प्राप्त मशरूम के 12 विभिन्न किस्मों के फलन घटकों आण्विकतः वर्गीकरण किया गया।

जीरा में बीज की बुवाई से पूर्व ईथोफोन (800 पीपीएम) और *टी॰ हरजीनम* (4 ग्राम प्रति कि.ग्रा. – बीज) से उपचारित करने पर प्रमुखतः बीज की उपज पर सकारात्मक प्रभाव पड़ा। वही *टी॰ हरजीनम, ऐ॰ वेसीकॉलर,* बेविस्टिन और केप्टान से झुलसा और तुलासिता रोग के कम अवसर पाये गये।

बाजरा के मुक्तपरागित किस्म सीजेडआईसी–923 से 40 कि.ग्रा. प्रजनक बीज, मोंठ काजरी मों–2 के 9.9 कि.ग्रा. नाभिक बीज और 391 कि.ग्रा. प्रजनक बीज और चारा घास के 184 कि.ग्रा. बीज उत्पादित किये गये। इसके अतिरिक्त विभिन्न फसलों के लेबल्ड (टीएफएल) बीज 4986 कि.ग्रा., औद्यानिकी, वानिकी और औषधीय पौधों के 1.35 लाख पौध तैयार किये गये।

प्लूरोटस मशरूम की पांच किस्में, *पी॰ सेजोर* काजू, *पी॰ सिट्रीनोपिलेटस, पी॰ फ्लैबीलेटस, पी॰ फ्लेरिडा* और *सेपीडस,* बाजरा और मूंगफली भूसे पर शीघ्र विकसित हुई फिर भी इनका अधिकतम उत्पादन गेहूँ वाले खाद्याधार भूसे पर हुई जिसमें *पी॰ सेपीडस* का उत्पादन अधिकतम रहा।

एकीकृत शुष्क क्षेत्र सस्योत्पादन पद्धति अनुसंधान

बिना उर्वरक दिये लगातार बाजरा की बुवाई से (291 कि.ग्रा./हे.) उपज प्राप्त हुई जबकि 20 और 40 कि.ग्रा. नत्रजन/हे. उर्वक देय से क्रमशः 445 और 522 कि.ग्रा./हे. उपज प्राप्त हुई। सर्वाधिक उपज (1058 कि.ग्रा./हे.) 5 टन एफवाईएम–40 कि.ग्रा. नत्रजन/हे. देने पर प्राप्त हुई।

बीकानेर में ग्वार की किस्म एचजी–100 सर्वाधिक उपज वाली (1175 कि.ग्रा./हे.) रही, जबकि जैसलमेर में किस्म आरजीसी–936 ने सर्वाधिक उपज (880 कि.ग्रा./हे.) दी। दोनों ही स्थानों पर 30 से.मी. से 45 से.मी. की दूरी में पंक्तियों में बुवाई अच्छी रही। ग्वार की सामान्य बुवाई (1298 कि.ग्रा./हे.) की अपेक्षा पंक्ति में बुवाई से 31 प्रतिशत अधिक उपज प्राप्त हुई। ग्वार में एफवाईएम द्वारा शतप्रतिशत नत्रजन, यूरिया द्वारा शतप्रतिशत नत्रजन तथा नियन्त्रण में देने की बजाय समन्वित रूप से 50 प्रतिशत नत्रजन (एफवाईएम द्वारा) और 50 प्रतिशत नत्रजन (यूरिया द्वारा) देने से क्रमशः 11.62, 9.47 और 36.24 प्रतिशत उपज में वृद्धि रही। सब्जी हेतु ग्वार की फलियों की 0.8 सीपीई पर सिंचाई देने पर सर्वाधिक उपज(7.8 टन/हे.) रही। पूर्ववर्ती फसल में वर्मी केम्पोस्ट देना ग्वार की उपज हेतु लाभकारी रहा। 2.5 और 5.0 टन प्रति हेक्टर गोबर की खाद देने से तिल की उपज 1.76 से 1.91 गुणा बढ़ी। जबकि यह बढ़त ग्वार में 0.019 से 0.61 गुणा ही रही।

बाजरा तथा तुम्बे की अर्न्तफसल (1:1 अनुपात में) की अपेक्षा, केवल बाजरा की खेती में बाजरा का उत्पादन 133 प्रतिशत (391 कि.ग्रा./हे.) अधिक रहा। ग्वार की सर्वाधिक उपज (718 कि.ग्रा./हे.) ग्वार एवं तुम्बा के (4:1 अनुपात में) अर्न्तफसल के अन्तर्गत दर्ज किया गया इसी प्रकार बाजरा तथा तुम्बा की अर्न्तफसल में (2:1 अनुपात) खरपतवार का प्रकोप भी महत्वपूर्ण रूप से कम रहा।

एक परीक्षण के अन्तर्गत सरसों के 51 जीनोटाइप्स में से 11 जीनोटाइप्सः सीएस–56, सीएस–54, सीएस–52, बीएम–201, डीआरएमआर–09–423–1, डीआरएमआर–09–517–4, डीआरएमआर–09–668–4, बीएम–199, डीआरएमआर–09–664–4 और जीएम–3 ने उच्च (15.7 डीएस/मी) और मध्यम (5.4 डीएस/मी) लवणीयता स्तर पर अंकुरण में (12.21 प्रतिशत) कमी दशायी। जीरे का बीजोंपचार जीए–250 पीपीएम द्वारा करने से सर्वाधिक बीजोत्पादन (304 कि.ग्रा./हे.) 7 डीएएस सिंचाई में प्राप्त हुई जो जीए–100, थायो–250 और थायो–500 पीपीएम से बीज उपचारित करने के समकक्ष रही।

कपास में 0.8 ईटीसी बूंद बूंद सिंचाई से कूंड सिंचाई (1801 कि.ग्रा./हे.) की अपेक्षा 27.5 प्रतिशत उच्च उपज प्राप्त हुई। कपास में पूर्ण सिंचाई (1.0 ईटीसी) की तुलना में 0.8 ईटीसी में 6.3 प्रतिशत और 0.6 ईटीसी में 25.5 प्रतिशत उपज कम रही। बिना आवरण की अपेक्षा वानस्पितिक आवरण से 17.9–48.5 प्रतिशत अधिक उपज रही। प्लास्टिक आवरण में सर्वाधिक उपज तत्पश्चात कपड़े और देशी सामग्री के आवरण के अन्तर्गत प्राप्त की गयी। भिंडी की सर्वाधिक उपज 20 x 20 से.मी. दूरी पर बुवाई करने पर प्राप्त हुई (बूंद बूंद सिंचाई में 4.5 टन/हे

और चेक बेसिन में 3.4 टन/हे.)। इसी प्रकार खरबूजा किस्म काजरी से भी बूंद बूंद सिंचाई में चेक बेसिन सिंचाई की तुलना में 19 प्रतिशत अधिक उपज प्राप्त हुई। टमाटर की संकर किस्म, कैलिक्स द्वारा 248 से 67.8 टन प्रति हेक्टर उत्पादन प्राप्त हुआ जबकि अन्य दो किस्मों से 38.9 और 15.0 टन/हे. प्राप्त हुआ। *ग्लैडियोलस* प्रजाति स्नोंप्रिंसेज (सफेद रंग), पुष्पवृंत की लम्बाई (45–50 से.मी.), प्रति वृंत पुष्प संख्या (15–19) पुष्पाकार (6.5 से.मी) और पुष्पनकाल (14 दिन) के अनुसार श्रेष्ठतम्, रही तत्पश्चात किस्म एड़ेबारान रही।

क्लाइटोरिया के 20 उत्परिवर्तियों का भुज में परीक्षण किया गया उनमें से आईएल–468, काजरी–752, आईजीएफआरआई–94 और जेएचसी–94 किस्मों द्वारा 5.5 टन/हे. से अधिक उपज प्राप्त हुआ। जबकि स्थानीय किस्म से (4.4 टन/हे.) और काजरी–466 से (4.6 टन/हे.) सबसे कम सूखा चारा उत्पादन प्राप्त हुआ। *क्लाइटोरिया* का बीजोंपचार फॉसफोरस घुलनशील सूक्ष्म जीवाणु और पौध वृद्धि कारक *राइजोबेक्टीरिया* से करने पर अनुपचारित की तुलना में चारा उपज क्रमशः 11.65 और 11.7 प्रतिशत अधिक रहा। बुवाई के समय जिंक, मेंगनीज और बोरोन (क्रमशः 3.0, 3.0 और 0.6 कि.ग्रा./हे.) के संयुक्त उपयोग से सूखा चारे की उपज में 23.75 प्रतिशत वृद्धि दर्ज की गयी।

जई + बाजरा क्रम में हरा चारा का उत्पादन सर्वाधिक (64.4 टन/हे.) था जबकि अधिकतम सूखा पदार्थ उपज, *सेंक्रस सीलियरिस* + *ल्यूसर्न* अर्न्तफसल पद्धति में प्राप्त हुई।

सल्फहाइड्रिल योगिकों, जैसे थायोग्लायकोलिक अम्ल और थायोयूरिया का मोंठ और ग्वार में उपयोग से क्लोरोफिल निहितता तथा सकल प्रकाश संश्लेषण दर में वृद्धि हुई। उच्च तापमान विशेषकर प्रजनन अवस्था में बाहरी तापमान से 3–5° से उच्च होने से ग्वार और बाजरा में सूखा पदार्थ और अन्न उत्पादन पर बुरा प्रभाव पड़ा। उच्च तापमान का ग्वार में नाइट्रेट रिडक्टेज प्रक्रिया और स्टॉर्च संकेन्द्रण में अधिक बुरा प्रभाव रहा।

बेर आधारित उत्पादन पद्धति में सकल प्राप्ति (रूपये 61520) सर्वाधिक और कृषिय पद्धति में न्यूनतम (रूपये 22460) रही। पाली में मेंहदी के 7 वर्ष पुराने पौधों से केवल मेंहदी की फसल के अन्तर्गत अधिकतम सूखा पत्ती उत्पादन (335.8 कि.ग्रा./हे.) दर्ज किया जबकि मेंहदी –ग्वार अर्न्त फसल में पत्ती उपज में प्रभावी कमी पायी गयी। 8 X 8 मी. और 6 X 6 मी. पेड़ दूरी की बजाय 10 X 10 मी. दूरी पर *एलीएन्थ्स एक्सेलसा*–बाजरा लगाने से बाजरे का दाना उत्पादन 9.4 प्रतिशत और 15.5 प्रतिशत अधिक रहा। इसी प्रकार 8 X 8 मी. और 6 X 6 मी. पेड़ दूरी की तुलना में सेंक्ररस सीलियरिस घास उत्पादन 10 X 10 मी. पेड़ की दूरी में 19.5 और 16.2 प्रतिशत अधिक रहा। *जिजीफस रोटुन्डीफोलिया* में ईंधन की लकड़ी और चारा की उपज अधिक, क्रमशः 1667.2 और 524.5 कि.ग्रा./हे. रहा जो, *ए. इन्डीका* में क्रमशः 1170.3 और 179.5 कि.ग्रा./हे. ही प्राप्त हुआ।

सरसों के अवशेष को 10एन सान्द्रता वाले फास्फोरिक अम्ल और सल्फ्यूरिक अम्ल द्वारा उपचारित करने से उनकी विघटन क्षमता 60 प्रतिशत तक बढ़ी जबकि 1एन हाइड्रोक्लोरिक अम्ल का उसके विघटन पर कोई प्रभाव नहीं रहा। बहुउद्देशीय वृक्ष की पत्तियों को विघटन दर *सी. मोपेन* तथा *डलबरगिआ सिसू* में न्यूनतम दर्ज की गयी। फल वाले पेड़ों में गूंदा में न्यूनतम सड़न दर गुणांक देखा गया।

पी. परप्यूरोजीनम से उपचारित बाजरा में पादप जैविक भार (30 प्रतिशत), जड़ वृद्धि (21 प्रतिशत), फॉस्फोरस लेयदर (6 प्रतिशत) बीज (19 प्रतिशत) और भूसा उपज (30 प्रतिशत) और फॉस्फोरस संकेन्द्रण तने में (15 प्रतिशत) जड़ (6 प्रतिशत) और बीज (33 प्रतिशत) आदि में महत्वपूर्ण सुधार दर्ज किया गया। सामान्य फास्फोरस कणों की अपेक्षा, 40 पीपीएम फॉस्फोरस नेनो – कण के उपयोग द्वारा ग्वार की जड़गांठ संख्या (50 प्रतिशत), प्रति पौध फलियों की संख्या (27 प्रतिशत) तथा बीजोत्पादन (23 प्रतिशत) आदि में महत्वपूर्ण सुधार देखा गया। जैव संस्लेषित जस्ते (10 पीपीएम) तथा लौह (30 पीपीएम) के नेनो कणों का पत्तियों पर उपयोग करने से ग्वार तथा मोठ की पादप वृद्धि में महत्वपूर्ण सुधार देखा गया।

समन्वित भू एवं जल संसाधन प्रबन्धन

निलम्बन पद्धति में वात कटाव द्वारा मृदाहनि (0.25 से 2 मी. भूतल के ऊपर से) जून मध्य से सितम्बर 2009 के दौरान 1.36 टन प्रति हेक्टर दर्ज किया गया। तुलनात्मक रूप में उसी पद्धति से मृदा का नुकसान मध्य अप्रैल से मध्य जून 2010 के बीच 1.76 टन प्रति हेक्टर रहा। रेतीली आँधी के समय औसतन मृदाहानि 17 कि.ग्रा.

प्रतिदिन रही तथा नियमित अन्तराज पर किए निरीक्षणों में परीक्षण स्थल पर यह हानि 25 कि.ग्रा. है, प्रतिदिन दर्ज की गई। अपरदन हुई मृदा में परीक्षित स्थल में कार्बन और नत्रजन निहितता क्रमशः 4 ग्राम/कि.ग्रा. और 0.77 ग्राम/कि.ग्रा. रही। जैसलमेर क्षेत्र में ग्रीन और एम्प्ट मॉडल और हरटन मॉडल सर्वाधिक उपयुक्त पाये गये। अपरदित मृदा के तत्वों के परीक्षण में रेतीले टीबों पर रेत का अपरदन उच्च (12.60 मि.मी. प्रति मिनट) रहा जबकि खडीन के फसलीय क्षेत्र में यह 0.39 मि.मी. रहा।

बीकानेर जिले में चारागाह भूमि के मृदा के भौतिक गुण, गहराई के अनुसार प्रमुख रूप से भिन्न पाये गये। गहराई के साथ परिमाण घनत्व में वृद्धि दर्ज की गयी। 16–40 से.मी. गहराई पर मृदा की औसत सर्वाधिक मृदारन्ध्रिता 36.95 प्रतिशत रही। सतही मृदा (0.16 प्रतिशत) पर जैविक कार्बन निहितता सर्वाधिक तथा मृदा की सर्वाधिक गहराई स्तर पर (0.08 प्रतिशत) न्यूनतम रही। मृदा की गहराई में वृद्धि के साथ उपलब्ध नत्रजन एवं पोटेश की निहितता कम पायी गयी। जैसलमेर में सिंचाई हेतु वर्षा से बहे पानी को इक्कठा करने हेतु फार्म भूमि पर सुमामाड परियोजना के अन्तर्गत 3200 मी^{3} क्षमता का सामुदायिक सतही जल संग्रहणक का निर्माण किया गया। भोपालगढ़ के चट्टानी कंकरीलें स्थल पर घास की चार प्रजातियाँ लगाई गई। *सेंक्रस सिलीयरिस* से 1272.7 कि. ग्रा./हे. तत्पश्चात् *डी॰ एन्यूलेटम* (944.4 कि.ग्रा./हे.) सूखे चारे का उत्पादन हुआ।

बेरीगंगा अनुसंधान प्रक्षेत्र में ब्लाक I से बरसाती जल बहाव से 78206.91 मी^{3} पानी संचित हुआ, जिसमें से 9401.0 मी^{3} पानी पत्थर निर्मित चेकबन्ध द्वारा रोका गया। इनके किनारों पर पौधों की 31–37 प्रजातियाँ पाई गई, जबकि इससे 50 मीटर की दूरी पर इनकी संख्या 11–25 ही रही। *एकेसिया सेनेगल, रस मॉयसोरेन्सिस, कामीफोरा विटी, ग्रीविया टेनेक्स, केलोट्रोपिस प्रौसीरा, कॉक्यूल्स पेन्डयूलस* और *लाईसियम बारबेरम* में प्राकृतिक पुर्नजीवन दर्ज किया गया। बीकानेर जिलें में रेत के टीले को संग्रहण क्षेत्रों में बदल कर वर्षा जल संग्रहण किया गया। सर्वाधिक जल संग्रहण एस्बेसटस सीट के प्रयोग के अन्तर्गत हुआ, तत्पश्चात् ईटों व सीमेन्ट और कोलायत मृतिका के प्रयोग का क्रम रहा।

पेनमन मोंटीन्थ मॉडल पर आधारित वार्षिक वाष्पीकरण (ईटी) अध्ययन में अन्तःस्थात्रीय विभिन्नता प्रदर्शित हई, जैसे 1623 मि.मी. (जैसलमेर) से 2177 मि. (बाड़मेर) तक। प्रत्येक 1 डिग्री. से॰ तापमान वृद्धि के साथ, वाष्पीकरण की सबसे कम बढ़त चुरू में (2.07 प्रतिशत) रही, जबकि सर्वाधिक बढ़त हनुमानगढ़ में (2.27 प्रतिशत) पाई गई। सर्वाधिक परिवर्तन सर्दी में, तत्पश्चात् मानसून और गर्मी में रहा। पश्चिमी राजस्थान में (1960–2005 के दौरान) बाजरा उत्पादकता तथा ग्रिडेड मानसूनी बरसात के बीच स्थितिय सम्बन्ध (दोनों की वार्षिकीय सार के अनुसार) 1980 के दशक तक वृहद दशकीय अर्न्त सम्बन्ध दर्शाते है जब रेखित आंकडें इस प्रकार से पूर्णतः सही बैठते है ($r > 0.5$) तथा 1960 में और 1980 के दशक के आंकड़े बेहतर सम्बन्ध तथा 1970 दशक के दौरान खराब ($r > 0.5$) सम्बन्ध दर्शाते है।

पशु उत्पादन सुधार और प्रबन्धन

अनुसंधान कृषक प्रदर्शन एवं प्रजाति संरक्षण हेतु सांडों के गांवो में वितरण हेतु थारपारकर गाय के समूह पूरक सान्द्र पोषक तत्वों के साथ *सेंक्रस* घास पर पालित किया गया। बकरियों की मारवाड़ी और परबतसरी प्रजातियों में क्रमशः 82 तथा 73 प्रतिशत तक मेमना जनन रहा जबकि इनमें जुड़वा जनन मारवाड़ी (37 प्रतिशत) की अपेक्षा परबतसरी में (47 प्रतिशत) अधिक दर्ज किया गया। मारवाड़ी प्रजाति की अपेक्षा परबतसरी बकरी में दुग्ध उत्पादन अधिक रहा। मारवाड़ी (32.3 कि.ग्रा.) की अपेक्षा परबतसरी प्रजाति में शरीर भार (37.6 कि.ग्रा.) अधिक रहा।

संस्थान के केन्द्रीय अनुसंधान फार्म, जोधपुर में थारपारकर गायों तथा झंवर गॉव में कृषक के खेत में पल रही गायों के दूध के नमूने विश्लेषित किये गये। इसमें संस्थान के फार्म पर, कृषक के फार्म के गायों की अपेक्षा दूध का घनत्व, ठोस भार–वसा नहीं, कुल ठोस और वसा की मात्रा अधिक, विशेष गुरूत्व बराबर और निस्सारित कुल वसा–कारक तत्व कम रहें। कृषकों की गाय में कम एसएनएफ और वसा निहितता बताती है कि उनकी गायों को कम पौषक तत्वों युक्त खाद्य पदार्थ दिया गया। अतः इन गायों को विटामिन 'ए' के अतिरिक्त खुराक और अन्य अलोच्य पौषक तत्वों की आवश्यकता है। ऊँट के पशु आहार को 25 प्रतिशत तक लाना बीज द्वारा (सम–नाइट्रोजन

आधार पर) स्थानापन्न करने से उनके रक्त में जैव रसायनिक और खनिज तत्व बराबर बने रहें और वे स्वास्थ्य में भी अच्छे रहे।

खुले और बन्द आवासीय प्रणाली में रखने पर बकरी के कार्यिकी और रक्त सम्बन्धी गुणों पर मौसमी दबावो के प्रभाव का अध्ययन किया गया। तापमान आद्रता सूंचकांक बताते है कि नवम्बर से फरवरी माह सर्वाधिक आराम दायक रहे। ठण्ड का दबाव (नवम्बर से फरवरी के तीसरे सप्ताह तक) उत्तरी हवा के तेज बहाव के कारण तीव्र रहा। मारवाड़ी बकरी का गुदा तापमान सर्दी की दोपहरी में उच्च रहा, वह इसके काले रंग के कारण है जो सूर्य से गर्मी खींचता है व इसके शरीर को गर्म रखता है। दोनों प्रकार के आवासों में सूक्ष्म जलवायु सुबह के समय बाह्य जलवायु के बराबर रही। जबकि दोपहर बाद खुले की अपेक्षा पूर्णतया छाया रहने के कारण बन्द आवासों में सूख्म जलवायु बेहतर रहा। गर्मी में रक्त में ग्लूकोज, यूरिया, क्रिएटेनिन और कॉलेस्ट्रोल खुले आवासों में अधिक पाये गये जबकि हीमोग्लोबिन, प्रोटीन और एल्बूमिन बन्द आवासों में अधिक रहे। सर्दी में स्थल वातावरण की बजाय पूर्व – पश्चिम दिशा वाले पशु आवासों (जिनका आकार 9 मी. लम्बे 4.8 मी. चौड़े और 3 मी. ऊँचे और 2.1 मी. साइड से), में तापमान 2 से 3 डिग्री. अधिक रहा।

पादप एवं पशु उत्पाद और मूल्य संवर्धन

ग्वार पाठा के जूस के मुख्य सक्रिय अंश का उपयोग करके इसके दो उत्पादः हेयर कंडीशनर (क्रीम के रूप में) तथा साबुन (अर्द्धपारदर्शक बट्टिा अथवा क्रीम के रूप में) तैयार किए गये। इसी प्रकार *सेल्वाडोरा ऑलिओडिस* (जाल) के बीज के गूदे को पीलू स्कवेश बनाने में प्रयुक्त किया गया। अराबा, बाड़मेर से प्राप्त 15 कि. ग्रा. अच्छे पीलू फल में 40 प्रतिशत अखाद्य वसा की मात्रा दर्ज की गयी। प्रोसोपिस कॉफी के सुधार के अध्ययन में यह पाया गया कि 50 : 50 भाग *पी॰ जूलीफ्लोरा* और कच्ची कॉफी का भाग स्वीकार्य रहा। इस प्रयास में *पी॰ जूलीफ्लोरा* पाउडर को 225° से॰ तापमान पर दो घंटे तक गर्म करके कॉफी पाउडर बनाया गया। इस पाउडर को मूल चिकोरी पाउडर/कॉफी में विभिन्न अनुपात में मिलाकर परीक्षित किया गया। 70:10:20 (*पी॰ जूलीफ्लोरा* बीजः चिकोरी : कच्ची कॉफी) का मिश्रण श्रेष्ठतम पाया गया। बहु पौषक बट्टिका और बहु पौषक संमिश्रण बनाने हेतु तीन *पी॰ जूलीफ्लोरा* आधारित चारा (तन्तु बाह्य, अर्न्त और मध्य भाग) का प्रयोग किया गया। इनको गेहूँ के चापड़ जो उच्च स्तरीय ब्लाक बनाने में प्रयोग किया जाता है, के स्थान पर प्रयोग में लिया गया। *सी॰ मेलो* और *सी॰ कैलोसस* की पौष्टिकता का परीक्षण किया गया। *सी॰ मेलो* के गूदे से स्क्वेश, जैम, कसार, लाडू और मेलो पेय बनाकर इसकी मूल्यसंर्वद्धन श्रृंखला विकसित की गयी।

समेकित नाशीजीवी प्रबन्धन

ग्लोमस फेसीकुलटेम को सूत्रकृमि के साथ तथा बगैर सूत्रकृषि वाली नर्सरी की मृदा में देने पर मिर्ची की पौध के बढ़त में वृद्धि हुई तथा *माइक्रोजिआ फफूँद* की वृद्धि 25 से 100 स्पोर्स/100 ग्राम मृदा तक दर्ज हुई। फफूंद के सभी उपचारो में नाइट्रोजन, फॉस्फेरस और पोटाश लेने की दर में वृद्धि रही तथा सर्वाधिक वृद्धि बगैर सूत्रकृमि वाली मृदा में देखी गयी। *पी॰ क्लमायडोस्पोरियम* और *जी॰ फेसिकुलेटस* के मिश्रित उपयोग से गांठ और सृत्रकृमि के अण्डे तथा उनकी कुल संख्या में महत्वपूर्ण कमी आई तथा नाइट्रोजन, फॉसफोरस व पोटाश ग्राह्यता में वृद्धि हुई।

एकेसिया टोरटिलिस और *पी॰ सीनेरारिया* के रोग ग्रसित पेड़ों पर विकसित *गैनोडर्मा ल्यूसिडम* के बेसिडियोंकापर्स परा अधिपरजीवी फफूँद का प्रकोप देखा गया। इसमें *राइजोपस* तथा *एस्पर्जिलस* सामान्यतः अधिक थे। प्रयोगशाला स्थितियों में *ट्राइकोडरमा स्यूडोकोनिन्गी* तत्पश्चात् *ए॰ फ्लेवस* (एलवाई) में अधिकतम वृद्धि तथा कॉलोनियां पायी गयी। *ट्राइकोडरमा* किस्म जीटीपी–4 में 25 दिन के बाद सर्वाधिक बीजाणुता (7.3×10^7) तथा किस्म जीटीपी–7 में सर्वाधिक कॉलोनियां (6/से॰मी^{2}) रही। *एकिया जेनेटा* लार्वा और सफेद लट से पृथकृत *मेटाराइजम* की नई स्ट्रेन *ए॰ जेनेटा* के खिलाफ 70–80 प्रतिशत मृत्युदर के साथ उच्चतम प्रभावी सिद्ध हुई तत्पश्चात् *कैटोप्सिला* स्पीसीज (70–90 प्रतिशत मृत्युदर) और सफेद लट (50–60 प्रतिशत मृत्युदर) का क्रम रहा। मूंग की फसलों को नीम गुलिका और नीम बीज पाउडर 800, 600 और 400 कि.ग्रा. प्रति हेक्टर की दर से और दो

बार नीम के तेल का छिड़काव करने से फसल कटने तक दीमक के आक्रमण से पूर्ण बचाव हुआ। पत्ती फुदको, सफेद मक्खी और काले और स्लेटी भृंगों की संख्या में भी प्रमुखतः कमी आई। जीरे में 10 दिन के अन्तराल में नीम के तेल के दो छिड़काव हरा चेपा प्रबन्धन में सर्वाधिक प्रभावी रहा।

सरसों फसल के अवशेषो (2 प्रतिशत और 4 प्रतिशत) द्वारा सुधरी मृदा में *बी॰ फरमस* (जैव–नियन्त्रण कारक) अच्छी तरह से बराबर जीवित रहे। मूली के अवशेष, सरसों और गोभी के अवशेषो से अधिक श्रेष्ठ रहे और इसमें 60 दिन बाद तक भी *बी॰ फरमस* की अधिकतम् जीवित दर रही। जबकि *टी॰ हरजीनम* व *पी॰ जुलीफ्लोरा* कम्पोस्ट श्रेष्ठतम खाद्य आधार रहा। सात आशाजनक खाद्य आधारो के संयोजनों में *पी॰ जूलीफ्लोरा* कम्पोस्ट + मूली + टाल्क + लिग्नाइट द्वारा एक नये उत्पाद के रूप में प्रत्येक जैवनियन्त्रक कारक के प्रोन्यन में संयोजकता प्रदर्शित की जहाँ *बेसिलस* और *टी॰ हरजीनम* का स्वतः जीवनकाल 180 दिन तक बनाये रखा जा सका। प्रयोगशाला में सरसों और खरपतवार अवशेषों के साथ, *मेक्रोफोमिना फेसिलोना* के विरूद्ध प्रतिनिषेध एक्टीनोमायसिटीज में अधिकतम् जीवितता दर रही। अनुपचारित मृदा (9.3 प्रतिशत) की तुलना में, अन्य सभी कम्पोस्ट में विरूद्ध प्रतिनिषेध की संख्या दर में (16.5–28.1 प्रतिशत) वृद्धि हुई।

बाजरा की 48 नर बांझ उपजातियों में से 18 तुलासिता (डीएम) से मुक्त रही, केवल एक (8 बी) में स्मट रोग का प्रकोप (16.6 प्रतिशत) दिखा तथा सभी ब्लास्ट।बीमारी से मुक्त रहे। बाजरा के बीज (किस्म 7402–एस) को कच्चे गौ दूध (1 : 9) जल मिश्रण, चार सान्द्रता में एमीनोएसिड का मिश्रण (1 : 10, 1 : 50, 1 : 100 और 1 : 200 दर) तत्पश्चात् *ग्लाइकोडियम वीरन्स* (0.6 प्रतिशत) से उपचार करने पर तुलासिता (डीएम) रोग के प्रकोप में कमी हुई। इसी प्रकार कच्चा गौ दूध (1 : 9) एमीनोएसिड (1 : 200) के साथ *जी॰ वीरन्स* (0.6 प्रतिशत) से बीजोपचार द्वारा तुलासिता का प्रकोप निम्नतम रहा।

रेगिस्तानी कृन्तकों में चुग्गा शंकालुता के प्रबन्धन में नारियल तेल और मूंगफली तेल + नमक के योगदान का दो तापमान स्तर 21° से॰ और 31.1° से॰ पर अध्यनित किये गये। *रेटस रेटस* प्रजाति में नारियल तेल (2 प्रतिशत) के प्रयोग द्वारा 15 दिन की शंकालुता अवधि को (कम तापमान पर) और उच्च तापमान पर (25 दिन तक) कम किया जा सका। मूंगफली तेल (2 प्रतिशत) + नमक (1 प्रतिशत) से शंकालुता अवधि 3 दिन (कम तापमान) और 5 दिन (उच्च तापमान पर) कम की जा सकी। *फेनाबुलस पेनान्टी* में तेल (2 प्रतिशत) + नमक (1 प्रतिशत) से कम तापमान पर 2 दिन और उच्च तापमान में 3 दिन शंकालुता अवधि कम रही।

बिना विकल्प परीक्षण के अन्तर्गत ब्रोडीफोकम बट्टिका के एक दिन की डोज से 3–11 दिनों में घरेलू चूहों में शतप्रतिशत मृत्यु दर पाई गई। परन्तु दूसरे खाद्य की उपस्थिति में मृत्यु दर 80 प्रतिशत रही। पौधे से प्राप्त घटक ''बायो'', एक नर प्रति प्रजनक की फील्ड प्रभावकारिता में चूहों की संख्या में अध्यनित स्थल में वैसे तो कोई कमी नहीं आई, परन्तु पकड़े गये उपचारित नर चूहों को सामान्य मादा के साथ प्रजनन कराने पर सात में से मात्र दो जोड़ो में ही सफल प्रजनन दर्ज किया गया।

झुंझनू जिले में कृन्तक सर्वेक्षण में प्रमुखतः *मेरिओनस हरीयानी* तथा *टटेरा इंडीका* जाति के कृतंक पाये गये। जंगली क्षेत्रों में, *एम॰ हरीयानी* और *टी॰ इंडीका* के साथ साथ *निसोकिया इंडीका* के बिल भी पाये गये। जोधपुर में *बेंडीकोटा बेन्गालेसिस* की द्विमासिक ट्रैपिंग के अन्तर्गत उनके सूचकांक में कोई परिवर्तन नहीं दिखा। लैगिंक अनुपात में इस वर्ष भी मादा की संख्या (1 : 1.28) अधिक रहीं। मादा चूहों में, गर्भधारी, अर्द्धवयस्क और वयस्क चूहों की उपस्थिति प्रदर्शित हुई। इन चूहों में प्रजनन पूरे वर्ष देखा गया।

गैर पारम्परिक ऊर्जा स्रोत, कृषियान्त्रिकी और शक्ति

नाडी के पानी के शोधन करने हेतु 30 लीटर प्रति दिन की क्षमता युक्त एक सौर जल संयंत्र का प्रारूपण व निर्माण किया गया। सौर जल शोधन संयन्त्र में अन्दर के प्रकोष्ठ में अधिकतम तापमान 147.5° से॰ रहा जबकि बाहरी तापमान 37.5° से॰ था। जब 2500, 5000 और 7500 पीपीएम तक सांद्रता वाले नमकीन पानी भरने पर इस सौर संयन्त्र की औसत आसवन क्षमता 8.76 लीटर पानी प्रति दिन दर्ज की गयी।

मृतिका (क्ले), वर्मीक्यूलाइट, वरमीक्यूलाइट के साथ रिफक्टर, ईंट और पत्थर की स्लेब से बनाये गये सौर कुकर का अधिकतम् स्थिर तापमान क्रमशः 93.4^{o} से॰, 92.5^{o} से॰, 98.9^{o} से॰, 84.8^{o} से॰ और 78.5^{o} से॰ रहा, जबकि औसत बाह्य तापमान 36.7^{o} से॰ था। इसी प्रकार एकल हॉट बॉक्स सौर कुकर, डबल रिफ्लेक्टर सौर कुकर और नॉनट्रेकिंग सौर कुकर के कुकिंग चैम्बर का अधिकतम स्थिर तापमान क्रमशः 119.1^{o} से॰ और 120.0^{o} से॰ 114.1^{o} से॰ तक रहा। जबकि औसत बाहरी तापमान 36.7^{o} से॰ था। प्रत्यक्ष एवं अप्रत्यक्ष टाइप सौर शुष्कक में स्थिर तापमान 66.2^{o} से॰ और 62.8^{o} से॰ रहा जब औसत बाहरी तापमान 35.0^{o} से॰ था। एकीकृत संग्रहक सौर वाटर हीटर और प्राकृतिक सरकूलेशन टाइप सौर वाटर हीटर में गर्म पानी का तापमान क्रमशः 55.5^{o} से॰ और 63.3^{o} से॰ रहा, जबकि नल के पानी का औसत तापमान 23.8^{o} से॰ था। पीवी चल यूनिट में सुधार करके इसे ग्वार पाठा जेल एक्सट्रेक्टर (350 वाल्ट एसी) और पीवी ब्लोवर (75 वाल्ट डीसी मोटर) चलाने हेतु परीक्षित किया गया। पीवी डस्टर में और सुधार किया गया और इसकी डस्टिंग क्षमता हूपर के छेद के आकारानुसार 30 से 120 ग्राम/मिनट के बीच दर्ज की गयी। अधिक उर्जा प्राप्ति हेतु कॉच वाले बूस्टर लगाकर थिन फिल्म हाइड्रोजिनेटेड एमोरफस एस आई माल्डूल (12.5 डब्ल्यूपी) का निष्पादन सुधारा गया। एसी/डीसी डिवाइस के चलाने और प्रभासन के लिए बैटरी चार्ज करने हेतु दो छोटे पीवी सिस्टम आधारित 60 डब्ल्यूपी पॉलीक्रिस्टलिन सिलिकोन मौल्डूल्स का निर्माण किया गया।

परम्परागत पद्धति से बुवाई की अपेक्षा ट्रेक्टर चालित तीन कूड़ वाले (छः पंक्ति) बहु फसली बुवाई यन्त्र से बुवाई द्वारा मूंग और ग्वार की फसल में 29–30 प्रतिशत तक उपज की वृद्धि हुई। एक 0.35 है प्रति घंटा की क्षेत्र क्षमता युक्त ट्रेक्टर चालित खरपतवार साफ करने के यंत्र का विकास किया गया। इसमें फसल में पंक्ति दर पंक्ति रिक्त स्थान के आधार पर ब्लेड की लम्बाई का चयन किया जा सकता है। इसी प्रकार एक सुधरा बिजाई यंत्र (0.60 हें प्रति घंटा क्षेत्र क्षमता) विकसित किया गया। इस ट्रेक्टर चालित बुवाई में यंत्र प्रति कूड़ दाब चक्रक एवं घुमन्तू पहिए युक्त बीज वितरण प्रणाली समाहित की गयी है।

बाजरा छिलका साफ करने तथा आटा बनाने से पूर्व इसकी सफाई हेतु बाजरा पर्लर नामक यन्त्र का निर्माण किया गया। इससे प्राप्त आटे की शेल्फलाइफ में उत्साहजनक रूप से वृद्धि देखी गयी। तुम्बा से बॉयो डीजल बनाने हेतु एक प्रायोगिक इकाई का निर्माण किया गया। तुम्बा से 98 प्रतिशत बॉयोडीजल की प्राप्ति रही। पेसिव कूल चेम्बर में सुधार किया गया और इसमें चेम्बर के अन्दर व बाहर हवा के संचरण हेतु छेद बनाये गये। छोटे स्तर पर प्रयोग हेतु (टांका ऊॅचाई 2.2 मी.) कम दबाव वाले बूंद बूंद सिंचाई पद्धति का विकास किया गया। 2.0 मी. ऊॅचाई पर वाटर कॉलम होने पर भी ड्रिपर से 2 एमपीएच पानी का वितरण हुआ।

सामाजिक आर्थिक अन्वेषण और मूल्यांकन

बाड़मेर और नागौर जिले के विभिन्न स्थलों पर गोंद उत्पादक कुमट (*अकेसिया सेनेगल*) पेड़ों के सर्वेक्षण का कार्य निरन्तर जारी रहा। गम इन्डयूसर के प्रयोग द्वारा अधिकाधिक गोंद उत्पादन प्राप्त करने हेतु फरवरी और जून के मध्य का समय सर्वाधिक उपयुक्त पाया गया। इस तकनीक के प्रयोग द्वारा किसानों ने 1.8–8 टन गोंद प्राप्त किया।

महात्मा गॉधी रोजगार गारंटी योजना (महानरेगा) कार्यक्रम के अन्तर्गत लूणी तहसील में करीब 45 प्रतिशत भूमिहीन और सीमान्त कृषकों को रोजगार प्राप्त हुआ। मजदूर रोजगार हेतु अधिकतम धन खर्च किया गया। ग्रामीण से शहरी क्षेत्रों में मजदूरों का प्रवजन कुछ कम हुआ, कृषि कार्य प्रभावित हुए और मजदूरी दर में वृद्धि हुई।

पाली जिले में तकनीक हस्तान्तरण के आर्थिक मूल्यांकन में प्रकट हुआ कि उन्नत कृषि तकनीकी के प्रयोग द्वारा खरीफ और रबी में उच्चतर आय सृजित हुई। बाजरा, ग्वार, मूंग की उन्नत किस्मों के बीज के उपयोग द्वारा अतिरिक्त रोजगार प्राप्त हुआ।

ऊँट उत्पादन के आर्थिक मूल्यांकन में बीकानेर जिले में ऊँट गाड़ी परिवहन प्रमुख व्यवसाय के रूप में प्रकट हुआ। ग्वार, मोंठ, मूंगफली का भूसा ऊटों के लिए सर्वाधिक पसंदीदा खाद्य रहा जो ऊँट पालन की कुल लागत का एक प्रमुख भाग रहा। सूखे चारे की अधिक कीमत और गाड़ी भाड़े की कम दर प्रमुख बाधाएँ रही। ऊँट

पालन हेतु औसतन प्रति परिवार 53 प्रतिशत तक निर्धारित खर्च पाया गया। जैसलमेर शहर के पास पर्यटन क्षेत्र में केमल सफारी प्रमुख व्यवसाय रहा, तत्पश्चात् कृषि और फिर मजदूरी। चारे पर कुल खर्च का 52 प्रतिशत रहा। परिवार का लगभग 76 प्रतिशत निवेश इन पशुओं पर व्यय किया गया।

श्री गंगानगर और जयपुर में फलीय उत्पाद की बाजार प्रभावकारिता के अध्ययन के अन्तर्गत किन्नू, गाजर, आंवला और टमाटर के प्रमुख विपणन साधनों की पहचान की गयी। इनकी वितरण श्रृँखला में बाजार प्रभावकारिता सूचकांक कींनू में 0.5, गाजर में 0.3, आंवला 0.4 और टमाटर में 0.7 रहे।

तकनीक मूल्यांकन और हस्तान्तरण

बाड़मेर, चुरू, जालोर, जोधपुर और पाली जिलों के लिए मानसून 2010 के दौरान सप्ताह में दो बार कृषि सलाह बुलेटिन जारी किया गया। वर्षा का पूर्वानुमान गर्मी में 83 प्रतिशत और मानसून में 57 प्रतिशत वर्षा तक सफल रहा। शुष्क राजस्थान हेतु एक माडल मौसम कोड (2010) विकसित किया गया।

ओसियाँ तहसील में खरीफ और रबी फसलों की उन्नत तकनीकों, उच्च उपज वाली किस्मों, कृन्तक नियन्त्रण तकनीक, कृषक महिलाओं द्वारा कम्पोस्ट खाद बनाना, पशुधन आहार पद्धति आदि का प्रदर्शन किया गया। कृषक महिलाओं में उन्नत तकनीक को अपनाने में, शिक्षा की कमी और कम इच्छाएं प्रमुख बाधाएँ रही। प्रशिक्षण कार्यक्रमों में महिलाओं की सहभागिता बहुत कम देखी गयी। उनमें जन संचार माध्यमों का उपयोग बहुत कम था। बहुत कम लोग समाचार पत्र खरीदते है। अधिकांश किसानों को कम्पोस्ट और केचुंआ खाद के बारे में जानकारी नही थी। बीमारी नियन्त्रण के तरीके के प्रति जागरूकता तो किसी भी प्रतिवादी में नही पायी गयी।

खरीफ और रबी की फसलों की उच्च उपज वाली किस्मों द्वारा उच्च बीजोत्पादन एवं अधिक आर्थिक लाभ प्राप्त किया गया। बाजरा–गेहूँ, ग्वार–गेहूँ और मूंग–गेहूँ में सुधरे पैकेज के उपयोग से गेहूँ तुल्यांक उत्पादन में क्रमशः 22.1, 35 और 27.7 प्रतिशत वृद्धि पायी गयी। सभी बुवाई पद्धतियों में मूंग–गेहूँ फसल पद्धति के अन्तर्गत सर्वाधिक सकल आय प्राप्त हुई।

कृषकों के चहेती मूंगफली–गेहूँ पद्धति की तुलना में मूंग–गेहूँ फसल पद्धति में 2.0–8.6 प्रतिशत उच्च उत्पादन प्राप्त किया गया। मूंगफली–गेहूँ के स्थान पर मूंग–गेहूँ और मूंगफली–चना फसल पद्धति अपनाने से क्रमशः 13 और 4 सिंचाई की बचत हुई। सभी सिंचाई और पोषक प्रबन्धन उपचारों में मूंगफली की किस्म एचएनजी–10 द्वारा सर्वाधिक उपज प्रदान की गयी। परिणाम बताते है कि सिंचाई की संख्या में कमी का उत्पादन पर कोई सराहनीय प्रभाव नहीं पड़ा। दीर्घावधि की किस्मों में एचएनजी–1. और कम समयावधि में किस्म टीजी–39 का निष्पादन अच्छा रहा।

महिला मुद्दे और सशक्तीकरण

किसान महिलाओं के ज्ञान और कौशल में वृद्धि हेतु उन्हें फसल की नई तकनीकियों तथा नई किस्मों जैसे मूंग (के–851), मोंठ (काजरी मोंठ–2), ग्वार (आरजीएम–112) और बाजरा की द्विउद्देश्यीय किस्म (एचएचबी–67) का ज्ञान कराया गया। कृषक महिलाओं को किचन गार्डन, कम्पोस्ट खाद बनाने और नीम आधारित कीटनाशक बनाने की विधियॉ सिखाने में मद्द की गई। चयनित गाँवों में महिलाओं को पशुओं के संतुलित आहार, स्वास्थ्य प्रबन्धन और दुग्ध उत्पादन में वृद्धि हेतु पशुओं को गर्मी में लाने और घर की आय बढ़ाने संबंधित क्षेत्रों में प्रशिक्षण दिये गये। एक हजार कृषक महिलाओं को आवश्यकता आधारित फसल उत्पादन, कम लागत के पोषक खान पान, फलों, सब्जियों, दाल, तिलहन, दूध और मशरूम के मूल्य संवर्द्धन व उत्पाद निर्माण पर भी विभिन्न प्रशिक्षण कार्यक्रम आयोजित किये गये। संस्थान द्वारा लूणावास में 4 दिसम्बर 2010 को कृषक महिला दिवस मनाया गया।

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, 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 21716 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, 42 foreign journals and two international databases (AGRIS and CABI) on CD ROM. 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 2010-11 (Lakh Rupees)

Head of expenditure	Funds allocated		Expenditure	
	Non-plan	Plan	Non-plan	Plan
Establishment charges	2850.00	-	2849.62	
Wages	28.00	-	28.37	
Overtime allowance	-	-		
Travelling allowance	8.00	21.00	8.00	21.00
Other charges, including equipment	181.00	249.00	180.66	246.59
Works, including maintenance	32.00	120.00	31.32	114.06
Total	3099.00	390.00	3097.97	381.65

Table II. Staff position during 2010-11

Post	Number of posts		
	Sanctioned	Filled	Vacant
Director	1	1	-
SCIENTIFIC			
Principal Scientist	18	07	11
Senior Scientist	40	26	14
Scientist	88	52	36
TECHNICAL			
Category-I	191	159	32
Category-II	84	69	15
Category-III	22	15	07
ADMINISTRATIVE			
Class-I	04	04	-
Class-II	58	49	09
Class-III	31	37	+06
SUPPORTING			
Skilled Supporting Staff	283	256	27

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. Potable water is still scarce over large areas, in spite of the Indira Gandhi Canal network, groundwater exploitation and creation of large-scale pipe water supply grids through government efforts. 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 2010

Southwest monsoon arrived in the eastern districts of Rajasthan by 3rd July, but delayed upto 20 days to reach western districts of arid Rajasthan. The first spell of 123 mm at Barmer, 209 mm at Jalor, 108 mm at Jodhpur, 147 mm at Nagaur, 106 mm at Pali, 233 mm at Jhunjhunu and 164 mm at Sikar enabled sowing of kharif crops and caused good rains in many parts. In the month of September, a depression from Arabian sea induced heavy rainfall in the region. Such heavy rainfall in September occurred only in 1967 and 1992 during the last fifty years. Withdrawal of monsoon was observed from 17th of September onwards.

By the end of monsoon season, eleven districts (Table 1 and Fig. I) received excess to above normal rainfall with high amounts of rainfall of 340 mm at Barmer, 398 mm at Bikaner, 570 mm at Churu, 519 mm at Hanumangarh, 351 mm at Sri Ganganagar, 357 mm at Jaisalmer, 459 mm

at Jalor, 503 mm at Jodhpur, 775 mm at Jhunjhunu, 406 mm at Nagaur, 818 mm at Sikar and 369 mm at Pali.

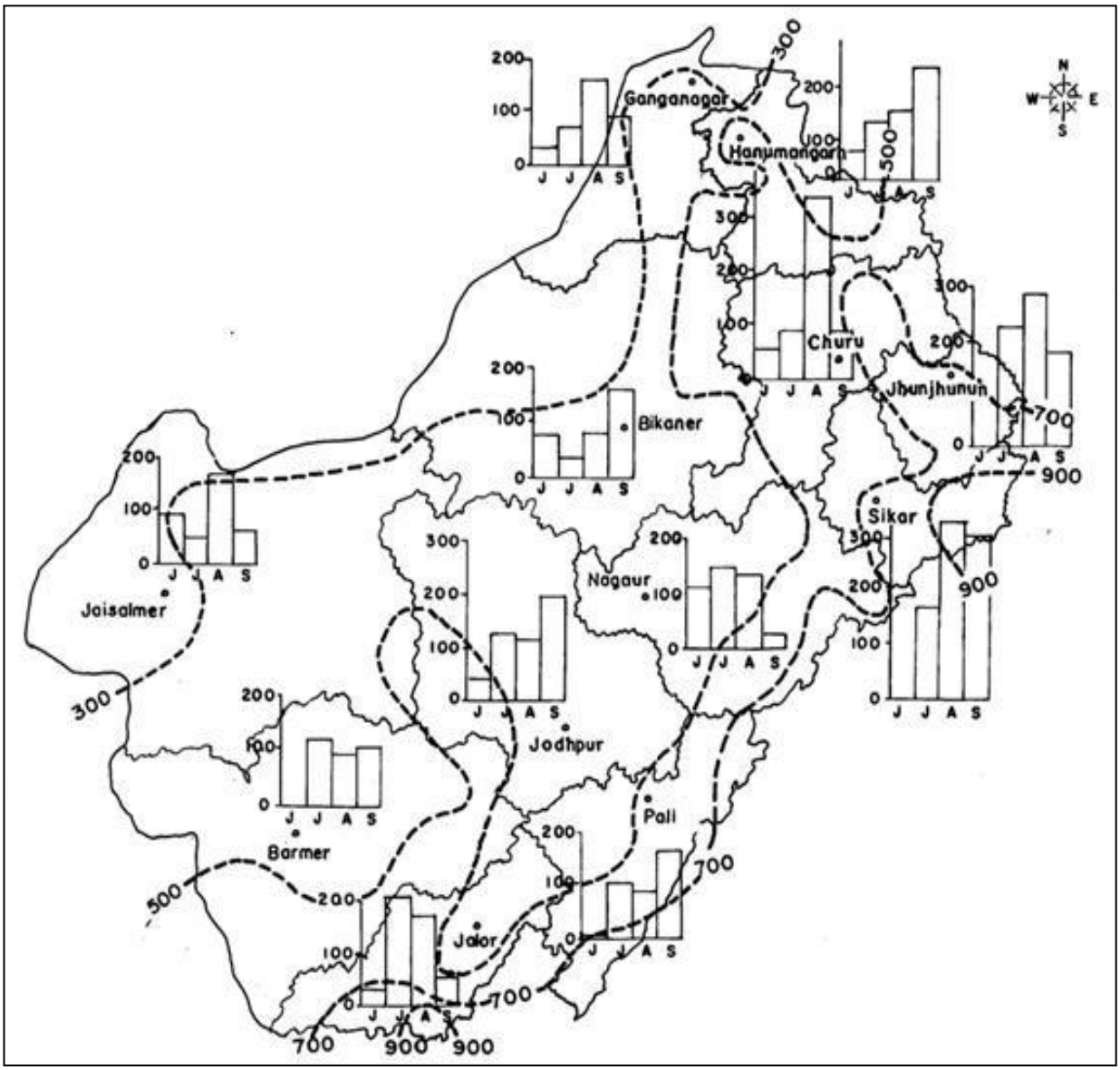

Fig. I. Monsoon rainfall (mm) over western Rajasthan during June-Septermber, 2010.

Table 1. Rainfall in arid Rajasthan during 2010

District	Month				Total (mm)	Normal (mm)	Departure (%)	Classification
	June	July	August	Sep.				
Barmer	17.5	123.0	91.0	108.0	339.5	242.6	39.9	Above normal
Bikaner	82.2	34.8	82.4	164.0	363.4	243.1	49.5	Above normal
Churu	52.0	87.0	342.0	89.0	570.0	314.4	81.3	Excess
Jaisalmer	90.4	43.4	161.8	61.8	357.0	161.4	121.4	Excess
Ganganagar	34.0	70.0	158.0	89.0	351.0	204.6	71.6	Excess
Hanumangarh	54.0	109.0	132.0	224.0	519.0	186.0	179.0	Excess
Jalor	15.0	209.0	174.0	61.0	459.0	349.1	31.5	Above normal
Jodhpur	45.4	133.9	120.7	202.9	502.9	330.6	52.1	Excess
Jhunjhunu	64.0	233.0	293.0	185.0	775.0	339.3	128.4	Excess
Nagaur	105.0	147.3	134.0	20.0	406.3	285.1	42.5	Above normal
Pali	7.2	105.5	92.1	164.4	369.2	398.7	-7.4	Normal
Sikar	29.0	164.0	323.0	302.0	818.0	410.5	99.3	Excess

The monthly mean maximum temperatures at Jodhpur were highest (Table 2) during April (41.3°C) and May (43.4°C) followed by June (40.9°C), but maximum temperature was highest on 23rd May (47.2°C). Monthly mean minimum temperature was lowest in December (9.9°C) followed by January (10.9°C), while the lowest temperature of 4.6°C was recorded on 12th December. Mean maximum wind speed was highest in June (8.7 km h^{-1}), while the mean minimum was in October (2.2 km h^{-1}). The duration of sunshine was highest in March (9.3 h day^{-1}) and lowest in August (5.6 h day^{-1}). Relative humidity was low in April (5-59%) and high in August (43-98%). Mean evaporation during crop growing period (July-September) was between 4.3 and 12.0 mm day^{-1}. The weather parameters recorded at Regional Research Stations of CAZRI are given in Tables 3-7.

Table 2. Summary of weather condition at Jodhpur during 2010

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Evaporation (mm day^{-1})	Relative humidity (%)		Wind speed (km h^{-1})	Sunshine (h day^{-1})
			Max.	Min.		I	II		
January	1.5	0	26.3	10.9	3.8	70	24	3.5	8.7
February	0.5	0	29.5	13.8	5.4	49	17	3.6	9.1
March	0.0	0	37.2	20.5	8.9	41	13	4.0	9.9
April	0.2	0	41.3	26.4	12.8	35	12	5.9	9.4
May	0.0	0	43.4	29.5	15.0	40	13	8.3	9.0
June	45.4	3	40.9	29.8	12.0	57	29	8.7	9.1
July	133.9	5	37.2	27.8	7.9	77	49	6.9	6.0
August	120.7	8	33.6	26.4	4.5	83	63	4.3	5.6
September	202.9	7	33.8	23.7	4.3	81	53	2.8	7.3
October	0.0	0	36.5	22.9	5.8	60	25	2.2	9.5
November	39.8	3	29.1	17.5	3.1	73	45	2.6	6.2
December	17.3	2	25.1	9.9	2.7	73	28	2.3	7.9
Total/Mean	562.2	28	34.5	21.6	7.2	62	31	4.6	8.1

Table 3. Summary of weather condition at Bikaner during 2010

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Evaporation (mm day^{-1})	Relative humidity (%)		Wind speed (km h^{-1})	Sunshine (h day^{-1})
			Max.	Min.		I	II		
January	1.0	0	22.8	5.3	4.1	74.3	35.8	3.5	7.3
February	2.1	0	27.7	10.7	3.3	63.1	24.8	4.2	7.3
March	0.0	0	36.9	19.4	6.4	46.5	16.5	5.2	8.8
April	0.0	0	33.1	20.6	9.2	35.0	12.3	4.9	6.5
May	9.2	2	44.0	28.8	11.5	41.6	15.1	7.2	8.2
June	82.2	2	41.3	29.1	15.6	56.5	26.4	7.9	5.9
July	34.8	4	38.6	29.1	8.1	69.0	46.4	7.7	7.6
August	82.4	6	36.5	27.2	8.4	82.8	53.5	5.8	7.8
September	164.0	4	30.0	20.9	6.6	70.5	43.5	3.7	5.6
October	0.0	0	36.4	20.7	7.3	66.4	28.3	3.7	9.6
November	20.0	2	29.7	14.0	5.9	74.2	40.5	2.3	8.1
December	0.0	0	24.4	6.4	4.0	76.6	33.7	2.3	8.0
Total/Mean	395.7	20	33.5	19.4	7.2	56.9	28.4	4.6	7.0

Table 4. Summary of weather condition at Bhopalgarh during 2010

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative humidity (%)		Wind speed (km h^{-1})	Sunshine (h day^{-1})
			Max.	Min.	I	II		
January	1.4	0	26.0	7.6	46	12	2.3	8.3
February	0.6	0	29.4	11.0	30	10	3.4	8.8
March	0.0	0	37.0	19.4	31	10	5.0	9.9
April	0.0	0	41.5	25.6	21	6	7.3	9.3
May	3.2	1	43.5	29.0	35	10	10.4	8.3
June	33.5	1	40.5	29.2	48	21	10.1	8.4
July	85.5	5	37.8	27.3	63	43	8.5	5.8
August	280.4	14	33.3	26.3	74	56	5.0	5.0
September	90.3	7	38.8	23.6	69	41	3.2	7.0
October	0.0	0	37.0	18.8	53	21	2.2	9.3
November	3.8	1	29.4	13.7	56	29	1.9	5.4
December	7.2	1	25.3	6.4	45	14	1.8	7.9
Total/Mean	505.9	30	35.0	19.8	48	23	5.1	5.0

Table 5. Summary of weather conditions at Chandan during 2010

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative humidity (%)		Wind speed (km h^{-1})	Sunshine (h day^{-1})
			Max.	Min.	I	II		
January	1.0	0	25.4	5.5	71	47	2.8	7.5
February	0.0	0	30.0	8.5	63	51	4.3	8.2
March	0.0	0	38.7	17.2	66	32	3.8	8.3
April	2.5	1	41.7	22.7	56	22	6.7	7.7
May	0.0	0	44.7	27.5	50	24	9.6	7.9
June	110.0	2	40.9	25.7	56	25	11.4	7.3
July	133.5	4	39.3	28.2	60	43	8.7	4.0
August	63.0	4	36.9	26.3	66	50	5.6	6.5
September	73.5	3	37.2	22.5	74	43	2.7	7.1
October	0.0	0	39.6	18.2	54	35	2.4	7.8
November	50.0	0	31.3	11.8	61	44	1.2	6.6
December	0.0	0	27.0	4.0	72	32	1.2	7.1
Total/Mean	433.5	14	36.1	18.2	62	37	5.0	7.2

Table 6. Summary of weather condition at Jaisalmer during 2010

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Relative humidity (%)		Wind speed (km h^{-1})	Sunshine (h day^{-1})
			Max.	Min.	I	II		
January	4.0	1	23.8	6.0	70	42	3.7	8.2
February	0.0	0	27.7	9.0	62	49	4.6	8.3
March	0.0	0	37.0	18.5	55	32	6.0	9.5
April	0.0	0	41.4	23.5	55	31	8.7	7.4
May	0.0	0	41.8	25.6	55	31	12.6	6.3
June	90.4	1	39.4	26.3	69	38	11.7	5.6
July	43.4	3	37.6	26.3	78	50	8.1	5.0
August	161.8	5	33.4	23.4	80	60	4.1	5.4
September	61.8	2	36.5	22.6	80	48	2.6	8.1
October	0.0	0	37.1	18.6	65	45	2.6	9.1
November	6.6	1	29.4	11.5	74	56	1.4	6.9
December	2.0	0	24.8	4.1	61	34	1.3	7.8
Total/Mean	370	13	34.2	18.0	67	43	5.6	7.3

Table 7. Summary of weather conditions at Kukma-Bhuj

Month	Rainfall (mm)	Rainy Days	Temperature (°C)		Relative humidity (%)		Wind speed (km h^{-1})	Sunshine (h day^{-1})
			Max.	Min.	I	II		
January	0	0	28.2	14.2	61	24	6.4	10.6
February	0	0	31.1	15.9	69	20	7.0	11.2
March	0	0	37.3	22.0	66	22	8.4	11.8
April	0	0	40.0	24.5	75	27	11.8	12.4
May	0	0	40.7	26.9	74	37	14.9	13.2
June	39.4	2	38.2	27.6	75	47	12.2	13.3
July	381.2	11	33.9	26.5	86	71	9.8	13.3
August	401.0	10	31.9	25.2	91	77	6.2	12.8
September	48.0	5	33.4	24.2	86	64	6.1	12.2
October	0	0	37.2	24.2	80	41	5.2	11.4
November	111.0	5	30.4	19.9	78	60	6.2	11.0
December	0	0	27.5	12.8	71	32	6.4	10.4
Total/Mean	980.6	33	34.2	21.9	76	44	8.4	12.0

Table 8. Summary of weather conditions at Pali

Month	Rainfall (mm)	Rainy days	Temperature (°C)		Evaporation (mm day^{-1})	Relative humidity (%)		Wind speed (km h^{-1})	Sunshine (h day^{-1})
			Max.	Min.		I	II		
January	1.0	0	27.6	8.9	3.6	64	34	4.8	8.6
February	0.0	0	30.6	12.6	5.5	50	25	5.3	9.1
March	0.0	0	37.8	19.8	9.5	38	21	6.5	8.9
April	0.0	0	42.0	25.8	13.5	40	22	9.4	9.3
May	0.0	0	44.0	29.2	16.3	51	23	12.5	9.6
June	7.2	1	41.7	29.4	13.6	57	35	12.4	8.2
July	105.5	10	37.3	27.6	7.5	82	59	9.6	6.2
August	92.1	9	31.5	25.7	4.1	90	72	7.5	4.6
September	164.4	6	33.5	23.3	4.3	84	60	4.4	6.8
October	1.4	0	36.6	20.0	5.3	70	39	3.8	9.1
November	61.1	6	29.3	16.1	2.8	81	55	4.1	6.3
December	4.7	1	26.0	7.6	2.3	87	41	3.5	8.1
Total/Mean	437.4	33	34.8	20.5	7.4	66	40	7.0	10.9

The weekly variations in rainfall, maximum and minimum air temperatures during kharif season at six representative stations of Indian arid zone (Fig. II) shows that the rainfall was above normal at Anantpur (596 mm), Bellary (627.2 mm), Bikaner (395 mm), Hisar (774.9 mm), Jaisalmer (357 mm) and Jodhpur (503 mm).

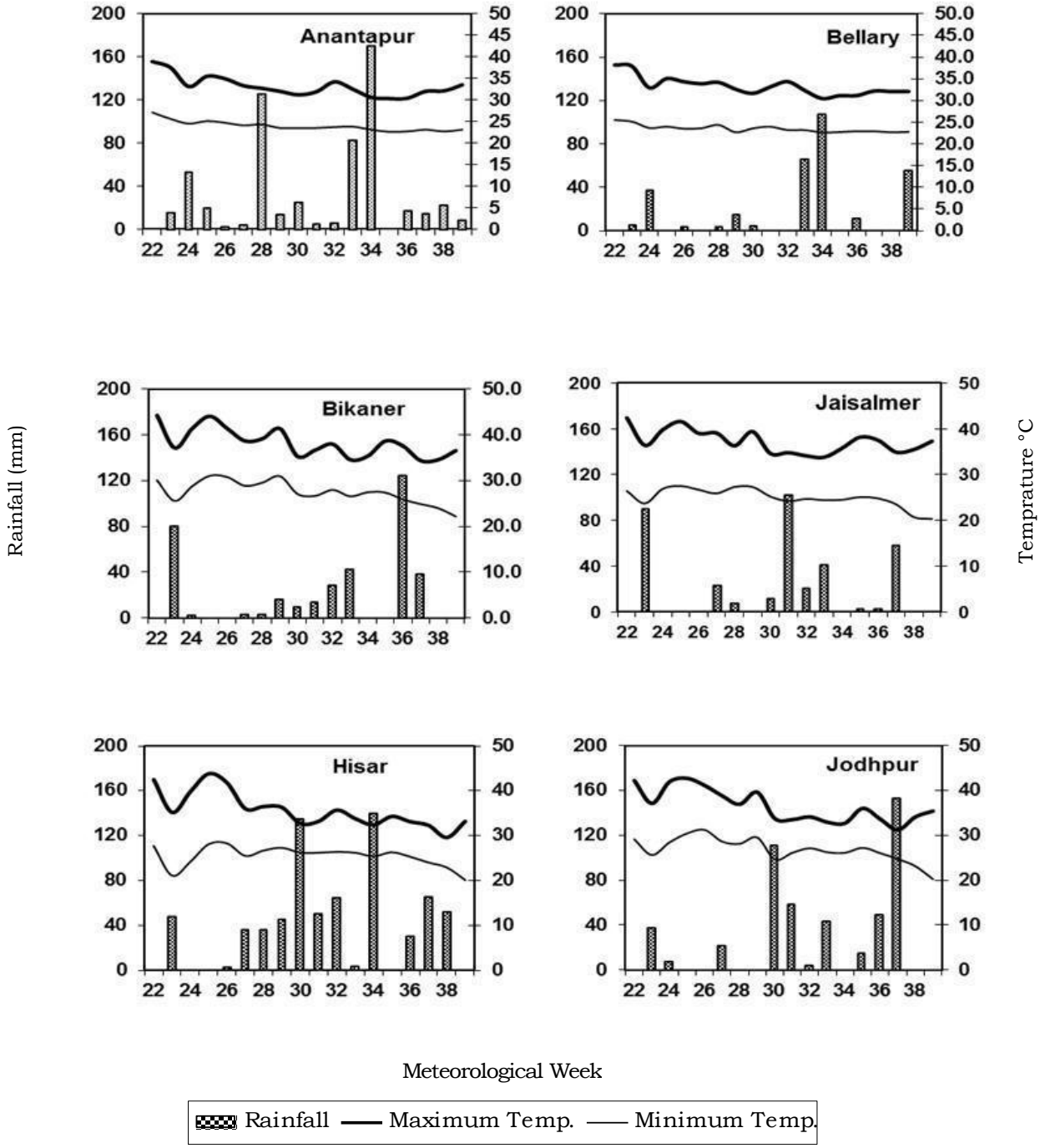

Fig. II. Weekly maximum and minimum temperatures and rainfall during 2010 at representative stations of the Indian arid zone.

INTEGRATED NATURAL RESOURCES APPRAISAL, MONITORING AND DESERTIFICATION

Integrated Natural Resources Survey of Dhanera and Deesa Tehsils of Banaskantha District

Climate: The mean annual rainfall of Dhanera is 488 mm, while its potential evapotranspiration is 1736 mm. This results in aridity condition with an annual aridity index of 72%. Deesa receives an annual rainfall of 575 mm, while its potential evapotranspiration is 1730 mm. Thus it has an aridity index of 66.7%. During the summer the mean day temperature reaches 43.5°C in May, but temperature falls from November to January with the mean minimum temperature at 4.9°C. The recorded extreme high temperature is 48.2°C, while the recorded extreme low temperature is 3.1°C. Despite being located in the arid fringe, both the tehsils had a fair percentage share of drought (Dhanera 33%; Deesa 36%) and floods (Dhanera 25%; Deesa 25%) during the last 36 years. No significant trend was noticed in rainfall between 1975 and 2010 (Fig. 1.1).

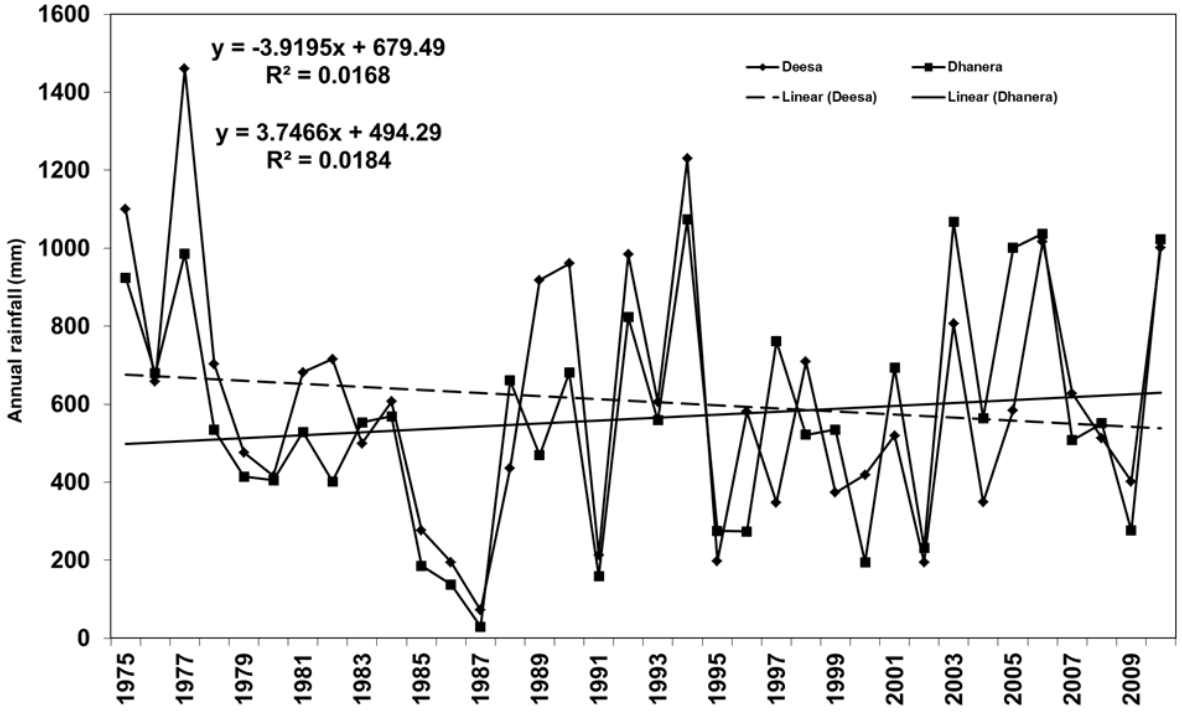

Fig. 1.1. Rainfall trend at Dhanera and Deesa (1975-2010).

Geomorphology: Landforms (Plate 1) of the two tehsils are greatly influenced by the Banas, Sukal and Bargaon river systems, which have deposited huge sandy alluvium in the plains. The maximum depth of alluvium is 300 m in parts of Deesa tehsil. The major landforms of fluvial

origin include younger alluvial plains (14.7%), older alluvial plains (61.6%), sandy undulating older alluvial plains (17.9%) and river beds (3.2%). About 2.1% area of these plains along the right bank of the Banas River in Malgarh-Akhol-Mahaderiya-Goliya-Dava-Bhadat-Dhanpur-Ghada-Agdol-Sodapur sector is gullied. Smaller gullies (<1 m deep, 1-2 m wide, 1st order) occur mostly near Ramson and Agdol, while the larger ones (15-20 m deep, 40-50 m wide, 3rd order) occur near Ghada, Bhadat and Sodapur. The gullies along the left bank of the Banas near Juni-Deesa in Deesa tehsil were further deformed during a major flood in 1973 when a dam near Danitwara collapsed. Sand dunes (2.60% area) in the form of 7-8 m high parabolic and 18-20 m high linear dunes occur to the west of alluvial plains in Shergarh, Jodiya, Rampura Chhota, Edal and Sia in Dhanera and Ramson-Samalwara-Valer-Rampur and Pechdal in Deesa tehsil.

Soils: Five soil series (Table 1.1, Plate 2), namely Sanchore, Dhanera, Arniwada, Asarda and Dune Complex have been identified in Dhanera and Deesa tehsils. Medium to fine textured soils of Dhanera, Arniwada, Asarda series cover ~ 92% area. The soils of Dhanera series are well to excessively drained, light yellowish brown to brown, very deep, weak sub angular blocky to medium moderate sub angular blocky structure, loamy sand to sandy loam in texture and non-calcareous. The solum is more than 1.50 m deep. Soils of Arniwada series derived from coarse textured alluvium of Banas river are non-calcareous, excessively drained loamy sand to sandy loam in texture (2-3% rock gravels on surface), yellowish brown to dark yellowish brown, underlain by phyllites, granite and mica-schist mixed weathered material. Soils of Asarda series are dominantly sandy loam to silty clay loam at surface and loam at sub surface with marks of stratification. Soils of Sanchore and Dune complex series constitute 8% area. Soils of Sanchore series occur in north and north western part of Dhanera, are well drained with rapid permeability, light yellowish brown to brown, fine sand to loamy sand, non-calcareous with an overburden of 10-20 cm thick intermittent hummocks. Dune soils occur in west and south western part of Dhanera.

Table 1.1. Soil series, extent and their characteristics in Dhanera and Deesa tehsils

Soil Series	Texture	Depth class	Extent (km^2)	Area (%)
Soils associated with Alluvial plains				
Arniwada	ls-sl	d5	1091.70	47.9
Asarda	sl-l-sicl	d5	333.85	14.5
Soils associated with sandy plains				
Dhanera	ls-sl	d5	687.53	30.4
Soils associated with sandy plains with scattered hummocks				
Sanchore	fs-ls	d5	165.45	7.1
Soils associated with sand dunes				
Dune Complex	fs	d5	20.26	0.08

Vegetation: Dominant species on sandy hummocky plains varied in Dhanera and Deesa. These were *Cassia auriculata* (RIV=12-37) *Capparis decidua* (RIV=2-13), *Acacia nilotica* (RIV=7) and *Salvadora oleoides* (RIV=8) in Dhanera. *Prosopis cineraria* (RIV=1-2), *Acacia tortilis* (RIV=1-6) and *Acacia leucophloea* (RIV=1-2) trees dominated in Deesa. Dominant shrubs were *Calotropis procera*

(RIV=3-4), *P. juliflora* (RIV=1-2), *Ziziphus nummularia* (RIV=2-6) and *Leptadenia pyrotechnica* (RIV=3). Grasses were few and mainly annuals such as *Eragrostis* spp., *Aristida* spp., *Oropetium* and *Dactyloctenium agyptium and Cenchrus biflorus*. Older alluvial plains in both tehsils had dominance of trees of *S. oleoides* (RIV=1-7), *S. persica* (RIV=1) *A. leucophloea* (RIV=1-2) and *P. cineraria* (RIV=1). Shrubs of *C. decidua* (RIV=2-8), *P. juliflora* (RIV=1-7), *Cassia auriculata* (RIV=10-42) and *C. occidentalis* (RIV=5-10) were dominant in Dhanera. In Deesa, *Tephrosia purpurea* (RIV=70-75) and *C. procera* (RIV=2-4) also dominated. Associated species are *A. nilotica, A. jacquemontii, Clerodendron phlomoides, Indigofera oblongifolia, Tecomella undulata and Balanites aegyptiaca*. The ground flora had 14-20 species but none was perennial grasses. *Amaranthus* spp, *Chloris* spp., *Tmetothylacus tenellus, Dactyloctenium aegyptium* and *Brachiaria ramosa* were prominent. River banks and younger alluvium supported thickets of *P. juliflora, A. nilotica, C. procera*, and *Euphorbia caducifolia* and occasionally, trees of *P. cineraria, S. oleoides* and *A. leucophloea. Aerva persica, Coccinia grandis, Z. nummularia* and *L. pyrotechnica* were major associates. In Deesa the major perennial trees were *S. oleoides* and *T. undulata* major shrubs were *A. jacquemontii, P. juliflora, C. procera, L. pyrotechnica* and *Z. nummularia*, while *Aristida, Eragrostis* were major grasses. Hills and piedmonts in Dhanera had lush cover of *B. serrata, Holoptelea integrifolia, Pithecellobium dulce, A. pendula, B. aegyptiaca, Bambusa* spp., *Ziziphus* spp., *Commiphora wightii, Dichrostachys cinerea* and *Grewia tenax*.

Severe degradation of range condition was noticed in 33% sites and rest were moderately degraded. Degradation was maximum in herbaceous component. The Shannon's diversity index (H' 1.00-1.76) in Dhanera suggests a moderate diversity in grazing lands. Lower dominance concentrations (DC or λ; 0.20-0.44) in perennials confirmed their balanced status as compared to herbaceous layer. In Deesa tehsil too, diversity index (H' 1.02-1.29) on different grazing lands indicated moderate perennial diversity. DC of >0.5 indicated dominance of a few species. Afforestation is possible through suitable grasses like *Dicanthium annulatum, C. setigerus* and *Panicum pedicellatum* on alluvial plains, *C. ciliaris, L. sindicus* and *P. antidotale* on sandy hummocks, *C. dactylon* and *P. pedicellatum* along younger alluvium. The suitable trees are *C. mopane, D. cineria, D. sisoo* and spp. of *Prosopis, Acacia*, and *Salvadora* as per habitat.

Croplands in both tehsils had very few trees but on fences and borders, as many as 23 perennials and 8 annuals were recorded. Most dominant were *Azadirachta indica, P. cineraria Z. nummularia, C. procera, A. leucophloea, A. nilotica, P. juliflora, E. nerifolia, Ailanthus excelsa, S. spontaneum, S. oleoides, T. undulata, A. jacquemontii, A. lebbek, A. rotundifolia, Moringa concanensis, B. monosperma* and *L. latisilqua*.

Surface water: Surface water resources are mainly in the ponds (nadis) that are used for cattle drinking and partly for the brick kilns activities. The tehsils together have 820 nadis that can store 35.447 mcm water under different capacity ranges (Table 1.2). Many nadis, having now brick kilns in their catchments, are maintained and cleaned properly by the kiln owners, while communities managed *nadis* have even sewage influx. Few are getting de-silted through MGNREGA programme. There is good scope for rainwater harvesting at individual and farm level for enhancing surface water resources. Four watersheds in Dhanera and nine watersheds in Deesa were delineated.

Table 1.2. Surface water storage capacity in Dhanera and Deesa tehsils

Tehsil	Large >50,000 m^3		Medium 25,000-50,000 m^3		Small <25,000 m^3		Total	
	No.	Vol. in mcm	No.	Vol. in mcm	No.	Vol. in mcm	No.	Vol. in mcm
Dhanera	29	3.525	79	2.992	95	3.049	203	9.566
Deesa	119	10.331	227	8.771	271	6.775	617	25.877

Groundwater: Major hydrogeological formations in the area are Alluvium (96.75%) and Schist/ phyllite/gneisses (3.05%). About 87% area has groundwater at >60 m bgl (av. depth 84.55 m bgl; Table 1.3), but the depth is more in Deesa tehsil (av. 94.82 m bgl) than in Dhanera tehsil (av. 69.50 m bgl). Water quality is largely good to brackish (av. EC 1.756 dS m^{-1}). About 99% area has water of EC <4.0 dS m^{-1} (Table 1.4). EC of groundwater in Dhanera tehsil is slightly higher (av. 2.028 dS m^{-1}) than in Deesa tehsil (av. 1.571 dS m^{-1}). The rate of depletion (Plate 3) of groundwater in the tehsils ranges from 0.87 to 15.24 m y^{-1} with an average of 4.49 m y^{-1} during the last five years, as reported by farmers. The discharge from the wells generally varies from 100 to 150 m^3 day^{-1}, with an average of 125 m^3 day^{-1} (Table 1.5). All the tubewells in the region are electrified and ~80% of cultivated area is sprinkler-irrigated.

Table 1.3. Depth to water in Dhanera and Deesa tehsils

Depth to water (m) bgl*	Area covered (sq. km)	Per cent area
30-40	25.60	1.11
40-50	131.56	5.71
50-60	135.82	5.90
>60	2010.16	87.28
Total	2303.14	100.00

*Below ground level.

Table 1.4. Area under different EC ranges in Dhanera and Deesa tehsils

EC range (dS m^{-1})	Area covered (sq. km)	Per cent area
< 2.0	1521.90	66.08
2.0-4.0	760.78	33.03
4.0-6.0	20.46	0.89
Total	2303.14	100.00

Table 1.5. Hydrogeological summary of Dhanera and Deesa tehsils

Aquifer	Depth to water (m bgl)			EC (dS m^{-1})			Water level decline (m y^{-1})			Discharge (m^3 day^{-1})		
	Min	Max	Av	Min	Max	Av	Min	Max	Av	Min	Max	Av
Alluvium	30.48	170.70	83.98	0.445	4.675	1.736	0.87	15.24	4.52	5	150	125
Schist/phyllite/ gneisses	60.96	152.40	97.53	0.696	4.583	2.215	2.44	5.79	3.74	100	150	125
Overall	30.48	170.70	84.85	0.445	4.675	1.756	0.87	15.24	4.49	5	150	125

Present land use: In Dhanera tehsil (118927 ha) cultivated land (including fallow land) constitutes 74.83% area (Plate 4) and irrigated croplands cover 26.10% area. Mustard, wheat, groundnut and cotton are the important irrigated crops. Castor, pearl millet and mung bean are

the important rainfed crops. Forest covers 6.05% area, especially on hills and gravelly plains. Pasture land covers 6.87% area, wastelands 2.58% and settlement and water bodies 8.67% area.

In Deesa tehsil (145668 ha), cultivated land (including fallow land) constitutes 80.35% and irrigated double-cropped land constitutes 45.2% area. Mustard, potato and wheat are the major rabi crops, and castor, pearl millet and mung bean are the major kharif crops. Pasture land covers 9.08%, gullied land 2.85%, forest 0.27%, and settlement and water bodies 7.45% area.

Land degradation: Dhanera and Deesa tehsils are apparently very little affected by land degradation processes, except in the hilly eastern margin. The sandy areas in the eastern part of the tehsils do not pose much threat of wind erosion. However, due to higher rainfall, potential exists for water erosion hazard. Pixel-based simulation for a typical high rainfall year (2006), using meteorological, remote sensing and field information, suggests that in Dhanera tehsil about 86% area carries 100-300 mm runoff per annum, mostly in the sandy plains, while in Deesa tehsil 69% area carries such runoff. The hilly area of Dhanera tehsil and the Banas river valley in Deesa tehsil mostly generate 300-400 mm runoff. Overall, Dhanera tehsil (Plate 5) has the potential of slight to moderate soil erosion (up to 10 t ha^{-1}) in 62.2% area in the west during a normal rainfall year, while its 34.9% area in the hilly east experiences high to very high erosion (10-40 t ha^{-1}). Severe to very severe erosion (>40 t ha^{-1}) occurs in ~3% area in the extreme east. Deesa tehsil experiences slight to moderate erosion in 46.2% area, and high to very high erosion in 53.5% area (Plate 6).

Soil Fertility Assessment and Mapping in Arid Rajasthan

In Pali district, the pH of normal and salt-affected soils varied generally from 7.8 to 9.8, the higher pH being noticed in grazing lands and in high-RSC and saline-water-irrigated soils. EC ranged from 0.101-70 dS m^{-1}. Organic carbon ranged from 0.06 to 0.77% but about 20% samples had <0.2% OC. Available P and K ranged from 2.24 to 98.00 kg $ha^{-1}$and 78-1102 kg ha^{-1}, respectively. About 30% samples were low in available P (<10 kg ha^{-1}) and 15% samples in available K (<130 kg ha^{-1}). Irrigated soils generally registered higher OC and P than the rainfed and grazing land soils (Table 1.6). In Jaisalmer tehsil, organic carbon ranged from 0.03 to 0.25%. About 50% samples contained <0.2% OC. Available P and K ranged from 2.2-27.0 kg ha^{-1} and 165-285 kg ha^{-1}, respectively.

Table 1.6. Fertility status of Pali district soils under different land-use systems

Land use	Organic carbon (%)	Av. P (kg ha^{-1})	Av. K (kg ha^{-1})
Rainfed	0.07-0.62	2.24-56.83	95.60-821.30
Irrigated	0.10-0.77	3.84-51.10	81.40-922.50
Grazing	0.06-0.59	3.30-98.00	78.00-1102.50

The DTPA Fe and Zn of the soils ranged from 1.28 to 18.00 and 0.12 to 1.52 ppm, respectively. Available Cu and Mn ranged from 0.2 to 1.7 and 2.44 to 33.95 ppm, and were mostly sufficient. In both the regions, Fe was found to be most deficient widely (30-50% of samples), followed by Zn (15-30%) in all the three land use systems. The assessment is based on critical limits as: Fe (<4.5 ppm), Zn (<0.6 ppm), Cu (<0.2 ppm) and Mn (<2.5 ppm).

Erosion Process Measurement and Spatio-Temporal Variability in Sediment Transport in Arid Ephemeral Stream Channels

During the year, 6 rainfall events, producing 280 mm rain, caused measurable run-off and sediment movement along the studied channel at Agolai. To measure the bedload movement, a sediment catcher (0.90 x 0.58 m) with 1.80 m circumference was designed, fabricated and fixed in the upper reach of the channel (Plate 7). Bedloads moved during rainfall on two consecutive days (35 mm on 15 September; 30 mm on 16 September) were collected for laboratory analysis. Runoff on 15 September transported 97.4 kg bedload to the catcher (flow depth 20-30 cm), that on 16 September could deliver 75.8 kg (flow depth 10-15 cm). Since a mixed load of rhyolite boulders and carbonate nodules was carried by the flows, the sediment size-weight relationship was not positive, and the lower flow of 16th September tended to carry greater weight of larger-size gravels than the flow of the 15th (Table 1.7) Cross profile measurements (Fig 1.2) along the channel showed very narrow (2-5 m), shallow (0.7-1.20 m) and v-shaped rocky profile in the upper part, wide (6.2-11.4 m) and deep (0.9-1.4 m) bed in the middle part and very wide (10-19 m), moderately deep (0.7-2.3 m) U-shaped bed (with weathered rocks, boulders and sand) in the lower part (Plate 8).

Table 1.7. Bedload carried by the runoff at Agolai

Grain size (mm)	15-Sep-10		16-Sep-10	
	Weight (kg)	% weight	Weight (kg)	% weight
1-2	28.700	29.5	24.000	31.7
2-4	6.300	6.5	4.200	5.5
4-6	13.550	13.9	6.800	9.0
6-8	10.500	10.8	3.050	4.0
8-10	3.550	3.6	6.580	8.7
10-15	9.315	9.6	6.950	9.2
15-20	6.820	7.0	4.330	5.7
20-30	4.500	4.6	4.000	5.3
30-40	3.600	3.7	5.000	6.6
40-60	3.400	3.5	3.300	4.4
60-80	5.000	5.1	5.020	6.6
>80	2.150	2.2	2.550	3.4
Total	97.385	100.0	75.780	100.0

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 2010 were tested for agro-advisory on crop planning and livestock management in Jodhpur district. Monsoon forecasts issued in May and June were lower than the actual rainfall, but model prediction for July and August were closer to the observed rainfall (Table 1.8). District-level rainfall forecast was lower than the actual in June, but closer to observed in July and August. At tehsil-level, the forecast was closer to observed in Jodhpur and Phalodi, but not in Bilara. Specific advisories like cool temperatures favouring downy mildew and white rust in mustard and Isabgol,

and also blight and powdery mildew in cumin, were given. Suggestions were also given on vaccination and health care for livestock.

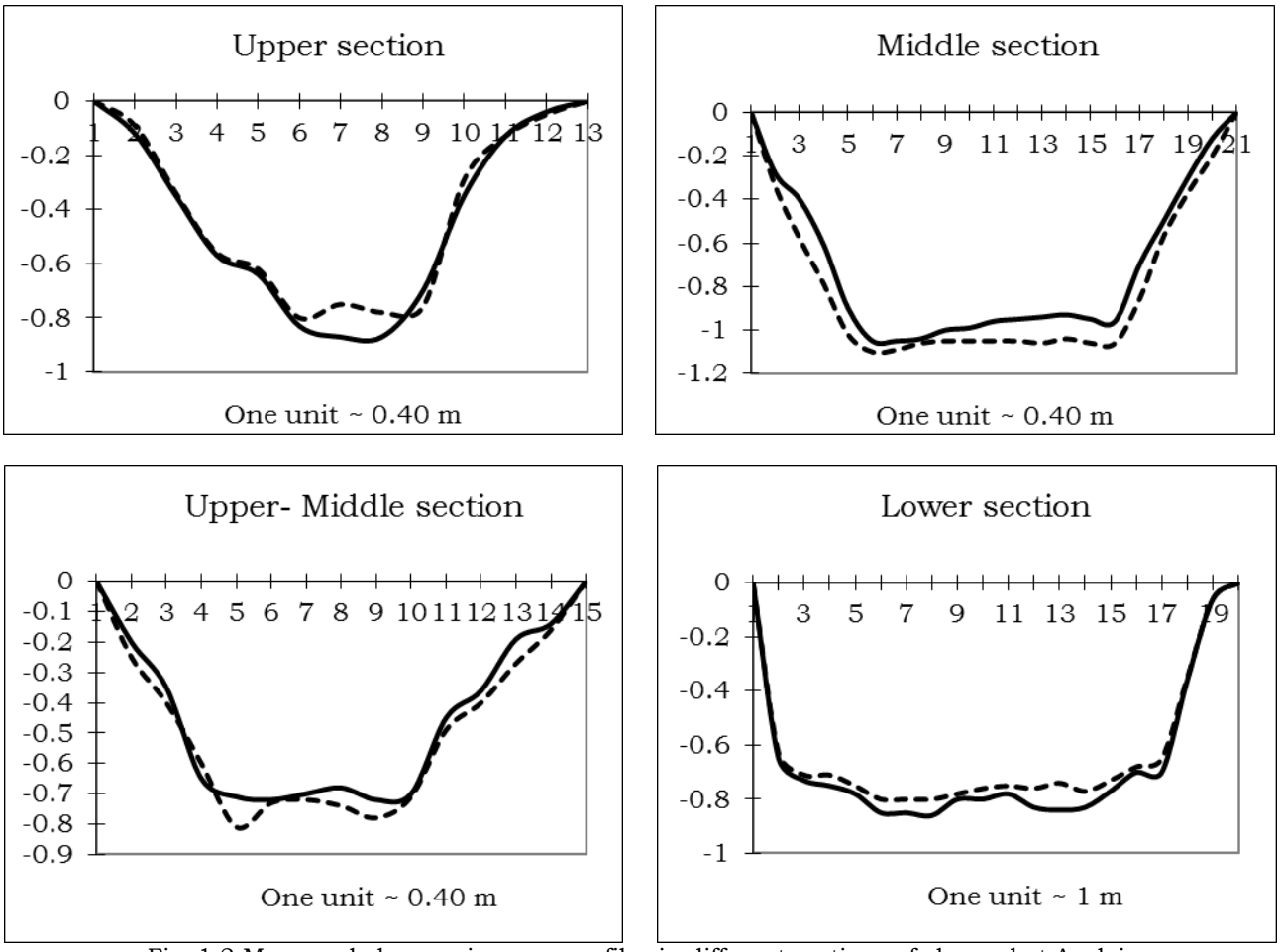

Fig. 1.2 Measured changes in cross profiles in different sections of channel at Agolai during rains in September 2010.

Table 1.8. Verification of extended-range rainfall forecast for kharif 2010 in arid Rajasthan

Month	Forecast (deviation from normal)	Actual rainfall (mm)	Normal rainfall (mm)	Per cent deviation
May forecast for JJAS	20-40%	432	270	60
June forecast for JAS	20-40%	381	239	59
June forecast for July	-20-40%	121	120	1
July forecast for August	20-40%	141	84	40
July forecast for August and September	20-40%	261	118	121
August forecast for September	20-40%	119	34	71

Assessment of the Soil Resources at RRS, Kukma for Identification of Problems and its Management

Effect of tillage and soil amendments on soil properties: An experiment was conducted with four tillage practices (deep:- tillage to 0.25 to 0.30 m depth with a tractor drawn mold board plough, followed by one pass of cultivator and harrow, shallow: tillage to 0.12-0.15 m depth by tractor drawn cultivator passing twice followed by leveling with harrow, minimum:- tillage by one time surface passing of cultivator and control with direct seeding) as main treatments and were split into four soil amendments (gypsum at 5 Mg ha^{-1}, farm yard manure (FYM) at 5 Mg ha^{-1}, both gypsum and FYM at 5 Mg ha^{-1} each, and control) as sub treatments. The tillage practices significantly lowered the enzyme activities in soil. At harvest, the activity of dehydrogenase enzyme was significantly higher in control plots that was on par with minimum tillage. Deep tillage reduced dehydrogenase activities by 54% and shallow tillage by 17% over the control. Similarly, deep tillage reduced alkaline phosphatase activities by 48.7% and shallow tillage by 40.9% over the control. The surface layers exhibited higher enzymatic activity in all the tillage treatments except deep tillage. Tillage did not influence the acid phosphatase activities (Fig. 1.3).

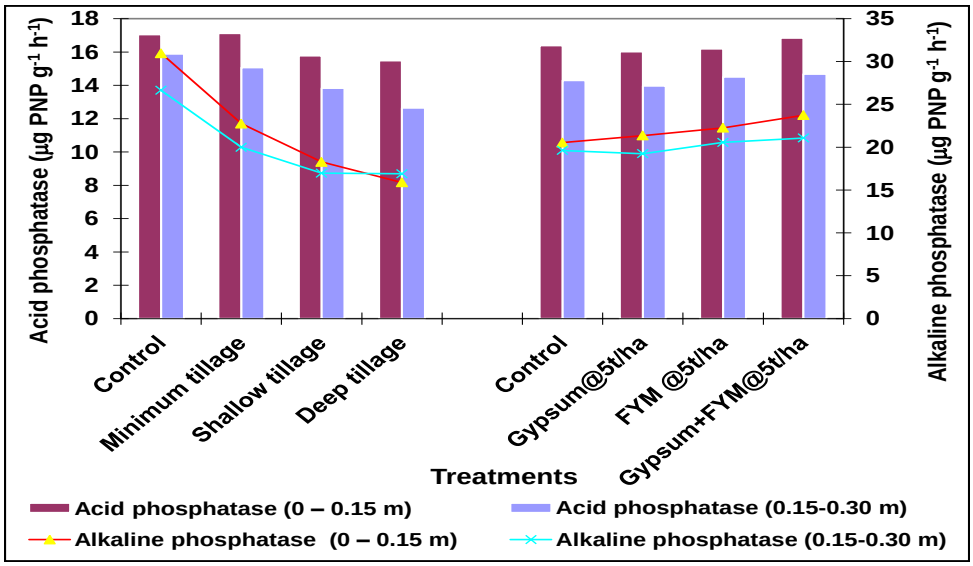

Fig. 1.3. Effect of tillage and soil amendments on soil enzymes.

BIODIVERSITY CONSERVATION AND IMPROVEMENT OF ANNUALS AND PERENNIALS

IMPROVEMENT OF PASTURE GRASSES OF ARID ZONE

Cenchrus ciliaris – Multilocation Trial

Ten genotypes were evaluated at Jodhpur, Bikaner and Pali. At Jodhpur IMTCC-10-4 had maximum green fodder (16083 kg ha^{-1}) and dry matter (4012 kg ha^{-1}). Productivity of IMTCC-10-2 was maximum, 162.5 kg green and 40.5 dry matter ha^{-1} day^{-1}. It had high green fodder (15544 kg ha^{-1}) and dry matter (3873 kg ha^{-1}). Significant variation was recorded for plant height and IMTCC-10-4 had maximum height (92.5 cm) with high leaf stem ratio (4.1). At Bikaner, genotypic variability was observed for green fodder yield and dry matter production. IMTCC-10-6 had maximum green fodder yield (5889 kg ha^{-1}), while IMTCC-10-7 (2708 kg ha^{-1}) maximum dry matter from one cut.

At Pali the highest green forage yield (16867 kg ha^{-1}) over the cuts (two) was in case of genotype IMTCC-10-1 followed by IMTCC-10-5 (15739 kg ha^{-1}) and IMTCC-10-9 (15278 kg ha^{-1}). The genotypes IMTCC-10-7, IMTCC-10-1, IMTCC-10-9 and IMTCC-10-3 flowered earlier (41-43 days). The genotypes IMTCC-10-10 had maximum plant height (102 cm) followed by IMTCC-10-8 (97.4 cm).

In another trial during second year CAZRI 541 showed maximum green forage (25067 kg ha^{-1}) and dry matter (6439 kg ha^{-1}) productivity. CAZRI 231, CAZI 421 and CAZRI 426 were also other promising genotypes for forage production.

Coordinated varietal evaluation trial: During the third year, significant variation was recorded for plant height and tillers/plant (Table 2.1). Entry CE-08-3 had highest plant height, green fodder and dry matter production. Per day productivity of this genotype was also high.

Table 2.1. Forage yield and related traits in varietal evaluation trial in *C. ciliaris* during the 3rd year (total of three cuts for yield data)

Entry code	GFY (kg ha^{-1})	DMY (kg ha^{-1})	GFY (kg ha^{-1} day^{-1})	DMY (kg ha^{-1} day^{-1})	Plant height (cm)	Tillers/ plant	L:S
CE-08-1	14500.0	3588.7	174.7	43.2	95.4	49.5	1.8
CE-08-2	14427.8	3489.2	173.8	42.0	100.3	52.9	2.6
CE-08-3	20155.6	4115.8	242.8	49.6	107.4	31.3	1.5
CE-08-4	-	-	-	-	-	-	
CE-08-5	18805.6	3661.0	226.6	44.1	96.4	31.2	2.2
CE-08-6	17500.0	3560.7	210.8	42.9	105.4	30.9	1.8
CD (5%)	NS	NS	NS	NS	6.4	8.1	NS

Cenchrus setigerus

Initial varietal trial of eight genotypes was established at Jodhpur and Pali and two cuts were taken (Table 2.2). VTCS-8 had maximum green fodder and dry matter yield and also per day productivity at Jodhpur, whereas VTCS-7 at Pali.

Table 2.2. Forage yield of different genotypes of *C. setigerus* during first season at Jodhpur and Pali

Entry Code	GFY (kg ha^{-1})		DMY (kg ha^{-1})		DMY (kg ha^{-1} day^{-1})	GFY (kg ha^{-1} day^{-1})	L:S	
	Jodhpur	Pali	Jodhpur	Pali	Jodhpur	Jodhpur	Jodhpur	Pali
VTCS-1	2305.6	16300	538.2	3490	28.12	6.56	3.8	1.2
VTCS-2	2800.0	17890	687.9	3800	31.11	7.64	6.5	0.9
VTCS-3	3488.9	14120	821.2	3150	42.55	10.01	4.3	1.0
VTCS-4	1866.7	15360	525.4	3330	20.74	5.84	5.8	1.7
VTCS-5	3383.3	16380	746.4	3600	41.26	9.10	5.0	1.1
VTCS-6	2372.2	17300	547.3	3850	26.36	6.08	3.3	1.3
VTCS-7	1916.7	18090	491.1	4120	21.30	5.46	4.8	1.3
VTCS-8	3966.7	13550	915.4	3080	48.37	11.16	3.3	1.7
CD (0.05)	NS	2940	NS	550	NS	NS	NS	0.2

Lasiurus sindicus

Initial varietal trial of seven genotypes was established at Jodhpur and Chandan. IVTS-2 (1023 kg ha^{-1}) showed maximum dry matter at Jodhpur, while IVTS-6 (630 kg ha^{-1}) at Chandan.

Maintenance of Pasture Germplasm

Fifty-eight accessions of pasture grasses were replanted and maintained. After seed collection genotype CAZRI 2221 of *C.ciliaris* showed maximum green fodder (25167 kg ha^{-1}) followed by CAZRI 2172 (20167 kg ha^{-1}), CAZRI 2164 (20000 kg ha^{-1}), CAZRI 223 (17167 kg ha^{-1}), CAZRI 2225 (16833 kg ha^{-1}) and CAZRI 358 (16667 kg ha^{-1}) (Plate 9).

Effect of Cuttings on Seed Production in *Cenchrus ciliaris*

Three promising genotypes of *Cenchrus ciliaris* viz., CAZRI 75, CAZRI 2178 and CAZRI 2221 were evaluated for quality seed production as influenced by foliage cutting during *Kharif* 2010. In the establishment season all the genotypes were cut at 50% flowering uniformly. Cutting at 45 days was also given to CAZRI 2178 and CAZRI 2221. For CAZRI 75, 50% cut could be given in place of 45 days, due to its slow growth at early age.

CAZRI 2178 and CAZRI 2221 were at par in pure seed yield (82.8 and 81.1 kg ha^{-1}), while CAZRI 75 had only 28.5 kg ha^{-1} seed yield. Seed purity was maximum with CAZRI 75 (92.7%). Uncut treatment had maximum pure seed yield (102.4 kg ha^{-1}) followed by 45 days cut (71.4 kg ha^{-1}). Low yield with 50% flowering (35.4 kg ha^{-1}) may be due to the less seed yield of CAZRI 75. Seed purity was maximum with 45 days cut (92%) and minimum with uncut (89.7%). Among the combinations, uncut CAZRI 2178 had maximum pure seed yield (142.1 kg ha^{-1}) followed by uncut CAZRI 2221 (120.0 kg ha^{-1}).

Therefore, in the establishment year, CAZRI 2221 was found as a better genotype for fodder production and seed yield, whereas uncut gave 43% higher seed yield, and 18% dry matter than the next better treatment i.e. 45 days cut. Uncut CAZRI 2221 was found better for both seed yield and fodder production.

Sweet Sorghum for Fodder at Pali

Twelve genotypes were evaluated for fodder production at Pali under rainfed conditions. The genotypes SPV 422 showed maximum green fodder yield (65300 kg ha^{-1}) with 45x10 cm spacing followed by SSV 7 (61000 kg ha^{-1}) and SPV 913 (62040 kg ha^{-1}), SSV 74 (60560 kg ha^{-1}) with 30 x 10 cm spacing after 70 days of sowing. The best yielding fodder sorghum variety HC (308) and dual purpose variety SSV 23 recorded highest yield of 69000 kg ha^{-1} and 49100 kg ha^{-1} under 45 x 10 cm spacing, respectively, whereas, *Desi* (white) produced lowest fodder yield (23000 kg ha^{-1}).

TREES AND SHRUBS

Effect of Gamma Rays on Morphological Traits and Nodulation in Fifteen-Month-Old Seedlings *of A. senegal*

Seeds of two genotypes viz., 35 and 113 (selected on the basis of seed yield from two individual trees from plantation of exotic collections) were irradiated with 20, 40, 60, 80 and 100 kr gamma rays. Fifteen-month-old 79 seedlings of these treatments were evaluated for seedling traits and nodulation. Significant variation is created using gamma rays. Maximum dry weight of individual seedlings was in case of 35-40 (31.8 g), followed by 35-0 (28.4 g), 35-20 (26.9 g) and 35-80 (22.5 g and 18.8 g). Maximum seedling length (2.1 m) and root length (1.77 m) of individual seedling was in case of 113-40. There was no nodulation in any treatment. Mean performance with different doses is given in Table 2.3.

Table 2.3. Mean performance of 15-month-old seedlings with different doses of gamma rays in *A. senegal*

Gamma rays (kr)	Shoot length (cm)	Root length (cm)	Collar diameter (mm)	Shoot dry wt. (g)	Root dry wt (g)	Seedling length (cm)	Shoot/root length ratio	Total dry wt (g)	Shoot/root dry weight ratio	No. of nodules
0	38.1	49.6	4.67	2.49	2.03	87.8	0.97	4.52	1.42	0
20	35.5	43.5	5.09	2.88	2.20	79.0	0.97	5.08	1.31	0
40	33.8	54.8	4.56	2.58	1.96	88.6	0.87	4.54	1.11	0
60	40.1	58.3	5.50	2.50	1.77	98.3	0.79	4.27	1.26	0
80	43.6	87.8	5.75	4.02	2.62	131.4	0.70	6.64	1.47	0
100	46.0	59.8	5.00	3.73	3.11	105.8	0.89	6.84	1.13	0
G. average	38.5	56.7	4.99	2.85	2.15	95.2	0.88	5.01	1.30	0
Genotype										
35 (n=44)	43.7	46.4	5.78	4.32	3.06	90.1	1.12	7.39	1.47	0
113 (n=35)	31.9	69.7	4.00	1.00	1.01	101.6	0.58	2.02	1.08	0

Effect of Gamma Rays and Genotypes on Germination, Seedling Traits and Nodulation in *A. senegal*

Seventy-four-day old seedlings (sown after 15 months of seed storage after gamma irradiation) were evaluated. Seed germination was poor and seedlings mortality increased with increase with dose and more than 69% seedlings died with 60, 80 and 100 kr gamma rays in both the genotypes. Number of nodules on individual seedlings varied from 0 to 18, mostly in the range of 0-6. Shoot length increased with 20 kr gamma rays in both the genotypes (Table 2.4).

Table 2.4. Mean values of different parameters with gamma rays in *A. senegal*

Gamma rays (kr)	% germination	% seedling mortality	Shoot length (cm)	Root length (cm)	Collar diameter (mm)	Seedling length (cm)	Shoot/root length ratio	No. of nodules
Genotype 35								
0	26.7	5.6	38.0	25.4	3.4	63.4	1.5	4.5
20	35.0	26.7	41.4	24.5	3.5	65.8	1.7	2.5
40	28.3	47.6	36.8	24.4	2.6	61.1	1.5	0.0
60	36.7	85.9	29.6	21.1	3.0	50.8	1.8	1.3
80	40.0	96.3	26.0	19.0	3.0	45.0	1.4	1.0
100	43.3	97.6	29.0	23.0	2.0	52.0	1.3	0.0
Genotype 113								
0	28.3	40.7	36.5	27.5	2.5	64.0	1.4	0.7
20	10.0	41.7	41.3	26.9	3.5	68.1	1.6	0.8
40	18.3	14.3	33.1	22.8	2.8	55.9	1.6	1.0
60	25.0	70.0	25.4	22.8	2.4	48.2	1.2	2.2
80	35.0	95.8	15.0	13.5	2.0	28.5	1.1	0.0
100	23.3	100.0	-	-	-	-	-	-

Variation in Nodules and Rhizobial Colonies in *Acacia senegal* and *Prosopis cineraria*

To isolate efficient rhizobia seventy-five seedlings each of *A. senegal* and *P. cineraria* were evaluated for nodulation in one-year-old seedlings. The nodules in general were present singly or in clusters on lateral extension of the main root, pink or brown in colour, having varying shapes (round and oval) and sizes (small and large) (Plate 10).

Rhizobial colonies were grown on yeast extract mannitol agar medium containing congo red to exclude contaminants. After three days incubation at 30°C variation in colony size and slime production was observed in the culture plates. 16.6% of colonies were small, 56.5% medium and 26.6% large in size with low, medium and high slime production (Plate 11).

Seed Yield in Exotic and Indigenous Collections of *A. senegal*

Twenty two-year-old plants of *A. senegal* were evaluated for seed yield and seed weight. Rajasthan and Sudan genotypes produced seeds, whereas most of the plants of Niger, Mali and Senegal origin are dying and did not produce any seeds. Maximum average seed yield per tree was in case of Sudan material (1931.1 g) ranging (for individual trees) between 445.0 g to 5290 g,

followed by Rajasthan (742.0 g). Mean 100-seed weight was 9.8 g and there was no relationship of seed yield with seed weight.

Performance of *Salvadora oleoides* germplasm

Seven-year-old 24 accessions of *S. oleoides* were evaluated for survival, height and fruit formation. There were significant differences among the accessions. Survival (%) varied from 40.0 for Acc 212 to 100.0 for Acc 213. Maximum height was for Acc 214 (2.35 m) followed by Acc 195 (2.3 0 m) and Acc 196 (2.06 m). The minimum height was for Acc 201 (0.93 m). There was flowering in most of the collections but no fruit set.

Guggul

Distribution: Survey of Guggul was completed in Barmer, Jalor, Sirohi, Pali and Nagaur districts and it was present in 26% of the sampled sites. Its density varied from 60 to 140 plants ha^{-1} in protected sites and 20 to 60 plants ha^{-1} in unprotected sites. Though it was co-dominant at all the sites, but its dominance improved in protected areas. Similar trend was seen in its vigor. It occurred at altitude of 270 to 527 m, preferring hills and piedmonts at 94% sites and plains at 6% sites. Its habitat was gravelly, stony pulverised soils. Most common associate species were *Prosopis juliflora, Euphorbia caducifolia, Boswellia serrata, Wrightia tinctoria, Grewia tenax, Acacia senegal, Calotropis procera* and *Maytenus emarginata.* Germplasm collected from 18 sites has been grown in the nursery.

Occurrence of guggal was more in western part and declined towards northern and eastern parts (Plate 12).

Growth studies on different provenances: Ten-year-old plantation of four provenances at Jaisalmer was evaluated for morphological traits (Table 2.5). In all the provenances crown was more pronounced in east-west direction than north-south direction. Provenance Dantiwara showed more growth for crown size, shoot diameter and mean girth of primary branches; while provenance Mangaliawas had more height and number of primary branches. Provenances Dantiwara and Mangaliawas are more suitable for extreme arid situations of Jaisalmer.

Table 2.5. Performance of guggal provenances at Jaisalmer farm

Trait		Provenance				Mean
		Dantiwara	Mangaliawas	Kukuma-Bhuj	Bhind-Morena	
Height (cm)		165±7	179±6	164±4	140±2	164
Primary branches (no.)		5.9±0.5	11.2±0.8	7.8±0.6	6.8±0.2	7.9
Crown diameter (cm)	NS	241±9	237±6	252±5	236	236
	EW	259±9	251±4	258±10	245.75	246
Shoot diameter (mm)		79.8±5.0	73.4±6	69.2±3	67.5±0.8	72.5
Primary branch diameter (mm)		43.8±1.2	34.9±0.8	33.2±1.6	35.1±0.9	36.8

Studies on the Four-Year-Old Local Provenances at Jaisalmer

Cuttings collected from individual high oleo-gum-resin oozing mature plants from three locations in Jaisalmer (Akal, Kali Dungar and Thaiyat) and one from Kailana (Jodhpur) were

rooted and transplanted in 2006. The four accessions showed significant variation for plant height, number of branches, crown size, shoot diameter and mean diameter of primary branches (Table 2.6). Kailana provenance showed significantly more growth with respect to height, number of primary branches and shoot diameter. However, provenance Kali Dungar has largest crown size.

Table 2.6. Morphological performance of 4-year-old guggal provenances at Jaisalmer

Traits		Provenance				Mean
		Akal	Kali Dungar	Thaiyat	Kailana	
Height (cm)		68 ± 7	71 ± 9	72 ± 6	76 ± 4	72
Primary branches (no.)		5.1 ± 1.6	4.0 ± 1.4	4.7 ± 0.4	5.8 ± 0.5	4.9
Crown diameter (cm)	NS	105 ± 8	125 ± 10	102 ± 6	111 ± 5	111.0
	EW	109 ± 6	131 ± 9	121 ± 12	115 ± 6	119
Shoot diameter (mm)		18.0 ± 1.7	22.8 ± 1.5	17.4 ± 1.2	25.6 ± 1.1	21.0
Primary branch diameter (mm)		8.7 ± 0.6	16.2 ± 1.4	14.2 ± 0.1	15.7 ± 0.2	13.7

Comparative growth of guggal propagated with seed and stem cuttings: Ninety-day old seedlings/plants raised from stem cuttings, planted in field in 2008, were evaluated. After three years of transplanting, plants raised from seeds attained more height (115 ± 4 cm), shoot diameter (19.0 ± 0.8 mm) and average girth of primary branches (9.3 ± 0.5 mm) than the plants from stem cuttings (66 ± 3 cm, 14.9 ± 0.2 mm and 7.4 ± 0.3 mm, respectively).

Biomass Productivity of *Haloxylon salicornicum* at Bikaner

Eight accessions, evaluated after five years of planting, differed significantly for above ground biomass. CZBHS-42 had maximum biomass (1785.0 g plant^{-1}) and foliage. Seed with perianth yield ranged from 151.5 to 241.9 g plant^{-1}, the maximum in CZBHS–39 (Table 2.7).

Table 2.7. Above ground biomass yield of different accessions of *H. salicornicum*

Accessions	Biomass (g plant^{-1})				
	Wood	Branch	Foliage	Seed*	Total
CZBHS-15	418.6 ± 82.8^{bc¶}	165.3 ± 64.8^{a}	329.5 ± 39.6^{b}	151.5 ± 47.1^{a}	1064.9 ± 79.3^{b}
CZBHS-21	258.6 ± 48.1^{a}	166.7 ± 48.9^{a}	224.6 ± 29.1^{a}	188.8 ± 12.5^{ab}	838.7 ± 92.1^{a}
CZBHS-39	477.1 ± 77.4^{c}	300.4 ± 64.4^{b}	393.2 ± 81.6^{c}	241.9 ± 24.4^{c}	1412.5 ± 139.8^{d}
CZBHS-40	653.3 ± 63.3^{de}	212.5 ± 49.9^{ab}	498.0 ± 46.3^{d}	171.5 ± 11.0^{ab}	1535.3 ± 71.2^{d}
CZBHS-42	708.8 ± 34.3^{e}	346.1 ± 97.4^{b}	567.4 ± 71.7^{e}	162.8 ± 16.4^{a}	1785.0 ± 152.1^{e}
CZBHS-46	605.8 ± 70.6^{d}	322.0 ± 68.2^{b}	392.0 ± 43.0^{bc}	209.5 ± 23.2^{bc}	1529.4 ± 71.0^{d}
CZBHS-52	366.0 ± 42.5^{b}	268.7 ± 55.2^{b}	419.1 ± 12.8^{c}	183.5 ± 28.8^{ab}	1237.3 ± 71.0^{c}
CZBHS-61	395.0 ± 73.2^{bc}	266.6 ± 49.7^{b}	250.8 ± 29.1^{a}	182.9 ± 19.0^{ab}	1095.2 ± 59.3^{b}

*Seed with perianth; ¶ Figure followed by different letter/letters in a column are significantly different (P<0.05).

Averaged over all the accessions, wood, branches, foliage and seeds with perianth constituted 36.4, 19.6, 29.0 and 14.9% of the total above ground biomass. The wood constituted 29.6-42.6% of total biomass and maximum contribution of wood to total biomass was in case of CZBHS-40. Similarly, foliage had 25.6-33.9% share in total biomass and the maximum in CZBHS-52.

HORTICULTURE

Germplasm Introduction, Collection and Evaluation

Cactus (*Opuntia ficus indica*): Forty-three exotic accessions, introduced from Tunisia and Italy in collaboration with ICARDA, were planted during January-February. Due to rotting 22 accessions were lost, and 42 plants representing 20 accessions could be rescued and regenerated.

Fig (*Ficus carica*): Fifty saplings of three varieties (Poona fig, Dinkar and Black Ischia) and one distinct genotype planted in the field showed 100% survival. These are evaluated and used as a source of bud wood and cutting materials for multiplication.

Karonda (*Carissa carandas*): Among seven accessions, K-2011 showed maximum plant height (4.23 m), canopy area (13.0 m^2) and fruit yield (14.7 kg $plant^{-1}$). Unfavorable environmental conditions during flowering and fruit set (February-March) adversely affected the fruit yield.

Gonda (*Cordia myxa*): Thirteen accessions collected during the last ten years were evaluated for its growth and fruit yield. The variation was more in canopy area (11.7-30.6 m^2) than plant height (2.49-3.48 m).

Budded khejri (*Prosopis cineraria*): To obtain more leaf and fodder, the budded khejri plants and control were lopped and manually harvested at four times fortnightly from 1st of June. The effect of different methods of leaf harvesting on fruiting and leaf yield will be observed.

Ivy gourd (*Coccinia grandis*): Three genotypes viz., Indira Kundru-35, CZIG-1 and CZIG-2 were collected and evaluated during kharif season and the fruit yield $plant^{-1}$ were 3.08, 2.32 and 4.10 kg respectively. Among all the Kundru genotypes, IIVR Sel. 1 was the highest fruit yielder (4.3 kg $plant^{-1}$).

Performance of Date Palm Cultivars at Chandan (Jaisalmer)

Spathe emergence: Four cultivars were evaluated for spathe emergence and days taken to dang stage. Khadrawi was earliest for spathe emergence and it took 37 days from spathe opening to doka stage and 16 days from doka to dang (Table 2.8).

Table 2.8. Phenological stages of different cultivars of date palm in 2010

Cultivar	Spathe emergence	Spathe opening	Doka stage	Dang stage
Halawi	February 18-21	March 6-12	June 15	July 7
Shamran	February 2-8	February 24-March 2	June 15-19	June 29
Khadrawi	February 1-21	February 24-March 9	June 13-21	June 22-29
Migraf	February 23	March 11	June 11	June 22

Acidity and chemical composition of the date palm fruits: Seven cultivars were evaluated for acidity of the fruits and chemical composition. Per cent acidity indicates the sweetness, more is the acidity more sweet is the fruit. At doka stage, maximum acidity was recorded for Umshok followed by Halawi and the lowest for Migraf. The values of acidity for different cultivars were almost same as recorded during 2009. The acidity of fruits at dang stage increased in four cultivars and the maximum increase was in Halawi, from 0.55% at doka stage to 0.82% at dang stage, Halawi showed minimum ash content and maximum crude protein (Table 2.9).

Table 2.9. Acidity and chemical composition of date palm fruits of different cultivars

Cultivar	Acidity (%)		Moisture (%)	Dry matter (%)	Organic matter (%)	Ash content (%)	Crude protein (%)
	Doka stage	Dang stage					
Medzool	0.32	0.30	24.60	75.40	97.77	2.23	4.03
Khadrawi	0.17	0.49	26.02	73.98	97.50	2.50	2.83
Khalas	0.39	0.47	20.39	79.61	97.06	2.94	2.83
Halawi	0.55	0.82	24.21	75.79	97.94	2.06	4.09
Umshok	0.72	0.68	29.52	70.48	96.83	3.17	3.44
Migraf	0.14	0.09	22.47	77.53	97.13	2.87	3.35
Shmran	0.19	0.28	-	-	-	-	-

PEARL MILLET IMPROVEMENT

Development of Inbreds

Sixteen new inbred lines from the advanced breeding material were identified and named CZI 2010/1 to CZI 2010/16 during kharif 2010. Two hundred twenty promising progenies were selected from 416 progenies in different stages of selfing and germplasm, and 68 new selections from ICRISAT material.

Development of New Hybrid Combinations

Three hundred five new hybrid combinations were made by crossing CAZRI inbreds with CAZRI male sterile lines and ICRISAT ms lines. A line x tester hybrids set was also constituted during summer planting by crossing CAZRI ms lines with three inbreds (CZI 2000/13, CZI 2004/8 and CZI 2005/21) as testers.

Hybrid Trials

Hybrid trial-I: Forty two experimental hybrids along with four checks (GHB 538, ICMH 356, RHB 121 and HHB 67) were evaluated. Grain yield in checks ranged from 1803 kg ha^{-1} (HHB 67) to 3281 kg ha^{-1} (GHB 538). Among experimental hybrids it ranged from 3009 kg ha^{-1} to 1273 kg ha^{-1}. The highest grain yield hybrid was ICMA 88004 x CZI 2008/8 (3009 kg ha^{-1}, 49 days), and was followed by ICMA 88004 x CZI 2005/21 (2895 kg ha^{-1}, 48 days), ICMA 88004 x CZI 2000/13 (2778 kg ha^{-1}, 50 days), and ICMA 88004 x CZI 2004/8 (2576 kg ha^{-1}, 50 days). The earliest flowering hybrid was ICMA 843 x CZI 2000/13, flowered in 45 days with grain yield of 2502 kg ha^{-1}.

Hybrid trial-II: Forty two experimental hybrids were evaluated along with four check hybrids (GHB 538, ICMH 356, RHB 121 and HHB 67). Trial mean was 2020 kg ha^{-1}. Grain yield among checks ranged from 1810 kg ha^{-1} (GHB 538) to 2323 kg ha^{-1} (RHB 121), while among experimental hybrids grain yield ranged from 1123 kg ha^{-1} to 2964 kg ha^{-1}. The hybrid recording highest grain yield was ICMA 92777 x CZI 2004/7 (2964 kg ha^{-1}, 50 days), followed by ICMA 93333 x CZI 2000/13 (2895 kg ha^{-1}, 46 days), ICMA 93333 x CZI 2007/13 (2879 kg ha^{-1}, 54 days) and ICMA 92777 x CZI 2008/4 (2655 kg ha^{-1}, 49 days). The earliest flowering check was HHB 67, that took

45 days to flower, while the earliest flowering experimental hybrid was ICMA 93333 x CZI 2000/13 (46 days to flowering) (Plate 13).

Hybrid trial-III: Forty two hybrids were evaluated with four check hybrids (HHB 67, GHB 538, ICMH 356 and RHB 121). Among checks ICMH 356 recorded the highest grain yield (3096 kg ha^{-1}) followed by GHB 538 (3036 kg ha^{-1}). HHB 67 flowered earliest (43 days), but had lowest grain yield among the checks. Among the experimental hybrids ICMA 94555 x CZI 2007/1 recorded the highest grain yield (2884 kg ha^{-1}) followed by ICMA 94555 x CZI 2005/9 (2847 kg ha^{-1}) and ICMA 95555 x CZI 2008/8 (2717 kg ha^{-1}).

Hybrid trial–IV: Forty experimental hybrids along with four checks (HHB 67, GHB 538, ICMH 356 and RHB 121) were evaluated. RHB 121 was the highest yielding check (3127 kg ha^{-1}). Experimental hybrids that recorded grain yield almost at par with RHB 121 were ICMA 97333 x CZI 2000/13 (3010 kg ha^{-1}, 45 days), ICMA 97111 x CZI 2008/9 (2797 kg ha^{-1}, 42 days) and ICMA 97111 x CZI 2008/8 (2732 kg ha^{-1}, 43 days). The earliest and high yielding hybrid was ICMA 96666 x CZI 2008/8 (2644 kg ha^{-1}, 41 days).

Hybrid trial–V: Forty experimental hybrids were evaluated along with four checks (HHB 67, GHB 538, ICMH 356 and RHB 121). Grain yield among checks ranged from 1835 kg ha^{-1} (ICMH 356) to 3034 kg ha^{-1} (RHB 121). In case of experimental hybrids the grain yield ranged between 1242 kg ha^{-1} to 2881 kg ha^{-1}. The highest yielding hybrid was ICMA 97444 x CZI 2000/22 (2881 kg ha^{-1}, 48 days), followed by ICMA 97444 x CZI 2008/9 (2879 kg ha^{-1}, 43 days) and ICMA 00444 x CZI 2008/3 (2548 kg ha^{-1}, 47 days).

LxT hybrid trial: Forty eight hybrids made on sixteen male sterile lines (CZMS 1A to CZMS 16A) developed at CAZRI were evaluated along with three checks (HHB 67, GHB 538 and ICMH 356). GHB 538, a check hybrid, recorded the highest grain yield (3018 kg ha^{-1}, 46 days). Experimental hybrids that recorded grain yield at par with GHB 538 and ICMH 356 are, CZMS 14A x CZI 2005/21 (2877 kg ha^{-1}, 47 days), CZMS 3A x CZI 2000/13 (2830 kg ha^{-1}, 47 days) and CZMS 4A x CZI 2000/13 (2703 kg ha^{-1}, 48 days).

Coordinated Trials at Jodhpur and Bikaner

Initial hybrid trial-I (IHT-I): Eighteen hybrids were evaluated. At Jodhpur IHT 106 (3092 kg ha^{-1}) recorded the highest grain yield, followed by IHT 112 (2972 kg ha^{-1}), IHT 107 (2963 kg ha^{-1}) and IHT 102 (2898 kg ha^{-1}). Earliest flowering was in IHT 118 and it took 42 days, while IHT 110 flowered in 44 days. At Bikaner IHT 106 (615 kg ha^{-1}) was the highest grain yielder followed by IHT 108 (509 kg ha^{-1}), IHT 109 (573 kg ha^{-1}) and IHT 112 (553 kg ha^{-1}).

Advance hybrid and population trial (AHPT): Fifteen entries (hybrids and varieties) were evaluated. At Jodhpur, AHPT 810 recorded the highest grain yield (2792 kg ha^{-1}) and flowered in 46 days. Next high yielding entry was AHPT 801 (2402 kg ha^{-1}, 49 days) and AHPT 802 (2232 kg ha^{-1}, 45 days). Earliest flowering entries were AHPT 812 (44 days) and AHPT 815 (44 days). At Bikaner, the highest seed yielder was APHT 810 (1235 kg ha^{-1}) followed AHPT 806 (767 kg ha^{-1}) .

Contribution to the coordinated trials: ICMA 98222 x CZI-2004/7, ICMA 96666 x CZI 2004/8 and ICMA 94555 x CZI 2004/8/S, new hybrid entries, were contributed to the all India trials for kharif 2010.

ICRISAT trials: Four ICRISAT trials, viz., early B line trial (64 entries), IC-ICZBC B line trial (42 entries), early maturing restorer trial (40 entries) and dual purpose restorer trial for arid zone (102 entries) were planted and evaluated for days to 50% bloom, plant height, head length and agronomic score. Fifty three full sib and fifteen half sib promising progenies were selected from this material for use in breeding programme.

ARID LEGUME IMPROVEMENT

Clusterbean

Mutation breeding: Fifty one mutant lines generated from varieties RGC-936 and HGS-365 were screened from M_1-M_4 generations for earliness in maturity and other plant characteristics. Mutants from HGS-365 performed better yielding (361 kg to 494 kg ha^{-1}, maturing in 82-84 days) than parent HGS-365. In case of RGC-936, the most promising mutants gave yield of 329 kg ha^{-1} and matured in 80 days.

Performance of stabilized breeding lines developed through hybridization: Forty eight stabilized breeding lines of cross of PNB X Suvidha were evaluated for their performance. The maturity period ranged from 80-92 days. The lines maturing in 80 days were No. 8, 9, 20, 23 and 44 with yield 177-302 kg ha^{-1}. In another trial breeding line No.48 was earliest to mature in 78 days followed by No.17 (80 days), and the others matured in 84-96 days. In general, medium to medium late maturing breeding lines resulted in better yield than the early ones.

Performance of selections from germplasm: Among thirty seven varieties selected from germplasm selection line No. 10, 24 and 29 were higher yielders (323-391 kg ha^{-1}) maturing in 90-96 days. In early maturing group (82-84 days) Selection line No.17, 21 and 32 gave yield of 229-281 kg ha^{-1}.

Coordinated Trials

Initial varietal trial (IVT): Among fourteen genotypes GR-1 and RG-8 were significantly better than the others with seed yield of 310-355 kg ha^{-1}, maturing in 86-87 days.

Advanced varietal trials (AVT-I and AVT-II): Among seven genotypes evaluated for their performance genotypes GR-103 and GR-108 performed significantly better (305-354 kg ha^{-1}) maturing in 86-87 days.

Mung bean

Mutation breeding: 48 early mutants developed through gamma irradiation (0, 10, 20, 30 and 40 Kr) were evaluated. Mutants CZM-24, CZM-25, CZM-26, CZM-41, CZM-47 and CZM-48 were higher yielders (1042-1427 kg ha^{-1}) than the check parent varieties, S-8 and K-851 (850-906 kg ha^{-1}). The 100-seed weight of mutants was in the range of 3.5-4.1 g.

Performance of selections from NATP germplasm: Among eighteen selections genotype No.102 was the highest seed yielder (708 kg ha^{-1}), maturing in 66 days with 100-seed weight of 3.2 g. The other promising genotype was No.169 with a yield of 604 kg ha^{-1} maturing in 61 days with 100 seed weight of 4.1 g.

Performance of 22 progeny selections (SSD): Progeny selections along with check varieties S-8 and K-851 were evaluated. Selection SP-11 was the highest seed yielder (786 kg ha^{-1}), followed by SP-18 (713 kg ha^{-1}), SP-10 (703 kg ha^{-1}) and SP-13 (687 kg ha^{-1}) maturing 61-66 days, with 100-seed weight of 3.4-3.6 g against check varieties (463-531 kg ha^{-1}).

Maintenance Breeding

Moth bean cv. CZM-2 and Maru Moth-1, Cowpea cv. CAZC-B and CAZC-10, clusterbean cv. Maru Guar and GDM-1, horse gram cv. Maru Kulthi-1, and mung bean cv. RGM-62 were maintained and multiplied.

SESAME (*SESAMUM INDICUM* L.) AT BHUJ

Performance of Varieties

Seventeen varieties were evaluated for different parameters of seed yield. Days to 50% flowering and maturity ranged from 39 to 47 and 73 to 90 days, respectively. Purva-1 matured in 73 days but seed yield level was low (442 kg ha^{-1}). The seed yield ranged from 338 to 570 kg ha^{-1} and the maximum was in case of Murg-1 maturing in 82 days. Other high yielding varieties were PT-64 (552 kg ha^{-1}) and PB Til-1 (522 kg ha^{-1}). PB Til-1 showed the maximum number of capsules per plant (71.4) followed by Murg-1 (65.8). PT-64 had the maximum seed filling rate (53.8%) followed by Murg-1 (53.0). Biomass production was maximum in C-1013 (2449 kg ha^{-1}) followed by GT-3 (2268 kg ha^{-1}).

Evaluation of Germplasm

179 accessions, procured from NBPGR, Regional Station, Jodhpur, differed significantly for seed yield and related traits. Days to 50% flowering ranged from 40 to 52, days to maturity from 75 to 91, seed yield plant^{-1} from 2.56 g (NIC 8658) to 21.56 g (NIC 17432), number of capsules plant^{-1} from 21.5 (NIC 8657) to 137 (NIC 17466) and capsule length varied from 2.0 cm (NIC 17873) to 3.35 cm (NIC 17505). The harvest index ranged from 9.7% (NIC 8672) to 34.2% (NIC 17923). Nine accessions were single stemmed and six showed shattering tolerance.

IMPROVEMENT OF WATER MELON (*CITRULLUS LANATUS*) FOR SEED YIELD AT JAISALMER

One hundred and twenty two accessions, collected from NBPGR, SKRAU, and Plant Genetic Resources Conservation Unit Georgia 30223, United States of America were evaluated for fruit and seed yield related traits (Table 2.10).

Seeds per fruit was maximum in landraces and minimum in exotic lines. Maximum number of seeds per fruit was in EC 677162 (1072), followed by DRB-661 (883) and DRB-653

(811). DRB-661 showed maximum seed weight per fruit, DRB 677 number of fruits, fruit and seed yield per plant, EC-677200 test weight and EC-677164 oil content. Landraces showed maximum number of seeds and seed yield per fruit, fruit yield and seed yield per plant followed by indigenous collections, while test weight was highest in exotic collections. Over all landraces were found promising for rainfed situations for higher seed yield and related traits (Plate 14).

Table 2.10. Variation for quantitative traits in watermelon

Characters	Range	Mean ± SEm	Coefficient of variation (%)
Fruit weight (g)	464-5635	1493.8 ±79.8	57.1
Rind weight (g)	295-3152	986.5 ± 54.8	59.3
Fruit diameter (cm)	28.8-65.8	43.8 ± 0.6	14.8
Fruit length (cm)	32.2-67.6	46.7 ± 0.7	15.9
Rind thickness (mm)	10.1-25.8	17.1 ± 0.3	20.3
Seeds per fruit (no.)	156.4-1072.0	499.8 ± 19.70	42.1
Seed yield per fruit (g)	18.5-66.5	40.7 ± 1.1	27.5
Fruits per plant (no.)	2.0-27.3	7.6 ± 0.4	53.6
Fruit yield per plant (kg)	1.08-34.5	13.2 ± 0.6	49.3
Test weight (g)	45.8-191.9	93.9 ± 3.6	40.9
Seed yield per plant (g)	25-870	273.6 ± 13.9	54.0
Seed oil content (%)	14.6-44.2	28.9 ± 0.4	14.0

MOLECULAR CHARACTERIZATION

Cumin, Coriander, Fenugreek and Fennel

Six lines of cumin, 22 of coriander, 13 of fennel and 17 of fenugreek from National Research Center on Seed Spices, Ajmer were molecularly characterized. In fenugreek, multilocus genotyping by 10 RAPD primers detected intraspecific variations amounting to 64.7% polymorphism in banding patterns, and molecular variance indicated a greater proportion of total genetic variation within population (91%) rather than among the populations.

Mung bean

Forty-four genotypes were assessed. Multilocus genotyping by twelve RAPD primers generated 166 markers and detected an average of intraspecific variation amounting to 82% polymorphism in banding patterns (Figs. 2.1 and 2.2). Un-weighted pair group method using arithmetic averages (UPGMA) dendrogram obtained from cluster analysis using Jaccard's similarity coefficient delineated all the 44 genotypes into six clusters. The genetic distance analysis validates existence of wide genetic diversity among mung bean genotypes tested.

Tropical Mushrooms

Twelve different strains, from mushroom fruiting bodies associated with the stem base of diseased trees, were molecularly identified using PCR amplified products of 5.8 S r RNA gene (Table 2.11).

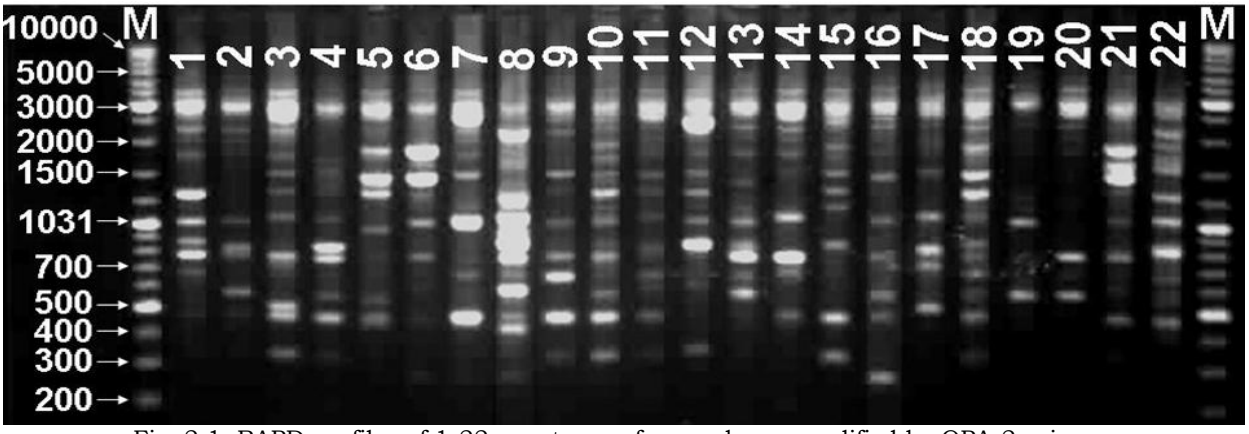

Fig. 2.1. RAPD profiles of 1-22 genotypes of mung bean amplified by OPA-2 primer.

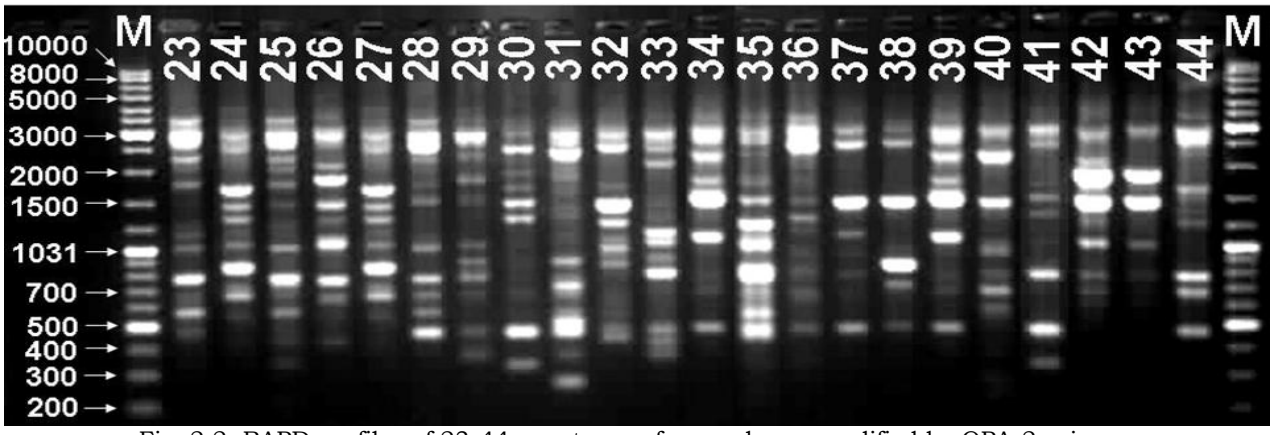

Fig. 2.2. RAPD profiles of 23-44 genotypes of mung bean amplified by OPA-2 primer.

Table 2.11. Different strains of wild mushroom

Strain	Mushroom identified
CAW-26	*Ganoderma species*
CAW-27	*Inonotus rickii*
CAW-28	*Inonotus rickii*
CAW-29	*Ganoderma lucidum*
CAW-30	*Inonotus porrectus*
CAW-31	*Inonotus porrectus*
CAW-32	*Inonotus rickii*
CAW-33	*Phanerochaete chrysosporium*
CAW-35	*Inonotus porrectus*
CAW-36	*Inonotus porrectus*
CAW-38	*Ganoderma lucidum*
CAW-39	*Ganoderma species*

MICRO PROPAGATION

Evaluation of *Phoenix dactylifera* Plants

During February-March five plants out of nine (raised through tissue culture of variety Muscut-2 and planted in 1989-90) flowered and were pollinated. Dark red fruits were harvested in 1st week of July. Average values for weight of fruit bunch/spathe, number of fruits in each bunch, weight of each fruit and TSS were 1.89 kg, 379, 8.66 g, and 37.8, respectively

SEED PRODUCTION

Technology for Quality Seed Production in Cumin (*Cuminum cyminum*)

The cumin seed variety RZ-209 was given six pre-sowing treatments; with two fungicides (captan and bavistin, 3 g kg^{-1} seed); one growth hormone (ethephon, 800 ppm); two biocontrol agents (*Aspergillus versicolar* and *Trichoderma harzianum*, 4 g kg^{-1} seed); water soaking/priming (3 hrs) followed by shade drying; and untreated as control. Pre-sowing seed treatments improved the seedling emergence, seed yielding attributes and seed yield. Seed priming, ethephon and *T. harzianum* had significant effect on plant height, branches per plant, seeds per umbel, seed yield and speed of germination (Table 2.12).

Table 2.12. Seed yield and yield attributes of cumin

Treatments	Plant height (cm)	Branches $plant^{-1}$	Umbels $plant^{-1}$	Seeds $umbel^{-1}$	Seed yield (kg ha^{-1})	Germination time (days)	Speed of germination
Captan	31.0	5.75	16.2	13.4	382.5	14.6	4.99
Bavistin	29.9	6.75	19.5	14.1	321.9	14.2	4.84
Ethephon	31.2	7.51	20.2	15.0	427.5	13.6	5.96
A. versicolar	29.9	6.85	17.3	12.9	358.1	14.2	5.75
T. harzianum	31.0	6.80	20.5	15.1	401.3	14.6	5.83
Priming	31.9	7.35	20.1	15.2	416.9	13.2	6.64
Control	28.9	6.02	18.8	12.2	346.9	14.3	4.78
SEm	0.56	0.37	1.08	0.50	11.4	1.12	0.12
CD (0.05)	1.65	1.07	3.17	1.47	34.0	1.35	0.36
CV (%)	4.14	12.18	12.90	8.07	6.03	1.90	5.00

Seed priming, *T. harzianum*, ethephon and *A. versicolar* increased the emergence by 26%, 23%, 20% and 18.46% over the control (Fig. 2.3). There was no significant effect on germination time. The speed of germination was maximum in primed seed. Early seedling emergence with ethephon and priming was due to prior activation of germination processes.

T. harzianum, *A. versicolar*, bavistin and captan increased seed germination and plant survival, but decreased the incidence of cumin wilt, blight and powdery mildew.

The incidence of powdery mildew was highest (43.2%) followed by wilt (3.86%) and blight (3.42%) in control, whereas, it was lowest in seeds treated with fungicides and bio-control agents (Fig. 2.4).

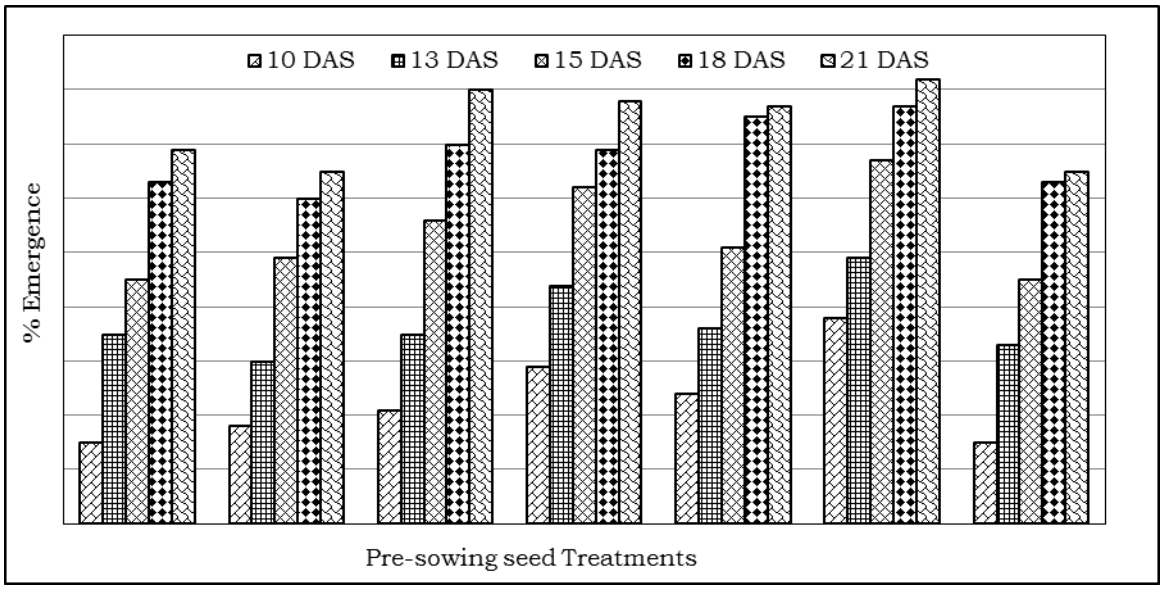

Fig. 2.3. Seedling emergence of cumin.

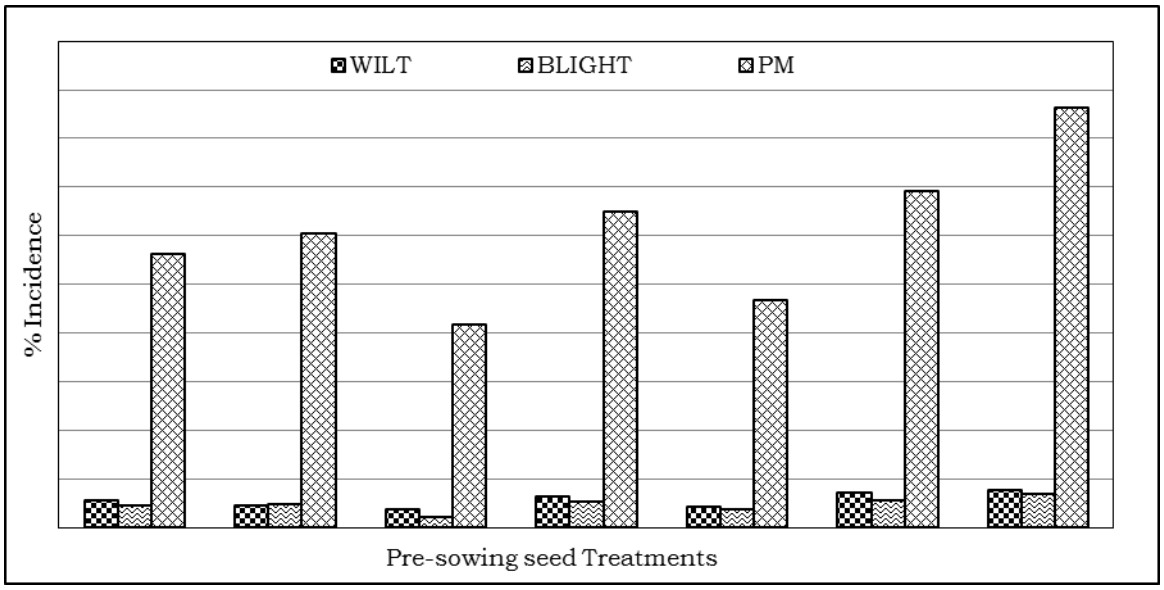

Fig. 2.4. Incidence of diseases in cumin.

ICAR Mega Seed Project

Forty kg breeder seed of pearl millet of open pollinated variety CZ-IC 923; 9.9 kg nucleus seed and 391 kg breeder seed of moth bean var. CAZRI Moth 2, and 184 kg seed of pasture grasses were produced. In addition to this, 4986 kg truthfully labelled (TFL) seed of various crops and 1.35 lakh seedlings of horticultural, forestry and medicinal plants were produced (Table 2.13).

Table 2.13. Crop wise seed production in kg

Crop	Variety	Jodhpur		Jaisalmer	Bhuj
		Truthfully labelled seed			
		Target	Production		
Grasses					
C. ciliaris		150	184	8	42
L. sindicus				317	
Crops					
Mung bean	RMG-62	350	355		
	RMG-268	200	301		
	SML-668	275	295		
Clusterbean	RGM-112	150	200	858	
	RGC-1066	50	54		
	RGC-936	50	30	850	
	HG365				87
Moth bean	CZM-3	100	85		
	CZM-2	75	80		
Sesame	RT-346	200	424		
	GT-2				42
Pearl millet	CZM-9802	600	772		
Guar (veg.)	M-83	-	6		
Mustard	Pusa Jaikisan	1000	950		
	GM-2	1000	1050		
Cumin	RZ-209	200	200		
Total	-	4400	4986		
Planting material					
Horticulture	-	40000	45125	1260	
Forestry	-	75000	75000	2000	
Medicinal	-	10000	15000		
Total	-	125000	135125		

Mushrooms

Spawn production: The spawn of five *Pleurotus* species and *Calocybe indica* were raised on boiled wheat grains mixed with 2% calcium sulphate and 0.5% calcium carbonate. *Lentinula edodes* spawn was raised on mango sawdust substrate

Effect of agro-waste substrates on the yield of *Pleurotus* species

Five *Pleurotus* species viz., *P. sajor-caju, P. citrinopileatus, P. flabellatus, P. florida* and *P. sapidus*, grown on six different agro-wastes, were evaluated for days to complete spawn run and biological efficiency (%) (Table 2.14).

All the species colonized faster on pearl millet and groundnut substrates, however, the maximum yield was on wheat substrate. Among five *Pleurotus* species maximum yield was in case of *P. sapidus* on wheat straw.

Cultivation of Shiitake and milky mushroom: Cultivation of Shiitake (*Lentinula edodes*) on mango saw dust based substrate in winter months, and milky mushroom (*Calocybe indica*) on wheat straw substrate during ending February to 1st week of May was done successfully.

Table 2.14. Effect of lignocellulosic agro-wastes on days to complete spawn run and biological efficiency (%) of *Pleurotus* species

Substrate	*P. sajor-caju*		*P. citrinopileatus*		*P. flabellatus*		*P. florida*		*P. sapidus*	
	1	2	1	2	1	2	1	2	1	2
Groundnut	17.3	61.2	18.0	52.4	17.5	39.8	14.2	72.8	17.0	73.1
Moth bean	19.0	88.0	20.5	81.2	22.0	72.2	17.2	89.2	23	102.1
Wheat	20.5	104.2	23.5	85.4	24.3	73.3	18.5	105.5	24.1	108.8
Pearl millet	16.2	49.2	17.5	51.1	15.8	53.6	14.0	69.9	15.5	65.5
Mung bean	17.3	62.6	21.2	62.2	22.0	48.8	16.5	68.2	21.5	68.2
Guar	18.2	78.8	22.5	70.2	22.9	55.5	17.5	96.8	22.3	96.8
CD (0.05)	1.2	11.6	1.1	9.4	1.7	9.3	0.8	8.8	1.3	8.8

1: Days to complete spawn run; 2: Biological efficiency.

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

Seed dynamics of *Lasiurus sindicus* in soil seed bank of rangeland at Jaisalmer: The seasonal variation of *L. sindicus* seeds in different soil layers in soil seed bank of the three major categories of rangeland showed that seeds were most abundant in uppermost parts of the soils, particularly in the 0-3 cm of soil depth (Table 2.15). There was considerable variation in the number of seeds at each soil depth among different categories of rangeland, the maximum in controlled grazing population, and the minimum in open grazing population. During post seed fall periods (December and March) and end of the summer (May), there was no seed at 9-12 cm of the soil depths. Maximum number of seeds were in October and minimum in May.

Vegetation dynamics of rangeland: The coverage of grassland changed significantly in season and category wise (Fig. 2.5). *L. sindicus*, dominant perennial grass species, showed different response to grazing, but it did not show any relationship between coverage change and grazing intensity. The coverage increased rapidly from 7% to 30% in fully protected, 9% to 26% in controlled grazing, and 5% to 11% in open grazing rangeland during May to October. Fully protected rangeland showed higher vegetation coverage in July, October and December, whereas controlled grazing rangelands showed higher vegetation coverage in March and May. In May, there was no difference of vegetation coverage between fully protected rangeland and open grazing rangeland; whereas controlled grazing rangeland showed significantly higher vegetation coverage then the other two rangelands. Over all, the vegetation coverage was 15.2% in fully protected, 14.6% in controlled grazing and 8.2% in open grazing rangelands of Indian arid ecosystem.

National Project on Vegetation Carbon Pool Assessment

For vegetation biomass assessment, circumference at breast height (CBH) and height of each tree at 10 forest sites and 4 outside forest sites in Jaisalmer district were recorded (Table 2.16).

Table 2.15. Number of *L. sindicus* seeds in different soil layers during different months in three categories of arid rangeland systems

Date	Soil layer (cm)	Number of seeds m^{-2}			Mean ± SE
		Fully protected rangeland	Controlled rangeland	Open rangeland	
14/03/2010	0-3	3.82	5.20	1.52	1.24±0.42
	3-6	0.94	1.38	0.61	
	6-9	0.57	0.82	0	
	9-12	0	0	0	
16/05/2010	0-3	1.90	3.21	0.72	0.64±0.26
	3-6	0.34	1.10	0.21	
	6-9	0	0.14	0	
	9-12	0	0	0	
26/07/2010	0-3	4.06	5.55	1.74	1.54±0.43
	3-6	1.35	1.92	1.10	
	6-9	0.53	1.20	0.41	
	9-12	0.28	0.35	0	
18/10/2010	0-3	6.21	9.74	3.20	2.80±0.71
	3-6	3.14	3.91	1.65	
	6-9	1.10	1.68	1.06	
	9-12	0.62	0.81	0.45	
05/12/2010	0-3	4.30	6.50	1.72	1.69±0.50
	3-6	1.75	1.95	1.63	
	6-9	0.84	0.93	0.62	
	9-12	0	0	0	

P. juliflora and *A. tortilis* were the most abundant trees. The sites with NDVI value ≥ 0.2 had mostly *P. juliflora*. Mostly height of the trees was not more than 4.0 m and average CBH of trees was 30-40 cm. However, big size tree of *P. cineraria* with CBH of 142 cm and height of 9.3 m was also observed. Among the shrubs, *Calotropis* sp. and *Zizyphus* sp. were most abundant. Outside the forest, significant amount of vegetation was recorded along IGNP canal and *Eucalyptus* block plantation in Mohangarh area of Jaisalmer.

Studies on Biology and Regeneration Potential of Endemic and Threatened Plant Species of the Thar Desert

Growth study of *Cordia gharaf*: Response of *C. gharaf* (planted in 2006) to application of N (0, 60 and 120 g $plant^{-1}$) and P (0, 30 and 60 g $plant^{-1}$) at the wasteland of Jaisalmer was studied. Plant height, branches $plant^{-1}$ and crown size responded positively to the application of nitrogen, while application of phosphorus at 60 g $plant^{-1}$ had significant effect on crown diameter only (Table 2.17). Collar diameter and main branch diameter were not affected with change in nitrogen and phosphorus levels.

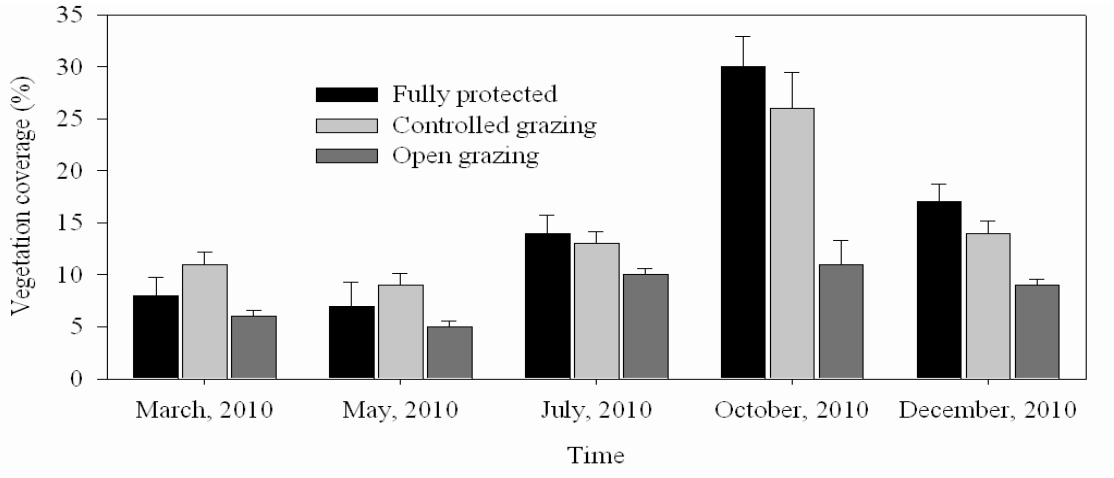

Fig. 2.5. Seasonal change of total grassland coverage in three major categories of arid rangeland system in Thar Desert.

Table 2.16. CBH and height of different tree species in Jaisalmer region

Species	CBH (cm)		Height (m)	
	Range	Average	Range	Average
Acacia nilotica	-	111.0	-	8.0
Acacia tortilis	10.0-82.2	34.0	0.8-7.0	3.8
Capparis decidua	10.0-12.0	10.4	1.4-1.9	1.7
Prosopis juliflora	10.0-48.0	21.3	0.8-6.4	3.6
Prosopis cineraria	16.0-142.0	66.2	2.1-9.3	5.3
Salvadora oleoides	22.0-71.0	35.3	2.3-3.3	2.8
Tinctoria sp.	22.0-39.0	31.0	2.9-4.9	4.1
Zizyphus rotundifolia	18.0-62.0	42.0	4.0-4.9	4.3

Table 2.17. Effect of nitrogen and phosphorus on morphological traits of *C. gharaf*

Treatment	Height (cm)	Branches plant^{-1}	Collar diameter (mm)	Crown diameter (mm)	Main branch diameter (mm)
Nitrogen (g plant^{-1})					
0	161.7	7.00	54.60	202.9	30.00
60	178.9	7.39	55.27	206.3	31.12
120	186.1	8.56	56.48	232.5	31.40
SEm	4.1	0.34	1.54	4.2	1.13
CD (0.05)	12.3	1.02	NS	12.5	NS
Phosphorus (g plant^{-1})					
0	173.1	7.56	55.31	203.8	30.50
30	173.9	7.67	55.36	210.7	30.88
60	179.7	7.72	55.68	227.2	31.15
SEm	4.1	0.34	1.54	4.2	1.13
CD (0.05)	NS	NS	NS	12.5	NS

INTEGRATED ARID LAND FARMING SYSTEMS RESEARCH

CROP PRODUCTION AND CROPPING SYSTEMS

Long-term Effects of Fertilizer-N and Organic Manure in Pearl Millet

Continuous cropping without fertilizer application produced 291 kg grain ha^{-1}, which was 34.6% lower than that with recommended level of N application. Pearl millet yield under pearl millet–clusterbean rotation was 587 kg ha^{-1} which was significantly higher than the yield obtained under continuous cropping (291 kg ha^{-1}). Adoption of pearl millet-clusterbean rotation also resulted in significantly higher stover yield (1417 kg ha^{-1}) as compared to continuous cropping of pearl millet (691 kg ha^{-1}).

Application of 20 and 40 kg N ha^{-1} produced 445 and 522 kg grain ha^{-1}. Application of 2.5 t and 5 t FYM alone produced 736 and 918 kg grain ha^{-1}, respectively. Similarly, combined application of 2.5 t FYM + 20 kg N produced 41.8% more grain than that at 40 kg fertilizer N. The maximum grain yield (1058 kg ha^{-1}) was obtained with the application of 5 t FYM along with 40 kg N ha^{-1}. Application of 20 and 40 kg N significantly improved stover yield (815 and 958 kg ha^{-1}) over without application of fertilizer (671 kg ha^{-1}). Applying similar quantity of N (20 and 40 kg) through organic source using 2.5 and 5 t FYM ha^{-1} produced 1245 and 2125 kg stover ha^{-1}.

Performance of Clusterbean Genotypes at Bikaner

The variety HG-100 gave higher plant height and number of branches per plant than HG-08 and HG-563. Number of pods per plant was higher in var. HG-563 which resulted in higher seed yield compared to other varieties (Table 3.1). The wider spacing (45 cm) gave higher seed and straw yield where as fertilizer doses were at par.

Table 3.1. Effect of fertilizer and spacing on yield of clusterbean genotypes under rainfed condition

Treatments	Plant height (cm)	Branches $plant^{-1}$	No. of pods $plant^{-1}$	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Varieties					
HG-100	85.56	5.13	38.19	915.5	2952.25
HG-08	67.19	4.19	45.33	932.1	2959.58
HG 563	67.72	4.65	46.08	1174.8	3375.75
CD (0.05)	NS	NS	7.45	91.97	355.45
Spacing (cm)					
30	77.88	3.98	38.26	918.33	2954.11
45	69.09	5.34	46.81	1096.60	3237.6
CD (0.05)	NS	0.758	6.087	74.68	NS
Fertilizer ($N:P_2O_5$ kg ha^{-1})					
10:20	65.38	4.65	41.09	970.28	2911.11
20:40	81.59	4.66	43.98	1044.6	3280.61
CD (0.05)	NS	0.758	6.087	NS	NS

Agronomic Evaluation of Promising Genotypes of Clusterbean at Jaisalmer

Application of higher levels of N and P_2O_5 at 20 + 40 kg per hectare recorded considerably higher numbers of pods plant^{-1} as well as grain yield plant^{-1} as compared to lower levels of N and P_2O_5 (10 + 20 kg ha^{-1}). Similarly, seed and straw yield per hectare also increased significantly with higher levels of N and P_2O_5 (Table 3.2). Crop sown at 45 cm spacing recorded 21.8 and 22.5% higher seed and straw yield over 30 cm spacing, respectively. Among different varieties of clusterbean, RGC 936 was found better in terms of yield and yield attributes followed by HG 100.

Table 3.2. Yield and yield attributes of clusterbean varieties grown with varying levels of fertility and spacing under rainfed conditions at Jaisalmer

Treatment	Yield attributes			Yield		
	Pods plant^{-1}	Seeds pod^{-1}	100-seed weight (g)	Straw (kg ha^{-1})	Seed (kg ha^{-1})	Harvest index (%)
Fertility levels (N + P_2O_5) kg ha^{-1}						
10 + 20	30.16	6.89	3.14	1399	662	32.71
20 + 40	41.50	7.08	3.10	1652	809	33.29
CD (0.05)	1.97	NS	NS	118	58	NS
Row spacing						
30 cm	33.00	6.95	3.13	1371	663	33.00
45 cm	38.66	7.03	3.11	1679	807	33.00
CD (0.05)	1.97	NS	NS	118	58	NS
Varieties						
HG 08-1	28.43	6.56	3.25	1279	581	31.59
HG 100	37.80	7.20	3.08	1642	793	33.51
RGC 936	46.83	7.41	3.12	1833	880	32.75
HG 563	30.28	6.78	3.03	1348	687	34.16
CD (0.05)	2.79	0.38	0.14	167	81	NS

Effect of Planting Pattern and Urea Spray on Clusterbean

Skip row planting recorded 31% higher seed yield over normal planting. The straw yield however was not affected with planting pattern, although it was higher with skip row planting. Spray of 1% urea both before and after flowering reduced the fall of leaves and hence provide photosynthetic source for longer time to the plant. The yield and yield attributes were recorded significantly higher with this treatment of foliar application. It increased the grain yield to the tune of 118% over control (Table 3.3).

Effect of N Sources on Clusterbean

Integrated application of 50% N through organic manure (FYM) and 50% N through inorganic fertilizer (urea) resulted in 11.62, 9.47 and 36.24% increase in the seed yield over the application of 100% N through organic, 100% through inorganic source and control respectively (Table 3.4).

Table 3.3. Yield and yield attributes of clusterbean under different planting pattern and foliar application of 1% urea

Treatments	Yield attributes			Yield (kg ha^{-1})		
	Pods plant^{-1}	Seeds pod^{-1}	100 seed weight (g)	Grain	Straw	Biological
Planting pattern						
Normal	38.64	6.89	3.40	749	1298	2047
Skip row	42.23	7.00	3.38	978	1378	2356
CD (0.05)	2.48	NS	NS	79	NS	192
Spray treatments						
F1*	40.08	6.95	3.42	804	1436	2240
F2	45.75	7.33	3.42	1285	1539	2824
F3	39.30	6.90	3.40	775	1361	2136
F4	36.60	6.60	3.32	590	1016	1606
CD (0.05)	3.51	NS	NS	111	162	272

*F1= Foliar application of 1% urea before flowering, F2= foliar application of 1% urea both at before flowering and after flowering, F3= Water spray both at before flowering and after flowering, F4= Control (no spray).

Table 3.4 Effect of N sources on the yield and monetary benefit of clusterbean

Treatment	Seed yield (kg ha^{-1})	Net returns (Rs. ha^{-1})	Benefit: cost
Control	458	2462	1:1.32
100% N through urea	570	3530	1:1.40
100% N through FYM	559	2711	1:1.28
25% N through FYM + 75% N through urea	608	3825	1:1.41
75% N through FYM + 25% N through urea	614	4400	1:1.49
50% N through FYM + 50% N through urea	624	4411	1:1.48
CD (0.05)	39	-	-

Effect of N Application Methods on Clusterbean

Application of 10 kg N as basal dose along with spraying of 1% urea at vegetative stage and 1% at flowering stage gave maximum seed yield of clusterbean (615 kg ha^{-1}), which was 7.14 and 28.12% higher than seed yield obtained with the application of 20 kg N as basal dose and control, respectively.

Effect of Nutrient Management and Drip Irrigation on Clusterbean

Vegetable clusterbean was raised under different drip irrigation levels on residual soil nutrient applied to the preceding chilli crop. Mean pod yield was maximum at 0.8 CPE followed by 0.6 and 0.4 CPE irrigation levels. Incorporation of vermicompost in the preceding crop benefited this year's crop also. Further, the response was best in 100% vermicompost treatment (Table 3.5).

Soil parameters of top 15 cm soil were measured at crop harvest to assess the effect of irrigation and nutrient levels (applied to preceding crop). Amongst different nutrient treatments, 100% N through VC registered maximum moisture content, minimum soil strength and low pH (Table 3.6).

Table 3.5. Effect of irrigation and nutrient levels on growth and yield of clusterbean

Parameter	Irrigation level (CPE)			Nutrient level*				
	0.8	0.6	0.4	N1	N2	N3	N4	N5
Pod yield (t ha^{-1})	7.81	7.53	6.82	7.44	8.38	7.98	8.16	4.99
Plant height (cm)	79.56	77.25	70.96	78.12	86.67	81.74	86.21	46.87
No. of pods plant^{-1}	126.42	121.80	104.31	113.71	131.19	119.80	125.53	97.31

*Nutrient level: N_1(100% N from fertilizers), N_2 (100% N from VC), N_3(75% N from fertilizers + 25% N from VC), N_4(50% N from fertilizers + 50% N from VC), N_5 (control).

Table 3.6. Effect of irrigation and nutrient levels on soil properties

Parameter	Irrigation level (CPE)			Nutrient level				
	0.8	0.6	0.4	N_1	N_2	N_3	N_4	N_5
Soil moisture (%)	10.64	9.93	9.21	9.50	10.65	9.52	10.36	8.66
Soil strength (kg cm^{-2})	4.21	4.28	4.64	4.70	3.71	4.23	4.10	4.86
Soil pH	8.60	8.42	8.53	8.57	8.48	8.54	8.46	8.55
Soil EC (dS m^{-1})	0.95	1.26	1.05	1.05	1.14	1.07	1.26	0.91

Crop Performance under Organic Farming

Grain yield of sesame increased by 1.76 to 1.91 times with the application of manure while in case of clusterbean, the increase was only 0.019 to 0.61 times (Table 3.7). Overall biological yield of both the crops was high because of high rainfall.

Table 3.7. Effect of level of manuring on yield of kharif crops (rainfed) under organic management

Level of manuring (t ha^{-1})	Crop yield(kg ha^{-1})			
	Sesame		Clusterbean	
	Grain yield	Biological yield	Grain yield	Biological yield
0.0	321.8	716.3	331.6	493.6
2.5	652.8	1233.8	396.9	1143.9
5.0	886.6	1429.2	466.7	1202.9
7.5	936.2	1455.8	534.3	1385.6

Compatible Crops 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 crop. Sole pearl millet gave 133% higher grain yield compared to 1:1 crop and colocynth live mulch. The straw yield of pearl millet was affected to the lesser extent due to introduction of colocynth mulch (Table 3.8).

Highest clusterbean seed yield (718 kg ha^{-1}) was recorded in 4:1 crop:colocynth ratio, while fodder yield was significantly higher in 3:1 clusterbean: colocynth ratio (Table 3.8).

Introduction of colocynth in moth bean had negative effect on yield while effect on stover yield was less compared to seed yield. Sole moth bean gave 37% higher yield as compared to 1:1 live mulch ratio with colocynth.

Table 3.8. Yield of pearl millet, clusterbean and moth been in different intercropping systems with colocynth

Crop: Colocynth	Yield (kg ha^{-1})						
	Pearl millet			Clusterbean		Moth bean	
	Straw	Grain	Biological	Seed	Stover	Seed	Stover
Sole crop	1871	910	2781	455	782	673	513
1:1	1551	391	1942	458	689	493	474
2:1	1769	500	2268	602	1064	423	436
3:1	1653	500	2153	564	1243	365	481
4:1	1929	474	2403	718	1000	468	679
CD (0.05)	134	86	182	109	141	61	61

Significantly lower number of weeds and weed dry weight m^{-2} were recorded in 2:1 crop: colocynth ratio except pearl millet in which lowest weed density was recorded in sole pearl millet (Table 3.9).

Table 3.9. Effect of different proportion of colocynth live mulch on weed indices under different crops

Treatments	Weed density (no. m^{-2})			Weed dry weight (g m^{-2})		
	Pearl millet	Clusterbean	Moth bean	Pearl millet	Clusterbean	Moth bean
Sole crop	22.20	38.42	26.52	8.43	14.93	10.43
1.1 (crop: colocynth)	61.43	31.17	34.74	24.22	12.31	13.81
2.1 (crop: colocynth)	46.65	16.43	38.23	18.04	6.92	14.52
3.1 (crop: colocynth)	48.05	25.62	45.44	19.21	9.52	17.63
4.1 (crop: colocynth)	52.31	12.23	37.51	20.61	5.14	15.22
CD (0.05)	4.32	6.35	5.15	2.28	2.72	2.55

The DHA activity (pkat g^{-1} soil) was lowest in pearl millet, while it was maximum in clusterbean rhizosphere. At 30 DAS, activity of acid phosphatase was significantly higher in sole moth bean, but the activity of acid phosphatase decreased with all the intercrop ratios in moth bean at 60 DAS. In case of clusterbean and pearl millet, acid phosphatase activity showed increasing trend from 30 DAS to 60 DAS. In contrast to acid phosphatase activity, alkaline phosphatase activity was lowest with sole moth bean. The activity of alkaline phosphatase increased considerably from 30 to 60 DAS in pearl millet. However, the activity of enzyme showed decreasing trend in case of moth bean from 30 to 60 DAS.

Salinity Tolerance in Indian Mustard

Fifty one genotypes of Indian mustard were screened for seed germination in second year under three salinity levels of irrigation water: low (3.3 dS m^{-1}), medium (5.4 dS m^{-1}) and high (15.7 dS m^{-1}) in laboratory and field condition. Variability for germination was found to be significant across the salinity levels. The overall reduction in germination was 48% at high salinity and 19% at medium salinity levels as compared to low level (control). A total of 11 genotypes viz., CS 56, CS 54 (best check), CS 52, BM 201, DRMR 09-423-1, DRMR-09-517-4, DRMR 09-668-4, BM 199, DRMR 09-664-4 and GM3, showed less reduction in germination (12-21%) at either high or medium salinity levels and, therefore, appeared to be more tolerant to salinity stress during

germination under both the laboratory and field conditions. Whereas another 11 genotypes viz., Basmati, DDRMR 09-594-4, Rohini, Kranti, DRMR 601, DRMR 701, Arawali, GM-2, BM 216, DRMR 09-591-4 and DRMR 09-11 showed highest reduction in germination due to saline water at high (18-77%) and medium (15-33%) salinity conditions.

Pre-sowing Seed Treatment in Cumin

A field experiment to study the effect pre-sowing seed treatments on emergence and yield of cumin crop revealed that 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 54, 62 and 63% more than control when seed treatment was given with GA 100, GA 250 and Thio 250 ppm, respectively. When irrigation was given at 14 DAS, the effect of seed treatments on EI was not significant. Seed treatment with GA250 ppm gave maximum seed yield (304 kg ha^{-1}) of cumin in 7 DAS irrigation treatment. Yields obtained with GA 100, Thio 250 and Thio 500 ppm treatments were at par with GA 250 ppm yield in 7 DAS irrigation treatment. When irrigation was given at 14 DAS, the effect of seed treatments on seed yield and total biomass was non-significant. The B:C ratio was 0.69 in control, while seed treatment with GA 100, GA 250, Thio 250 and Thio 500 gave B:C ratio of 1.07, 1.1, 1.13 and 1.16, respectively in 7 DAS irrigation treatments. When irrigation was given at 14 DAS, the B:C ratio was close to zero because of low yields.

Increasing Water Productivity in Cotton through Drip Irrigation

The effect of irrigation (1.0, 0.8 and 0.6 ETc) with and without phospho-bacteria inoculation and growth retardant c*ycocel* spray under drip were compared with conventional furrow irrigated cotton cv. RCH-134 BG-II (Plate 15). The water requirements under 1.0 ETc furrow irrigation and 1.0, 0.8 and 0.6 ETc drip irrigation were 652.0, 546.0, 503.6 and 461.2 mm, out of which 284.1 mm was met out by rainfall. Drip irrigation in cotton at 0.8 ETc gave 27.5% higher seed cotton yield compared to 1801 kg yield in furrow irrigation (Table 3.10). Decrease in seed cotton yield compared to full irrigation (1.0 ETc), was proportionately less under 0.8 ETc (6.3%) than 0.6 ETc (25.5%). Yield reductions were associated with reduction in boll numbers and seed cotton weight $plant^{-1}$. Significant effects of phosphorus solubilizing bacteria (PSB) inoculation on plant height (8.2%), seed cotton weight $plant^{-1}$ (17.7%), bolls $plant^{-1}$ (13.7%), seed cotton yield (23.6%) and water productivity (23.2%) were observed in comparison to control. The foliar spray of Cycocel @ 500 ppm thrice at boll development stage, improved the cotton yield attributes by 6-8% and seed cotton yield by 9.8% over control.

Influence of Row Spacing and Irrigation Method on Different Crops

Summer ladyfinger: Irrespective of the method of irrigation, fruit yield was maximum at 20x20 cm spacing (4.5 t ha^{-1} in drip and 3.4 t ha^{-1} in check-basin). The moisture use by ladyfinger varied between 55.6 and 58.1 cm under drip while under check-basin it varied between 65.2 and 68.0 cm. The lowest water use efficiency (WUE) of 6.8 and 3.8 kg ha^{-1} mm^{-1} was recorded with 20 x 10 cm spacing under drip and check-basin irrigation.

Table 3.10. Effect of irrigation, phospho-bacteria inoculation and cycocel spray on growth, yield attribute and seed cotton yield of Bt cotton

Treatment	Plant height (cm)	Seed cotton weight (g plant^{-1})	Boll plant^{-1}	Seed cotton yield (kg ha^{-1})	Water productivity (kg m^{-3})
Irrigation method					
Furrow irrigation	95.0	151.3	50.0	1801	0.276
Drip irrigation	93.7	168.7	58.7	2190	0.433
CD (0.05)	3.5	6.9	1.9	69	0.014
Irrigation level					
1.0 ETc	102.7	181.1	64.5	2450	0.449
0.8 ETc	95.4	172.9	60.8	2295	0.456
0.6 ETc	82.8	152.1	50.7	1826	0.396
CD (0.05)	11.1	18.2	5.5	167	0.032
Inoculation					
Control	90.0	155.0	54.9	1959	0.388
PSB	97.4	182.4	62.4	2421	0.478
CD (0.05)	4.8	9.5	2.2	102	0.021
Growth retardant					
Control	90.8	162.0	57.0	2087	0.414
Cycocel	96.5	175.4	60.4	2293	0.453
CD (0.05)	4.8	9.5	2.2	102	0.021

The ladyfinger crop was severely infested by *Empoasca kerri* (jassid) (5-20 jassids per leaf) and spotted ball worm (*Etiella zinknella*) under drip irrigation while check-basin irrigated crop was comparatively less affected.

Muskmelon: Muskmelon cv. Kajri gave 19% higher yield under drip irrigation compared to the yield under check-basin irrigation.

Tomato: Three tomato varieties (2 hybrids Calyx 248, Dev NP 5031 and one JK Desi) were grown under drip irrigation. Hy. Calyx 248 took 40 days for flowering and picking started 55 days after transplanting, whereas the other hybrid Dev NP 5031 took 50 days for flowering and 70 days for picking. Hy. Calyx 248 was better for vegetable purpose as its taste was sour. Hy. Calyx 248 produced 67.8 t tomato ha^{-1} while the other two varieties produced 38.9 and 15.0 t ha^{-1}.

Gladiolus: In rabi season, twelve gladiolus varieties were grown to assess as component of cropping systems under drip irrigation. Variety snow princess (white coloured) was found best with respect to spike length (45-50 cm), total number of florets per spike (15-19), floret size (6.5 cm) and duration of flowering (14 days) followed by variety Aldebaran (yellow) with respect to spike length (40-44 cm), total number of florets per spike (15-17), floret size (5.7 cm) and duration of flowering (14 days). Snow princess took the minimum days (40-45) to flower while variety Snow flower took 63-65 days.

Based on two-year study, tomato-gladiolus-musk melon/lady finger cropping system under drip system performed best.

Evaluation and Management of Perennial Forage Legumes in arid Gujarat

Among twenty accessions of clitoria tested accessions IL 468, CAZRI 752, IGFRI 94 and JHC 94 yielded more than 5.5 t ha^{-1}, whereas the local strain (4444 kg ha^{-1}) followed by CAZRI 466 (4609 kg ha^{-1}) gave the least dry forage yield (Table 3.11).

Table 3.11. Evaluation of clitoria for growth and yield attributes

Growth/yield parameters	Range	Mean	CD (0.05)
Plant height (cm)	60.63-80.40	69.35	17.08*
Primary branch	4.16-7.17	5.52	1.22*
Leaves $plant^{-1}$	95.99-296.49	188.21	44.82*
Fresh wt $plant^{-1}$ (g)	37.53-69.73	52.88	18.67**
Dry wt $plant^{-1}$ (g)	15.66-26.21	22.27	5.73*
Green forage yield (kg ha^{-1})	7626-10315	8506	215.71**
Dry forage yield (kg ha^{-1})	4444-6145	5209	121.22*

*Significant (P=0.05); **significant (P=0.01).

Seed treatment of clitoria with rhizobium, phosphorus solubilizing microbes (PSM) and plant growth promoting rhizobacteria (PGPR) increased dry forage yield by 11.65 and 11.7%, respectively over the control. Seed treatment with rhizobium did not significantly influence the dry forage yield over the control. The maximum dry forage yield of 5383 kg ha^{-1} was recorded in treatments receiving N and P at 50% of recommended dose of fertilizer along with application of rhizobium, PSM and PGPR. The lowest yield of 3802 kg ha^{-1} was recorded in control.

In another field experiment, micronutrients namely, Zn (0, 1.5, 3.0 and 4.5 kg ha^{-1}), Mn (0, 1.5, 3.0 and 4.5 kg ha^{-1}) and B (0, 0.3, 0.6 and 0.9 kg ha^{-1}) were applied in soil at the time of sowing of clitoria. The results indicated that application of micronutrients significantly influenced the forage production of clitoria. The response of clitoria for dry forage yield to Mn was linear whereas it was quadratic to Zn and B. Soil application of Mn @ 4.5 kg ha^{-1} resulted in maximum increase in forage yield (21.2%), followed by Zn (13.7%) @ 3 kg ha^{-1} and B (12.5%) @ 0.6 kg ha^{-1}. Combined application of Zn, Mn and B @ 3.0, 3.0 and 0.6 kg ha^{-1}, respectively at the time of sowing increased dry forage yield by 23.75% over control.

Four species of wild groundnut namely, *Arachis glabrata*, *A. prostrata*, *A. rigonii* and *A. pusilla* collected from Junagadh (Gujarat) were evaluated for establishment and growth. *A. glabrata* recorded maximum length of braches (100.1 cm) followed by *A. prostrata* (98.06 cm). The lowest branch length of 84.03 cm was recorded in *A. pusilla.*

Forage Production under Limited Irrigation Condition

During rabi season oat produced maximum green and dry fodder yield under 50 mm CPE irrigation followed by *Cenchrus ciliaris* + lucerne system while lucerne produced lowest yield. During summer 2010, maximum green fodder yield was recorded with pearl millet under irrigation at 50 mm CPE level while at 75 CPE level *C. ciliaris* + lucerne produced maximum green fodder yield. The performance of sorghum was very poor at 75 mm CPE level. In both rabi and summer season during second year, the green fodder yield was maximum with oat – pearl millet sequence (64.4 t ha^{-1}). Similarly dry matter yield was maximum with *C. ciliaris* + lucerne intercropping

system (Table 3.12). However mean data revealed that oat – pearl millet sequence produced maximum green fodder and *C. ciliaris* + lucerne intercropping system produced maximum dry fodder and irrigation at 50 mm CPE gave the highest fodder yield in all crop sequences. It can be concluded that irrigation at 50 mm CPE was best for oat – pearl millet sequence and 75 mm CPE for *C. ciliaris* + lucerne intercropping system for getting higher productivity of quality fodder.

Table 3.12. Green and dry fodder yield of different sequences and irrigation levels

Treatments	Green fodder yield (t ha^{-1})			Dry fodder yield (t ha^{-1})		
Cropping sequences	Rabi	Summer	Total	Rabi	Summer	Total
Lucerne	19.16	12.71	31.87	3.49	3.75	7.24
Oat-pearl millet	44.39	20.02	64.41	7.44	4.08	11.52
Cenchrus + lucerne	34.96	18.11	53.07	7.37	5.44	12.81
Oat-sorghum	44.30	10.21	54.51	7.39	2.43	9.82
Mean	35.70	15.26	50.97	6.42	3.93	10.35
Irrigation levels						
50 mm CPE	45.01	21.22	66.23	7.77	5.38	13.15
75 mm CPE	36.20	14.54	50.74	6.64	3.89	10.53
100 mm CPE	25.90	10.03	35.93	4.86	2.49	7.35
Mean	35.70	15.26	50.97	6.42	3.92	10.34

CROP PHYSIOLOGY

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

In moth bean, application of sulphydryl compounds i.e. thioglycollic acid (TGA) and thiourea (TU) increased Chl 'a' content by 22.3 to 34.4% compared to no application (Table 3.13). Improvement in total Chl with the application of 1000 ppm TU, 400 ppm TGA, 300 ppm TGA, 750 ppm TU, 500 ppm TU, and 200 ppm TGA was 27.5, 25.1, 21.9, 21.7, 19.3 and 17.8% compared to control. In clusterbean, improvement in total Chl with the application of 1000 ppm TU, 400 ppm TGA, 750 ppm TU, 300 ppm TGA, 200 ppm TGA, and 500 ppm TU was 34.2, 31.9, 29.7, 27.8, 22.3 and 17.5%, respectively compared to control (Table 3.13).

In moth bean, net photosynthetic rate (Pn) ranged from 9.26 to 13.6 μ moles m^{-2} s^{-1}. Application of –SH compounds resulted in 12.8-41.2% higher Pn compared to control (Fig. 3.1A). The Pn of clusterbean varied from 9.83-15.5 μ moles m^{-2} s^{-1}. Application of –SH compounds brought 21.2 to 57.4% improvement in Pn compared to water spray (control) (Fig. 3.2A).

In moth bean, stomatal conductance (gs) was highest with the application of 400 ppm TGA followed by 1000 ppm TU, 750 ppm TU, 300 ppm TGA, 500 ppm TU and 200 ppm TGA. Application of –SH compounds had 14.3 to 36.3% higher stomatal conductance compared to control (Fig. 3.1B). In clusterbean, application of –SH compounds recorded 15.0-44.0% higher stomatal conductance than water spray (control) (Fig. 3.2B).

Table 3.13. Effect of –SH compounds on chlorophyll content (mg g^{-1} fresh weight) in leaves of moth bean and clusterbean

Treatment	Moth bean			Clusterbean		
	Chl 'a'	Chl 'b'	Total Chl	Chl 'a'	Chl 'b'	Total Chl
Control	1.192 ± 0.059	0.749 ± 0.019	1.941 ± 0.076	1.285 ± 0.040	0.779 ± 0.021	2.063 ± 0.111
TGA 200 ppm	1.457 ± 0.056	0.829 ± 0.021	2.286 ± 0.069	1.639 ± 0.058	0.885 ± 0.055	2.524 ± 0.088
TGA 300 ppm	1.517 ± 0.070	0.848 ± 0.024	2.365 ± 0.080	1.728 ± 0.086	0.908 ± 0.053	2.636 ± 0.184
TGA 400 ppm	1.568 ± 0.091	0.860 ± 0.028	2.428 ± 0.113	1.799 ± 0.028	0.924 ± 0.023	2.723 ± 0.124
TU 500 ppm	1.467 ± 0.081	0.847 ± 0.030	2.314 ± 0.105	1.566 ± 0.058	0.857 ± 0.028	2.424 ± 0.131
TU 750 ppm	1.497 ± 0.065	0.864 ± 0.040	2.361 ± 0.094	1.760 ± 0.059	0.917 ± 0.041	2.677 ± 0.092
TU 1000 ppm	1.601 ± 0.058	0.873 ± 0.026	2.474 ± 0.084	1.834 ± 0.067	0.935 ± 0.030	2.769 ± 0.081
CD (0.05)	0.108	0.036	0.108	0.098	0.048	0.191

Value represents mean ± SEm.

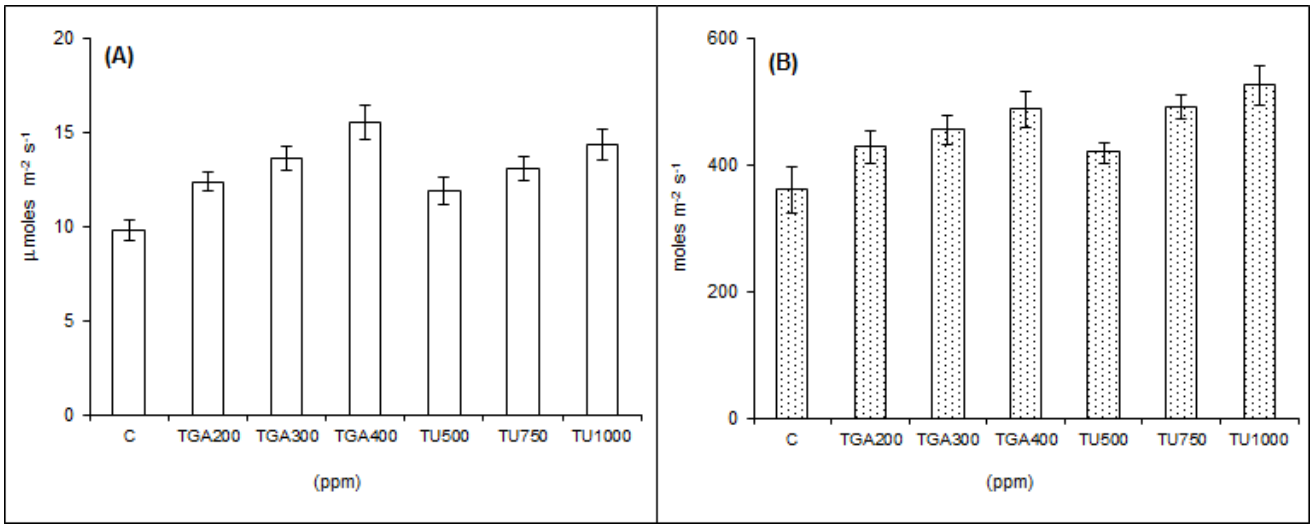

Fig. 3.1. Effect of foliar spray of sulphydryl compounds on net photosynthetic rate (A) and stomatal conductance (B) in moth bean (Bar represents mean ± 1 SE).

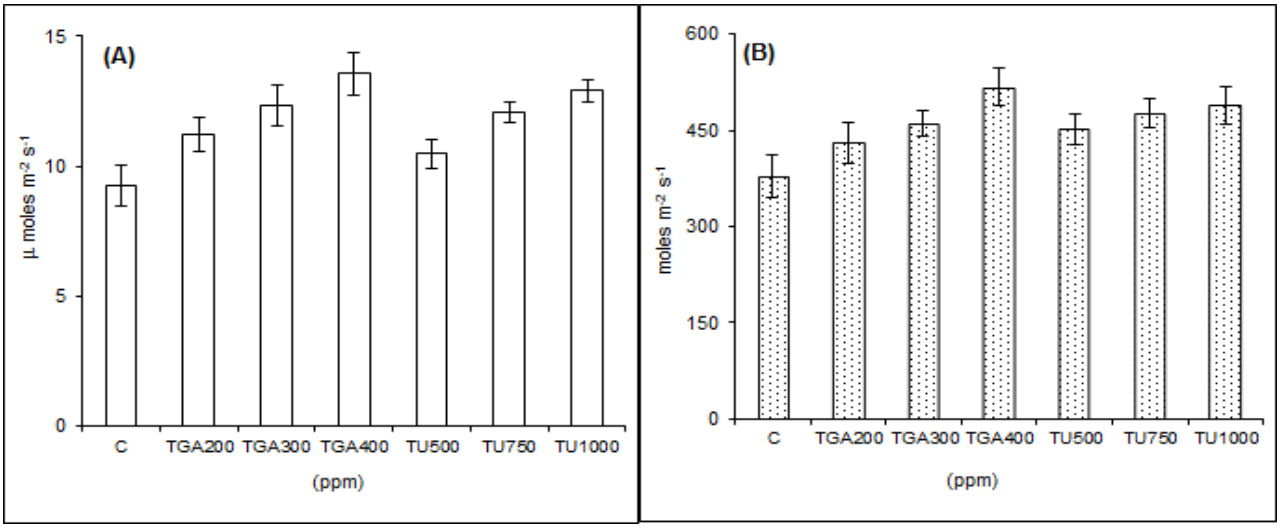

Fig. 3.2. Effect of foliar spray of sulphydryl compounds on net photosynthetic rate (A) and stomatal conductance (B) in clusterbean (Bar represents mean ± 1 SE).

Effect of High Temperature on Clusterbean and Pearl millet

Clusterbean and pearl millet plants grown in 10 kg earthen pots were subjected to high ambient temperature at two growth stages by covering them with polythene sheet wherein the temperature was 3-5°C higher than control. Exposure to high temperature adversely affected total dry matter production and grain yield, though it was more at reproductive stage (F) than at vegetative stage (V). This led to decrease in harvest index compared to control (Table 3.14).

Table 3.14. Effect of high temperature at different growth stages on harvest index of clusterbean and pearl millet plants

Treatments	Clusterbean	Pearl millet
Control	24.0	21.9
H (V)	19.1	17.8
H (F)	16.4	7.6
H (V+F)	15.4	4.0

Plants exposed to high temperature recorded greater water deficit, depression in nitrate reductase activity (NRA) besides lower starch accumulation in both the crops (Table 3.15). The deleterious effect of high temperature was more in clusterbean with respect to NRA and starch accumulation because it recorded lower relative water content (RWC) in its leaves as compared to pearl millet thereby adversely affecting the plant metabolism.

Exposure of both the crops at vegetative stage to high temperature (3-5°C higher than ambient) though led to comparable drop in plant water potential (about 44%) still clusterbean recorded 12.2% while pearl millet registered 7.2% drop in RWC.

Table 3.15. Effect of high temperature at different growth stages on certain physiological parameters in clusterbean and pearl millet plants

Treatments	Plant water potential	Nitrate reductase activity	Starch
	(% decrease over respective control)		
Clusterbean			
H (V)	44.4	74.7	33.7
H (F)	45.2	33.2	63.1
H (V+F)	58.7	37.3	63.1
Pearl millet			
H (V)	44.3	50.8	14.3
H (F)	21.4	11.4	7.9
H (V+F)	21.4	17.2	16.9

Effect of Foliar Spray of Iron and Zinc on Clusterbean and Pearl millet

Clusterbean was foliar sprayed with different concentrations of iron (0.5, 1.0 and 2.0%) and zinc (0.25, 0.50 and 1.0%) as the aqueous solution of their sulphate salts at post flowering stage. Toxicity was observed in case of $FeSO_4$ spray especially at higher concentration (1 and 2%). Therefore, pearl millet plants were sprayed with half the concentration. Thirty rain events within 90 days cropping period kept the ambient temperature low. Consequently the effects of these foliar sprays did not encompass the possible interaction effects of high temperature. Further, there was no advantage of water spray over the no spray master control treatment.

Foliar spray of zinc at low concentration i.e. 0.25% in case of clusterbean and 0.125% in pearl millet resulted in about 6 and 15.8% increase in total day matter, respectively. Clusterbean did not register any significant increase in seed yield while pearl millet reflected about 10.1% increase in grain yield due to the zinc spray. The increase could be due to higher chlorophyll content (5.56-21.24%) recorded under various zinc treatments after one week of spray. However, measurement of crop water status and nitrate reductase activity at that time did not clearly reflect any improvement. Iron spray also reflected similar trend in case of pearl millet with approximately 4-15% increase in total dry matter and grain yield. However, it was deleterious in case of clusterbean.

FARMING SYSTEMS

Integrated Farming System for Sustainable Agriculture in Indian Arid Zone

Variety GHB-536 of pearl millet gave higher net return (Rs. 26,760 ha^{-1}) and B:C ratio (2.39). Among kharif pulses net returns and B:C ratios were at par (Table 3.16). Net returns and B:C ratio of pearl millet (var. HHB 67) were at par in *P. cineraria* based agroforestry system and sole cropping. Economics of mung bean was marginally higher in *Z. mauritiana* based agroforestry system than in sole cropping system (Table 3.16 and 3.17). Further, per hectare net returns were maximum in ber based production system (Rs. 61,520) and minimum in arable farming system (Rs. 22,460) (Table 3.18).

Table 3.16. Productivity (kg ha^{-1}), net returns (Rs. ha^{-1}) and B:C ratio of dryland crops in arable farming system

Crop	Variety	Grain	Fodder	Net return	B:C ratio
Pearl millet	HHB 67	1055	5005	22460	2.24
	GHB-538	1275	5540	26760	2.39
Mung bean	SML-668	540	2162	23161	2.71
Cow pea	V-585	650	3565	24120	2.78
Moth bean	CAZRI-3	550	3000	24070	2.79

Table 3.17. Performance of dryland crops under various agroforestry systems

Crops	Grain (kg ha^{-1})	Fodder (kg ha^{-1})	NR (Rs. ha^{-1})	B:C ratio
Pearl millet + *P. cineraria*	920	5065	21880	2.23
Pearl millet + *Acacia tortilis*	1425	5215	26390	2.38
Mung bean + *Z. mauritiana*	566	2150	23580	2.74

Soil pH and EC were higher in *Z. maurtiana* + moth bean production system (pH 8.44 and EC 0.14 dS m^{-1}) than the sole moth bean (pH 8.31 and EC 0.12 dS m^{-1}). However, the trend was not perceptible in *P. cineraria* based production system. Soil moisture studies revealed that in *Z. mauritiana* based agri-horticulture system, the moisture utilization from 0-15 cm soil layer was 1.92 and 1.05% in mung bean and 4.32 and 2.58% in clusterbean during seed development phase at 1 and 2 meter distance from tree trunk, respectively. The respective soil moisture utilization from 0-15 cm soil layer was 1.25 and 2.69% in mung bean and 3.93 and 4.25% in clusterbean at 1 and 2 meter distance from tree trunk.

Table 3.18. Economic evaluation of various farming system components

Farming system components	Net returns (Rs.)	Contribution of crop/grass (%)	B:C ratio
Arable farming system	22460	100	2.24
Agroforestry with *P. cineraria*	30180	80	2.61
Agri-horticulture with *Z. Mauritiana*	61520	38	2.67
Farm forestry with *H. binata*	3015	77	3.04
Silvipasture with *C. ciliaris* + *C. mopane*	40862	92	3.66
Silvipasture with *C. ciliaris* + *Z. rotundifolia*	37235	90	3.62

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

Six year old plantation of *Pongamia pinnata* planted at 8 m x 4 m and 5 m x 4 m spacing were used in this study. The survival per cent was low (15.6%) which could be due to severe drought condition in the preceding year. Continuous trench of 0.4 m wide and 0.75 m depth was made to harvest the runoff water. Casualty replacement (84.4%) was completed during rainy season. During post rainy season, ring basin irrigation was given in first year for higher establishment percentage. Establishment after five months of sapling transplanting was 94%. Biometric observations of six year old plants were recorded as plant height of 1.1 to 1.85 m and collar diameter of 3.0 to 3.8 cm.

Seven-year-old plantation of Henna was used for intercropping with clusterbean. Casualty replacement (50%) was completed during rainy season. In henna based agroforestry system, henna plant height varied from 52.0 to 80.8 cm and branches per plant were 6.5 to 9.2. The maximum henna dry leaf weight (159.7 g m^{-1} row length) and dry leaf yield (335.8 kg ha^{-1}) were recorded under sole henna followed by strip cropping (Table 3.19). Significantly low dry leaf weight per meter row length (except 6 m wide henna alley) and dry leaf yield (DLY) (kg ha^{-1}) were recorded from henna-clusterbean intercrop combinations.

Table 3.19. Yield and yield attributes of henna based agroforestry system at Pali

Treatments	Plant height (cm)	Branches plant^{-1} (No.)	DLY (kg ha^{-1})
Clusterbean: henna (1:1)	52.0	7.8	216.8
Clusterbean: henna (1:2)	72.5	8.7	206.4
Clusterbean: henna (1:3)	61.6	6.5	166.0
Clusterbean: henna (1:5)	72.4	6.7	53.6
3 m wide Alley	74.4	8.7	158.1
6 m wide Alley	80.8	9.2	48.3
Strip cropping	72.3	7.7	257.8
Sole henna	80.0	7.5	335.8
CD (0.05)	14.2	1.4	31.2

Ailanthus excelsa based Silvi-Agri-Pastoral System

A. excelsa attained a height of 260, 282, and 384 cm tree^{-1} in 6 x 6, 8 x 8 and 10 x 10 m spacing, respectively. The growth in collar diameter (CD) and mean basal area followed similar pattern. Mean basal area in 10 x 10 m spacing was 43.8% higher than in 6 x 6 m spacing and 35.4% higher than in 8 x 8 m spacing. The trend indicated that per tree biomass accumulation was maximum in 10 x 10 m spacing as basal area generally corresponds with biomass.

Mean annual increment (MAI) in height was 52.0, 56.4 and 76.8 cm tree^{-1} in 6 x 6, 8 x 8 and 10 x 10 m spacing, respectively, while current annual increment (CAI) ranged from 29.0 cm tree^{-1} (6 x 6 m spacing) to 111.0 cm tree^{-1} (10 x 10 m spacing) (Fig. 3.3a). Similar trend was observed for CD (Fig. 3.3b).

Total basal area of tree was 1.26, 1.0 and 1.0 m^2 ha^{-1} in 6 x 6, 8 x 8 and 10 x 10 m spacing, respectively, indicating an increase of 29.4, 48.0 and 52.0% in same sequence of spacing over previous year values. The increment in total canopy cover expansion over previous year was in order of 27.9, 37.9 and 50.8% in 6 x 6, 8 x 8 and 10 x 10 m spacing, respectively.

In wider spacing of trees, pearl millet grain yield was 9.4% higher than in 8 x 8 m spacing and 15.5% higher than in 6 x 6 m tree spacing (Table 3.20). Similar trend was observed in straw production of pearl millet.

In case of moth bean, crop grain and straw production did not vary much under different spacings. *Cenchrus ciliaris* grass production was 19.5% higher in 10 x 10 m than in 8 x 8 m tree spacing and 16.2% higher than in 6 x 6 m spacing (Plate 16).

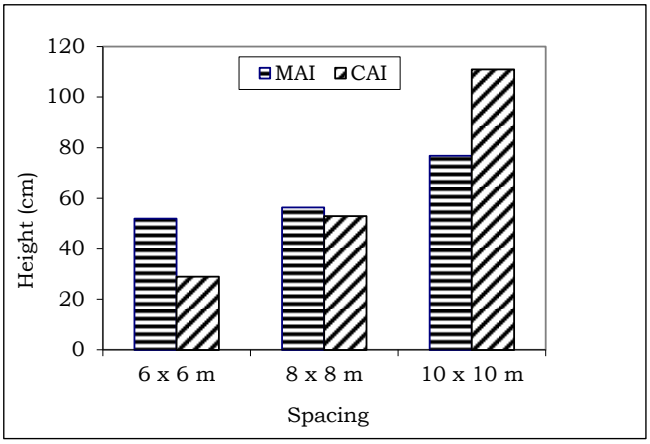

Fig. 2a. Mean and current annual increment in height.

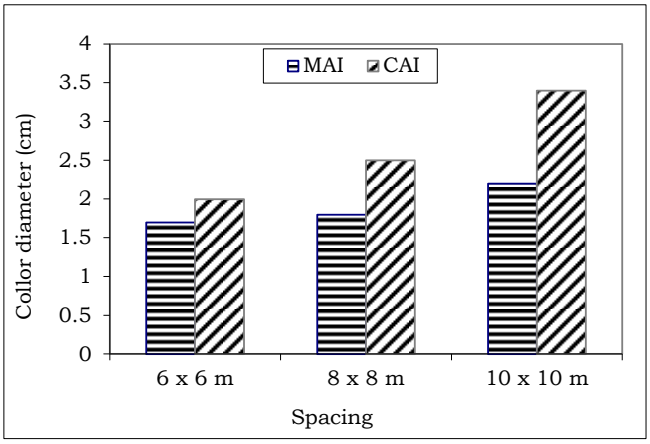

Fig. 2b. Mean and current annual increment in collar diameter.

Table 3.20. Grain and fodder yield (kg ha^{-1}) in *A. excelsa* based silvi-agri-pastoral system

A. excelsa (m)	Grain yield (kg ha^{-1})		Crop straw/grass yield (kg ha^{-1})		
	Pearl millet	Moth bean	Pearl millet	Mung bean	*C. ciliaris*
6 x 6	1312	233	3818	639	1750
8 x 8	1408	250	4154	789	1821
10 x 10	1552	256	4627	683	2174

Alternate Land Use Systems involving Arid Legumes at Bhuj

Field experiments at the farmers' fields were conducted to determine the suitable agri-horti intercropping system under arid regions of Gujarat. Four arid legumes, i.e. clusterbean cv. HG 365, cowpea cv. GC-3, green gram cv. K851 and moth bean cv. CZM-2, were evaluated for their performance as intercrop with fruit trees namely aonla, ber and pomegranate. All four arid legumes as intercrops performed better under the fruit plantations in terms of their plant height, branches plant^{-1} and dry matter production than their sole cropping. However, continuous rainfall during reproductive stages of legumes severely damaged the intercrops.

Development of Ber based Oleri-Horti Models at Bikaner

Number of okra fruits plant^{-1} and weight per fruit were 14.2 and 16.8% higher, respectively under drip irrigation compared to furrow irrigation. Averaged across all mulching treatments the drip gave 11.0% higher yield compared to furrow method (Fig. 3.4).

Averaged across irrigation methods the improvement in plant height and number of branches per plant was 14.2-43.5% and 12.7-49.5%, respectively with different mulching materials compared to no mulch. Yield attributes i.e. number and weight of fruit showed significant improvement with mulching. Number of fruit per plant with indigenous material (IM), hessian cloth (HC) and plastic mulch (PM) was 18.5, 25.6 and 36.6% more than no mulch (NM). Mulching gave 17.9-48.5% higher yield compared to no mulch. Yield was highest with plastic mulch followed by hessian cloth and indigenous material mulch.

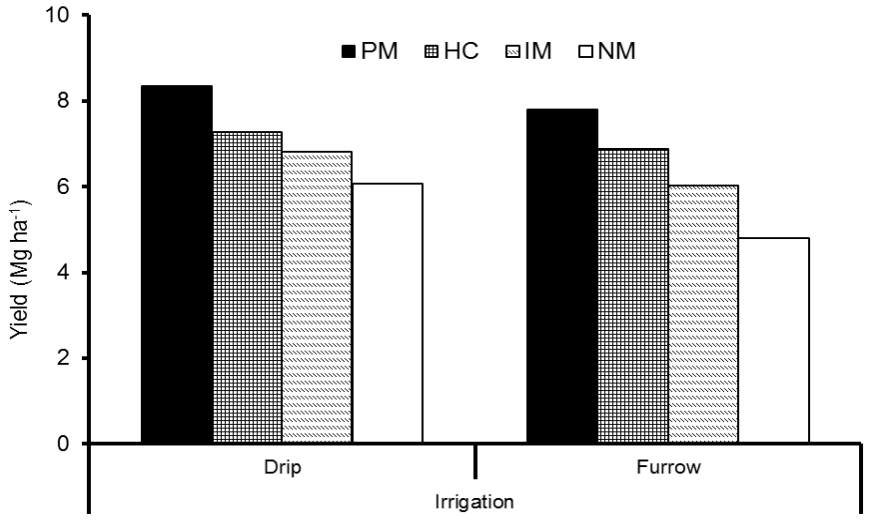

Fig. 3.4. Effect of method of irrigation and mulching on yield of okra.

Agroforestry Models with Organic Inputs

Silvi-pasture system at CAZRI farm Bhopalgarh (shallow soil depth): Grass yield increased by 20.9% and 25.2% with the application of 2.5 t ha^{-1} and 5.0 t ha^{-1} manure as compared to control (1787.5 kg ha^{-1}). Only 6.1% mortality in un-manured plants and 2% mortality in manured plants of *A. senegal* were observed. Plant growth was slow due to rocky stony site, though, manuring increased height and collar diameter.

Silvi-pasture system at Jodhpur (medium soil depth): In absence of manuring, grain yield of pearl millet was low because of continuous depletion of soil fertility over last four years. On the contrary, yield was 2.10 and 2.68 times higher with the application of 2.5 and 5.0 t ha^{-1} manures than control. As the manure level increased, harvest index increased from 15.7 to 19.8%. Similar trend was observed in clusterbean which recorded 1.17 and 1.29 times increase in grain yield with the application of 2.5 and 5.0 t ha^{-1} manure over control. Increase in yield from 2.5 to 5.0 t ha^{-1} manure application was only 5.2%.

Four years old plants of *Z. rotundifolia* and *A. indica* were pruned. Yield of fuel wood and fodder was 1667.2 and 524.5 kg ha^{-1} in *Z. rotundifolia* compared to 1170.3 and 179.5 kg ha^{-1} in *A. indica* in manured trees. Corresponding values in the un-manured trees were 1243.6, 433.7, 937.4 and 106.2 kg ha^{-1}, respectively. Besides, *Z. rotundifolia* plants produced 116.2 kg fruits.

Other Studies on Trees and Shrubs

Improvement of Infrastructural Facilities in the Botanical Garden

Survey and search for RET & E species has been completed in seven districts namely Barmer, Jaisalmer, Jalor, Pali, Sirohi, Nagaur and Jodhpur. Density of different RET & E species was found very low and in isolated patches where they formed colony comprising of one to nearly

40 plants per hectare. New specimens of these species were added to herbarium. Eleven maps showing location of occurrence of RET & E species were prepared.

Based on visit to herbarium at FRI, Dehradun and Blatter Herbarium, Xt. Xavier College, Mumbai, *Barleria prinoitis* var. *dicantha* and *Anogeissus sericea* var. *nummularia* could be identified and located. Seeds and saplings of RET & E species were raised and transplanted in the field (Table 3.21). Two new blocks of *Acacia jacquemontii* and *Cullen plicata* were prepared by transplanting their saplings. *Moringa concanensis* attained a maximum height of 2 m with profuse branching and collar thickness of 1 cm diameter indicating its successful establishment.

In both *Ceropegia bulbosa* var. *bulbosa* and *Ceropegia bulbosa* var. *lushii*, there was profuse vegetative growth followed by anthesis and fruit set making seeds available for regeneration during next season.

Table 3.21. Details of collection of planting material and their regeneration

Plant species	No. of places of seed collection	Number of seeds germinated	Number of saplings transplanted	Survival in field (no.)
Acacia jacquemontii	5	100	40	35
Barleria prionitis var. Dicantha	4	-	74	19
Ceropegia bulbosa var. Bulbosa	2	-	6	6
Ceropegia bulbosa var. Lushii	2	-	6	6
Citrullus colocynthes	2	50	-	-
Commiphora wightii	28	20	62	50
Cullen plicata	2	500	62	57
Ephedra ciliate	4	-	28	none
Lasiurus sindicus	1	50	-	-
Moringa concanensis	13	200	38+28	18
Neurada procumbens	1	10	-	-
Seddera latifolia	10	20	11	none
Tecomella undulata	11	500	28	26

Effect of Planting Density and Cutting Intensity on Productivity of *Haloxylon recurvum* and *Acacia jacquemontii*

Plant height of *Acacia jacquemontii* at 18 MAP (months after planting) with 2000, 3000 and 4000 plant ha^{-1} was 5.9, 11.8 and 16.6 cm lower compared to 1000 plant ha^{-1}. Number of branches per plant with 2000, 3000, and 4000 plant ha^{-1} was 5.8, 10.5 and 19.8% less compared to 1000 plant ha^{-1} (8.6). Canopy area with 2000, 3000, and 4000 plant ha^{-1} was 19.3, 25.3 and 52.3% less compared to 1000 plant ha^{-1}.

Growth attributes viz. plant height, number of branches, canopy area of *H. recurvum* after 12 month of cutting were significantly influenced by planting density. Plant height at 3500 and 4000 plant ha^{-1} was 20.3 and 25.0% lower compared to 2500 plant ha^{-1}. Number of branches per plant with 3000, 3500 and 4000 plant ha^{-1} was 7.3, 23.2 and 25.6% less compared to 2500 plant ha^{-1}. The canopy area per plant was 0.39 and 0.43 m^2 less at 3500 and 4000 plant ha^{-1} compared to 2500 plant ha^{-1} (0.80 m^2).

SOIL FERTILITY AND SOIL MICROBIOLOGY

Improvising the Quality of Mustard Residues

The residues were treated with 0.5 and 1.0 N concentrations of HCl, H_2SO_4 and H_3PO_4 to break their ligno-cellulosic bond and to increase their decomposability. This resulted in hydrolysis and a decrease in the hemicellulose and cellulose content, but changes in lignin content were marginal. Treating the mustard residues with 1.0 N concentration of H_3PO_4 and H_2SO_4 increased their decomposability by 60%, which could be due to the effect of chloride on microbial population. Treating the residues with 0.5 N HCl had no effect on decomposability (Fig. 3.5).

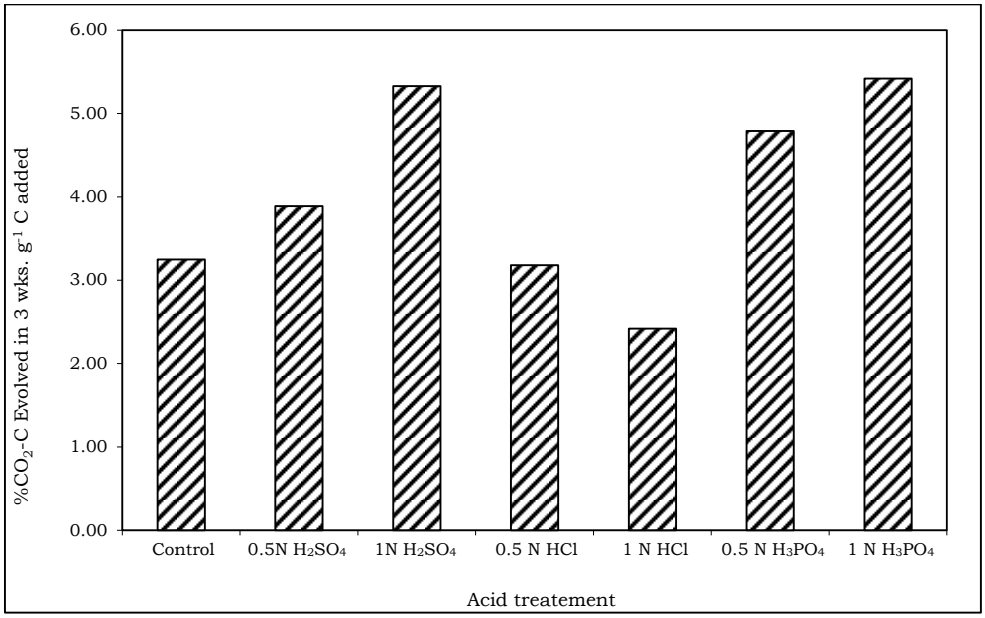

Fig. 3.5. Effect of treatment of mustard residues with different mineral acids on their decomposability.

Decomposition of Leaf Litter of Predominant Tree Species

The mass loss of leaf litters varied significantly with time, species and moisture content. Among different MPTs, the mass loss of leaf litter followed the order *Acacia tortilis* > *Acacia senegal* > *Dalbergia sissoo*> *Colophospermum mopane*. Among the litters of fruit tree species, the mass loss followed the order *Citrus aurontifolia* > *Aegle marmelos* > *Cordia myxa* at both moisture levels (field capacity and 50% field capacity).

For all species, the decomposition data best fitted the exponential decay function. Between the two moisture levels, the decay rate coefficient for each species was more in soils maintained at field capacity as compared to 50% field capacity (Table 3.22). Among the four MPTs, decomposition rate was lowest for *C. mopane* followed by *Delbergia sissoo*. Among the fruit trees species, the lowest decay rate coefficient was observed in *Cordia myxa*. Between the surface-positioned and buried soil litters, higher rate of decomposition and decay rate coefficients were observed in buried position as compared to surface litters.

Table 3.22. Daily decay rate coefficient (k_D x 10^{-3}) and time required for 50% decomposition (t_{50}) and 99% decomposition (t_{99}) of leaf litters of various MPTs and fruit tree species

Tree species	Field capacity			50% field capacity		
	k_D x 10^{-3}	t_{50}	t_{99}	k_D x 10^{-3}	t_{50}	t_{99}
MPTs						
Acacia tortilis	12.8	54.1	390.6	10.1	68.6	495.0
Colophospermum mopane	8.5	81.5	588.2	6.7	103.4	746.2
Dalbergia sissoo	9.8	70.7	510.2	7.4	93.6	675.6
Acacia senegal	10.3	67.2	485.4	8.8	78.7	568.1
Fruit trees						
Cordia myxa	7.2	96.2	694.4	5.9	117.4	847.4
Aegle marmelos	15.2	45.5	328.9	12.2	56.8	409.8
Citrus aurontifolia	20.3	34.1	246.3	15.2	45.5	328.9

Application of leaf litters @ 2.5 tones ha^{-1} had a significant effect on plant height, pod number and yield of clusterbean as compared to control. Maximum yield of clusterbean was obtained with the application of leaf litters of citrus and bael (Table 3.23).

Table 3.23. Effect of leaf litters on yield and yield attributes of clusterbean

Treatments	Height (cm)	Number of branches	Number of pods	Total dry matter (kg ha^{-1})	Grain yield (kg ha^{-1})
Control	42.7	6.3	15.3	2250.0	832.5
Colophospermum mopane	49.0	5.7	18.0	2812.5	950.0
Citrus aurontifolia	59.7	8.0	25.3	2979.2	1014.2
Dalbergia sissoo	58.0	7.0	21.3	2541.7	999.2
Acacia tortilis	56.0	9.3	20.7	2520.8	943.3
Aegle marmelos	59.3	6.0	25.0	2916.7	1011.7
Cordia myxa	52.3	6.7	20.7	2854.2	927.5
Acacia senegal	56.0	4.6	21.0	2895.8	909.2
LSD (0.05)	8.88	NS	5.89	453.4	110.5

New P Mobilizers under Arid Eco-System

Seed inoculation with a phosphatase and phytase producing fungus, *Penicillium purpurogenum*, significantly improved phosphatases (acid and alkaline), phytase, and dehydrogenase activities compared to uninoculated fields. The depletion of organic P by *P. purpurogenum* was much higher than mineral and phytin P. The fungal contribution was significantly more than the plant contribution to the mineralization of mineral-P. However, both pearl millet and *P. purpurogenum* were equally competent for hydrolysis of phytin P. A significant improvement in plant biomass (30%), root length (21%), P uptake (6%), seed (19%) and straw yield (30%) of pearl millet and P concentration of shoot (15%), root (6%) and seed (33%) resulted from inoculation with *P. purpurogenum* (Table 3.24). It was observed that *P. purpurogenum* can thrive well under arid-ecosystems.

Table 3.24. Straw yield, seed yield, and P concentration of pearl millet inoculated with *Penicillium purpurogenum*

Treatment	Yield (kg ha^{-1})		P concentration (mg g^{-1})		
	Straw	Seed	Shoot	Root	Seed
No inoculation	1940	880	4.82	3.24	10.2
Seed inoculation	2520	1050	5.52	3.44	13.6
LSD (P = 0.05)	369	137	0.29	0.18	1.7

Nano Technology

Effect of nano phosphorus on performance of clusterbean: A greenhouse experiment was conducted to study the effect of different concentrations of nano-P (0, 10, 20, 30 and 50 ppm), applied through foliar spray two weeks after germination to clusterbean (cv. RCG 936). The results revealed a significant improvement in plant height, dry matter, nodule number and weight, root length and area, chlorophyll content, soil phosphatases (acid and alkaline), esterase, phytase, dehydrogenase activities, soil carbon content and P uptake. The more effect was noticed with foliar application of nano-P between 30 and 50 ppm concentrations.

A comparison was made with the foliar application of 40 ppm nano-P and Normal P to clusterbean. The results clearly indicated significant improvement in nodule number (50%), pods per plant (27%) and seed yield (23%) when P was applied as nano form than normal particle.

Effect of nano-particles of Zn and Fe: The Zn and Fe nano-particles were synthesized (32-40 nm size) by chemical (sol-gel method) and biological technique. Foliar application of the chemical-synthesized Zn nanoparticles at a concentration of 1.5 ppm solution on 15 days old chick pea (*Cicer arietinum*) plants resulted in 8.5% enhancement in total biomass within 7 days as compared to application of the same concentration of normal ZnO.

It was found that aerosol spray is better for use of nano-particles at a concentration of < 5 ppm with < 20 nm size. The best shape of nano-particle that penetrates into the plant cell is nano-cube. Foliar application of bio-synthesized Zn (10 ppm) and Fe (30 ppm) nanoparticles resulted in significant improvement (within 4 weeks) in growth of clusterbean and moth bean.

Development of Nano-Particles Induced Polysaccharide Powder for Application in Desert Soils: Ten polysaccharide producing organisms were isolated from arid soils and their polysaccharide production was enhanced by 4 to 9 times through the application of Fe and Zn nanoparticles. Methodology was developed for purification of microbial polysaccharides and powered them for field use to increase soil aggregation, moisture retention and C build up in arid soils. Preliminary investigation showed at least 60% improvement in soil aggregation due to the application of nano-induced microbial polysaccharide powder.

INTEGRATED LAND AND WATER RESOURCES MANAGEMENT

Evaluation of Wind Erosion Models in Jaisalmer Region

Soil loss due to wind erosion: A total of five dust storm events were recorded in the year 2009 and one dust storm during 2010. Wind erosion was less active during 2010 due to well distributed annual rainfall of 368 mm in comparison to only 73.6 mm during 2009. Soil loss was computed from observed mass flux in suspension mode (0.25 to 2 m above surface). Cumulative soil loss in suspension mode during the middle of June to the end of September 2009 was 1.36 t ha^{-1} whereas extrapolation to very near to surface (z = 0.01 m) resulted into a total soil loss of 12.02 t ha^{-1}. In comparison, the amount of soil loss in suspension mode during the middle of April to the middle of June 2010 was 1.76 t ha^{-1}. After June onwards during 2010, significant soil loss due to wind erosion was not recorded due to heavy rainfall. Extrapolation also resulted in an average soil loss @ 17 kg ha^{-1} min^{-1} during dust storm events and @ 25 kg ha^{-1} day^{-1} during periodical observations.

Carbon and nitrogen loss through wind erosion: The average contents of C and N in eroded soils from the experimental site were 4 g kg^{-1} and 0.77 g kg^{-1}, respectively. In general, both C and N contents were higher during dust storm events than during local wind erosion events. In comparison to C and N content of eroded soil mass, the average contents of C and N of surrounding top soils of the experimental site were 5.01 and 0.44 g kg^{-1}, respectively. This indicated that apart from dust emission, deposition of eroded particles in the rangelands is common, which finally led to enrichment of top soils. Carbon and N content of eroded soils was highest during dust storm event on July 9, 2009 (5.13 and 0.50 g kg^{-1}) and then reduced to the lowest (3.35 and 0.33 g kg^{-1}) at the end of September. Month-wise comparison revealed that during the month of July, both C and N contents were significantly higher than rest of the year. Cumulative loss of nutrient matters along with the eroded mass during $3^1/_2$ months period from the middle of June to the end of September was 5.404 kg C ha^{-1} and 0.512 kg N ha^{-1}.

Pedotransfer Functions for Estimating Soil Hydraulic Properties of Arid Soils

Infiltration characteristics of major land use systems of Jaisalmer region of the Indian Thar desert were measured using double ring infiltrometer. The data was evaluated in four infiltration models: Kostiakov (1932) model, Horton (1940) model, Philip (1957) model, and Green and Ampt (1911) model. It was found that out of 16 experiments, most of the data were best fitted by either Green & Ampt model (Eq 1) or Horton model (Eq 2).

$$i = i_c + \frac{B}{I} \quad (1)$$

$$i = i_c + (i_0 - i_c)e^{-kt} \quad (2)$$

where, i = instantaneous infiltration rate (mm min^{-1}) of soil, i_c = steady state infiltration rate (mm min^{-1}), B = constant, I = cumulative infiltration (mm), i_0 = initial infiltration rate (mm min^{-1}) at t = 0, k = constant that determines the rate at which i_0 reaches to i_c, t = time (min). It was found that steady state infiltration rate was very high (12.60 mm min^{-1}) in sand dunes, whereas it was as low as 0.39 mm min^{-1} in cultivated areas of khadin (Fig. 4.1).

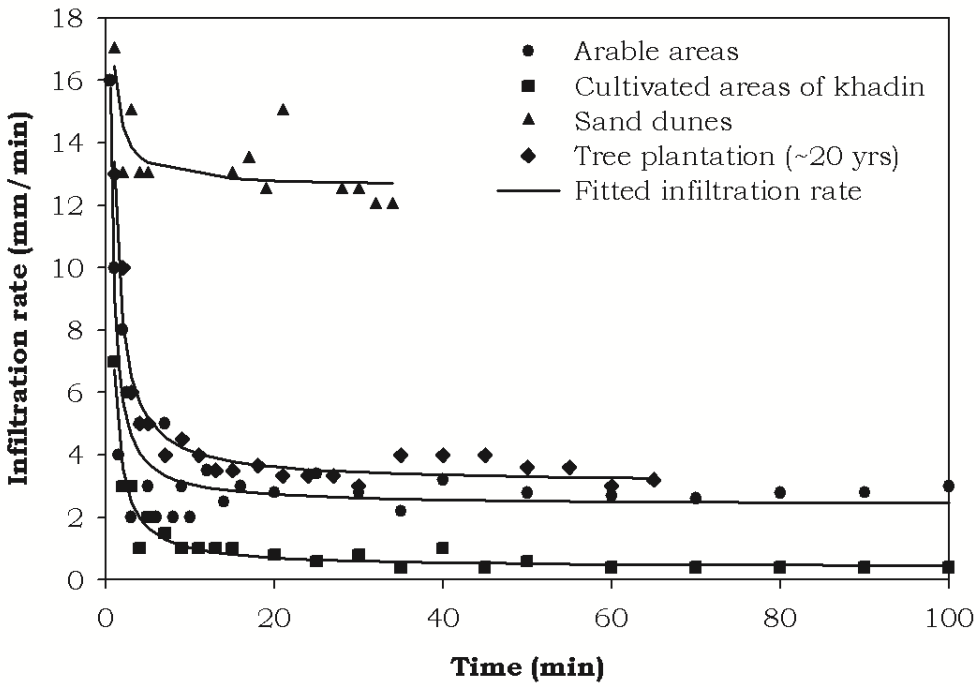

Fig. 4.1. Infiltration rate vs time for selected sites.

Soil Properties of Grazing Lands in Sandy Arid Plains of Bikaner

The physical properties of grazing land varied significantly with depth (Table 4.1). The bulk density increased with depth. The average porosity of soil was 36.95% being highest in 16-40 cm soil depth.

Table 4.1. Soil physical and chemical properties under grazing land use system in Gajner soil series

Property	Depth (cm)			
	0-15	16-40	41-65	66-90
Bulk density (Mg m^3)	1.55 ± 0.007	1.58 ± 0.005	1.60 ± 0.009	1.66 ± 0.008
Porosity (%)	36.60 ± 0.74	38.15 ± 0.85	37.00 ± 0.60	36.05 ± 0.68
pH	8.32 ± 0.05	8.36 ± 0.03	8.38 ± 0.01	8.44 ± 0.04
Organic carbon (%)	0.160 ± 0.005	0.136 ± 0.004	0.088 ± 0.002	0.084 ±0.001
Nitrogen (%)	0.015 ± 0.0005	0.012 ± 0.00051	0.010± 0.0006	0.008± 0.0006
Available P_2O_5 (kg ha^{-1})	12.75 ± 0.102	13.42 ± 0.178	10.95 ± 0.188	9.98 ± 0.126
Available K_2O (kg ha^{-1})	260.9 ± 1.96	232.2 ± 1.17	202.0 ± 1.14	173.0 ± 1.37

Values are mean ± SEm, n= 20.

The surface soil had lowest pH and it increased with depth. The organic carbon content was highest in surface soil and lowest in deepest soil layer. Available N and K_2O content decreased with increase in soil depth. In contrast, available P_2O_5 content was highest at 16-45 cm soil depth.

Rehabilitation of Degraded Rangelands and Stabilization of Production in Arable Arid Land

As the SUMAMAD Project mainly focuses on livelihood development, technology on multi-nutrient feed block (MNFB) for the rearing of livestock was disseminated. The farmers were trained to prepare the MNFB. An overall improvement in the health of animals fed with the MNFB was noticed. The materials used in preparation of the feed blocks were local feed and fodder resources in different ratios of roughages and concentrates. Another recommended method of feed improvement is the urea treated fodder. The initial intake of feed by animals was low due to the pungent smell of the ammonia, however, after a few trials the animals adapted to the taste and smell of the urea treated feed. We observed an increase in milk production of the bovine.

Due to acute shortage of water for *khadin* farming, a community surface water reservoir with a capacity of 3200 m^3 was constructed with the help of local government. This is for the irrigation in the run-off farms lands.

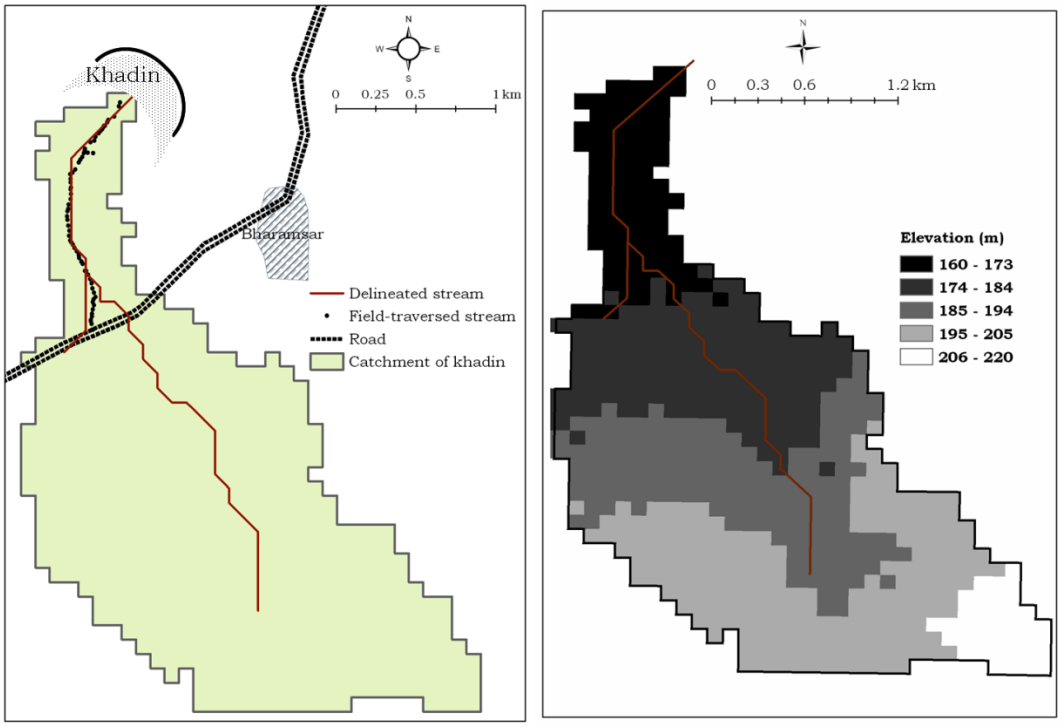

Fig. 4.2. Delineated streamline and the catchment area of khadin at Bharamsar village.

The catchment area of a *khadin* was delineated and the steady state infiltration characteristics at different portion of the khadin were assessed. It was found that the catchment area was ~20 times of the cutivated area under the *khadin* runoff farming system (Fig. 4.2). The

steady state infiltration rate at cultivated area of the *khadin* was 0.39 mm min^{-1} whereas it was 3.75 mm min^{-1} at gravely catchment areas.

Improving Land Use through Crop Intensification, Tillage Options and Nutrient Economy in Pali Region

In the third consecutive season of sorghum-wheat cropping system, bed planting (beds of 40 cm width and 15 cm height with 30 cm wide furrows) performed at par with conventional sowing during kharif. *Dhaincha* (2:2) intercropped with sorghum was incorporated at 40DAS as green and brown manuring (knocked down by 2, 4 D). This planting pattern produced green dhaincha biomass between 64.8-88.9 q ha^{-1} and 57% of sorghum dry fodder yield was achieved compared to sole cropping (101 q ha^{-1}). Seed yield of sorghum also followed similar trend (Table 4.2). Intercropping of sorghum with cowpea (CP) and green gram (GG) (2:2) produced 70 and 62% of sole sorghum dry fodder yield and additional grain yield of 270 and 215 kg of green gram and cowpea, respectively. The grain yield of intercrops was higher under bed planting system compared to conventional planting.

Table 4.2 Effect of planting system and intercropping on sorghum-wheat cropping system

Treatment	Sorghum		Intercrop			
	DFY (q ha^{-1})	Grain yield (kg ha^{-1})	Grain yield (kg ha^{-1})		Stover yield (kg ha^{-1})	
			GG	CP	GG	CP
Planting system						
Bed	69.76	692.78	291	234	750	860
Conventional	73.46	879.70	259	196	710	740
CD (0.05)	NS	NS				
Cropping system						
Sorghum + Dhaincha (GM)	57.10	619.70				
Sorghum + Dhaincha (BM)	58.34	636.25				
Sorghum + Green gram	71.61	833.49	270		725	
Sorghum + Cowpea	69.45	770.22		215		800
Sole sorghum	101.55	1071.54				
CD (0.05)	17.58	201.59				

Grass Production at Rocky-Stony Site of Bhopalgarh

Maximum grass yield on FEQ basis was obtained from sole *Cenchrus ciliaris* (Table 4.3).

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

Tree species	Grass yield (kg ha^{-1})
A. indica	1527.6
T. undulata	1787.5
A. senegal	1978.2
C. wightii	2011.3
C. ciliaris sole	2133.7
Natural pasture	386.9

Comparative performance of grass species: Four grass species were planted at the rocky stony site of Bhopalgarh. *C. ciliaris* performed best followed by *D. annulatum* (Table 4.4).

Table 4.4. Comparative performance of grass in rocky stony site

Grass species	Survival (%)	Seed yield (kg ha^{-1})	Dry fodder yield (kg ha^{-1})
Cympogan javankusa	95.2	25.2	393.3
Dicanthium annulatum	96.4	42.3	944.4
Cenchrus ciliaris-358	99.1	56.9	1272.7
Cenchrus setigerus	96.9	68.6	446.3

Hydrological Monitoring and Catchment Development of Beriganga Research Farm

Total rainfall of 584.3 mm was recorded during the monsoon season. The maximum rainfall (80.4 mm) was recorded on 25th June. Eleven rainfall events of >15 mm effectively contributed to the runoff generation from Block-I (9.5-27.8% of the individual rainfall events; av. 17.78%). The total runoff generated was 78206.91 m^3, out of which 9401.0 m^3 was retained by the four masonary check-dams (Table 4.5).

Table 4.5. Rainfall, runoff, silt load, EC and pH

Rainy days	Rainfall (mm)	Runoff (m^3)				Silt Load at B1B (g l^{-1})	EC (µs cm^{-1})	pH
		Stream B1b1 A =26.8 ha L = 500 m S = 6%	Stream B1b2 A =50.0 ha L = 210 m S = 19.5%	Stream B1B A =19.6 ha L = 200 m S = 2.25%	Total runoff			
07/06/10	32.8	348.3	1849.8	848.6	3046.73	2.2	300	7.9
06/07/10	42.0	1117.2	2901.0	1325.4	5343.57	2.9	311	7.7
24/07/10	26.3	267.8	1045.9	510.3	1823.97	2.2	275	7.8
25/07/10	80.4	5457.1	10675.6	4380.8	20513.56	3.1	356	7.9
02/08/10	28.1	378.1	1199.1	561.8	2139.02	2.1	265	7.6
03/08/10	17.2	12.9	274.2	242.7	529.82	2.0	245	7.8
14/08/10	56.2	2416.2	5151.8	2181.0	9749.01	2.9	311	7.7
08/09/10	35.7	891.6	2216.7	993.6	4101.90	2.4	276	7.8
13/09/10	78.6	4255.5	8325.2	3450.9	16031.57	3.0	330	7.9
14/09/10	34.5	871.7	2120.3	953.4	3945.38	2.5	247	7.7
15/09/10	24.3	209.7	919.3	452.5	1581.39	2.2	240	7.6
Total	456.1	16226.2	36678.8	15901.0	68805.9*			

*Excluding 9401 m^3 runoff retained by masonary check-dams.

The number of species along the banks was 31-37 in contrast to 11-25 recorded 50 m away. More than 65% area was covered by canopy of woody perennials, which declined to nearly 20% at 50 m distance. Natural regeneration was noted in *Acacia senegal, Rhus mysorensis, Commiphora wightii, Grewia tenax, Calotropis procera, Cocculus pendulus* and *Lycium barbarum*. *Acacia senegal* consistently declined away from the stream banks. *Acacia tortilis* first increased along with *Salvadora oleoides* and then declined after 30 m from the banks. *Maytenus emarginatus* and *Prosopis cineraria,* being xeric, increased from stream bank to 50 m distance.

Different shrubs showed cyclical increase in density with the distance. These included *Lycium barbarum, Ziziphus nummularia, Euphorbia caducifolia* and *Grewia tenax*, while *Capparis decidua* and *Commiphora wightii* showed smaller changes with distance. Annual grasses increased up to 30 m from the banks and then declined. *Dactyloctenium aegyptium* and *Cyperus rotundus* appeared along the banks but were absent 20 m away. Perennial forbs declined up to 30 m, then increased rapidly and declined in next 10 m (Fig. 4.3).

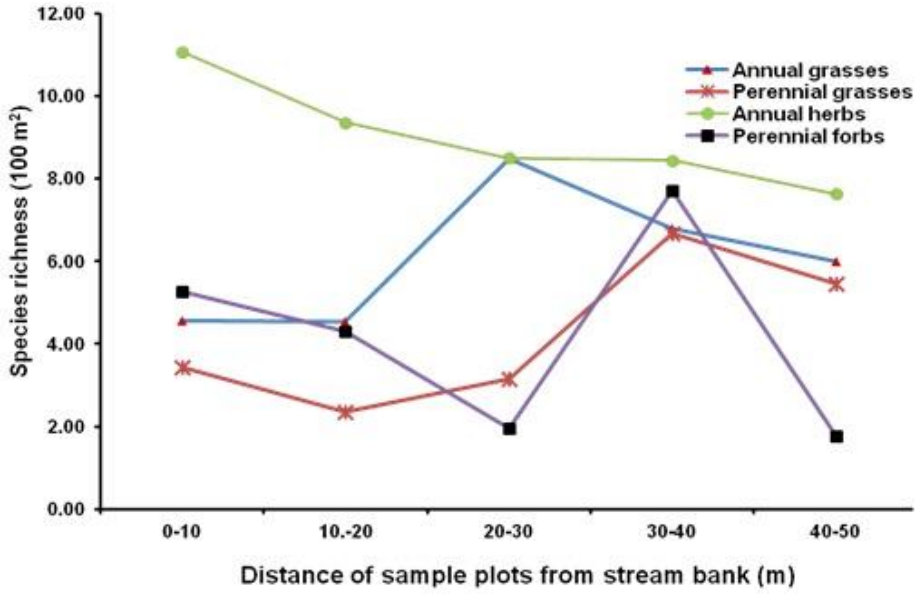

Fig. 4.3. Effect of anicuts on dominance of different components of herbaceous vegetation.

Rainwater Harvesting by Transforming Sand Dunes into Catchment Areas in Bikaner District

During the first year, the maximum water was collected in asbestos sheet treatment followed by bricks with cement and use of Kolayat clay (Table 4.6). But the heavy clay loss resulted in formation of small gullies in Kolayat clay treatment.

Table 4.6. Water collected under different mulch materials during different rainfall events

Material used	Water collected at different dates (Lit/200 m²)		
	I (22.7.10)	II (3.8.10)	III (13.8.10)
Polyethylene sheet (250 micron)	3200	1400	3000
Asbestos/Cement sheet	8100	4600	6500
Coltar spray	3800	2000	3000
Kolayat clay	4000	3000	4500
Brick with cement	6000	3500	4200
Rainfall (mm)	42.6	23.5	34.6

Impact Assessment of Global Warming on Reference Evapotranspiration

Based on Penman-Monteith (PM) model, the normal evapotranspiration (ET) for Barmer, Bikaner, Pali, Churu, Ganganagar, Jaisalmer and Hanumangarh stations of Rajasthan were calculated (Fig. 4.4). It revealed wide inter-station variability (e.g., 1623 mm at Jaisalmer to 2177 mm at Barmer).

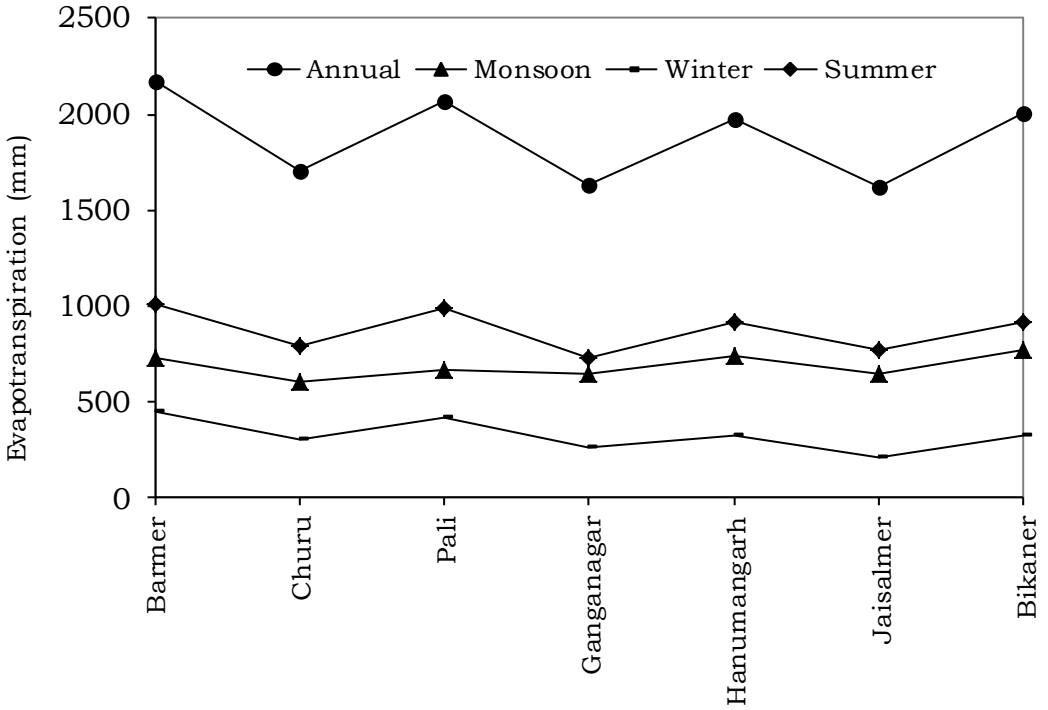

Fig. 4.4. Annual and seasonal evapotranspiration estimation by Penman-Monteith model.

The minimum rise in ET with each 1°C rise in temperature was at Churu (2.07%), while the maximum was noticed at Hanumangarh (2.27%). The highest change was for winter season, followed by monsoon and summer (Table 4.7). Thus, with increased warming more water loss is predicted during the winter months than during the summer.

Table 4.7. Seasonal variation in ET (%) with 1°C rise in temperature

Station	Change in ET (%)		
	Monsoon	Winter	Summer
Barmer	2.308	2.375	2.028
Churu	2.185	2.543	1.795
Pali	2.359	2.543	1.980
Ganganagar	2.182	2.782	1.895
Hanumangarh	2.272	2.894	2.035
Jaisalmer	2.239	2.131	1.939
Bikaner	2.302	2.702	2.054

Climate Variability and Pearl Millet Productivity in Arid Rajasthan

Analysis of the spatial correlation between gridded monsoon rainfall data (JJAS) and pearl millet productivity in western Rajasthan (1960-2005) suggested a broad decadal pattern of relationship between the annual summaries of the two till the 1980s when the plotted data mostly formed tight groups, such that the 1960s and 1980s had better relationship ($r>0.5$), and the 1970s had poorer one ($r<0.5$). From the 1990s scattering of the data increased when, despite higher mean rainfall, the relationship was mostly poor ($r<0.5$), save and except few cases of improved relationships. This could be a result of higher spatio-temporal variability in seasonal rainfall, including rainfall intensity and time of occurrence, although broadly the number of rainy days increased from NW (15 days) to E and SE (>40 days). On an average, sowing rains were received after 30 days (from 1st June) in eastern part to 45 days in western parts. Various grids in the western part received no sowing rains in 9 to 14 years.

IMPROVEMENT OF ANIMAL PRODUCTION AND MANAGEMENT

Performance of Tharparkar Cattle

A herd of Tharparkar cattle was maintained on *Cenchrus* dominated pasture along with concentrate supplementation for research and demonstration to the farmers and distribution of males to villagers for its conservation. The age at first calving of Tharparkar cattle was 48.9±1.0 months, lactation yield 1952.0±203.7 litres in 305-days and 2062.2±205.7 litres in 311 days. Peak yield was 8.57±0.39 litres. Per day milk yield of lactation length was 6.41±0.66 litres and calving interval 5.35±0.55 litres. The average dry period and calving interval of the herd were 123.6±31.2 and 439.8±1.0 days, respectively.

Production Performance of Goats

Kidding performance: Mating was once in a year during May and kidding in October in a flock of 150 goats of Marwari and Parbatsari breeds maintained with 6 hours daily grazing/browsing on naturally protected silvipasture. Out of total breedable does, 82% Marwari and 73% Parbatsari does had kidding. Twinning was more in Parbatsari goats (47%) than in Marwari (37%). The male and female ratio was 1:1.37 and 1:0.50 in Marwari and Parbatsari breeds, respectively.

In case of Marwari goats, average milk for pre-weaning, 150-days and total lactation period were 61.9, 88.6 and 118.2 litres, respectively with the peak yield 0.93 litres. The lactation length was 228.8 days. However, the milk production of Parbatsari goats was comparatively higher than Marwari breed, and the average milk yield of pre-weaning, 150 days and total lactation yield was 62.9, 87.7 and 128.2 litres. The peak yield and lactation length of Parbatsari goats were 0.89 litres and 225.8 days, respectively.

Body weight of Marwari kids at birth, 3, 6, 9 and 12 months of age were 2.6, 8.3, 12.3, 13.5, and 16.4 kg for females, and 2.8, 9.2, 14.2, 17.7 and 23.5 kg for males. In case of Parbatsari kids the weights were 3.0, 9.0, 13.9, 16.8 and 22.5 kg for females and 2.9, 8.2, 10.5, 13.0 and 14.5 kg for males. The body weight of dams at kidding in Parbatsari (37.6 kg) was higher than Marwari (32.3 kg) breed (Plate 17).

Growth pattern of adult sheep and goats: There was not much change in body weight during December to May and thereafter it increased up to October due to advancing pregnancy stage accompanied with good feed and environmental conditions. However, the animals lost their body weight in the beginning of monsoon but the major loss was after October to November due to kidding and initiation of lactation (Fig. 5.1).

Vitamin A Status in Lactating Cattle under Different Feeding Management Conditions

Vitamin A status of farm-managed and the farmers' cows maintained under arid rangeland condition was studied during peak of summer using milk retinol equivalent as an indicator of vitamin A status of the animal. Milk samples of 16 Tharparker cows maintained at Institute

Central Research Farm, Jodhpur and 11 cows of the farmers of Jhanwar village were collected and analyzed for density (DN), specific gravity (SG), solids-not-fat (SNF), total solids (TS), hexane extractable (HL) total lipids (g/100 ml and g/100 g) and fat. Carotene and retinol levels, total milk-retinol equivalent (RE) and milk-lipid RE were estimated.

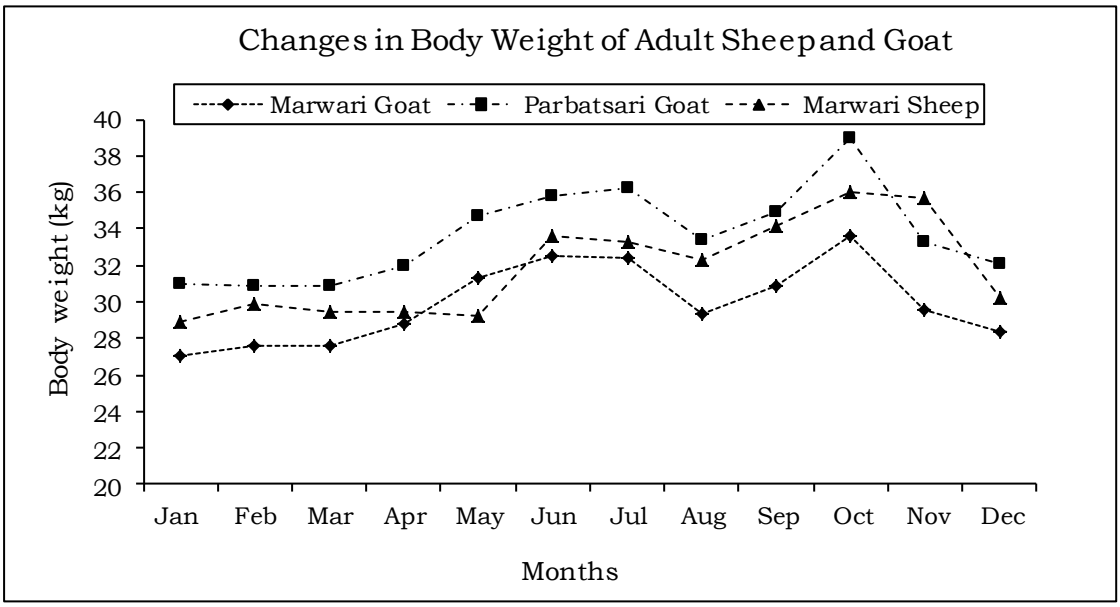

Fig. 5.1. Growth performance of small ruminants.

Milk DN, SNF, TS and fat were higher, specific gravity was similar and HL was lower, though not significant, in the farm managed than the farmers' cow-milk (Table 5.1). Low SNF and fat contents in milk of farmers' cows shows the poor nutritional status of the cows, and it suggests supplementation of vitamin A and other critical nutrients to farmers' cows. The milk carotene and retinol levels in both the groups of animals were lower than normal values. Milk carotene, retinol, RE and milk-lipid RE were appreciably higher in farm managed cattle than farmers' cows. The present values for milk retinol, total RE and milk-lipid RE were lower than the values recorded for these cows during monsoon and winter seasons. The low retinol activity recorded in the summer milk samples of both groups of cows, suggests need of an appropriate strategy for supplementation of vitamin A in farm as well as farmers' cows maintained under arid rangeland conditions.

Mineral Profile of Livestock *vis-à-vis* Health Status

Feeding trial for eighty days was conducted on eight growing male camels to study the blood and mineral profile. Animals of control group (T1) were offered pelleted cattle feed @ 1.0 kg each, while in the T2 group, 25% of pelleted cattle feed was replaced by Lana (*Haloxylon salicornicum*) seeds on iso-nitrogenous basis. Animals of both the groups were offered guar (*Cyamopsis tetragonoloba*) phalgati as a roughage source and water *ad libitum*. Blood collected

from all the animals in the morning before feeding at fortnightly intervals was analyzed. Total protein (g/dl), albumin (g/dl), globulin (g/dl), glucose (mg/dl) and serum urea (mg/dl) for T1 and T2 groups were 5.63 and 5.32; 3.31 and 3.30; 2.32 and 2.01; 125 and 124.5; and 24.11 and 22.42, respectively. The differences between the groups for blood biochemical parameters were non-significant. Animals of both the groups maintained good health. The blood mineral values of Ca (mg/dl), P (mg/dl), Na (meq/l), K (meq/l), Mg (meq/l), Zn (ppm), Fe (ppm), Mn (ppm) and Cu (ppm) for Control group (T1) and Treatment group (T2) were 10.60 and 11.24; 7.08 and 8.87; 161.25 and 159.25; 6.72 and 7.05; 4.12 and 3.86; 1.12 and 1.27; 2.87 and 2.91; 1.12 and 0.97, and 1.10 and 1.17, respectively. Differences only in Ca and Na level were significant. Study showed that camels fed with *Lana* seeds in arid region maintained biochemical and mineral profile and were in sound health.

Table 5.1. Milk composition of farm managed and farmers' cattle maintained during summer

Trait	Farm cows (n=16)	Farmers' cows (n=11)
Density, g/ml	1.06±0.038	1.03±0.001
Specific gravity, by formulae	1.03±0.0003	1.03±0.0003
Solids-not-fat, %	8.19±0.06	7.72±0.156
Total solids, %	12.37±0.22	11.80±0.237
Fat, %	4.19±0.10	4.08±0.29
Hexane extractable lipids, g/100 ml	3.25±0.28	4.00±0.42
Total lipids, g/100 gm	3.45±0.34	4.11±0.43
Carotene, µg/100 ml	6.27±1.20	3.38±1.21
Retinol, µg/100 ml	8.39±0.43	3.05±1.04
Retinol equivalent (RE)*, µg/100 ml	9.43±0.50	3.61±1.07
RE, µg/100 ml milk-lipids	214.11±49.56	114.81±43.3

* 1 µg RE=3.33 I.U. vitamin A.

Climate Stress on Goats and its Amelioration

Climate stress: The diurnal differences of temperature humidity index (THI) values were significantly higher in most of the months except monsoon period when relative humidity was more. The difference (range 10-17) was more during winter from 2nd week of October to February than in summer from 4th week of March to April (range 9-14.7). The maximum THI was in the morning (80.7) and afternoon hours (89.6) during May 20-26. However, the minimum value was 50.9 in the morning and 67.4 in the afternoon during January 10 to 16. THI indicated comfortable environment was during November to February. The cold stress period was during fourth week of November to third week of February in the night and morning hours and THI ranged from 50.9 to 59.4. The cold stress was more severe with the increase in air velocity from north direction.

Physiological parameters in open and closed housing: Rectal temperatures (RT), respiration rate (RR) and pulse rate (PR) were recorded to study the stress conditions in the animals. The diurnal variation in RT, RR and PR was in all the seasons under different housing systems as the afternoon temperature was much higher than morning hours in desert ecosystem and the goats also got exposed to direct sun light during grazing. RT, RR, and PR in afternoon hours were more

than in morning during all the seasons. The higher RT of Marwari goats in afternoon hours in winter was due to the black colour of Marwari goat that absorbs the heat from the sun.

The effect of housing system was not significant on RT in morning hours. However, higher RT was recorded in afternoon hours in open type than closed type housing in all the seasons (Table 5.2). Microclimates of all housing systems were similar to macro-climate in morning hours but in afternoon the microclimate of closed type was better than open type due to the complete shade in closed area. Similarly, the RR and PR were higher in goats of open type housing system during afternoon hours of summer season (March to October) in comparison to closed type housing where due to shade the effect was not so pronounced in afternoon hours.

Table 5.2. Seasonal variation in physiological parameters of Marwari goats under different housing systems

Physiological parameter	Open-type housing		Closed-type housing	
	Morning	Evening	Morning	Evening
Rectal Temperature (°F)				
Winter (November-February)	98.6	102.2	99.3	102.6
Summer (March-June)	99.1	102.1	100.2	101.9
Rainy + Autumn (July-October)	100.3	102.7	100.8	102.1
Respiration Rate (No. minute^{-1})				
Winter	26.5	30.2	27.4	31.1
Summer	30.0	38.1	30.5	34.9
Rainy + Autumn	32.3	38.9	32.7	36.2
Pulse Rate (No. minute^{-1})				
Winter	99.9	102.2	100.5	103.1
Summer	104.0	118.0	103.5	105.8
Rainy + Autumn	103.7	109.7	104.4	105.2

Blood parameters under stress conditions: Heamoglobin (Hb), glucose, urea, creatinine, protein, albumin and cholesterol of blood during summer were analyzed. Blood parameter values except Hb, protein and albumin in open-housing system were more than in closed-type housing (Table 5.3).

Table 5.3. Blood parameters of lactating goats during summer

Shelter	Blood parameter						
	Hb (%)	Glucose (mg 100 ml^{-1})	Urea (mg 100 ml^{-1})	Creatinine (mg 100 ml^{-1})	Protein (g 100 ml^{-1})	Albumin (g 100 ml^{-1})	Cholesterol (mg 100 ml^{-1})
Open type	7.63±0.22	57.3±4.4	28.3±2.2	1.42±0.17	7.38±0.11	3.13±0.16	95.1±10.5
Pucca type	7.84±0.12	50.6±3.4	25.8±1.8	1.24±0.07	7.44±0.06	3.20±0.08	80.0±13.5

Designing and construction of east-west orientation animal shelter: An east-west orientation animal shelter with proper direction, roof material and optimum ventilation was designed and constructed for small ruminants (Plate 18). The dimensions of this shelter were 9 m long, 4.8 m wide with 3 m height from centre and 2.1 m from sides. Side-wall of 1.2 m height of stone slabs was erected around the shelter to protect animals from cold waves during winter and rest of the portion was open from all sides with adjustable ventilation. The roof was fabricated with angle

irons and asbestos sheets with provision of false ceiling of thatched panels for better insulation to reduce heat loss in winter. The temperature in the animal shelter was 2 to 3°C higher than the macro environment in winter. Efforts will be made to increase the insulation capacity of roof for better micro-climate and higher animal productivity.

PLANT AND ANIMAL PRODUCTS, AND VALUE ADDITION

Development of Aloe Products

Aloe hair conditioner: Hair conditioner was made using aloe juice (58.3%), whole egg raw protein (10%) and olive oil. The product is in the cream form with shelf life of more than seven months. Further testing is continuing.

Aloe soap: Aloe soap in two different forms, (a) semi-transparent aloe soap bar and (b) aloe soap cream were prepared with different proportions of aloe juice. Transparent soap, using 5% aloe juice, was found suitable for normal skin, while the cream soap containing 33% aloe juice, was good for dry skin. Olive oil, palm oil, coconut oil and castor oil were also used as ingredients. Effectiveness of the products is being tested.

Processing of aloe leaf waste: Pectins, used for preparation of jam and jelly in the food industry, were isolated from grinds of aloe leaf and these were 5.4% of the dry leaf weight.

Products of Economic Importance from Arid Zone Plants

***Salvadora oleoides*:** Juice from the fruit pulp was dried and was found to have good shelf life for preparation of instant *Peelu* squash, etc. in the off-season. 15 kg good-quality fruits (*Peelu*) from Araba in Barmer district showed 40% seed fat. Analysis of 5-year-old seeds showed no change in fat content with time (42.8% in 2005, 42.6% in 2010).

Refinement of *Prosopis* coffee: The coffee prepared from *P. juliflora* pods has flavor of *Prosopis.* To make it more acceptable, three variations of coffee (pure *P. juliflora* coffee, 70% *P. juliflora* coffee + 30% raw coffee, and 50% *P. juliflora* coffee + 50% raw coffee) were prepared and organoleptic evaluation was done. 50:50 combination of *P. juliflora* and raw coffee was more acceptable. As cold coffee 70:30 combination was also acceptable.

Development of shade card and organoleptic evaluation of coffee prepared from *P. juliflora* pods: Desired quality and colour of coffee powder was normally achieved by the initial temperature set at 150°C for 6 hours. After various trials the same quality and colour was achieved by pre-heating the oven and then roasting the *P. juliflora* powder at 225°C for two hours. The end point was found using the shade card. The powder thus prepared was mixed with original chicory powder and/or original coffee in various ratios and organoleptic evaluation was done at 9 point hedonic scale. Among the eight variations, 70:10:20 (*P. juliflora:* chicory: raw coffee) combination was found to be the best.

Evaluation of milling products of *P. juliflora*: Twenty five milling products obtained by processing of *P. juliflora* pods were analyzed for organic matter, minerals, crude protein, ether extract and total carbohydrates, and gross energy were estimated. The three milling products viz., fibrous epicarp (A), fibrous endocarp (B) and amorphous mesocarp (C) were used for multi-nutrient blocks and multi-nutrient mixture. On an average A, B and C milling products, contained 95.3, 95.8 and 94.0% organic matter (on dry matter basis); 4.7, 4.2 and 6.0% minerals; 7.37,

10.70 and 12.76 crude protein; 3.92, 4.24 and 9.16% ether extractives; 84.4, 80.9 and 72.1% total carbohydrates; and 425, 436 and 467 kcal gross energy, respectively.

The standard blocks contained 32.1% wheat bran besides other ingredients. Attempts were made to explore possibility to replace wheat bran, which is used as fibrous fraction in standard feed block formulations, with three types of *P. juliflora* milling products.

Nutritional Value and Value Addition to Locally Grown Fruits Cucumis *melo* and C. *callosus*

Organoleptic evaluation of value added products: Chutney prepared from kachri (*C. callosus*) and other products from *Phoot kakdi* (*C. melo*) were tested for organoleptic characters. Jam and Melo sip (ready to drink preparation) showed better acceptability than the other products (Table 6.1).

Table 6.1. Organoleptic evaluation of *C. callosus* and *C. melo* food products

Organoleptic characters	Chutney	Squash	Jam	Cussar	Laddo	Melo sip
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Colour	7.36 ± 2.29	7.55 ± 1.37	8.36 ± 0.92	7.73 ± 1.1	7.56 ± 1.13	8.84 ± 1.13
Flavour	6.9 ± 1.22	7.27 ± 1.19	7.18 ± 1.47	7.45 ± 1.21	7.78 ± 0.67	7.92 ± 1.17
Taste	8 ± 0.89	7.55 ± 1.13	7.91 ± 1.22	6.64 ± 1.96	7.44 ± 0.88	8.00 ± 1.21
After taste	7.36 ± 0.92	6.91 ± 1.22	7.82 ± 1.16	6.64 ± 2.34	7.56 ± 1.13	8.61 ± 0.92
Overall acceptability	7.36 ± 0.8	7.64 ± 0.81	8.09 ± 0.94	7.09 ± 1.92	7.56 ± 1.13	8.34 ± 1.1

Nutritional evaluation of *C. melo* and *C. callosus*: Fat content (per 100 g on fresh weight basis) was 1.12 g in *C. melo* and 1.4 g in *C. callosus*.

Development of *C. melo* value chains: The intervention utilized ITK of '*Barani Bari*' of Bikaner area. Ten demonstrations were laid on farmers' fields in six villages. Seeds of AHS-82 from CIAH, Bikaner were used for raising the crop. After 45 days of sowing, average yield per hectare was 40 kg day^{-1} continuously for 30 days. This fetched an average gross income of Rs. 21,000 ha^{-1}. The pulp of *C. melo* fruit was used to prepare squash, jam, cussar, *laddoo* and Melo sip.

INTEGRATED PEST MANAGEMENT

Bio-formulations and Field Testing of Selected Biocontrol Agents for the Management of *Ganoderma* Disease of *Prosopis cineraria*

Isolation of Hyperparasites from Basidiocarps of *Ganoderma lucidum*: Basidiocarps of *G. lucidum* developed on diseased trees of *A. tortilis* and *P. cineraria* were found infected with fungal hyperparasites (Table 7.1). Maximum number of isolations were made from *A. tortilis* during October-December, whereas in *P. cineraria* during July-September. Infection of molds (*Rhizopus* and *Aspergillus* species) was common on basidiocarps. Under natural conditions, hyperparasites appeared at more than 50% humidity and temperature range of 25-35°C and low diffuse light near the base of the diseased trees.

Table 7.1. Growth of fungal hyperparasites on basidiocarps of Ganoderma lucidum

Host	Basidiocarps examined (no.)	Basidiocarps showing parasitic fungi (no.)	Hyperparasites isolated from basidiocarps (no.)
Acacia tortilis	45	8	5
Prosopis cineraria	22	4	3
Albizia lebbeck	6	-	-
Delonix regia	8	-	-

Parasitism of various fungal isolates on the basidiocarps of *Ganoderma lucidum*: Parasitic activities of seven microbial isolates were observed on basidiocarps of *G. lucidum* grown on *Prosopis cineraria/Acacia tortilis* trees under natural conditions (Table 7.2). Maximum growth and number of colonies were in case of *Trichoderma pseudokoningii* followed by *A. flavus* (LY).

Table 7.2. *Ex-situ* parasitism of various fungal isolates on the basidiocarps of *Ganoderma lucidum*

Microbial isolate	Formation of number of colonies/cm^2 after 30 days	cfu/ml after 30 days of growth on basidiocarps	Days required for sporulation
T. pseudokoningii	8	2.1 x 10^7	20-25
T. viride	5	3.8 x 10^7	25-30
T. harzianum	5	2.3 x 10^6	25-30
Gliocladium virens	6	4.3 x 10^7	25-30
Rhizopus spp.	7	2.3 x 10^{10}	25-30
Aspergillus flavus (LY)	8	6.4 x 10^8	15-20
A. flavus (Y)	5	5.2 x 10^7	20-25

Testing of selected strains of *T. pseudokoningii* on *G. lucidum* under field conditions: Among five isolates of *T. pseudokoningii* on basidiocarps of *G. lucidum,* growth and colonies ranged from 3-6 colonies/cm^2 and 5.5 × 10^6 to 7.3 × 10^7. Strain GTP4 showed the highest sporulation (7.3 × 10^7 cfu ml^{-1}) and *Trichoderma* strain GTP7 maximum colonies (6/cm^2) after 25 days.

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

Survival of *B. firmus* in different substrates: Biocontrol agent (*B. firmus*) survived equally well on 2% and 4% residues of cruciferous crops (viz., radish, mustard and cauliflower) amended soil. The population of *B. firmus* increased significantly in all the substrates in 20 days with maximum in radish + lignite + FYM (Table 7.3). With time there was a change in the population of *B. firmus* but radish residues maintained its superiority and had maximum survival after 60 days.

Table 7.3. Population of *B. firmus* on different substrates (g^{-1} substrate)

Substrate	Population of *B. firmus* ($x10^{10}$) after		
	20 days	40 days	60 days
Radish + lignite + FYM	3.2	3.3	4.1
Cauliflower + lignite + FYM	2.7	2.0	1.5
Cabbage + lignite + FYM	2.8	2.5	0.5
Lignite	0.7	0.5	1.2
Fly ash	0.5	0.7	0.7
Talc	0.4	0.4	0.6

Initial population ranged between $2.8x10^7$ and 1.4×10^8 g^{-1} substrate.

Survival of *T. harzianum* in different substrates: *P. juliflora* compost was the best food substrate in enhancing the population of *T. harzianum* (Table 7.4) in comparison to other composts and FYM.

Table 7.4. Population changes of *T. harzianum* in different composts, FYM and non-amended soil*

Amendment	Colony forming units ($\times 10^4$ g^{-1} amendment)			
	Days			
	0	20	40	60
Calotropis	3.5	3.3	35.5	27.5
P. juliflora	5.5	5.0	45.0	29.2
Brassica	4.0	4.0	22.7	24.6
FYM	4.7	2.9	20.7	4.1
Non-amended soil	1.6	2.4	14.0	11.4
LSD (P = 0.05)	Treatment = 1.1; Interval = 0.9 and Treatment × Interval = 2.5			

*Estimated on selective medium: Four petri plates per samples.

Survival of *B. firmus* and *T. harzianum* in promising food substrate combinations: Among seven combinations of promising food substrates, *P. juliflora* compost + radish + talc + lignite showed their compatibility in promoting individual bio-control agents in a new consortium product, where shelf life of *Bacillus* and *T. harzianum* could be maintained up to 180 days (Table 7.5).

Developing Bio-Control Agent Enriched Composts for Suppression of Soil Borne Plant Diseases

Efficacy of bio-control fortified compost on plant mortality due to dry root rot in clusterbean: Least plant mortality (2.36%) due to dry root rot in clusterbean was recorded in the

treatment where *P. juliflora* compost was combined with weed compost compared to non-amended control (7.5%). Maximum population of *T. harzianum* (1.2 x 10^2 g^{-1} soil) was also estimated in this combination followed by sole application of *P. juliflora* compost (0.8 x 10^2 g^{-1} soil).

Table 7.5. Population changes of *B. firmus* (x10^{12}) and *T. harzianum* (x10^4 g^{-1} amendment) in food substrate combinations

Treatment	Days											
	30		60		90		120		150		180	
	B. f	*T h**	30	*T h**	30	*T h**	30	*T h**	30	*T h**	30	*T h**
P. juliflora compost + talc+ wood saw dust (A)	-	28	-	30	-	60	-	10	-	30	-	12
Radish + lignite + FYM (B)	0.5	-	4	-	9	-	47	-	4	-	14	-
50% conc. of A+B	0.5	26	2	90	8	30	45	10	9	10	19	4.2
P. juliflora compost + radish + talc + lignite	0.6	18	10	40	7	40	24	10	11	10	26	7.0
A + radish	0.5	44	3	40	7	10	19	5	6	1	20	6.0
P. juliflora compost + radish + talc+ FYM	0.7	17	2	40	11	5	22	10	3	0.5	2	1.2
P. juliflora compost + talc + B	0.6	24	7	50	9	20	16	10	6	0.5	8	1.2

*Actual estimations were made at 10^5 dilutions. Brought to 10^4 for keeping uniformity.

Survival of antagonists in different composts: In laboratory, survival of antagonistic actinomycetes against *Macrophomina phaseolina* was maximum in combination of mustard and weed residue compost. In all other composts there was enhancement in the population of antagonistic actinomycetes (16.5-28.1%) compared to non-amended control (9.3%).

Disease Tolerance in Pearl Millet

Forty-eight male sterile lines (ms-lines) were screened for resistance against downy mildew (DM), smut incidence and blast disease. Eighteen lines were free from DM, two lines (1A and 5A) had less than 10% and in other lines incidence was from 7.1 to 85.7% (3B). Average DM pressure of 60.3% was recorded on infector rows (Nokha local). Only one line (8B) showed smut incidence of 16.6% and all were free from blast disease (*Pyricularia penniseti*).

Effect of bio-control treatments on DM incidence and protection of pearl millet, and change in leaf temperature, pH and EC: Seeds of pearl millet cv. 7042S treated with raw cow milk (RCM 1:9 dilution), amino acid (AA) mixture (Amino rich) in 4 concentrations of 1:10, 1:50, 1:100 and 1:200 followed by *Gliocladium virens* (0.6%) reduced the incidence of DM. Seed treatment of RCM (1:9) and AA (1:200) with *G. virens* (0.6%) had the lowest DM incidence (48.3%) with highest protection (40.3%) over the control with leaf temperature 37.7°C, pH 6.92, and minimum EC (0.11 m mhos) (Table 7.6).

However, the maximum ear head length (9.6 cm), ear head girth (7.5 cm) and 1000-seed mass (8.59 g) were in case of RCM + AA (1:50) + *G. virens*.

Table 7.6. Effect of bio-control treatments on downy mildew incidence, disease protection; leaf temperature, pH and EC of pearl millet cv. 7042S

Treatment	Incidence (%)	Disease protection (%)	Temperature (°C)	pH	EC (m mhos)
Seed treatment of RCM (1:9) + Amino Acids (1:10) + *G. virens* (0.6%)	63.1	22.0	37.2	7.85	0.22
RCM (1:9) + AA (1:50) + *G.v.* (0.6%)	52.0	35.8	37.6	7.32	0.21
RCM (1:9) + AA (1:100) + *G.v.* (0.6%)	57.1	29.5	38.0	6.80	0.14
RCM (1:9) + AA (1:200) + *G.v.* (0.6%)	48.3	40.3	37.7	6.92	0.11
Seed treatment of *G. v.* (0.6%)	68.1	15.9	37.1	7.03	0.18
Seed treatment of sterilized distilled water (Neutral Control)	80.9	---	37.8	7.62	0.24
Seed treatment of Metalaxyl (0.6%) (Positive control)	36.6	54.8	37.7	6.83	0.25

(Ambient temp. 35.3°C and R.H. 33% at 12.37 pm).

Testing *P. cineraria* Extracts and Insect Emissions as Attractants for Longhorn Beetles

Both male and female longhorn beetles were collected near source of light at night. The field collected female beetles isolated from males laid eggs, but these were unviable.

The beetles exposed to acetone and alcoholic extracts of khejri wood reacted positively to the source, but the response was not spontaneous. The exposure of beetles to abdominal washings and wiping of the opposite sex did not elicit instant response.

IPM Schedule for Mung Bean

Field efficacy of neem formulations in mung bean crop under organic farming: Neem formulations (neem pellets and neem seed powder @ 800 kg, 600 kg and 400 kg ha^{-1}, and two neem oil sprays) in mung bean crop gave total protection from termite attack till harvest as compared to 3.0-5.3% plant mortality in the control. There was significant reduction in populations of leafhopper (31.0 to 51.3%), whitefly (41.3 to 54.6%) and the both black and grey weevils (7.6 to 23.3%). Grain yield in all the treatments was more than control.

For management of green peach aphid (*Myzus persicae*) in cumin, two sprays of neem oil at 10 days interval starting from 1st week of January proved effective in reducing its population. The number of ladybird beetle (*Adalia bipunctata*) was not affected confirming the safety of neem oil to this predator.

Isolation, Characterisation and Multiplication of Native Microbial Entomopathogens (*Bacillus* and *Metarhizium*) for the Management of Insect Pests

Microbial pathogens (fungal and bacterial) were isolated from dead insects collected from fields and the ones died under laboratory conditions. New strains of *Metarhizum*, isolated from

Achaea janata larvae and white grubs, were highly effective against *A. janata* (70-80% mortality), *Catopsilia* sp. (70-90% mortality) and white grubs (50-60% mortality). Strains of fungal pathogens, isolated from soil and dead insects, caused 50-60% mortality of termites in the laboratory. In *Catopsilia pyranthe* locally isolated native *Bacillus* strains gave 30% mortality in comparison to 100% with commercial preparation of *B. thuringiensis* (Dipel), whereas in case of whitegrubs, *Bacillus* strains isolated from white grubs gave 20-90% compared to 10% mortality with commercial preparation.

NEMATOLOGY

Effect of *G. fasciculatum* in Nematode Infested Soil on Growth and Nutrient uptake in Chilli and Multiplication of Root-knot Nematode

Application of *G. fasciculatum* (Gf) in nursery soil with and without nematode caused a progressive increase in the growth of chilli seedlings with the increase in the inoculum of arbuscular mycorrhizae (AM) fungus from 25 to 100 spores/100 g soil. The increase in plant growth was more in absence of nematode. The highest dose of AM fungus drastically reduced the adverse effect of nematode and dry weight of seedlings significantly improved. Presence of nematode adversely affected AM fungus spore production in soil. All the doses of AM fungus reduced gall and egg mass numbers/plant and final population of *Meloidogyne incognita* (Mi), the maximum reduction was in treatment receiving highest inoculum of AM fungus (Table 7.7).

Table 7.7. Effect of *G. fasciculatum* on growth and nutrient uptake in chilli, and multiplication of root-knot nematode

Treatment (No. of spores of Gf 100^{-1} g soil)	Dry weight (mg)		Nutrient uptake (mg $plant^{-1}$)			AM spore count/50 g soil	Nematode population (10^3)
	Shoot	Root	N	P	K		
25	4.33	2.15	63.2	9.61	1 .94	210.0	0.00
50	5.04	2.36	75.5	11.84	2.33	231.3	0.00
75	5.24	2.60	82.1	13.19	2.54	240.0	0.00
100	5.61	2.84	89.6	14.76	2.78	250.7	0.00
25 + Mi	3.08	1.62	39.9	6.57	1.26	165.0	71.07
50 + Mi	3.34	1.83	47.7	7.75	1.49	175.3	57.87
75 + Mi	3.99	1.92	59.2	9.33	1.75	183.0	53.69
100 + Mi	4.24	1.99	63.3	10.04	1.84	185.3	50.65
Nematode check	1.93	1.10	14.3	2.74	0.72	0.0	129.27
Absolute check	3.86	1.80	49.8	7.14	1.60	0.0	0.00
LSD (P = 0.05)	0.65	0.29	7.3	1.33	0.23	13.1	0.09

All levels of *G. fasciculatum* enhanced N, P and K uptake by plants and maximum uptake was in case of highest inoculum level of *G. fasciculatum* in absence of nematode. Least effect of nematode on N, P and K uptake was observed in the treatment applied with maximum inoculum of the fungus.

Effect of *G. fasciculatum* and *Pochonia chlamydosporium* on Growth and Nutrient uptake in Chilli and Multiplication of *M. incognita*

Both *G. fasciculatum* (Gf) and *Pochonia chlamydosporium* (Pc) effectively suppressed the adverse effect of nematode on plant growth and enhanced fresh and dry weights of shoot and root in chilli (Table 7.8). Combining *G. fasciculatum* with *P. chlamydosporium* resulted in higher mitigation of adverse effect of nematode on the dry weights and it was more than the application of individual bioagents.

Table 7.8. Effect of *G. fasciculatum* and *P. chlamydosporium* on plant growth parameters and nutrient uptake of chilli and *M. incognita* population

Treatment	Dry weight (mg)		Nutrient uptake (mg/plant			Spore count/ 50 g soil	Nematode population (10^3)
	Shoot	Root	N	P	K		
Gf	6.04	2.23	102.22	12.93	2.31	173.3	0.00
Pc	5.43	1.75	78.72	9.10	1.81	0.0	0.00
Gf + Pc	6.69	2.72	118.5	16.76	2.78	190.0	0.00
Gf + Mi	3.88	1.85	65.39	7.91	1.48	136.0	66.69
Pc + Mi	3.80	1.49	35.40	6.36	1.17	0.0	73.80
Gf + Pc + Mi	4.83	2.15	83.70	11.14	1.98	153.7	40.92
Nematode check	2.12	1.06	17.14	2.98	0.64	0.0	137.81
Absolute check	4.30	1.77	65.23	7.21	1.39	0.0	0.00
LSD (P = 0.05)	0.77	0.49	13.55	1.71	0.28	19.2	0.11

Combined application of *P. chlamydosporium* and *G. fasciculatum* caused significant reduction in gall and egg mass number/root systems and nematode population, and increased uptake of all the nutrients and which was more than their individual effects. The per cent increase in N, P and K uptake were 79.5, 73.3 and 67.8% more than the nematode check.

RODENTS

Study on Bait Shyness and Poison Aversion Behavior and it's Mitigation in Desert Rodents

Effect of different additives (coconut oil, and groundnut oil + salt) at two temperature levels i.e., 21°C (18 to 25°C) (low), and 31.10°C (28 to 35°C) (high), was studied on mitigation of bait shyness in *Rattus rattus* and *Funambulus pennanti*.

R. rattus

Coconut oil (2%): Bait shy experimental rats were exposed to coconut oil treated bajra bait for 3 days, which reduced the shyness period by 15 days at low temperature, and 25 days at high temperature.

Groundnut oil (2%)+salt (1%): Shyness period was reduced by 3 days at low temperature, whereas by 5 days at high temperature.

F. pennanti

Groundnut oil (2%) + salt (1%): Bait shy experimental squirrels were exposed to groundnut oil and salt treated bajra baits for 3 days which reduced the shyness period by 2 days at low temperature and by only 3 days at high temperature (Table 7.9).

Table 7.9. Effect of different additives on mitigation of bait shyness at different temperature regimes in *R. rattus* and *F. pennanti*

Species	Persistence of bait shyness (days)							
	Coconut oil				Groundnut oil + salt			
	Lower temperature		Higher temperature		Lower temperature		Higher temperature	
	Earlier	Present	Earlier	Present	Earlier	Present	Earlier	Present
R. rattus	40	25	60	35	40	37	60	55
F. pennanti	-	-	-	-	20	18	25	22

Bio-Efficacy of Brodifacoum (0.005%) Wax Cake Formulation against Commensal Rodents

Brodifacoum wax cake formulation was evaluated against two most common rodents, the lesser bandicoot rat (*Bandicota bengalensis*) and the house rats (*Rattus rattus*) in laboratory and compared then with similar formulation of bromadiolone.

No choice tests: Single day exposure of brodifacoum (0.005%) wax cakes registered cent per cent mortality of both in no choice trials. The house rats with a mean body weight of 127.7 g recorded a mean consumption of plain bait 5.66 g/100 g body wt/day at pretreatment stage. The intake of the wax based brodifacoum by test rats was also 5.43 g/100 g body wt indicating good acceptability of the wax cakes. This intake resulted in 100% kill of test house rats within 3-11 (mean: 5.9) days and ingesting 2.62 mg kg^{-1} of active ingredient (a.i.). Bromadiolone wax cakes (0.005%) too revealed similar efficacy i.e., cent per cent mortality of *R. rattus* within 4-9 days under no choice tests (Table 7.10). The lesser bandicoot rats with average body weight 226.5 g recorded a normal intake of 10-15 g/day/animal i.e., 4.83-6.16 g/100 g body wt (Mean 5.37 g). Poison bait intake in one day exposure was quite comparable to the pre-treatment plain food i.e., 4.83 g/100 g body weight yielding cent per cent mortality of test bandicoots. Mean a.i. of poison ingested by experimental bandicoot rats was 2.39 mg kg^{-1}. The death period (Mean: 6.0 days and range 3-10 days) was also similar to that recorded in case of house rats. Bromadiolone (0.005%) too registered 100% mortality of bandicoots in one day exposure within 3-10 days (mean 6.9 days) with an intake of 3.25 mg kg^{-1} of a.i. in single day exposure to the toxic bait (Table 7.10).

Choice tests: The experimental rodents were exposed to brodifacoum wax cakes (0.005% a.i.) in presence of an alternate plain food. The mean intake of poison bait (3.57 g/100 g body wt) and plain bait (4.07 g/100 g body wt) by house rats was significantly at par indicating that the poison bait is fairly well acceptable and palatable to house rats. Due to availability of an alternate plain food the intake of the a.i. of brodifacoum was reduced to 1.80 mg kg^{-1} as against 2.62 mg kg^{-1} (in no choice) registering relatively decreased mortality of 80% with an increased death period (range: 4-13 days; mean: 7.37 days). Bromadiolone (0.005% a.i.) wax cake formulation on the other hand

had registered 60% kill within 3-10 (Mean: 6.7 days) with an ingestion of similar quantity of a.i. (1.75 mg kg^{-1}) in a single day exposure of toxic bait. For *B. bengalensis* also the wax block formulation of brodifacoum showed fairly good acceptability and palatability which was evidently reflected from the non-significant differences in mean intake of plain (3.37 g/100 g body wt) and poison baits (3.00 g/100 g body wt). Like house rats, the relative mean intake of poison bait by lesser bandicoots in one day exposure was lesser (3.00 g/100 g body wt) as compared to no choice test (4.83 g/100 g body wt). Therefore the ingestion of a.i. was also lowered to 1.5 mg kg^{-1} resulting in reduced mortality to 70% as compared to 100% in no choice tests (Table 7.11). Bromadiolone (0.005%) also showed non-significant differences in the mean intake of plain and poison baits with 80% kill within 4-14 days after one day exposure.

Table 7.10. Bio-efficacy of brodifacoum wax cake under no-choice feeding trials in house rats

Rodenticide	Poison bait intake g/100 g bwt	Poison a.i ingested (mg kg^{-1})	Mortality	Days to death	
				Mean ± SEM	Range
Rattus rattus					
Brodifacoum (0.005%) wax cake (Present trial)	5.43 ± 0.63	2.62 ± 0.31	10/10	5.9 ± 0.85	3-11
Bromadiolone (0.005%) wax cake (Earlier trial)	5.87 ± 0.82	2.93 ± 0.41	10/10	5.4 ± 0.56	4-9
Bandicota bengalensis					
Brodifacoum (0.005%) wax cake (Present trial)	4.83 ± 0.56	2.39 ± 0.28	10/10	6.0 ± 0.65	3-10
Bromadiolone (0.005%) wax cake (Earlier trial)	6.51 ± 0.40	3.25 ± 0.20	10/10	6.9 ± 0.85	3-10

Table 7.11. Bio-efficacy of brodifacoum wax cake under choice feeding trials in house rats

Rodenticide	Intake of bait (g/100 g bwt) (Mean ± SEm)		Poison a.i. ingested (mg/kg) (Mean ± SEm)	Mortality	Days to death	
	Plain bait (I)	Poison bait (II)			Mean ±SEm	Range
R. rattus						
Brodifacoum (0.005%) wax cake (Present trial)	4.07 ± 0.33*	3.57± 0.46*	1.80± 0.23	8/10	7.37± 1.15	4-13
Bromadiolone (0.005%) wax cake (Earlier trial)	3.55 ± 0.22*	3.50 ± 0.22*	1.75 ±0.11	6/10	6.67 ±0.76	3-10
B. bengalensis						
Brodifacoum (0.005%) wax cake (Present trial)	3.37± 0.33*	3.00 ± 0.37*	1.50 ± 0.19	7/10	6.7 ± 0.89	4-11
Bromadiolone (0.005%) wax cake (Earlier trial)	4.82 ± 0.30*	4.97 ± 0.25*	2.49 ± 0.12	8/10	9.75 ±1.14	4-14

*Non-significant.

The anticoagulant poisoning and death was confirmed from symptoms like typical oozing out of blood from nose, mouth and anus in both the species in no choice and choice trials.

Bioefficacy of Herbal Rodenticide, 'Bio' for Anti Fertility Effects on the House Rats

A plant origin compound, 'Bio' containig glucosides of *Tripterygium ilfordii* (GTW) in form of green coloured non-sticky noodle formulation (a.i. 0.25%) was evaluated for its field efficacy as a male sterilant against commensal rodents. The field trial was also conducted in two godowns in Basni Grain mandi. Before initiation of the trial, live trapping was conducted to understand the species composition. Both the premises were infested mainly with house rats (>80%) followed by *Mus musculus*. The trapped rodents were, however released in the same locations. In each godown 'Bio' noodles were laid at 5 bait stations most frequented by house rats (mainly along the walls @ 20 g per bait station). Thus in each location 100 g 'Bio' was applied. The consumption of bait was recorded daily for 10 days. Based on the intake, the baits were replenished every 5 days (i.e., on day 15, 20 and 25). The rats got the exposure of 'Bio' for about 30-35 days. Trapping after 35 days did not show any reduction in rodent population in the study area. However, when the trapped male rats from the treated area were paired with normal females, only two out of 7 pairs registered successful breeding with 2 and 5 young ones, respectively.

Rodent Surveys in Jhunjhunun District

Survey was carried out in crop fields of different villages viz., Titanwad, Udawas, Padampura, Bhurio ki Dhani, Puron ki Dhani and Beed fortest area during kharif crop season. Based on the burrow structure, *Meriones hurrianae* and *Tatera indica* were the predominant species in these areas. In the forest area, burrows of *Nesokia indica* were also recorded, besides those of *M. hurrianae* and *T. indica*. Commensal rodents viz., *R. rattus* and *M. musculus* were observed in the indoor habitats. The field rodents were reported to inflict 2-4% plant damage to bajra, mung bean and sorghum at vegetative stage.

Incidence of *Bandicota bengalensis* in Arid Zone

Bimonthly trapping data of lesser bandicoot rats in Jodhpur during 2010 revealed a trap index (animals trapped/trap/day) ranging between 0.04 and 0.06 (Mean: 0.05) with similar trends for 2008 and 2009. During 2007 it was 0.08 (Table 7.12). The sex ratio in the collections was in favour of females this year also (1:1.28). The collections included bandicoots of all ages as evident from their body weights [95 and 355 g (males) and between 65 and 318 g (for females)]. Comparision of mean body weights of bandicoots with other native rodents viz., *R. rattus* and *T. indica* (80-150 g), *M. hurrianae* (40-160 g) and *M. musculus* (15-20 g) showed greater concern as it is likely to increase rodent biomass/unit area and damage in arid zones.

The bandicoots collected during the year recorded a mean Head Body length of 190.5 ± 5.7 mm. Similarly the lengths of hind foot, tail and ear were 36.89 ± 0.34 mm, 169.1 ± 1.42 mm and 17.26 ± 0.73 mm, respectively. Characteristically the mean tail length in these collections was 89.4% shorter than HB similar to that reported by ZSI (68-98%) (Table 7.13). Females have 6-8 pairs of mammae. Hairs are short and rough. Tail is darker and uni coloured.

All the males showed scrotal testes, whereas in case of females the collections comprised of pregnant, females with perforate and non-perforate vagina indicating presence of sub adults and adults. Pregnancy was noticed round the year in the range of 16.6-60.0 (Table 7.14). Analysis of

last four year data (2007-10) indicated year round pregnancy between 16.6 (July)-53.3% (November). The pregnant females weighed between 209-346 g depending on the stage of pregnancy. The females weighing over 294 g delivered 4-8 young ones in a litter within a week of trapping. These observations revealed that bandicoots breed round the year.

Table 7.12. Relative incidence of lesser bandicoots during 2007-10

Month	Trap index (rodents trapped/trap/day)			
	2007	2008	2009	2010
January	0.11	0.06	0.06	0.06
March	0.03	0.04	0.04	0.04
May	0.05	0.03	0.04	0.05
July	0.10	0.08	0.06	0.06
September	0.14	0.07	0.03	0.05
November	0.09	0.03	0.05	0.06

Table 7.13. Mean body weight and other morphometric observations on *B. bengalensis* collected from Jodhpur during 2010

Trapping months	Body wt. (g)	HB (mm)	HF (mm)	Ear (mm)	Tail (mm)	Tail% of HB
January	232.4 ± 12.39	202.6 ± 4.73	37.7 ± 0.81	14.5 ± 0.35	166 ± 3.43	81.9
March	246.28 ± 15.36	210.42 ± 5.01	35.57 ± 0.19	15.71 ± 0.60	166.1 ± 5.05	78.9
May	214.66 ± 27.49	171.44 ± 10.29	37.83 ± 0.79	17.55 ± 0.60	171 ± 3.50	99.0
July	230.18 ± 24.30	185.36 ± 6.38	36.36 ± 0.71	18.45 ± 0.66	167.1 ± 5.58	90.1
September	199.77 ± 29.68	184.0 ± 7.71	36.88 ± 1.53	19.11 ± 0.90	169.3 ± 6.25	92.0
November	237.27 ± 15.95	189.18 ± 4.98	37.0 ± 1.04	18.27 ± 0.72	175 ± 4.20	93.6
Mean	226.76 ± 6.85	190.5 ± 5.70	36.89 ± 0.34	17.26 ± 0.73	169.1 ± 1.42	89.4

Table 7.14. Seasonal prevalence of pregnancy (%) in lesser bandicoot rat

Year	Per cent pregnant females					
	Jan	Mar	May	July	September	November
2007	20	25	33	0	16.6	100
2008	28	33	25	50	37.5	33.3
2009	60	16.6	50	0	20	40
2010	50	25	33	16.6	60	40
Mean of 4 yrs	39.5	24.9	27.8	16.6	33.5	53.3

NON-CONVENTIONAL ENERGY SOURCES, FARM MACHINERY AND POWER

Solar Devices

Solar water purifier: The double walled device has the outer box of galvanized sheet (1295 mm x 585 mm x 200 mm) and inner box made of aluminium sheet (22 SWG, 1200 mm x 500 mm x100 mm) with glass wool in the annular space. The inner tray is painted black by black board paint. Two clear window glass panes each of 4 mm thickness have been fixed over it with an openable wooden frame. A 4 mm thick plane mirror is fixed as reflector with tilting arrangement that can be varied from horizontal surface up to 120 degree depending upon the season. The absorber area is 0.60 m^2 and 20 glass bottles each of 750 ml can be kept inside it for purification of water. The performance of the solar water purifier was carried out by measuring stagnation temperature and heating nadi water in the bottles, placed in the solar water purifier at 10 AM. The temperature of water in the bottles reached to 95°C by 2 PM. The average maximum stagnation temperature inside chamber of solar water purifier was 147.5°C when ambient temperature was 37.5°C. All harmful bacteria are destroyed at temperature more than 70°C, making solar treated nadi water potable.

Solar distillation of brackish water: Performance of solar desalination unit was carried out by filling it with potable and saline water having 2500, 5000 and 7500 ppm dissolved salt. The average distilled water output was 8.762 litres per day.

Performance of solar thermal devices: The maximum stagnation temperatures were 93.4°C, 92.5°C, 98.9°C, 84.8°C and 78.5°C in solar cooker made of clay, vermiculite, vermiculite with reflector, brick and stone slab respectively when average ambient temperature was 36.7°C. Guar korma, gram churi and crushed barley were successfully boiled in the cookers. The maximum stagnation temperatures inside cooking chamber were 114.1°C, 119.1°C, and 120.0°C in single hot box solar cooker (Plate 19), double reflector hot box solar cooker (Plate 20) and non-tracking solar cooker respectively when average ambient temperature was 36.7°C. Green gram split, rice, potato, bati, spinach, fenugreek, cabbage, capsicum and carrot were successfully cooked in all solar cookers.

The stagnation temperatures were 66.2°C and 62.8°C inside solar dryer direct type and solar dryer in-direct type, respectively, when average ambient temperature was 35.0°C. Spinach, mint, fenugreek, mushroom and tumba were successfully dried. The hot water temperatures were 55.5°C and 63.3°C in integrated collector storage solar water heater and natural circulation type solar water heater, respectively when average tap water temperature was 23.8°C.

Performance of PV mobile unit: The PV mobile unit was further improved by incorporating additional fixtures to hold the maximum power tracker and storage battery firmly on the platform while moving it with ease. The unit was successfully tested to run *Aloe vera* gel extractor (350 W AC). The mobile unit was also tested for operating the PV blower having a 75 W DC motor

connected to blower provided with a cylindrical casing of aluminium sheet with an outlet for exit of air. The device was tested for separating the seed from thrashed material of clusterbean. Although the speed of the air was about 25-30 km h^{-1}, there were some problems in getting the desired results for cleaning. Needful improvements in the design are underway.

Larger PV duster: The performance of larger PV duster was studied with variation in the size of the holes through alignment of two eccentrically pivoted plates, provided at the base of the hopper for fall of powder. The capacity of dusting varies from 30 to 120 g min^{-1} depending on the size of the holes in the hopper. Although, the capacity of the PV duster has enhanced with larger motor, agitator and impeller, it resulted in the increase of weight, which is about 12 kg and therefore needs to be provided on a moveable structure.

Effect of reflectors on amorphous silicon PV modules: Performance of thin film hydrogenated amorphous Si modules (12 Wp) was studied with additional two mirror boosters to increase the energy gains. Keeping module normal to incident radiation and mirror boosters at appropriate tilt enhanced short circuit current (J_{sc}) by a factor of about 40% at noon with reduction in open circuit voltage (V_{oc}) to 9%, a manifestation of higher cell temperature. On providing space at the rear side for the movement of air at the base, the V_{oc} reduction was only 6% with the same order of current enhancement.

PV dryer: A mathematical model was developed to predict the temperature rise along and across the height of drying chamber. The model was verified for drying of mint leaves (10 kg) from 85% moisture content to 7% within 22 hours during June with maximum air temperature of 50°C. Drying trials of spinach (7 kg) during autumn and mushroom in winter also indicated that the rise in temperature inside the drying chamber was close to the predicted one. Further the drying was uniform and the quality of the dried product was better retaining aroma and colour.

PV systems for multipurpose activities: Two small PV systems based on 60 Wp polycrystalline silicon modules were fabricated to charge a battery with inclusion of protective blocking diodes and inverter for using the energy for illumination and operating AC/DC devices. The system was used in operating PV winnower, illuminating tube light (20W) and also for running churner (80 W).

Long term performance of PV modules: Some PV modules of PV pump have become yellowish from the sides after exposure to irradiance for more than sixteen years. This may be due to degradation of EVA after long exposure. The adverse effect on the PV output is obvious with 40% reduction in Jsc values resulting in the inferior performance of the PV generator.

Integrated solar device: The device comprises a trapezoidal tank (85.5 x 31.8 x 18/16 cm) kept inside an insulated box (103.5 x 51 x 45.5 cm) with double glazed front window (33.7 x 88.5 cm) and top window (47 x 100.5 cm) respectively and equal sized reflectors for both windows. Initial results indicated a temperature rise of more than 35°C when tap water temperature was 14°C with more uniformity in the water temperature at the top and bottom of the water tank compared to earlier developed devices, indicating better heat transfer and circulation. Integrated devices were used to dehydrate mint, spinach, watermelon crush and mushroom.

Power generation from solar energy based PEM fuel cell: A solar heating unit has been fabricated for testing the performance of PEM fuel cell. The dimensions of this solar unit are 60 x 60 x 23.5 cm. It consists of a blackened tray (dimensions: 40.5 x 40.5 x 10 cm) made of aluminium sheet. Double glass glazing with wooden frame (8.5 cm) has been provided over the tray. The glass-wool has been filled on all sides of the tray and covered with wooden frame. This solar unit provided a stagnation temperature of 100°C.

Farm Machinery and Tools

Field evaluation of three furrow (six-row) multi-crop seed drill for furrow slants: Tractor drawn three furrow (six row) multi-crop seed drill for furrow slants was evaluated at the institute farm with mustard crop during rabi season and green gram and clusterbean during kharif season. On an average, 29-30% increase in grain yield was found over conventional method of sowing. The cost of the seed drill is Rs. 35,000 approximately, whereas culti based local sowing device costs about Rs. 20,000.

Tractor drawn weeder: The weeder is made of straight blades (bakhar type) mounted on a pair of tynes. Each blade is made of 5 mm thick carbon steel, 275 mm long and, 55 mm wide. Three such blades were mounted on the main frame (length, 2000 mm and width, 500 mm) made out of 75 x 75 x 10 mm MS angle iron with attached standard three point linkages for mounting the unit on a tractor. Two sets of blades, one each mounted on a pair of tynes, are fastened with nut bolts at the front side of the frame, whereas another set is provided on the rear side to give stability to the unit (Fig. 8.1). It has provision of adjustment on the frame and also the length of the blade can be selected depending upon row to row spacing of crops. The developed weeder covers larger area (field capacity, 0.35 ha h^{-1}), reducing the human drudgery.

Field testing of an improved traditional seed drill: An improved seed drill has been developed, which comprises a tractor drawn cultivator, seed distribution system with drive wheel and press wheel for each furrow. It was field tested in rabi season by sowing mustard crop with the field capacity, 0.60 ha h^{-1} and placing seeds at the depth of 3.8 to 4.0 cm. The total crop yield was 20% more over traditional method of sowing, which may be attributed to proper placement of seed and early germination due to press wheel in the improved seed drill. Since the seed metering system and press wheel assembly are mounted on the cultivator, it becomes a low cost seeding device.

Other Devices/Products

Pearling of pearl millet: Pearling of pearl millet grain was carried out by a pearler (Fig. 8.2) developed for the purpose to peel and strip various layers of bran before making the flour. The flour from pearled grain as well as unpearled grain was stored for 30 days. The flour was analysed periodically (7, 14, 21 and 28 days) for shelf life by chemical methods (Table 8.1). The values of fat acidity and free fatty acid increased at higher rate in case of unpearled flour compared to pearled flour. Peroxide value, indicative of oxidative changes in lipids, steadily increased early in storage, reached a maximum, and then gradually declined. The results indicated that shelf life of pearl millet flour derived from pearled grain can be appreciably improved. Analysis of different fractions indicated that grit fraction is a good source of dietary energy.

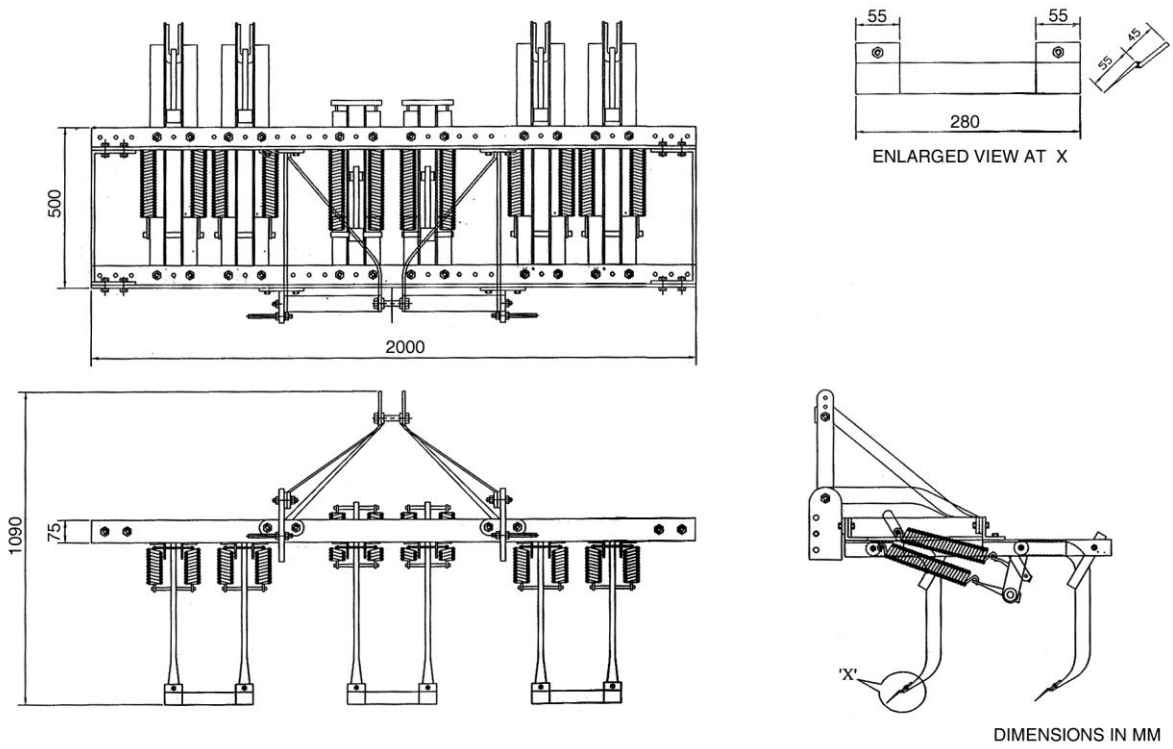

Fig. 8.1. Details of tractor drawn weeder.

Tumba oil based biodiesel production: An experimental unit (batch type) for preparing biodiesel from tumba (*Citrullus colocynthes*) was fabricated, which has a capacity of 25 litres. It comprises of heating unit, processing chamber with provisions for mixing and separation. The specific gravity of biodiesel prepared through this system was 0.85-0.86 and viscosity was in the range of 1.63-2.34 $mm^2 s^{-1}$ at 40°C. The flash point, cetane number and cetane index were 168-170°C, 52 and 55, respectively. The recovery of the bio diesel from raw tumba oil was 98%.

Improved passive cool chamber: The design of passive cool chamber was improved by increasing the evaporating area. It consists of a double walled chamber made of baked bricks with dimensions of 120 x 120 x 73 cm (outer chamber) and 80 x 80 x 42 cm (inner chamber) and holes provided in outer and inner chambers for better circulation of air (Plate 21). Provisions have also been made for water evaporation from the bottom side of the cool chamber by providing suitable channels, which further enhances temperature reduction and maintain high humidity in the chamber. The water filled up in the annular side walls helps maintain high humidity inside the inner chamber and reduces temperature. Three cool chambers have been installed at the farmer's field, one each in Jodhpur, Nagaur and Barmer.

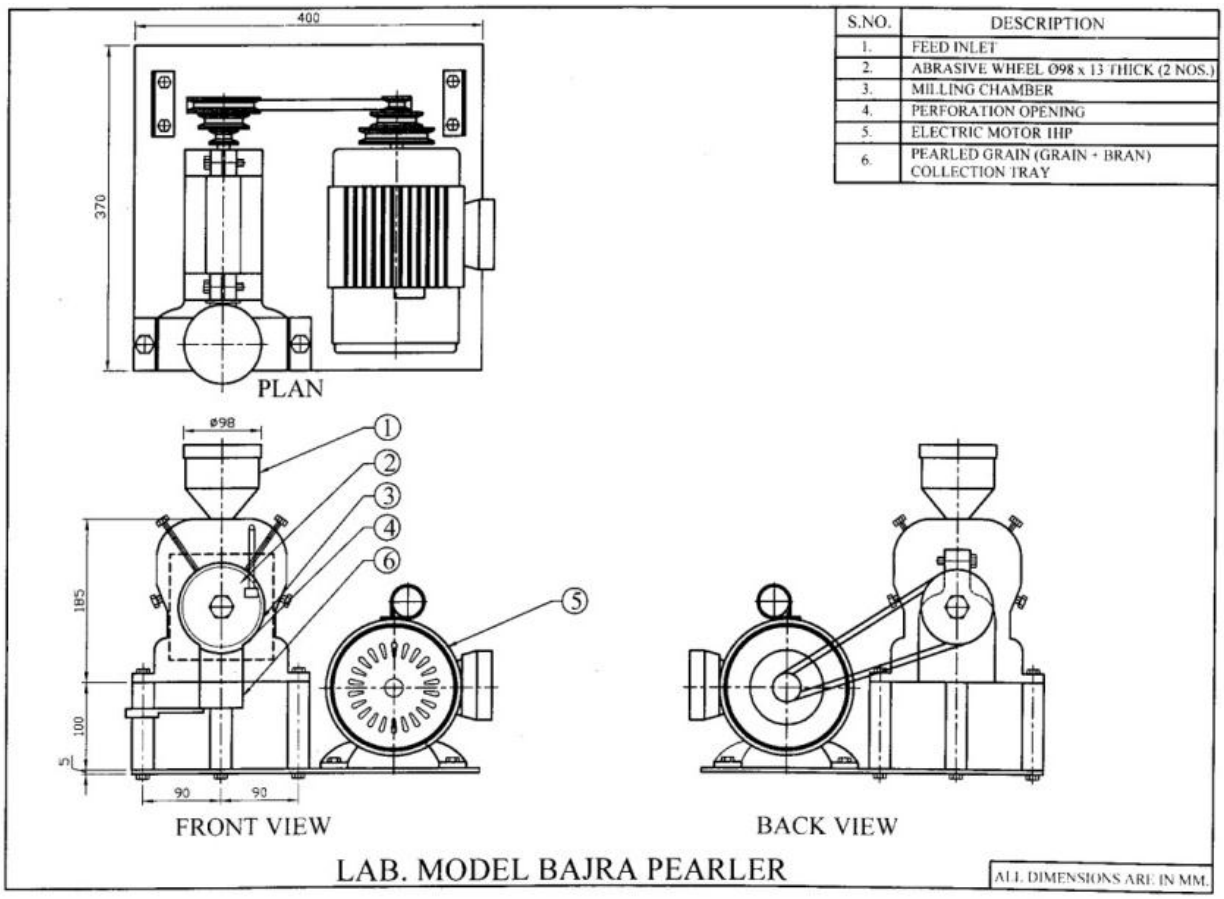

Fig. 8.2. Lab model of pearl millet pearler.

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

Treatment	No. of days			
	7	14	21	28
Fat acidity (mg KOH 100 g^{-1} meal)				
Unpearled	4.5	15.2	40.1	78.9
Pearled	2.3	6.3	21.7	36.6
Free fatty acid (%)				
Unpearled	2.3	7.6	20.1	39.6
Pearled	1.2	3.2	10.9	18.4
Peroxide value (meq kg^{-1} oil)				
Unpearled	38.6	90.2	10.9	57.5
Pearled	49.4	36.4	33.0	36.1

Development of low-pressure drip irrigation system: In addition to earlier studied low pressure dripper (8 lph at 1 kg cm^{-2}), another dripper rated 4 lph at 1 kg cm^{-2} pressure was selected and field tested for its pressure discharge characteristics. It was observed that the drippers provided a discharge of 2 lph even at a pressure of 2.0 m height of water column (Fig. 8.3). The

manufacturing variation and uniformity coefficient were found as 5% and 94% respectively. Therefore gravity fed (tank's height, 2.2 m) low-pressure drip irrigation system using these drippers would be suitable for small applications.

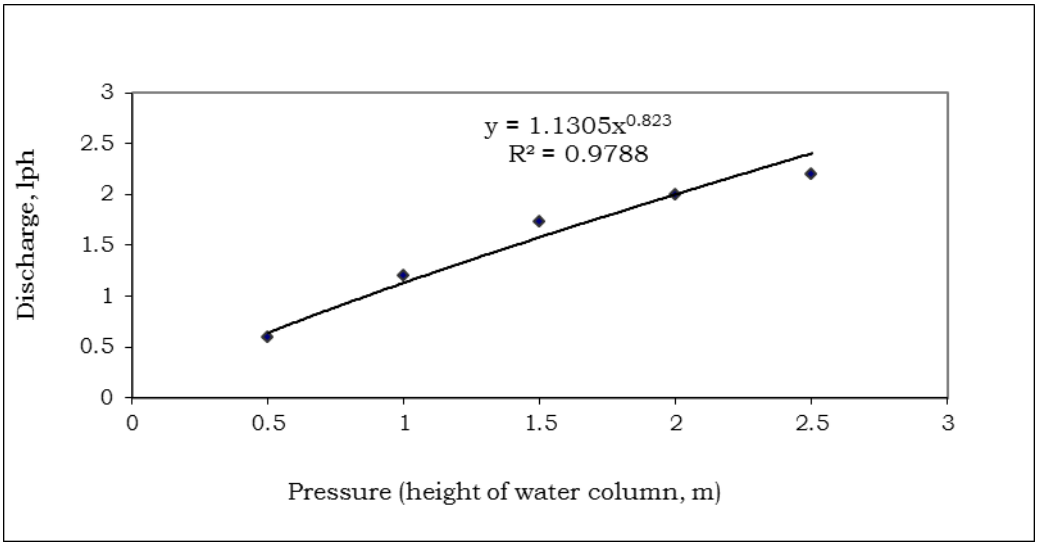

Fig. 8.3. Pressure discharge characteristics of dripper.

SOCIO-ECONOMIC INVESTIGATION AND EVALUATION

Survey of Gum Producing Trees

Survey was conducted in different habitats in Barmer and Nagaur districts (Table 9.1) to assess the density of *Acacia senegal* trees. The maximum density (30-40 trees ha^{-1}) was on big sand dunes (50-80) in Barmer and minimum in Nagaur 7-8 trees ha^{-1}.

Table 9.1 Morphological characteristics of *A. senegal* trees from various locations

Village (Tehsil/ District)	Average land holding (ha household^{-1})	Trees (ha^{-1})	Height (m)	Collar dia. (cm)	Canopy dia. (m)
Jakhada (Baytu/Barmer) (17)*	6.3	13.0	9.0	21.0	9.5
Chauhatan (Chauhatan/Barmer) (18)*	9.2	23.0	8.7	19.7	8.6
Binjrad (Chauhatan/Barmer) (35)*	12.4	30.2	15.3	19.7	14.4
Deedwana (Deedwana/Nagaur) (14)*	4.6	7.8	13 .1	15.2	11.0

*****Number of households surveyed.

Standardization of Time of Application of Gum Inducer Dose

In *A. senegal* with application of ethephon, maximum gum was produced during April (100-1000 g $plant^{-1}$) and minimum in September (3-10 g $plant^{-1}$). In case of untreated (control) plants, gum exudation during March and April was almost negligible. February to June was the most suitable period for obtaining maximum gum using gum inducer.

Extension and Adoption of Gum Inducing Technique and Mechanization of Procedure

Some farmers of Chauhatan and Baytu tehsils of Barmer district have adopted the gum inducing technology on 16000 trees of *A. senegal* during 2009-10, and produced 8 t of gum arabic which is worth Rs. 40,00,000. About 4000 *A. senegal* trees were treated in the villages of Osian, Phalodi and Shergarh tehsils in Jodhpur with a production of 1.8 t of gum arabic valued at Rs. 9,00,000.

Impact of MGNREGA on Livelihood Security

Fifty-two sample families comprising mainly farm women (18%) from all sectors of a village in Luni tehsil of Jodhpur district were interviewed for impact study. Under this scheme, various works related to renovation of traditional water sources, plantation of trees and construction of gravel roads were undertaken. Maximum amount was spent for labour employment which worked as a drought proofing measure. There was slight decrease (18.0%) in rural to urban migration due to such employment opportunities. This scheme provided 45% of income to the landless and marginal farmers. As per 30% of the respondents, there was shortage of labour for agricultural operation and wage rate was also increased. The landowners, however, managed agricultural operations by increasing wage rates or mutual exchange of labour or by giving land to share croppers. 90% farm families did not acquire any durable farm assets from the income of

MGNREGA, but a few procured mobile telephones. The income was mainly spent to meet out day to day household activities as 2009-10 was a severe drought year. In majority of the cases (90.0%) women discussed with the male members of the family for decisions.

Economic Impact Assessment of Technology Transferred in Arid Zone of Rajasthan

In Pali district results of decomposition analysis indicated that in kharif crops of pearl millet, clusterbean and mung bean, an additional income was generated to the extent of 37, 38 and 49%, respectively over the traditional varieties. Similarly, the new technology also contributed in rabi crops of wheat and mustard to the extent of 48 and 40% over the traditional varieties. In addition to income, additional employment was generated to the extent of 35, 28 and 44% due to improved varieties of pearl millet, clusterbean and mung bean crops. In rabi crops, contribution of new technology was between 41 and 43% and rest was due to increase in complementary inputs.

Economic Analysis of Camel Production System in Arid Rajasthan

Sample survey showed that camel carting was the main occupation among camel carters in Bikaner city. Agriculture was the secondary occupation for 70% of camel carters. Camels were stall fed during free time. Feed was the major item of total cost (60%) as they can't take animal for grazing. The most preferred fodder was clusterbean, moth bean, chickpea and groundnut straw. Camels were given salt at 15 days interval to fulfil their mineral requirement. Mange (PAM) disease was treated on appearance of symptoms. Common ailments of camel were treated using ethno veterinary practices. Average fixed investment per household was Rs. 74,097 of which animals alone accounted for 53%. The average cost of maintaining a camel unit (1.5 animals) was Rs. 1,28,252. The proportion of fixed cost and variable cost in total cost of maintaining a camel unit were 10% and 90%, respectively. Average net return per camel carting household per year was Rs. 49,997; while returns over variable cost were Rs. 62,393. Family labour income per household per year was Rs. 87,497 with B:C of 1.39. The financial viability of camel carting indicated a payback period of 2 years. The camel carting was financially viable at 12% discount rate. Higher cost of dry fodder during scarcity period and low carting charges were the major constraints.

Economics of Camel Use in Tourism

A sample (n = 70) survey was carried out among the camel safari operators in Chhatrel, Damodara, Khade Ram Ki Dhani, Kinoi Sand Dunes, Khuhari and in different localities in Jaisalmer city. Camel safari was the main occupation with average herd size of 2.17 units of male camel. Farming (59%) and labour (23%) were the major secondary occupations. Camels were stall fed during free time. Feed was the major item of total cost (52%) followed by labour (31%) as camel owner has to move with tourists during trip. Clusterbean straw was the most preferred fodder. Average fixed investment per household was Rs. 55,731 of which animals alone accounted for 76%. The average cost of maintaining a camel unit was Rs. 71,680. The proportion of fixed cost and variable cost in total cost of maintaining a camel unit was 13% and 87%, respectively. Average net return of camel safari household per year was Rs. 11,300 while returns over variable cost were Rs. 20,791. Household labour income per year was Rs. 33,300 with B:C of 1.6. The financial viability of camel carting indicated a payback period of 4 years. The camel tourism enterprise was financially viable at 12% discount rate in terms of both net present worth and benefit cost ratio (1.29).

Marketing Efficiency of Horticultural Commodities under Different Supply Chains in India

During 2007-08, about 7.51 lakh ha area was utilized under horticultural crops against gross cropped area of 221 lakh ha. Sriganganagar and Jaipur were selected for collection of primary data on kinnow, carrot, aonla and tomato crop based on highest area under cultivation. For each crop, information was collected from 120 farmers, 30 wholesalers and 30 retailers. Secondary information was collected from market functionaries. Following important marketing channels were identified:

Kinnow: Producer → Contractor → Commission Agent/Wholesaler → Retailer → Consumer

Carrot: Producer → Trader/Wholesaler → Commission agent → Retailer → Consumer

Aonla: Producer → Contractor/Trader → Commission agent → Retailer → Consumer

Tomato: Producer → Commission agent → Wholesaler/Trader → Retailer → Consumer

The share of channels in total quantity sold was 71, 85, 87 and 80% in *kinnow*, carrot, aonla and tomato marketing, respectively. Farmers' share in consumer's rupee was 32.2% in *kinnow*, 25% in carrot, 27.6% in aonla and 41.5% in tomato. The share of marketing cost and marketing margin in the consumer's rupee was 15.5% and 56.9% in aonla, 30.4% and 28.2% in tomato, 29.5% and 38.3% in *kinnow* and 23.8% and 51.1% in carrot crop. The measurements of marketing efficiency index in above supply channels was 0.5 in *kinnow*, 0.3 in carrot, 0.4 in aonla and 0.7 in tomato, respectively.

The marketing cost, marketing margin and length of marketing channel had negative relationship with marketing efficiency while other factors had positive relationship.

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

Average age of the farmers from Baniawas (Pali Panchayet Samiti) and Kushalpura, Karmawas-Malian villages (Raipur Panchayat Samiti) was 48.7 years, 69% of them were literate, having joint family (62.0%), with average family size of 7.4 members. Agriculture was the primary occupation. Average land holding was 3.37 ha, and 86.2% of them had open wells for irrigation.

Status of groundwater resources: Average depth of open wells in Pali and Raipur was 10.1 m and 47.5 m, respectively. Average depth of tube wells in Raipur was 204.4 m, and 86.2% of wells had electric motor pumps. The estimated water yield of open and bore wells in Raipur Panchayat Samiti varied from 2600 to 18000 litres hr^{-1}.

Utilization of groundwater and consequences of depletion: The groundwater was mainly used to grow rabi crops, for drinking and to grow fodder. The net irrigated area per well varied from a meagre 0.01 to 9.60 ha and the area under the irrigated crops, viz. cotton, chilli, wheat, etc. is decreasing.

Knowledge and training needs of farmers about efficient use of groundwater: The knowledge index of farmers varied from 14.3 to 79.6%. Majority of the farmers (63.2%) had medium level, 21.1% high level and 15.8% had low level knowledge on efficient use.

TECHNOLOGY ASSESSMENT AND TRANSFER

Integrated Agrometeorological Advisory Service for Farmers of Arid Rajasthan

Agro-advisories based on monsoon 2010 forecasts that indicated timely and normal rainfall were the highlights of the bi-weekly bulletins issued during kharif season for Barmer, Churu, Jalor, Jodhpur and Pali districts. Monthly bulletins were also prepared for the entire arid Rajasthan and Gujarat [The success of rainfall forecast was 83% during summer (April-May), 57% during monsoon (June-September), 95% during post-monsoon (October-December) and 94% during January to March]. Temperature forecast had 28-40% success depending on the season. Early warning of pests and diseases with extended rainfall period was given to farming community. Considering 2010 as a good monsoon year, a model Good Weather Code for crops, grasses and agro-forestry in arid Rajasthan was developed. Climate Risk Management Matrices for crop, pests and disease management during kharif and rabi seasons were also prepared.

Dissemination of Improved Farm Technologies and Constraints Analysis in Osian Tehsil

Improved technologies of moth bean and clusterbean: Twenty four demonstrations on moth bean (RMO-225) and clusterbean (RGM-112 and RGC-1003) were conducted in a selected village of Osian tehsil, Jodhpur district. The impact of demonstrations is presented in Table 10.1.

Table 10.1. Effect of variety on seed yield of moth bean and clusterbean crops

Crop	Variety	No. of demonstrations	Seed yield (kg ha^{-1})	Yield increased (%)
Moth bean	RMO-225	12	565	63.76
	Local		345	
Clusterbean	RGM-112	8	560	34.93
	RGC-1003	4	535	28.91
	Local		415	

Improved Fodder Production Technology

Two demonstrations of improved varieties of dual purpose pearl millet (HHB-67) were conducted at farmers' field. The seed yield was increased by 21.31% over local variety and there was no change in fodder production.

Effect of Variety and Neem Cake on Groundnut Yield

Field demonstrations on improved variety of groundnut, Girnar-2 and application of neem cake (@ 400 kg ha^{-1}) along with farmers' practices revealed that Girnar-2 gave 1745 kg ha^{-1} seed yield compared to 1270 kg ha^{-1} with local check. The seed yield increased by 37.40% over the local. Application of neem cake in local check increased seed yield by 18.80% over control. Similarly, application of neem cake @ 400 kg ha^{-1} in Girnar-2 produced 14.0% higher seed yield over Girnar-2 without neem cake application. This was due to nutrients provided by neem cake as well as protection from termites and white grubs.

Rodent Control

Damages caused by rodents on field crops was assessed, and training on preparation, application and precautionary measures of use was imparted to farmers. Infestation of Indian desert gerbil (*Meriones hurrianae*) and Indian gerbil (*Tatera indica*) were found in 53-65 burrows ha^{-1} in kharif crops. Rodent control succeeded with zinc phosphide was 49.2 to 66.0% in pearl millet, mung bean, moth bean, clusterbean and groundnut. Control success in groundnut was the least (49.2%) due to typical crop phenology providing safe shelter to rodents. Increase in grain yield due to rodenticidal treatment (over control) ranged between 8-11.45%; in pearl millet (9.73), mung bean (11.45), moth bean (10.8), clusterbean (9.75) and groundnut (8.05) crops.

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

Crop demonstrations: Nineteen kharif crop demonstrations on pearl millet (HHB-67), mung bean (K-851), moth bean (CAZRI Moth-2), and clusterbean (RGM-112) were conducted in selected farmers' field.

Enriched compost making: Compost pits were made and filled by six farm women in the month of April. Compost was utilized in organic kitchen garden during September-October and cabbage, spinach, coriander, and carrot were grown.

Skills for feeding and health management of livestock: Women learnt about scientific livestock feeding system like balance feeding for increasing optimum production, economically and livestock health management, including mineral mixture requirement, deworming with broad-spectrum anthelmentric like albendazole/fenbendazole.

Constraints in dissemination of improved agriculture technologies among the farmers in the Indian arid zone: The study was conducted in Jodhpur and Bikaner districts, covering three villages from each district. Altogether 180 sample farm families were selected randomly covering marginal, small and large categories from each village.

Lack of education was a big impediment in gaining the knowledge of various improved methods of agriculture. 41.0% sample respondents were illiterate. Of the literates, the level of education was mainly upto primary and middle level. The respondents could not remember the technical words like name of improved seeds, insecticides, fungicides and calculation of the actual dose of chemical fertilizer and plant protection. More than 66% respondents showed less desire to the yield of pearl millet. Risk of crop failure was the main reason. Participation of farmers in training programme was very low (17%). The participation in field day was nil.

Utilization of mass media sources was very less; only 42 and 29% respondents owned radio and television sets respectively. Half of them did not listen to agricultural programmes, only 2% used to listen frequently, and 24% used to watch regularly. One fifth of respondents subscribed newspaper and therefore its impact was very poor. 93% sample farmers applied farm yard manure without making compost and vermi-compost due to lack of knowledge. Use of chemical fertilizers in pearl millet was limited to 17%. Majority of farmers perceived that chemical fertilizer requires

water in time. None of the respondents was aware about the disease control method in pearl millet and use of fungicides and insecticides.

Farmers Participatory Action Research Programme (FPARP)

Field demonstrations were conducted in six villages of Jodhpur district. High yielding varieties of kharif and rabi crops produced higher seed yield with higher economic returns over local varieties (Table 10.2 and 10.3).

Table 10.2. Effect of variety on the seed yield of different kharif crops

Crop	Variety	Seed yield (kg ha^{-1})	Yield increased over local check (%)
Mung bean	Local	409	-
	RMG 268	540	32.02
Clusterbean	Local	446	-
	RGC 936	515	23.8
	RMG 112	537	27.3
Pearl millet	Local	419	-
	HHB 67	617	47.3
Moth bean	Local	285	-
	RMO 225	442	55.08
Groundnut	Local	1280	-
	Girnar 2	1735	35.5

Table 10.3. Yield and net returns as influenced by variety and improved cultivation practices of rabi crops

Crops	Improved cultivation practices (yield kg ha^{-1})	Farmers practices (yield kg ha^{-1})	Yield increased (%)	Net returns (Rs. ha^{-1})
Wheat				
Local	-	2750	-	20250
Raj 3077	3536	-	28.58	28896
Mustard				
Local	-	1720	-	16740
Pusa Jai Kisan	2145	-	24.71	23915
Cumin				
Local	-	346	-	22820
GC 4	525	-	51.73	44900

Adoption of improved package of practices in pearl millet-wheat, clusterbean–wheat and mung bean-wheat enhanced wheat equivalent yield by 22.1, 35 and 27.7%, respectively (Table 10.4). The increase in the total productivity of pearl millet-mustard, mung bean-mustard and clusterbean-mustard cropping systems was recorded by 17.1, 26 and 26.3%, respectively. Pearl millet-cumin and clusterbean-cumin also exhibited an increase of 18.4 and 30.0% respectively due to improved technologies over farmers' practices.

Table 10.4. Effect of variety and nutrient management on total productivity and monetary benefit of different cropping systems

Cropping systems	Total productivity in terms of equivalent yield (kg ha^{-1})*		Net returns (Rs. ha^{-1})		Benefit: cost ratio	
	Improved practices (variety+ INM)	Farmers practices	Improved practices (variety+ INM)	Farmers practices	Improved practices (variety+ INM)	Farmers practices
Pearl millet-wheat*	4336	3550	27072	22000	1.08	1.07
Clusterbean-wheat*	4906	3635	34842	23520	1.45	1.17
Mungbean-wheat*	6053	4740	48306	36280	1.98	1.76
Pearl millet-mustard*	2023	1727	17910	16340	0.79	0.90
Mung bean-mustard*	3180	2525	39270	32000	1.61	1.73
Clusterbean-mustard*	2505	1984	28480	20980	1.32	1.12
Pearl millet-cumin*	638	539	40860	33800	1.78	1.68
Clusterbean-cumin*	736	565	34490	36600	1.57	1.84

*indicates equivalent yield to the respective crops.

Among all the cropping systems, highest net return (Rs. 48,306 ha^{-1}) was realised with mung bean-wheat cropping system due to use of improved technologies which was 33.2% higher over farmers' practices. The benefit cost ratio was also maximum with mungbean-wheat cropping systems.

Cropping Systems

Mung bean-wheat cropping system gave highest groundnut equivalent yields (GNEY) followed by groundnut-chickpea. Both these systems had 2.0-8.6% higher yield than farmer preferred groundnut-wheat system. Along with higher equivalent yields, the substitution of groundnut-wheat by mung bean-wheat and groundnut-chickpea saved 13 and 4 irrigations, respectively. Results show that substitution of groundnut by mung bean and wheat by chickpea is suitable crop diversification option. Nutrient application showed significant yield improvement of crops. Averaged across all cropping systems, application of 25, 50, and 75, 100% RDGF and 100% RDGF + S gave 10.2, 25.5, 42.3, 48.9 and 50.3% higher yields compared to no application.

Farmers irrigate groundnut crop at weekly interval i.e. ~ 4 irrigation per month. Averaged across all the irrigation and nutrient management treatments cultivars HNG-10 gave higher yield (1999.4 kg ha^{-1}) followed by GG-20 (1900.4 kg ha^{-1}) and TG-37 (1333.9 kg ha^{-1}). Averaged across all the cultivars and nutrient management treatments the average yields under 4, 3 and 2 irrigations per month were 1851.3, 1813.0 and 1569.3 kg ha^{-1}. Decreasing the irrigation frequency from 4 irrigations per month to 3 and 2 irrigations per month resulted into 2.1 and 15.2% reduction in yields. Results show that irrigation frequency can be decreased from 4 to 3 irrigations month^{-1} without any appreciable reduction in yield and thus it is possible to save 5 to 8 irrigations in groundnut crop.

Among the long duration varieties, HNG-10 gave 26.9% higher yield than GG-20 (Farmer practice). In the short duration varieties, TG-39 performed better than TG-37. Nutrient application

had significant influence on the yield of groundnut. Across all varieties the application of N, P, N+P and N+P+Gypsum recorded 34.5, 34.3, 57.3 and 59.4% higher yield over no fertilizer application.

Averaged across two farmer sites, the HNG-10 gave 27.4% higher yields compared to GG-20 (Fig 10.1). The short duration varieties gave lower yields than the long duration varieties but they saved 5-6 irrigations.

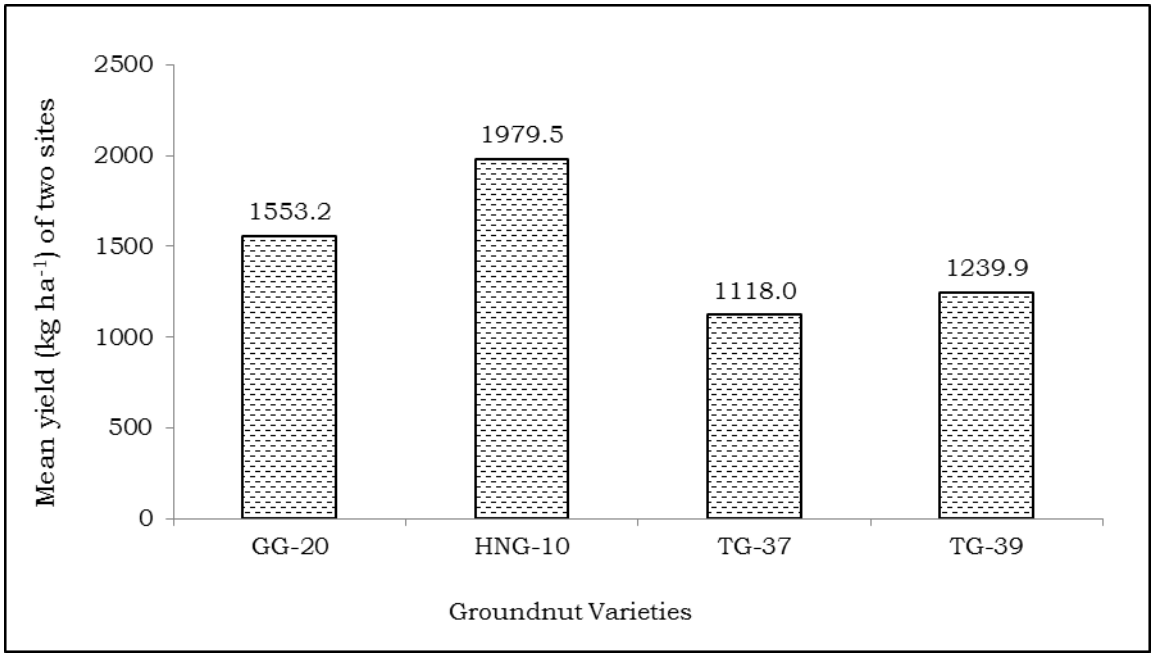

Fig. 10.1. Yield of different cultivars of groundnut at Geegasar, district Bikaner.

Dissemination of Improved Farm Technologies and Constraints Analysis in Osian Tehsil

Rodents survey, and three demonstrations on rodent management technologies and rodenticidal evaluations at farmers fields conducted during 2010 in Bheenjwadia village of Jodhpur district revealed infestation of Indian Desert gerbil and Indian gerbil in the crop fields. The level of infestation was 53-55 burrows ha^{-1} in kharif crops. On farm training was organized on rodent management on extent of rodent problem, the rodent species of the region, techniques of preparation and application of poison baits and precautions in their use. More than 15 farmers participated in the training.

The results of the field demonstrations indicated that rodent control success with zinc phosphide was 60 to 65% in bajra, mung bean, moth bean, clusterbean and groundnut. In the treated fields, the immigrating pest populations were also managed due to sustained effects of anticoagulant rodenticides. Increase in grain yield of crops (Table 10.5) was also observed.

Table 10.5. Field demonstration on rodenticidal treatments in Bheenjwadia village

Crops	Treatment	No. of burrow treated ha^{-1}	Control success (%) at 4 DAT	Yield (kg ha^{-1})	Increase in yield (%)
Pearl millet	Zinc phosphide Control	53 46	64.3 0.0	620 540	14.81
Mung bean	Zinc phosphide Control	58 55	60.0 -7.1	535 455	17.58
Moth bean	Zinc phosphide Control	60 53	63.0 0.0	460 385	19.48
Clusterbean	Zinc phosphide Control	50 48	62.4 -8.33	515 450	14.44
Groundnut	Zinc phosphide Control	65 49	65.0 -4.1	1275 1145	11.35

EMPOWERMENT OF WOMEN AND MAINSTREAMING OF GENDER ISSUES

Capacity Building of Farm Women through Selected Agro-Based Technologies

For enhancing knowledge and skills of farm women various off-campus and on-campus activities were undertaken.

Crop demonstrations: To disseminate improved technologies for adoption of new varieties of mung bean (K-851), moth bean (CAZRI Moth-2), clusterbean (RGM-112) and dual-purpose variety of pearl millet (HHB-67), demonstrations were given to farm women.

Kitchen gardens: Kitchen gardens were established in the backyard of three farm families with the help of farm women with adequate emphasis on the efficient use of farm wastes as organic inputs by making compost pits. The farm women were motivated to make simple neem-based bio-pesticides with farm based materials.

Enriched compost making: Compost pits were made and filled by six farm women in the month of April and the compost was utilized in kitchen garden in the month of September-October for growing spinach, cabbage, coriander and carrots for household consumption.

Imparting knowledge and skills for feeding and health management of livestock: In the selected village, women were given scientific knowledge of livestock feeding system. They were educated about the use of balanced feeding to increase the milk yield thereby their family income. They were also given knowledge on livestock health management and de-worming, which is regularly followed by the farm women.

Training to women, and school dropouts: Different types of vocational trainings as per the need and interest of women were given on crop production; low cost diet; value addition in fruits, vegetables, cereals, pulses, oilseeds, milk and mushroom, and other income generating activities. More than 1000 women were trained in these programmes.

Women day in agriculture: Women day in agriculture was celebrated in village Lunawas Charna (Panchayat Samiti Luni) on 4 December 2010. More than 200 farm women participated and lectures were delivered by the experts on women empowerment, increase in crop production and livestock management.

EDUCATION AND TRAINING

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

WORKSHOPS, SYMPOSIA, FARMERS' FAIR AND TRAININGS

Programme	Date(s)	Participants	Organizer
Farmers Awareness Programme on Weather-based Agro-advisory Service	February 25	Farmers, NGOs	CAZRI and IMD
Workshop under IDMP for PIAs and WDTs of Barmer, Pali, Jaisalmer and Jodhpur districts	April 5-6	70	Department of Watershed Development and Soil Water Conservation, Govt. of Rajasthan,
Farmers-Scientists-Media Interactive Meeting on Agro-Advisory Service and Feedback	June 21	Farmers, NGOs and Media	CAZRI and IMD
Farmers' Fair and *Kisan Gosthi*	September 29	300 farmers	CAZRI and KVK, Jodhpur
Workshop on Vetting for District Level Contingency Plans	October 10	29	CRIDA, Hyderabad
MTC on Sustainable Rainfed Farming Systems for Dry Land and Arid Areas	October 19-26	18	Directorate of Extension, Govt. of India
Workshop on Application of PRA Tools in Agricultural Extension	January 19-21, 2011	35, from CAZRI, Jodhpur, RRSs and KVKs	HRD Cell CAZRI and EEI, Anand

TRAINING ON MUSHROOM CULTIVATION FOR PROSPECTIVE ENTREPRENEURS

Name of the Training	Date	Participants
Tropical Mushroom Production Technology	November 29-December 1	20

FOR FIELD LEVEL EXTENSION WORKERS BY KVK, JODHPUR

Subject	No. of courses	No. of participants
Value addition	3	120
Sonamukhi cultivation	1	24

TRAINING PROGRAMMES ORGANIZED FOR EXTENSION PERSONNEL AND FARMERS

Subject	Duration	No. of trainees	Sponsor
Division of Transfer of Technology, Training and Production Economics			
Model Training Course on Improved Livestock Management Technologies for Livelihood Security in Dry Land and Arid Areas (on-campus)	February 2-9	15 subject matter specialists from 7 states	Directorate of Extension, Ministry of Agriculture, GOI, New Delhi
Training–cum-demonstration programme on Homemade Cattle Feed and Mineral Mixture Bricks for Animal (off-campus)	December 14	25 farmers	Ambuja Cement Foundation, Mundwa (Nagaur)
Interactive Meeting of Pilot Study on Livestock Centric Intervention for Livelihood Improvement in Nagaur District of Rajasthan (on-campus)	September 29	12 farmers and other officials from RLDB, Jaipur and CAZRI, Jodhpur	CAZRI, Jodhpur
Regional Research Station, Bikaner			
Chara Utpadan Teknique (Agronomy)	February 22-27,	25	Project Director, ATMA, District Bikaner and CAZRI
Mahilano Ka Sarvangin Vikas Main Udhaniki Ka Mahatva	December 13-16	25	Project Director, ATMA, District Jhunjhunu and CAZRI

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						
Rodent Management in Kharif Crops	-	-	1	15	1	15
Multi nutrient mixture			1	40	1	40
Compost Making			1	30	1	30
Improved Livestock Technologies			1	32	1	32
Improved Cultivation Practices of Kharif Crops	-	-	5	77	5	77

Improved Cultivation Practices of Cumin Crop			1	16	1	16
Improved Cultivation Practices of Rabi Crops (Mustard, Wheat and Cumin)	-	-	1	22	1	22
Total			11	232	11	232
KVK, Jodhpur						
Crop Production	2	20	21	893	23	913
Horticulture	5	51	15	347	20	398
Plant Protection	5	54	14	427	19	481
Livestock	4	93	7	120	11	213
Home Science	6	126	17	604	23	730
Agro-forestry	5	69	20	451	25	520
Agricultural Extension	6	86	19	490	25	576
Total	**33**	**499**	**113**	**3332**	**146**	**3831**
KVK, Pali						
Agriculture Extension	4	65	10	210	14	275
Agronomy	8	240	16	480	24	720
Home Science	5	150	6	112	11	262
Horticulture	3	150	8	230	11	380
Veterinary Science	4	180	12	430	16	610
Total	24	785	52	1462	76	2247
Regional Research Station, Jaisalmer						
Community Rangeland and its Importance for Improvement of Livelihood	-	-	1	33	1	33
Planting Horticultural Crops in *Khadin* to Increase the Economic Return	-	-	1	28	1	28
Total			2	61	2	61
Regional Research Station, Kukma, Bhuj						
Improved Cultivation of Ber in Arid Gujarat	1	107			1	107
Improved Cultivation on Budding in Ber			1	50	1	50
Total	1	107	1	50	2	157

EXTENSION ACTIVITIES BY KVK, JODHPUR

Name of activity	Date	No. of participants
Field day on Pasture Land Development	September 6	100
Field day on Kharif Crops	September 8	215
Field day on Technology Demonstration on Pulses	September 15	209
World Food Day	October 16	100
Women Day in Agriculture	December 4	200

AWARDS AND VISITS

AWARDS

- Fellow of the National Academy of Agricultural Sciences (NAAS) 2010 to Dr. O.P. Yadav for his outstanding contribution in pearl millet improvement for drought tolerance.
- Prof. K.P.V. Menon Commendation certificate 2010 to Dr. Arun Kumar for Best Poster on "Augmentative Bio-Control: An Eco-Friendly Approach for Plant Disease Management", International Conference of Indian Phytopathological Society, IARI, New Delhi.
- Certificate of Excellence 2010 to Dr Devi Dayal by the Academy of Plant Sciences, National Seminar of APSI, at Osmania University, Hyderabad.
- Best Poster Award to Dr. A.S. Rao and Dr. S. Poonia, National Seminar on Impact of Climate Change on Biodiversity and Challenges in Thar Desert, DRC, ZSI, Jodhpur, 9.7.2010.
- Institute Foundation Day Awards, 2010, for the best research paper to Dr. P.C. Moharana and Dr. Amal Kar (Scientists), as best workers to Shri S.B. Sharma (Technical category), Shri Karan Singh (Administrative) and Shri C.K. Soni (Supporting)on 1st October, 2010.
- First Prize for Exhibition Display of the Institute Activities to CAZRI during Sheep Mela Exhibition and Kissan Gosthi, at CSWRI, Avikanagar, Tonk, March 5, 2011.
- Best Poster Award 2010 to Drs. Birbal, V.S. Rathore, N.S. Nathawat and Ms. Seema Bhardwaj, National Seminar on Precision Farming in Horticulture, Dec, 28-29, 2010, College of Horticulture & Forestery, Jhalawar (Rajasthan).
- First Prize for Poster Presentation to Dr. (Mrs.) Sharmila Roy, Xth Agriculture Science Congress-AGROVISION-2011, NBFGR, Lucknow.

VISITS ABROAD

- Dr. J.C. Tarafdar visited School of Engineering & Applied Sciences, Washington University in St. Louis, USA from March 1 to April 30 to attend Training on Exposure to Method to Use Microbes as Bio Nano Factories, its Purification and Characterization
- Dr. Suresh Kumar visited National Institute of Agricultural Botany, Cambridge, United Kingdom from June 28-July 9 to attend Training on DUS Testing and Plant Variety Protection
- Dr. Priyabrata Santra visited International Centre on Theoretical Physics (ICTP), Trieste, Italy form August 30 to September 10 to participate in College on Soil Physics: Soil Physical properties and Processes under Climate Change
- Dr. P.R. Meghwal visited Agadir, Morocco from October17-22 to attend VII International Congress on 'Cactus Pear and Cochineal' and General Meeting of FAO-ICARDA International Technical Cooperation Network on Cactus Pear and Cochineal

- Dr. R.S. Mertia visited Bibilotheca, Alexandria, Egypt form November 6-11 for Presentation of Country Report of UNESCO-SUMAMAD Project and to participate in International Conference on Biodiversity Conservation
- Dr. Dheeraj Singh visited Essen and Hannover, Germany form November 6-12 to attend International Conference on Our Common Future organized by Volkswagen Foundation
- Dr. M.M. Roy visited Cairo, Egypt from December 9-15 to attend 10th International Conference on Development of Drylands

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

Research Papers in Journals

Arun-Kumar 2010. Role of traditional plant protection practices for legume crops in arid areas of Rajasthan. *Journal of Arid Legumes* 7(1): 43-46.

Arun-Kumar, Mali, P.C. and Manga, V.K. 2010. Changes of some phenolic compounds and enzyme activities on infected pearl millet caused by *Sclerospora graminicola*. *International Journal of Plant Physiology and Biochemistry* 2(1): 6-10.

Azam, M.M., Waris, A. and Nahar, N.M. 2010. Suitability of some wildly grown seed oils for use as biodiesel. *Energy Sources* Part A, 32: 657-664.

Bareja, M., Praveen-Kumar and Lodha, S. 2010. Effect of composts on microbial population dynamics and activity, dry root rot severity and seed yield of cowpea in Indian arid region. *Phytopathologia Mediterranea* 49: 381-392.

Bhatt, R.K., Baig, M.J., Tiwari, H.S. and Roy, S. 2010. Growth yield and photosynthesis of *Panicum maximum* and *Stylosanthes hamata* under elevated CO_2. *Journal of Environmental Biology* 31: 549-552.

Bohra, H.C., Khan, M.S., Patel, A K. and Mathur, B.K. 2010. Milk carotene and retinol levels in cattle and goats. *Indian Veterinary Journal* 87(1): 45-46.

Bohra, H.C., Patel, A.K. and Kaushish, S.K. 2010. Palatability, digestibility of various constituents and nitrogen retention in Marwari sheep offered *Salicornia bigelovii* biomass and *Cenchrus ciliaris* straw mixed diet. *Indian Journal of Animal Sciences* 79(10): 1050-1053.

Chaudhary, K.K. and Kaul, R.K. 2010. Effect of the time of application on the biocontrol efficacy of *Pasteuria penetrans* against root-knot nematode, *Meloidogyne incognita*. *Journal of Phytology* 2: 70-74.

Chaudhary, K.K. and Kaul, R.K. 2010. Management of root-knot nematode in chilli by *Pasteuria penetrans* infested soil as transplant application. *Plant Disease Research* 25: 51-54.

Chaudhary, V. and Tripathi, R.S. 2010. Incidence of rodent pests in cumin (*Cuminum cyminum* L.*)* and their management. *Journal of Horticulture Sciences* 5(1): 64-67.

Devi Dayal, Shamsudheen, M. and Meena, S.L. 2010. The present status, potential and constraints in the production of clusterbean (*Cyamopsis tetragonoloba* (L.) Taub) in Kachchh region of Gujarat. *Journal of Arid Legumes* 7(1): 10-13.

Dhir, R.P., Singhvi, A.K., Andrews, J.E., Kar, A., Sareen, B.K., Tandon, S.K., Kailath, A. and Thomas, J.V. 2010. Multiple episodes of aggradation and calcrete formation in Late Quaternary aeolian sands, central Thar Desert, Rajasthan, India. *Journal of Asian Earth Sciences* 37: 10-16.

Dudi, A. and Singh, A.R. 2010. Awareness of the rural and urban women about female foeticide. *Indian Research Journal of Extension Education* 10: 35-38.

Gajja, B.L., Mertia, S. and Purohit, H. 2010. Management of environmental degradation in agricultural production system in arid region of Rajasthan. *Current Agriculture* 34(1&2): 51-60.

Gajja, B.L., Purohit, H. and Sharma, S.B. 2010. Growth, instability and acreage response of mustard crop in arid zone of Rajasthan. *Current Agriculture* 34(1&2): 42-49.

Gawaria, K.M. and Gajja, B.L. 2010. Economic efficiency of wheat crop in arid system of Rajasthan. *Current Agriculture* 34(1&2): 61-68.

Hari Dayal, Singh, D., Lal, G. and Singh, S.K. 2010. Effect of nitrogen, phosphorus and zinc fertilization on soil nutrients status and yield of ber (*Zizyphus mauritiana* Lamk) cv. gola in arid and semi-arid region. *Environment and Ecology* 28 (IA): 328-331.

Henry, A. and Mathur, B.K. 2010. Studies on varietal diversity in mung bean genotypes in arid regions. *Journal of Arid Legumes* 7(2): 151-152.

Israel, S., Mawar, R. and Lodha, S. 2010. Combining sub-lethal heating and on-farm wastes: Effects on *Fusarium oxysporum* f. sp. *cumini* causing wilt on cumin. *Phytoparasitica,* DOI 10/2007.

Kachhawaha, S. and Singh, S. 2010. Hypoderma infestation in chinkara (*Gazella benettii*) – Case report. *Intas Polivet* 22(1): 117-118.

Kachhawaha, S. and Tanwar, R.K. 2010. Biochemical and enzymatic changes in downer cow syndrome. *Indian Journal of Animal Science* 80(4): 338-339.

Kaul, R.K. and Chaudhary, K.K. 2010. Biocidal efficacy of *Pasteuria penetrans* alone and in combination with carbofuran against *Meloidogyne incognita* in chilli. *Plant Disease Research* 25: 51-54.

Khem Chand, Jangid, B.L. and Gajja, B.L. 2010. Growth and instability in area and production of legumes in arid fringes of Rajasthan. *Journal of Arid Legumes* 7(2): 136-139.

Khem Chand, Jangid, B.L., Rao, S.S. and Singh, Y.V. 2009. SWOT analysis of henna cultivation in arid fringe of Rajasthan. *Annals of Arid Zone* 48(1): 79-83.

Khem Chand, Jangid, B.L., Rohilla, P.P. and Kachhawaha, S. 2010. Economics of camel production in Rajasthan. *Journal of Camel Practice and Research* 17(1): 15-20.

Khem Chand, Jangid, B.L., Roy, P.K. and Rao, S.S. 2010. Price spread and efficiency of henna marketing in western Rajasthan. *Indian Journal of Agricultural Marketing* 24(2): 136-144.

Kumar, M., Praveen-Kumar and Bohra, P.C. 2009. Effect of land use systems on soil properties and relationship between SOC and available nutrients in typical arid soils of Rajasthan. *Annals of Arid Zone* 48: 25-28.

Kumar, P. and Syamal, M.M. 2010. Character association studies in bottle gourd. *Indian Journal of Horticulture* 67 (Special Issue): 461-463.

Kumar, S., Purohit, C.S. and Kulloli, R N. 2010. *Ex-situ* conservation of rare plant – *Moringa concanensis* Nimmo Ex Dalz. and Gibs. *Journal of Economic and Taxonomic Botany* 34(3): 693-698.

Kumar, V., Vyakarnahal, B.S., Basavaraj, N. and Birbal 2010. Effect of growth retardants and methods of application on growth and yield of potato. *Indian Journal of Horticulture* 67: 308-313.

Kumar, V., Vyakarnahal, B.S., Basavaraj, N. and Birbal 2010. Response of potato cultivars to different mulches under rainfed conditions. *Indian Agriculurist* 54(1& 2): 1-6.

Kumawat, R.N., Mahajan, S.S. and Mertia, R.S. 2009. Dry matter partitioning, nutrient content and uptake by colocynth (*Citrullus colocynthis* L.) in relation to spacing and nitrogen under rainfed conditions. *Annals of Arid Zone* 48(2): 119-123.

Kumawat, R.N., Mahajan, S.S. and Mertia, R.S. 2010. Effect of spacing and nitrogen on productivity and nitrogen use indices of colocynth (*Citrullus colocynthis*) under rainfed condition. *Indian Journal of Horticulture* 67: 317-322.

Kumawat, R.N., Mahajan, S.S. and Mertia, R.S. 2010. Growth and development of groundnut (*Arachis hypogeae*) under foliar application of 'panchgavya' and leaf extracts of endemic plants. *Indian Journal of Agronomy* 54(3): 324-331.

Kumawat, R.N., Mahajan, S.S. and Mertia, R.S. 2010. Growth and yield of groundnut in relation to soil application of panchgavya and foliar spray of endogenous plant leaf extracts. *Journal of Food Legumes* 23(2): 124-127.

Kumawat, R.N., Mahajan, S.S. and Mertia, R.S. 2010. Response of clusterbean (*Cyamopsis tetragonoloba* L.) to foliar application of panchgavya grown on light textured soils of Indian Thar Desert. *Environment and Ecology* 28(4): 2404-2409.

Kumawat, R.N., Mahajan, S.S., Kandpal, B.K. and Mertia, R.S. 2010. Effect of intra row spacing and nitrogen on growth and physiology of colocynth grown on desert soils. *Indian Journal of Horticulture* 67(4): 470-473.

Kumawat, R.N., Mahajan, S.S., Mertia, R.S. and Sinha, N.K. 2010. Response of colocynth (*Citrullus colocynthis* L.) to different levels of nitrogen and spacing grown on desert soils of Jaisalmer. *Environment and Ecology* 28(4): 2381-2385.

Lodha, S. 2010. Potentials of cruciferous residues in suppression of soil borne plant pathogens. *Indian Phytopathology* 63: 250-260.

Lodha, S. and Harsh, L.N. 2010. Combined effects of bio control agents and residues on root rot mortality in Indian mesquite (*Prosopis cineraria*). *Acta Horticulturae* 883: 317-322.

Lodha, S. and Mawar, R. 2010. Efficacy of native bio-control agents on soil microflora, dry root rot incidence and seed yield of rainfed arid crops. *Indian Phytopathology* 61: 313-317.

Lodha, S., Mawar, R. and Singh, V. 2010. Non-chemical options for managing soil borne plant pathogens in Indian Arid Zone. *Acta Horticulturae* 883: 331-336.

Mahla, H.R., Kumar, D. and Shekhawat, A. 2010. Effectiveness and efficiency of mutagens and induced variability in clusterbean (*Cyamopsis tetragonoloba*). *Indian Journal of Agricultural Sciences* 80(12): 1033-1037.

Mahla, H.R., Shekhawat, A. and Kumar, D. 2010. A study on EMS and gamma mutagenesis in clusterbean [*Cyamopsis tetragonoloba* (L.) Taub]. *Plant Mutation Reports* 2(2): 28-32.

Mathur, B.K. and Henry, A. 2010. Optimum plot size and shape of plots for field experiments on clusterbean under rainfed conditions of arid areas. *Journal of Arid Legumes* 7(2): 148-150.

Mathur, B.K., Sharma, T., Ganai, A.M. and Purohit, G.R. 2010. *In-situ* degradability of guar (*Cyamopsis tetragonoloba*) korma and other arid feeds in sheep using polyester bag techniques. *Journal of Arid Legumes* 7(1): 14-23.

Meena, M.L. and Singh, D. 2010. Impact of training and demonstration in adoption of henna production technology by farmers. *Journal of Extension Systems* 26(1): 84-89.

Meena, M.L., Sharma, N.K. and Singh, D. 2010. Constraints perceived by the farmers in adoption of improved cumin production technology. *Asian Journal of Extension Education* 27(1&2): 48-52.

Meghwal, P.R., Sharma, H.C. and Singh, S.K. 2010. Micro propagation on guava (*Psidium guajava* L.). *Indian Journal of Horticulture* 67 (Special issue): 55-58.

Mertia, R.S., Birbal and Kumawat, R.N. 2010. Performance and field management of six prominent cultivars of date palm (*Phoenix dactylifera*) in extreme arid regions of Thar Desert, India. *Acta Horticulturae* 882: 65-68.

Mertia, R.S., Santra, P., Kandpal, B.K. and Prasad, R. 2010. Mass-height profile and total mass transport of wind eroded aeolian sediments from rangelands of Indian Thar Desert. *Aeolian Research* 2: 135-142.

Mertia, R.S., Sinha, N.K., Kandpal, B.K., Singh, D. 2010. Evaluation of Indian myrrh (*Commiphora wightii*) landraces for hyper arid Thar Desert. *Indian Journal of Agricultural Science* 80(10): 869-871.

Moharana, P.C. and Kar, A. 2010. Quantitative measurement of arid fluvial processes: Results from an upland catchment in Thar Desert. *Journal of the Geological Society of India* 76: 86-92.

Pancholy, A., Jindal, S.K., Singh, M. and Rajora, M.P. 2009. Growth components at juvenile stage and their relationship with height at different growth stages in *Acacia albida*. *Annals of Arid Zone* 48(2): 139-145.

Patel, N., Jindal, S.K. and Singh, M. 2010 Seed characffters and effect of Bruchid infestation on *Acacia senegal* (L.) Willd in Gujarat and Rajasthan. *Journal of Tropical Forestry* 10(1): 16-20.

Pathak, R., Joshi, U.N., Singh, M. and Henry, A. 2010. Guar and its polysaccharide – A Review. *Journal of Arid Legumes* 7(1): 1-9.

Pathak, R., Singh, M. and Henry, A. 2010. Genetic diversity analysis in clusterbean using quality parameters. *Journal of Arid Legumes* 7(2): 144-147.

Pathak, R., Singh, S.K., Singh, M. and Henry, A. 2010. Molecular assessment of genetic diversity in clusterbean (*Cyamopsis tetragonoloba*) genotypes. *Journal of Genetics* 89(2): 243-246.

Rajora, M.P., Jindal, S.K. and Singh, M. 2009. Seed yield and seed germination in primary and secondary spikes in buffel grass. *Annals of Arid Zone* 48(1): 57-62.

Rao, S.S., Regar, P.L. and Singh, Y.V. 2010. *In-situ* rainwater conservation practices in sorghum (*Sorghum bicolor*) under rainfed conditions in arid regions. *Indian Journal of Soil Conservation* 38(2): 105-110.

Rao, S.S., Regar, P.L., Singh, Y.V. and Khem Chand 2010. Effect of micro irrigation on water productivity of cumin (*Cuminum cyminum*) at varying fertility levels. *Indian Journal of Agricultural Sciences* 80(6): 507-511.

Rathore, V.S. and Singh, J.P. 2010. Distribution, diversity and significance of *Acacia jacquemontii* Benth in hot arid region. *Range Management and Agroforestry*. Symposium issue (B): 229-230.

Rathore, V.S., Singh, J.P. and Beniwal, R.K. 2009. Rainfed farming systems of hyper arid northwestern Rajasthan: An analysis. *Annals of Arid Zone* 48(2): 125-131.

Regar, P.L., Rao, S.S. and Joshi, N.L. 2010. *In-situ* rainwater conservation practices on productivity of chickpea (*Cicer arietinum*) in the rainfed condition of arid Rajasthan, India. *Indian Journal of Soil Conservation* 38(2): 111-115.

Rohilla, P.P. and Patel, A.K. 2010. Antihelmintic-28 in controlling nematodes in sheep and goats. *The Indian Veterinary Journal* 87(10): 1035-1036.

Roy, D.K., Singh, D., Sinha, N.K. and Pandey, D.N. 2008. Weed management in winter maize + potato intercropping system. *Indian Journal of Weed Science* 40(1&2): 41-43.

Roy, M.M. 2010. Ameliorating forage availability from non-arable lands: Issues and strategies in arid regions of India. *Range Management and Agroforestry* (Symposium Issue A), 39-40.

Saha, D.K. 2010. Transhumance migration and its changing patterns. *Rajasthan Journal of Sociology* 2: 20-25.

Santra, P., Das, B.S. and Chakravarty, D. 2010. Delineation of hydrologically similar units in a watershed based on fuzzy classification of soil hydraulic properties. *Hydrological Processes* DOI: 10.1002/ hyp.7820.

Santra, P., Mertia, R.S. and Kushawa, H.L. 2010. A new wind erosion sampler for monitoring dust storm events in the Indian Thar Desert. *Current Science* 99(8): 1061-1067.

Shah, N.K., Saxena, P., Azmi, M.I., Roy, Sharmila and Tyagi, P.K. 2010. Ecofriendly pest management in berseem (*Trifolium alexandrium*) and mustard (*Brassica campestris*) mixed forage crop. *Indian Journal of Agricultural Sciences* 80: 1062-1066.

Singh, B. and Chauhan, T.R. 2010. Adoption of mung bean production technology in arid zone of Rajasthan. *Indian Research Journal of Extension and Education* 10(20): 73-77.

Singh, J.P and. Rathore, V.S. 2010. Role of shrubs in augmenting fodder availability and environmental restoration in hot arid region. *Range Management and Agroforestry* Symposium issue (B): 262-263.

Singh, R.N., Saha, D.K. and Singh, B. 2010. Transfer of agriculture technology through VRC programme-A case study. *Agriculture Extension Review* 22(3): 7-11.

Singh, Y.V., Rao, S.S. and Regar, P.L. 2010. Deficit irrigation and nitrogen effects on seed cotton yield, water productivity and yield response factor in shallow soils of semi-arid environment. *Agricultural Water Management* 97(7): 965-970.

Sinha, N.K. and Srivastava, A.K. 2010. Screening of waterlogged resistant maize varieties by determining root porosity. *Environment & Ecology* 28(3A): 1695-1699.

Sinha, N.K. and Srivastava, A.K. 2010. Screening of waterlogged resistant maize varieties by determining leaf porosity. *Current Advances in Agricultural Sciences* 2(2): 262-264.

Tanwar, S.P.S., Rokadia, P. and Singh, A.K. 2010. Productivity, nutrient balance and economics of kabuli chickpea (*Cicer kabulium*) as influenced by integrated nutrient management. *Indian Journal of Agronomy* 55(1): 33-37.

Tanwar, S.P.S., Singh, A.K. and Joshi, N.L. 2010. Changing environment and sustained crop production: A challenge for Agronomy. *Annals of Arid Legumes* 7(2): 91-100.

Verma, N., Tarafdar, J.C. and Srivastava, K.K. 2009. Standardization of inoculum dose of AM fungus for *Prosopis cineraria* seedlings. *Indian Journal of Forestry* 32: 397-400.

Verma, N., Tarafdar, J.C. and Srivastava, K.K. 2010. Periodic changes in *Prosopis cineraria* associated AM population at different soil depth and its relationship with organic carbon and soil moisture. *African Journal of Microbiology Research* 4: 115-121.

Verma, N., Tarafdar, J.C. and Srivastava, K.K. 2010. Role of AM strains on biomass production and P, Cu, Zn uptake in *Prosopis cineraria*. *The Indian Forester* 136: 205-214.

Yadav, B.K. and Tarafdar, J.C. 2009. Extracelular acid phosphatase and phytase activities of buffel brass (*Cenchrus ciliaris* L.) genotypes. *Journal of the Indian Society of Soil Science* 57: 332-337.

Yadav, B.K. and Tarafdar, J.C. 2010. Studies on phosphatases activity and clusterbean production as influenced by the P mobilization organism *Emericella rugulosa*. *Legume Research* 33: 114-118.

Yadav, B.K., Niwas, Ram, Yadav, R.S. and Tarafdar, J.C. 2009. Effect of *Chaetomium globosum* inoculation and organic matter on phosphorus mobilization in soil and yield of clusterbean. *Annals of Arid Zone* 48: 41-44.

Yadav, O.P. 2010. Drought response of pearl millet landrace-based populations and their crosses with elite composites. *Field Crops Research* 118: 51-57.

Yadav, O.P. 2010. Evaluation of landraces and elite populations of pearl millet for their potential in genetic improvement for adaptation to drought-prone environments. *Indian Journal of Genetics and Plant Breeding* 70: 120-124.

Chapter in Books

In *Feeding and Management of Livestock during Drought and Scarcity* (Eds. N.V. Patil, B.K. Mathur, A.K. Patel, M. Patidar and A.C. Mathur), Scientific Publishers (India), Jodhpur, 336 p.

Bhati, T.K. 2010. Shrub and legume based pastures for sustainable animal production–Problems and prospects. pp. 198-205.

Bohra, H.C. 2010. Supplementary feed blocks and nutrient mixture: An approach for balanced feeding during droughts. pp. 41-58.

Harsh, L.N. 2010. Multipurpose trees as alternate feed resources for better livestock production in dry areas particularly in arid zone. pp. 152-160.

Khan, M.S. 2010. Potable and hypersaline water use efficiencies in arid livestock. pp. 231-240.

Mathur, B.K. 2010. Feeding practices of livestock during drought conditions-importance of feed supplements. pp. 1-20.

Patel, A.K. 2010. Management of shelter for amelioration of environment stress for optimum production. pp. 206-217.

Patidar, M. 2010. Silvipastoral approach to combat fodder crises during drought. pp. 161-170.

Patil, N.V. 2010. Drought: Impact on agriculture and livestock, major nutritional strategies to overcome ill effects in livestock. pp. 59-79.

Rajora, M.P. 2010. Propagation and management of grasses of arid zone. pp. 171-177.

Rohilla, P.P. 2010. Role of probiotics in improving livestock productivity. pp. 241-256.

Singh, H. 2010. Processing and conservation of feed resources for livestock feeding during drought. pp. 112-123.

Singh, J.P., Mathur, B.K., Rathore, V.S. and Beniwal, R.K. 2010. Weeds as a source of fodder in hot arid zone: A review. pp. 124-144.

Mathur, A.C. 2010. Impact of drought on reproduction and fertility in animals. pp. 284-297.

Kachhawaha, S., Patil, N.V., Gahlot, A.K., Mathur, B.K. and Mathur, A.C. 2010. Diseases management and control in ruminants in arid region. pp. 317-327.

In *Climate Change and Stress Management: Sheep & Goat Production* (Eds. S.A. Karim, Anil Joshi, S.K. Sankhyan, A.K. Shinde, D.B. Shakyawar, S.M.K. Naqvi and B.N. Tripathi). Published by Satish Serial Publishing House, Delhi-110033.

Patel, A.K. 2010. Effect of environmental stress on animal productivity and its amelioration through shelter management. pp. 231-248.

Patil, N.V. and Patel, A.K. 2010. Forage production and feeding plan for small ruminants during scarcity in drought prone region. pp. 89-100.

In *Modern Trends in Library and Information Science* (Eds. Pawan K. Gupta and Tirth Das). Scientific Publishers (India), Jodhpur, 524 p.

Das, T. 2010. Digital Libraries: An overview. pp. 250-264.

Dave, R.K. and Das, T. 2010. Open source software for library management. pp. 290-304.

In Others Books

Goyal, R.K. and Roy M.M. 2010. In water resources problems and management in perspective of Punjab (India). In *Water Availability and Management in Punjab* (Eds. M.S. Rao, Suhas

Khobragade, Bhism Kumar and R.D. Singh). pp. 365-370. Published by National Institute of Hydrology, Roorkee.

Khem Chand, Lal, G. and Mathews, C. 2010. Prospects, problems and opportunities in marketing of seed spices. In *Lead Papers* (Eds. Gopal Lal, O.P. Aishwath, S.N. Saxena, Y.K. Sharma, R.S. Mehta and S.S. Meena), pp. 131-132. National Consultation on Seed Spices Biodiversity and Production for Export-Perspective, Potential, Threats and their Solutions, NRCSS, Ajmer.

Pande, P.C. 2010. SAREGA: Solar appliances for rural energy guaranty and assurance. Jawahar Lal National Solar Mission- The Road Ahead (Eds. Jagat S. Jawa and S. Swarn), pp. 11-19. Electronics Today, Mumbai.

Raj Bhansali, R. 2010. Biology and multiplication of *Prosopis* species grown in the Thar Desert. In *Desert Plants Biology and Biotechnology* (Ed. K.G. Ramawat), pp. 371-406. Springer Berlin Heidelberg.

Raj Bhansali, R. 2010. Clonal propagation of woody plants of arid zone. In *Advances in Applied Biotechnology* (Ed. P. Parihar), pp. 241-256. Agrobios (India), Jodhpur.

Raj Bhansali, R. 2010. Date palm cultivation in the changing scenario of Indian arid zones: Challenges and prospects. In *Desert Plants Biology and Biotechnology* (Ed. K.G. Ramawat), pp. 423-459. Springer Berlin Heidelberg, New York.

Raj Bhansali, R. 2010. Management of *Ganoderma* basal stem rot disease of *Prosopis cineraria* (L.) Druce through biocontrol fungi. In *Plant Diseases and its Management* (Ed. P.C. Trivedi), pp. 135-151. Pointer Publishers, Jaipur.

Rao, A.S. 2010. Climate variability and crop production over the arid Rajasthan. In *Climate Change and Agriculture over India* (Eds. G.S.L.H.V.P. Rao, G.G.S.N. Rao and V.U.M. Rao), pp. 201-217. PHI Learning, New Delhi.

Rao, A.S. and Poonia, S. 2010. Climate change scenarios influencing the Thar Desert Ecosystem. In *Impact of Climate Change on Biodiversity and Challenges in Thar Desert* (Eds. Ramakrishna, Kailash Chandra, Padma Bohra and Gaurav Sharma), pp. 33-41. Desert Regional Centre, Zoological Survey of India, Jodhpur.

Roy, M.M. 2010. Mitigating green house gases: Options in agriculture. In *Impact of Climate Change on Biodiversity and Challenges in Thar Desert* (Eds. Ramakrishna, Kailash Chandra, Padma Bohra and Gaurav Sharma), pp. 1-7. Desert Regional Centre, Zoological Survey of India, Jodhpur.

Roy, M.M. and Bhati, T.K. 2010. Strategies to improve livelihood in arid areas through sustainable management of natural resources. In *Productivity Enhancement through Sustainable Management of Natural Resources* (Eds. S.P. Wani, K.H. Aranta and K.L. Sherawat), pp. 139-148. International Crop Research Institute for the Semi Arid Tropics, Patancheru, Hyderabad (AP), India.

Roy, M.M. and Singh, K.A. 2010. Forage legumes for sustainable livestock production and wasteland management. In *Lead Paper*: *International Conference on Nuturing Arid Zones for People and the Environment: Issues and Agenda for the 21st* Century (Eds. R.S. Tripathi, R.K. Kaul, Praveen-Kumar, Amal Kar and N.V. Patil), pp. 178-185. Arid Zone Research Association of India, Jodhpur.

Singh, R. and Singh, B. 2009. Integrated nutrient management in clusterbean-Indian mustard cropping systems in arid zone. In *Legumes in Dry Areas* (Eds. D. Kumar, A. Henry and K.P.R. Vittal), pp. 333-339. Indian Arid Legumes Society and Scientific Publishers, Jodhpur.

Tripathi, R.S. 2010. Rodent pest management in arid land farming systems. In *Sustainable Crop Protection Strategies* (Eds. H.R. Sardana, O.M. Bambawale and D. Prasad), pp. 486-502.

Vittal, K.P.R., Kar, A. and Rao, A.S. 2010. Indicators for assessing drought hazard in arid regions of India. In *Natural and Anthropogenic Disasters: Vulnerability, Preparedness and Mitigation* (Ed. Madan Kumar Jha), pp. 237-255. Capital Publishing Co., New Delhi.

Papers in Conference Proceedings

Gajja, B.L. and Mertia, R.S. 2010. Management of Natural Resources for sustainable agricultural production in arid region of Rajasthan. In *National Seminar on Management of Natural Resources and Environment in India*, pp. 588-596. GAD Institute of Development Studies, Amritsar.

Gajja, B.L. and Mertia, R.S. 2010. Management of environmental degradation in agricultural production in arid region of Rajasthan. In *National Symposium on Natural Resource Management in Agriculture (NRMA-II)*, pp. 53-60. PEROM Society, Rajasthan College of Agriculture, Maharana Pratap Univ. of Agril. & Technology, Udaipur.

Mathur, A.C., Dutt, G., Patil, N.V. and Mathur, B.K. 2010. Increasing dominance of buffaloes over cows as milk animals in arid districts of Rajasthan. In *Proceedings of International Buffalo Congress on Optimizing Buffalo Productivity through Conventional and Novel Technologies*, NASC, New Delhi.

Mathur, A.C., Dutt, G., Patil, N.V., Mathur, B.K. and Kachhawaha, S. 2010. Managemental practices and reproductive performance of buffaloes in rural arid region of Rajasthan. In *Proceedings of International Buffalo Conference on Optimizing Buffalo Productivity through Conventional and Novel Technology*, 1-4 February, 2010, New Delhi 2: 102.

Nahar, N.M. 2010. Solar energy for sustainable development. In *Proceedings of National Conference on Energy and Sustainable Development*, pp. 1-10. Jodhpur Institute of Engineering and Technology.

Nahar, N.M. 2010. Design, development of efficient solar desalinator for rural arid areas. In *Proceedings of International Congress on Renewable Energy (ICORE)*, pp. 199-204. Solar Energy Society of India, New Delhi.

Nahar, N.M. 2010. Solar water heaters for developing countries. In *Proceedings of World Sustainable Energy Days 2010*, pp.1-11. Solar Thermal Conference Wels, O. Öe. Energiesparverband, Austria.

Pande, P.C. 2010. Photovoltaics in agricuture. In *Proceedings National Conference on Advances on Materials and Devices for Renewable Energy Sources (NCAMDRES –10)*, pp. 49-59. JEC Groups of Colleges, Kukas, Jaipur.

Pande, P.C., Singh, A.K., Dave, B.K. and Purohit, M.M. 2010. A preheated solar PV dryer for economic growth of farmers and entrepreneurs. In *Proceedings of International Congress on Renewable Energy (ICORE)*, pp. 68-73. Solar Energy Society of India, New Delhi.

Patidar, M. and Rajora, M.P. 2010. Effect of irrigation scheduling on fodder yield of different cropping sequences under limited irrigation condition in arid zone. In *Extended Summaries of XIX National Symposium on Resource Management Approaches Towards Livelihood Security,* p. 227. December 2-4, Bengaluru. Indian Society of Agronomy, ICAR, University of Agril Sciences, Bengaluru Kanataka.

Patil, N.V. and Singh, J.P. 2010. Optimal utilization of feed resources for enhancing livestock productivity in arid region. In *Animal Nutrition Strategies for Environment Protection and Poverty Alleviation* (Eds. A.K. Pattanaik, A.K. Verma, and N. Dutta), Vol. I, pp. 50-56. Lead

Papers. Proceedings of VII Biennial Animal Nutrition Association Conference, Bhubaneswar, India.

Roy, S. 2010. Response of fodder production systems to oribatid mite community structure in semi-arid central India. *Range Management and Agroforestry Symposium Issue* (A): 33-34.

Tewari, P. and Seena, M. 2010. Validation of indigenous technical knowledge of grain storage. In *Post-Harvest Management of Seed for Quality Assurance and Farmer's Prosperity*, pp. 112-113. IARI, Karnal.

Tewari, P., Gajja, B.L. and Waris, A. 2010. Impact of increasing buffalo population on workload of women in arid zone. In *International Buffalo Conference on Optimizing Buffalo Productivity through Conventional and Novel Technologies*, pp. 374-380. CIRB & ICAR, New Delhi.

Tomar, A.S., Singh, R.P., Bhati, T.K., Bhandari, M.C., Bhati, P.S. and Bagujar, V.K. 2010. Impact of technology on in-situ ber budding in arid zone of Rajasthan. In *Proceeding of National Symposium on Food Security in Context of Changing Climate*, pp. 79-80. CSUA&T, Kanpur.

Books/Bulletins

Birbal, Rathore, V.S., Singh, J.P., Nathawat, N.S. and Bhardwaj, S. (Eds.) 2010. उद्यानिकी विकास : महत्व एवं तकनीक। CAZRI, RRS, Bikaner, 134 p.

Birah, A., Tripathi, R.S., Mohan Rao, A.M.K. and Srivastava, R.C. 2010. *Rodents and their Management in Andaman and Nikobar Islands*. AINP on Rodent Control and CARI, Port Blair. 12 p

Devi Dayal, Bhagirath Ram, Shamsudheen, M. and Singh, Y.V. 2010. *Dissemination of Technologies through Farmer's Participatory Approach in Kachchh, Gujarat*. Regional Research Station, Central Arid Zone Research Institute, Kukma-Bhuj, Gujarat, 24 p.

Gupta, Pawan K. and Das, T. 2010. *Modern Trends in Library and Information Science*. Scientific Publishers (India), Jodhpur, 524 p.

Kundu, S., Adhikari, T., Biswas, A.K., Tarafdar, J.C., Goswami, A. and Subba Rao, A. 2010. *Nano-Science and Nanotechnology in Soil Fertility and Plant Nutrition Research*. IISS Technical Bulletin, Indian Institute of Soil Science (ICAR), Nabibagh, Bhopal, 46 p.

Rao, A.S. and Poonia, S. 2010. किसान जागरूकता कार्यक्रम मौसम आधारित कृषि सेवाए। काजरी, जोधपुर, 19 पृ.

Sridhara, S., Nagachaitanya, B., Ravindra Babu, T. and Tripathi, R.S. 2010. *The Larger Bandicoot Rat, Bandicota indica (Bechstein)*, Technical Bulletin No. 16. All India Network Project on Rodent Control, Central Arid Zone Research Institute, Jodhpur, 39 p.

Tripathi, R.S., Kaul, R.K., Praveen Kumar, Kar, Amal and Patil, N.V. (Eds.) 2010. *Lead Papers-International Conference on Nurturing Arid Zones for People and the Environment: Issues and Agenda for 21st Century*. Arid Zone Research Association of India, Jodhpur, 380 p.

Yadava, N.D., Pal, Suresh, Beniwal, R.K. and Rajora, M.P. 2010. *Sewan: Production and Conservation Technology*. Prateeksha Publications, Jaipur, India. 87 p.

Yadava, N.D., Singh, J.P., Rathore, V.S. Nathawat, N.S., Birbal and Singh, S. 2010. चारा उत्पादन तकनीक। CAZRI RRS, Bikaner and Project Director, ATMA, Bikaner, 84 p.

Popular Articles

In *मरू कृषि चयनिका, गोल्डन जुबली विशेषांक,* भाग ग्यारह (जनवरी–दिसम्बर, 2010), केन्द्रीय शुष्क क्षेत्र अनुसंधान संस्थान, जोधपुर। 80 पृ.

Bhagirath Ram, Devi Dayal, Manga, V.K., Shamsudheen, M. and Kumar, A. 2010. गुजरात के कच्छ क्षेत्र में तिल की उन्नत एवं लाभदायक खेती। पृ. 20-26.

Henry, A. and Roy, P. K.2010. ग्वार की उन्नत खेती। पृ. 4-12.

Kumar, D. 2010. मरू क्षेत्र में मोठ की सफल खेती। पृ. 13-19.

Kumar, P. and Meghwal, P.R. 2010. संचित शुष्क क्षेत्रों में गाजर की लाभकारी खेती। पृ. 34-38.

Lodha, S. and Mawar, R. 2010. गेहूँ की फसल को रोगों से कैसे बचायें। पृ. 62-64.

Manga, V.K., Arun-Kumar, Bhagirath Ram and Solanki, M.S. 2010. शुष्क क्षेत्रों के लिए बाजरा की उन्नत किस्में। पृ. 1-3.

Meghwal, P.R. and Kumar, P. 2010. खजूर की व्यवसायिक खेती। पृ. 39-48.

Pathak, R., Singh, S.K. and Pancholi, A. 2010. कृषि में सूक्ष्मजीवी कीटनाशियों का उपयोग। पृ. 58-61.

Purohit, C.S., Kulloli, R. and Kumar, S. 2010. विलुप्त प्रायः पादप प्रजाति सरगुड़ा का संरक्षण। पृ. 65-67.

Rao, A.S., Poonia, S. and Purohit, R.S. 2010. पश्चिमी राजस्थान में अकालों का तुलनात्मक विवेचन। पृ. 49-53.

Sharma, P., Malaviya, P.K., Singh, H. and Mishra, D. 2010. जीरा सफाई एवं श्रेणीकरण मशीन का विकास। पृ. 68-72.

Srivastava, S. 2010. मृदा की घटती उर्वरता के कारण एवं प्रबंधन। पृ. 54-57.

In किसान जागरूकता कार्यक्रम मौसम आधारित कृषि सेवा । (Eds. A.S. Rao and Surendra Poonia) शुष्क क्षेत्र अनुसंधान संस्थान, जोधपुर, 19 पृ.

Bhati, T.K. and Singh, B. 2010. पश्चिमी राजस्थान में टिकाऊ खेती के लिए जलवायु के अनुरूप फसल विविधिकरण एवं मौसम पूर्वानुमान के अनुसार फसल प्रबन्धन । पृ. 3–4.

Lodha, S. 2010. मौसम के बदलाव से जनित फसलों के रोग । पृ. 5–9.

Mathur, B.K., Mathur, A.C. and Patil, N.V. 2010. शुष्क क्षेत्र में मौसमनुसार होने वाले पशुओं के मुख्य रोग एवं उपचार । पृ. 13–17.

Meghwal, P.R. and Hari Dayal 2010. फलदार पेड़ एवं मौसम । पृ. 10–12.

Rao, A.S., Poonia, S., Purohit, R.S., Mertia, R.S., Sharma, M.D., Laxmi Narayan, Singh, B. and Choudhary, S. 2010. मानसून एवं वर्षा पूर्वानुमान की उपयोगिता किसान जागरुकता कार्यक्रम मौसम आधारित कृषि सेवा । पृ. 1–2.

In चारा उत्पादन तकनीक (Eds. N.D. Yadava, J.P. Singh, V.S. Rathore, N.S. Natahawat, Birbal and Satendra Pal), क्षेत्रीय अनुसंधान केन्द्र, काजरी, बीकानेर एवं परियोजना निदेशक, कृषि प्रौद्योगिकी प्रबन्धन एजेंसी (आत्मा), बीकानेर । 84 पृ.

Beniwal, R.K. Soni, M.L., Yadava, N.D. and Singh, J.P. 2010. वन चारागाह प्रबन्धन। पृ. 17-18.

Birbal, Rathore, V.S., Singh, J.P., Nathawat, N.S. and Yadava, N.D. 2010. शुष्क क्षेत्रों के लिए उद्यान चारागाह। पृ. 19-22.

Rathore, V.S., Birbal, Singh, J.P., Yadava, N.D. and Nathawat, N.S. 2010. चारा उत्पादन हेतु कृषि वानिकी प्रारूप। पृ. 14-16.

Rathore, V.S. Birbal, Singh, J.P. Nathawat, N.S., Yadava, N.D. and Beniwal, R.K. 2010. चारा फसलों का उपयुक्त फसल चक्र। पृ. 36-42.

Yadava, N.D., Beniwal, R.K and Soni, M.L. and 2010. मरूक्षेत्र में बहुवर्षीय घासों की उन्नत तकनीक। पृ. 9-13.

Yadava, N.D. Soni, M.L. and Beniwal, R.K. 2010. शुष्क क्षेत्रों की विभिन्न भू परिस्थितियों में चारा उत्पादन। पृ. 5-8.

In उद्यानिकी विकास महत्व एवं तकनीक (Eds. Birbal, V.S. Rathore, J.P. Singh, N.S. Nathawat and S. Bhardwaj), क्षेत्रीय अनुसंधान केन्द्र, काजरी, बीकानेर । 134 पृ.

Bhardwaj, S., Rathore, V.S., Birbal, Nathawat, N.S. and Soni, M.L. 2010. उद्यानिकी फसलों में पोषक तत्व प्रबन्धन : सिद्वान्त एवं तकनीकें। पृ. 79-84.

Birbal, Rathore, V.S., Nathawat, N.S., Bhardwaj, S. and Singh, J.P. 2010. शुष्क एवं अर्धशुष्क क्षेत्रों में खरीफ सब्जी उत्पादन। पृ. 16-20.

Birbal, Rathore,V.S., Nathawat, N.S., Bhardwaj, S. and Singh, J.P. 2010. गृह वाटिका। पृ. 8-15.

Nathawat, N.S., Rathore,V.S., Birbal and Bhardwaj, S. 2010. उद्यानिकी फसलों में पादप वर्धी नियंत्रकों एवं नियामकों का प्रयोग : महत्व एवं तकनीक। पृ. 121-126.

Rathore, V.S., Birbal, Singh, J.P., Nathawat, N.S. and Bhardwaj, S. 2010. बीजीय मसाला फसल उत्पादन : महत्व व उत्पादन तकनीक। पृ. 27-36.

Rathore, V.S., Singh, J.P., Birbal, Nathawat, N.S. and Bhardwaj, S. 2010. शुष्क एवं अर्धशुष्क क्षेत्रों में उद्यानिकी विकास : महत्व एवं संभावनाऐं। पृ. 4-7.

Singh, J.P. and Rathore, V.S. 2010. उद्यानिकी फसलों का वैकल्पिक भूमि उपयोग पद्धतियों में समावेश। पृ. 118-120.

Soni, M.L.,Yadava, N.D. and Bhardwaj, S. 2010. बागवानी विकास हेतु मृदा संसाधन : जानकारी एवं प्रबन्धन। पृ. 85-87.

Yadava, N.D. 2010. उद्यानिकी फसलों में जल प्रबन्धन । पृ. 88-92.

Yadava, N.D., Beniwal, R.K. and Soni, M.L. 2010. मरूक्षेत्र में बहुवर्षीय घासों की उन्नत तकनीक। पृ. 9-13.

Other Popular Articles

Bhardwaj, S., Birbal, Rathore,V.S., Nathawat, N.S. and Singh, J.P. 2010. खाद्य सुरक्षा : चुनौतियॉ एवं समाधान। *चोखी खेती* 9: 3-5.

Bhardwaj, S., Rathore, V.S., Birbal, and Nathawat, N.S. 2010.शुष्क क्षेत्रों की समस्याऐं एवं सम्भावनाऐं। *संवाद* 3: 11-12.

Birbal, Rathore,V.S., Bhardwaj, S. and Nathawat, N.S. 2010. अधिक उपज के लिए कद्दू वर्गीय सब्जियों में वृद्वि नियामकों का प्रयोग करें। *चोखी खेती* 10: 6.

Jangid, B.L., Rao, S.S. and Rohilla, P.P. 2010. फव्वारा सिंचाई पद्धति का उपयुक्त संचालन । *खेती* 63: 16-18 & 21.

Kachhawaha, S., Singh, D., Choudhary, M., Dudi, A. and Maroo, A. 2010. बकरियों के बच्चों का रख–रखाव। *राजस्थान खेती प्रताप* : 24–25.

Kar, A. 2010. Managing water in Thar. *Geography and You* 10 (July-August): 36-40.

Kar, A. 2010. Presidential address. *Souvenir Volume, Twenty-third Conference of Indian Institute of Geomorphologists & National Seminar on Global Environmental Change: Geomorphological Issues and Challenges*, pp. 21-24. Department of Geography, Gauhati University, Guwahati.

Poonia, S. and Rao, A.S. 2010. पश्चिमी राजस्थान के अकाल। *पर्यावरण ऊर्जा टाइम्स* पृ. 8-10.

Purohit, C.S., Kulloli, R.N. and Kumar, S. 2010. भारतीय मरूस्थल में लुप्तप्रायः पादप प्रजातियों का संरक्षण एवं संवर्धन। *कृषि किरण* 3: 57-60.

Purohit, C.S., Kulloli, R.N. and Kumar, S. 2010. सरगूड़ा पादप प्रजाति का संरक्षण एवं समवर्धन । *खेती* (Oct): 30-31.

Rathore, V.S. 2010. रबी फसलों में उन्नत तकनीकियॉ अपनाऐं – अधिक उपजाऐं अधिक कमाऐं। *कृषि भारती* 2: 34-35.

Singh, B. and Singh, Y.V. 2009. प्रशिक्षण का किसानों के ज्ञान पर प्रभाव। *कृषि विस्तार समीक्षा* 19(4): 10-12.

Tanwar, S.P.S., Shiv Datt, Jodha B.S. and Singh, A.K. 2010. खरीफ में चारा उत्पादन की संभावनाऐं । *खाद पत्रिका* 51(7): 30-34.

Tewari, P. 2010. जन स्वास्थ्य एवं महिलाऐं। *ईशीर समाचार* (April-June): 5.

Tripathi, R.S. 2010. चूहा फसल का दुश्मन। *Farm and Food* (June) 16: 4-6.

Extension Folders/Leaflets

Arvind Kumar, Devi Dayal, Shamsudheen, M. and Hargovind. 2010. *Improved Cultivation of Pomegranate in Kachchh*. CAZRI, RRS, Kukma-Bhuj. 6 p. (in Gujarati).

Arvind Kumar, Shamsudheen, M., Devi Dayal, and Hargovind 2010. *Improved Cultivation of Papaya in Kachchh*. CAZRI, RRS, Kukma-Bhuj. 6 p. (in Gujarati).

Devi Dayal, Shamsudheen, M and Bhagirath Ram 2010. *Improved Cultivation of Clusterbean in Kachchh*. CAZRI, RRS, Kukma-Bhuj. 6 p. (in Gujarati).

Devi Dayal, Shamsudheen, M. and Bhagirath Ram 2010. *Improved Cultivation of Sesame in Kachchh*. CAZRI, RRS, Kukma-Bhuj. 6 p. (in Gujarati).

Devi Dayal, Shamsudheen, M., Arvind Kumar and Hargovind 2010. *Improved Cultivation of Fenugreek in Kachchh*. CAZRI, RRS, Kukma-Bhuj, Gujarat. 6 p. (in Gujarati).

Devi Dayal, Shamsudheen, M., Arvind Kumar and Hargovind 2010. *Improved Cultivation of Fennel in Kachchh*. CAZRI, RRS, Kukma-Bhuj, 6 p. (in Gujarati).

Devi Dayal, Shamsudheen, M., Arvind Kumar and Hargovind 2010. *Rodent Control*. CAZRI, RRS, Kukma-Bhuj, 6 p (in Gujarati), Gujarat, 6 p.

Meghwal, P.R. and Daya, H. 2010. *किसान जागरुकता कार्यक्रम मौसम आधारित किसान सेवा*। किसान जागरुकता कार्यक्रम मौसम आधारित किसान सेवा । केन्द्रीय शुष्क क्षेत्र अनुसंधान संस्थान, जोधपुर एवं भारत मौसम विज्ञान विभाग, पुणे.

Shamsudheen, M, Devi Dayal, Arvind Kumar and Hargovind 2010. *Improved Cultivation of Date palm in Kachchh*. CAZRI, RRS, Kukma-Bhuj, 6 p (in Gujarati).

Shamsudheen, M, Devi Dayal, Arvind Kumar and Hargovind. 2010. *Improved Cultivation of Coriander in Kachchh*. CAZRI, Regional Research Station, Kukma-Bhuj, Gujarat, 6p.

Shamsudheen. M, Devi Dayal and Bhagirath Ram, 2010. *Improved Cultivation of Cumin in Kachchh*. CAZRI, RRS, Kukma-Bhuj, 6 p (in Gujarati).

Shamsudheen. M, Devi Dayal and Bhagirath Ram, 2010. *Improved Cultivation of Castor in Kachchh*. CAZRI, RRS, Kukma-Bhuj, 6 p (in Gujarati).

Shamsudheen. M, Devi Dayal, Bhagirath Ram, Panwar, H.S. and Varu, P.M. 2010. *Post Harvest Management and Value Addition in Ber*. CAZRI, RRS, Kukma-Bhuj, 6 p (in Gujarati).

Singh, B., Singh, R. and Singh, Y.V. 2010. *रायड़ा की उन्नत खेती* । काजरी, जोधपुर, 3 पृ.

Singh, B., Singh, R. and Singh, Y.V. 2010. *बाजरा की उन्नत खेती* । काजरी, जोधपुर, 3 पृ.

Singh, B., Singh, R. and Singh, Y.V. 2010. *ग्वार की उन्नत खेती* । काजरी, जोधपुर, 3 पृ.

Singh, R., Singh, B. and Singh, Y.V. 2010. *तिल की उन्नत खेती* । काजरी, जोधपुर, 3 पृ.

Singh, R., Singh, B. and Singh, Y.V. 2010. *दलहनी फसलों की उन्नत खेती* । काजरी, जोधपुर, 3 पृ.

Singh, R., Singh, B. and Singh, Y.V. 2010. *गेहूँ की उन्नत खेती* । काजरी, जोधपुर, 3 पृ.

Singh, Y.V., Singh, R. and Singh, B. 2010. *जीरे की उन्नत खेती* । काजरी, जोधपुर, 3 पृ.

Singh, Y.V., Singh, R. and Singh, B. 2010. *अरण्डी की उन्नत खेती* । काजरी, जोधपुर, 3 पृ.

Tewari, P., Seena, M., Singh, Y.V. and Roy, M.M. 2010. *Kachra (Cucumis melo) An Underutilized Gift of Nature*. Central Arid Zone Research Institute, Jodhpur, 4 p.

Tomar, A.S., Tripathi, R.S., Kaul, R.K., Singh, R.P., Roy, Sharmila, Bhati, P.S. Badgujar, V.K. and Bhandari, M.C. 2010. *सब्जियों की फसलों में पौध संरक्षण*। कृषि विज्ञान केन्द्र, काजरी, जोधपुर 4 पृ.

RESEARCH PROGRAMMES

ICAR-FUNDED PROJECT

Integrated Basic and Human Resources Appraisal, Monitoring and Desertification

- Assessment of changes in fertility status of soils in Central Research Farm of CAZRI under different land use systems
- Integrated natural resources survey of the arid tehsils of Banaskantha and Sirohi districts
- Soil fertility assessment and mapping in arid Region of Rajasthan
- Assessment of the soil resources at CAZRI, RRS, Kukma, Bhuj for identification of problems and its management
- Harvesting fuzziness and spatial variability in land resource data for sustainable and dynamic land use planning
- Studies on evapotranspiration and yield relationships in sesame
- Quantitative erosion process measurement and spatio-temporal variability in sediment transport in arid ephemeral stream channels

Biodiversity Conservation, Improvement of Annuals and Perennials

- Biotechnological applications for characterization and improvement of arid zone plant species
- Improvement of pasture grasses and legumes of arid zones: *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
- Survey, collection, conservation and evaluation of some underexploited indigenous fruit types/cultivars in arid region
- Collection, evaluation and conservation of arid rangeland shrubs
- 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 seame (*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 rangeland 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

Integrated Arid Land Farming System Research

- Biotechnological applications for characterization and improvement of arid zone plant species
- Improvement of pasture grasses and legumes of arid zones: *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
- Survey, collection, conservation and evaluation of some underexploited indigenous fruit types/cultivars in arid region
- Collection, evaluation and conservation of arid rangeland shrubs
- 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
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Management of Land and Water Resources

- Study of intensive agroforestry models developed with organic input in arid zone
- Hydrological monitoring and catchments development of Beriganga research farm
- 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

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

- Products of economic importance from arid zone plants
- 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

Integrated Pest Management

- Bio-efficiency of arbuscular fungi for the management of root-knot nematode and nutrient uptake in solanaceous crops.
- Exploration and identification of biocontrol fungi for the management of Ganoderma disease
- 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
- Extensive field evaluation of three-furrow (six-rows) multi-crop seed drill for prototype manufacture
- Development of solar systems for purification of brackish water for drinking
- Development of low pressure drip irrigation systems
- Design and development of tractor drawn weeder
- Improvement of passive cool chamber with alternative materials

Socio-economic Investigation and Evaluation

- Economic analysis of camel production system in arid Rajasthan
- 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

- Popularization of selected CAZRI technologies for strengthening production systems in Dantiwada village of Jodhpur district and Salasar village of Sikar district

- Study on constraints in dissemination of improved agriculture technologies among the farmers in Indian arid region
- 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

Externally Funded Project

- 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
- Hydrological database development and capacity building for watershed management in arid ecosystem
- Development and application of biotechnological tools for millet improvement: QTL mapping and marker-assisted selection to improve drought tolerance in pearl millet
- ICAR Mega seed project on seed production in agricultural crops
- Nation wide mapping of land degradation at 1:50,000 scale (five districts of western Rajasthan)
- 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
- All India Network Project on Rodent Control
- National Network Project on Arid Legumes

REVOLVING FUND SCHEMES

The Institute has eight schemes under Revolving Fund. Revenue of Rs. 1701926 was generated through such schemes.

REVENUE GENERATED

Particular	Amount (Rs.)
Sale of farm produce	1703986
Analytical testing fee	280000
Rent charges	776349
Interest on loans and advances	726623
Miscellaneous receipts	3971947
Interest on TDR	1335838
Total	8794743

INFRASTRUCTURE DEVELOPMENT

- Renovations of server room in Agricultural Knowledge Management Unit, CAZRI, Jodhpur
- Replacement of drainage system in CAZRI, Jodhpur
- Electrical rewiring in type IV qtrs., CAZRI, Jodhpur
- Upgradation of street light fittings, cables, timer panel, feeder pillar, etc., in office building area, CAZRI, Jodhpur
- Renovation of examination hall and server room in Library Building for on line NET/ARS Examination at CAZRI, Jodhpur
- Renovation of Silva Lab. Under NAIP Project at CAZRI, Jodhpur
- Renovation of Laboratories under NAIP Project at CAZRI, Jodhpur
- Construction of seed store and yard at CAZRI, Jodhpur
- Providing and installation of feeder pillar for tube well of seed project at CAZRI, Jodhpur
- Construction of pump room, water tank and supply lines for tube well at RRS, Bikaner
- Construction of threshing yard floor at RRS, Bikaner
- Repair/renovation works of toilets and strengthening of porch of office building at RRS, Pali.

INSTITUTE MEETINGS

ICAR Regional Committee-VI

The 21st Meeting of ICAR Regional Committee VI (States: Rajasthan and Gujarat; Union Territories: Daman & Diu, and Dadra & Nagar Haveli) on Centre-State Coordination for Research and Development Linkages in Agricultural Research, Education and Extension, was held at Swami Keshwanand Rajasthan Agricultural University, Bikaner, on 21-22 October 2010, under the chairmanship of Dr. S. Ayyappan, Secretary, DARE, and Director General, ICAR. The meeting was organized by Central Arid Zone Research Institute (CAZRI), Jodhpur. It was inaugurated by Shri Virendra Beniwal, Chief Whip, Govt. of Rajasthan. Shri Murari Lal Meena, Minister of State for Technical Education (Agriculture), Revenue, Colonization and Sainik Kalyan, Govt. of Rajasthan, was the Guest of Honour. The meeting was attended by DDGs and ADGs from ICAR, New Delhi, as well as by the VCs of agricultural universities, Directors of Institutes and PCs of AICRPs in the Region. The States and UTs were also represented. Dr. J.S. Samra, CEO, NRAA, Dr. S.K. Bhargava, ICAR Governing Body Member, Dr. H.S. Sur, Advisor (Agriculture), Planning Commission, Dr. A.S. Faroda, former Chairman, ASRB, New Delhi, Dr. O.P. Pareek, former Director, CIAH, Bikaner, Dr. K.A. Singh, Director, IGFRI, Jhansi, Dr. D.C. Bhandari, Director, NBPGR, New Delhi and Dr. Ashok Mishra, Coordinator, Jain Irrigation System, Jalgaon were the Special Invitees for the meeting.

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 13, 2010
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	:	August 15-17 and September13, 2010
Discussion	:	Appraisal meeting with Dr. M.M. Roy, Director, CAZRI; meetings at CAZRI, Jodhpur with staff and Dy. Director-General, ICAR.

Institute Management Committee (IMC)

The IMC meeting was held on May 21, 2010. Issues related to budget and expenditure of the Institute, audit report, purchase of equipments and other administrative matters were discussed.

Institute Research Council (IRC)

Three meetings were held on May 24-26, 2010, in which the annual progress reports of various ongoing and externally funded projects were discussed. Five projects were extended/re-scheduled, 11 projects were concluded and 14 new projects were approved.

Institute Joint Staff Council (IJSC)

Meeting was held on April 29, 2010. 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

National Science Day (28th February): Theme of the day was Chemistry in Our Lives. On this day Drs. H.A. Khan, J.C. Tarafdar and Praveen-Kumar, Principal Scientists expressed their views on importance of Chemistry from morning to night, food production and in our day to day life. It was organized by Dr. A. Pancholy.

International Women Day (8th March): On this day Dr. Padma Bohra, Director I/c, ZSI, Regional Centre, Jodhpur, Dr. Kriti Rajimwale, Prof. of Sociology, JNVU, Jodhpur and Dr. Nisha Patel, Sr. Scientist were the speakers. Dr. M.M. Roy, Director told about significant contributions of women in development of the nation.

World Environment Day (5th June): Environmental Information System (ENVIS) Centre organized an essay competition for school children on the theme "Importance of Biodiversity Conservation and Future". Dr. K.R. Solanki, Former ADG (Agroforestry), ICAR, New Delhi delivered a keynote address on "Forestry for Environment Protection". Dr. M.M. Roy, Director presided over the function. Dr. Suresh Kumar welcomed the guests and Shri Tirth Das, ENVIS coordinator briefed about ENVIS activities.

World Day to Combat Desertification (17th June): Dr. J.C. Tarafdar, National Fellow shared his expert views on "Improving Soil Quality through Beneficial Soil Biota: Current Status and Researchable Issue for Indian Desert". Dr. J.C. Tewari welcomed the guests. Dr. Mahesh Kumar briefed about ENVIS activities at CAZRI and Shri Tirth Das, ENVIS Coordinator proposed vote of thanks.

Inter Zonal Sports Tournament (9-13 November): The ICAR Zonal (Final) Tournament 2010 was organised by CAZRI, Jodhpur at Gaushala Sports Complex, Jodhpur. More than 400 sports persons and officials from 36 ICAR Institutes representating 5 Zones participated in the tournament. The sports meet was inaugurated by the Chief Guest, Dr. Narendra Kumar, Director, Defence Laboratory, Jodhpur. Ms. K. Preethi, CPCRI, Kasargod and Mr. P.K. Parida, CRRI,

Cuttack were adjudged as Best Woman and Man Athlete, respectively. The overall Championship was awarded to NAARM, Hyderabad. Sport meet was organized by Dr. Anurag Saxena.

हिन्दी सप्ताह (14–19 सितम्बर): हिन्दी सप्ताह के अन्तर्गत हिन्दी में प्रार्थना–पत्र, निबन्ध–लेखन, हिन्दी टंकण एवं टिप्पण, पोस्टर प्रदर्शन, राजभाषा संगोष्ठी, हिन्दी वाद–विवाद प्रतियोगिता आदि आयोजित किये गये। 14 सितम्बर को आयोजित समारोह के मुख्य अतिथि श्री जी.सी. अग्रवाल, मण्डल रेल प्रबन्धक एवं अध्यक्ष नगर राजभाषा समिति तथा श्री श्रवण कुमार मीणा, प्रोफेसर, हिन्दी विभाग, जोधपुर विश्वविद्यालय थे। समारोह की अध्यक्षता डॉ. एम.एम. रॉय, निदेशक, काजरी ने की। समापन समारोह में सभी विजयी प्रतिभागियों को निदेशक काजरी ने पुरस्कार वितरित किये।

CAZRI Foundation Day (1st October): Foundation day was celebrated, and all the retired CAZRIAN's were invited. Chief Guest was Prof. Naveen Mathur, Vice-Chancellor, JNV University, Jodhpur. Appreciation certificates and momentos were given to the best workers (one each from Technical, Administrative and Supporting Staff). Scientists for best poster and best sportmen were also awarded.

PARTICIPATION IN CONFERENCE, WORKSHOP, SYMPOSIUM/SEMINAR AND TRAINING

SEMINAR/SYMPOSIUM/WORKSHOP

Date	Name of the seminar, organizers and venue	Name of the participant
January 11-12	Solar Energy Conclave 2010, Ministry of New and Renewable Energy, New Delhi	N.M. Nahar P.B.L. Chaurasia
January 21	National Seminar on Geographical Applications in the Management of Natural Disasters, at RK More College, Pune	Amal Kar
January 28-30	XLIV ISAE Annual Convention and Symposium, IARI, New Delhi	A.K. Singh, Harpal Singh H.L. Kushwaha
January 28-31	22nd Kerala Science Congress, Kerala Forest Research Institute, Peechi, Thrissur, Kerala	Shamsudheen M.
January 29-31	National Seminar on Stress Management in Small Ruminant Production and Product Processing, the Indian Society of Sheep with collaboration of Goat Product Utilization, CSWRI, Avikanagar and CIRG, Makhdoom at CSWRI, Avikanagar	A.K. Patel Dheeraj Singh M.L. Meena N.V. Patil
February 9	National Seminar on Impact of Climate Change on Biodiversity and Challenges in Thar Desert, at JNVU, Jodhpur	R.S. Tripathi
February 17	National Symposium on Developments in Diagnostic and Therapeutic Approaches for Economically Important Diseases of Livestock and Companion Animals, College of Veterinary Science, Hyderabad	Subhash Kachhawaha
February 18-20	National Symposium on Climate Change and Rainfed Agriculture at CRIDA, Hyderabad	A.S. Rao
February 19	Brain Storming Session on Project Proposal on Effect of Climate Change in Kachchh, Patan and Banaskantha Districts at Gujarat, Ecology Commission, Gandhinagar, Gujarat	Shamsudheen M.
February 20-21	12th Indian Agricultural Scientists and Farmer Congress and National Symposium on Food Security in Changing Climate, Bioved Research Institute of Agricultural and Technology, Allahabad, ISDC, University of Allahabad, Allahabad	P.K. Malaviya
February 25-27	National Conference on Advances on Materials and Devices for Renewable Energy Sources (NCAMDRES–10). JEC Groups of Colleges, Kukas, Jaipur	P.C. Pande P.B.L. Chaurasia

March 4-5	International Conference on Jawaharlal Nehru Solar Mission- The Road Ahead, World Trade Centre, Cuff Parade, Mumbai	P.C. Pande
March 11-12	National Workshop under VCP Project at Indian Institute of Remote Sensing, Dehradun	Shamsudheen. M
March 13-14	National Conference on Energy and Sustainable Development, Jodhpur Institute of Engineering and Technology, Jodhpur	P.C. Pande N.M. Nahar
March 18	Workshop on Environment Conservation Laws, Barmer	P.B.L. Chaurasia
March 19-21	All India Coordinated Pearl Millt Improvement Project Workshop at ARS Mandor, Jodhpur	V.K. Manga
March 25	Workshop on Environmental Laws and Environment Conservation, organized by Forest Department, Government of Rajasthan at RAU, Bikaner	J.P. Singh
April 1	Interactive Session on Implementing Jawahar Lal Nehru National Solar Energy Mission, Confederation of Indian Industry and Ministry of New and Renewable Energy, New Delhi	N.M. Nahar
April 5-6	National Workshop of ENVIS, Sikkim State Council of Science and Technology, Gangtok, Sikkim	Tirth Das
April 12-17	International Workshop on Climate Risk Management in Agriculture, QUAT, Bhubaneshwar	A.S. Rao
Apr 20-21	Workshop on Commons Make Economic Sense, Foundation for Ecological Security (FVS) at IDS, Jaipur, Rajasthan	Khem Chand
April 20-22	Indo-European Workshop on Solar Energy, Indian Institute of Technology, Rajasthan, Jodhpur	N.M. Nahar
April 21-23	National Conference on Knowledge Management in the Globolized Era, IASRI, Library Avenue, Pusa Campus, New Delhi	Tirth Das
April 23	Workshop on Inventorization and Documentation of Local Specific Problems Requiring S&T Interventions, organized by DST, Regional Office at Veterinary College, Bikaner.	J.P. Singh N.D. Yadava
April 28	Grand Energy Challenges Symposium organized by Melbourne Institute of Technology and TERI, India Habitat Centre, New Delhi	P.C. Pande
May 19	Orientation Workshop for Preparation of District Level Contingency Plans, NBSS and LUP, Nagpur	Raj Singh
May 22	Seminar on Biodiversity in Arid and Semi-Arid Regions and Urban Environments, organized by National Institute of Ecology, Rajasthan State Pollution Control Board, Department of Forest, Govt. of Rajasthan at Forest Training Institute, Jaipur	J.P. Singh

May 22	Workshop on MGNREGA vs. Productivity, Seva Mandir at KVK, Udaipur, Rajasthan	Khem Chand
May 27-28	26th Annual Workshop on Arid Legumes, PC, AICRP on Arid Legumes, VPKAS, Almora	Raj Singh
June 1	Workshop on Unique Tribal Heritage Agricultural Systems, held by the Ministry of Tribal Affairs, Govt. of India, at New Delhi	Amal Kar
June 4	National Conference on Business Action on Climate Change, organized by Confederation of Indian Industries, Jaipur at SMS Convention Centre, Jaipur	J.C. Tewari
June 9-10	Stakeholders Workshop of AFRI, Jodhpur, organized by AFRI, Jodhpur at Conference Hall, TREE, Jaipur	J.C. Tewari
June 21-23	Conference on Regional Consultation Workshop on Strategies for Arresting Land Degradation in the South Asian Countries, organized by SAARC Agricultural Centre, Dhaka, and ICAR at NBSS&LUP, Kolkata	Amal Kar
July 1	Workshop on Developing, Commissioning, Operating and Managing an Online System for NET/ARS-Prelim Examination by ASRB, ICAR under NAIP at Delhi	R.S. Tripathi
July 3	National Workshop on ATIC Manager, ICAR, Division of Agricultural Extension, Krishi Anusandhan Bhavan, Delhi	R.N. Singh
July 7	National Seminar on Seed Spices Biodiversity and Production for Export-Perspective, Potential, Threats and their Solutions; Indian Society of Seed Spices at National Research Centre on Seed Spices, Ajmer, Rajasthan	S.S. Rao
July 9	National Seminar on Impact of Climate Change on Biodiversity and Challenges in Thar Desert, Desert Regional Centre, Zoological Survey of India, Jodhpur	A.S. Rao B.K. Mathur H.C. Bohra M.M. Roy M.P. Singh Nisha Patel R.S.Tripathi Satya Vir Surendra Poonia S.K. Jindal
July 12	Workshop on Disposal of Appeals under RTI at ISTM, New Delhi	M.M. Roy
July 15	State Level Workshop on Water Management and Environmental Security, organized by SK RAU Bikaner	N.D.Yadava
July 15-26	Directors' Conference and ICAR Foundation Day Celebrations at NASC, New Delhi	M.M. Roy
July 22-23	Workshop on Strategic Planning for Performance Monitoring and Evaluation System (PMES), organised by Department of Animal Husbandry, Dairying and Fisheries, Ministry of Agriculture, New Delhi	A.K. Patel

July 28-29	ICAR-Industry Meet, NASC Compex, New Delhi	P.C. Pande
August 17-18	Annual Workshop of Network Project on Harvesting, Processing and Value Addition of Natural Resins and Gums, organized by Coordinator, Network Project, IINRG, Ranchi at YSPUH & F, Solan	J.C. Tewari
August 29-30	National Conference on Budget Analysis and Utilization, NIAM, Jaipur	Dheeraj Singh M.L. Meena
August 30-31	Conference on Towards Sustainable Agriculture: The Way Forward in Rajasthan, BARC at IDS, Jaipur	Khem Chand
September 3-5	National Workshop on AICRP on Rapseed and Mustard at VRS KVV, Gwalior, organized by DRMR, Bharatpur	Shiv Datt
September 18-20	International Conference on Traditional Practices in Conservation Agriculture Asian Agri-History Foundation, Rajasthan Chapter held at JRN Vidyapeeth University, Udaipur, India.	Arun Kumar
September 18-22	International Conference on Traditional Practices in Conservation Agriculture, organized by Asian Agri-History Foundation, Secunderabad at Janardan Rai Nagar Rajasthan Vidyapeeth University, Pratap Nagar, Udaipur	Bhagirath Ram, Shamsudheen, M.
September 29-30	Brain Storming Workshop on Making IPM Effective in India held at NASC, New Delhi from	S.K. Lodha
September 28-30	Renewable Energy Workshop, Indian Institute of Technology, Jodhpur	P.C. Pande N.M. Nahar P.B.L. Chaurasia
September 30 – October 1	National Conference on Plant Biotechnology Towards Nutrition and Nutraceutical Potential organized by Sarojini Naidu Vanita Maha Vidyalaya, Hyderabad	Devi Dayal
October 8	National Workshop on District Level Contingency Plans (Rajasthan and Gujarat), organized by Division of Transfer of Technology and Production Economics, CAZRI, Jodhpur	B.K. Mathur M.M. Roy
October 9	Workshop on Water Conservation (for NGOs) at Hotel Maple, Jodhpur	M.M. Roy
October 11-12	Desert Biodiversity Workshop, organised by Tourism and Wildlife Society of India held at AFRI, Jodhpur	R.S. Mertia
October 13-14	Water Conservation, Indian Environment Association & DST, New Delhi, Jodhpur.	Pratibha Tewari
October 14	District Level Workshop on Integrated Development of Small Ruminants, Rabbits and Dairy, NABARD, Monarch Food Plaza, Pali-Marwar	Khem Chand
October 17-22	VII International Congress on Cactus Pear and Cochineal and General Meeting of FAO-ICARDA International Technical Cooperation Network on Cactus Pear and Cochineal, Agadir, Morocco	P.R. Meghwal

October 23-24	Management of Natural Resources and Environment in India, GAD Institute of Development Studies, Amritsar	B.L. Gajja
November 6-8	UNESCO-SUMAMAD Phase II-Eighth Annual Workshop held at Alexandria, Egypt	R.S. Mertia
November 6-12	International Conference on Our Common Future, organized by Volkswagen Foundation, Essen and Hannover, Germany	Dheeraj Singh
November 9-10	International Conference on Biodiversity Conservation held at Bibilotheca, Alexandria, Egypt	R.S. Mertia
November 11-13	Indo Taiwan Joint Workshop on Bamboo Flowering and Rodent Control at Guwahati	R.S. Tripathi
November 12-14	National Symposium Optimizing Forage Production from Arable and Non-arable Lands for Increasing Livestock Production, RMSI and ICAR, IGFRI Jhansi	J.P. Singh M.M. Roy Sharmila Roy V.S. Rathore
November 14-17	National Seminar on Development in Soil Science-2010, ISSS, IISS Bhopal	M.L. Soni S. Bhardwaj
November 18-19	Workshop on Common Property Resources, Pastoral Production Systems and Green Revolution: From Conflict to Convergence, organized by Foundation for Ecological Security, Anand at CAZRI, Jodhpur	A.K. Misra A.K. Patel D.K. Saha J.P. Singh M.M. Roy R.S. Mertia
November 18-21	4th Indian Horticulture Congress 2010- Horticulture, Horti-Business and Economic Prosperity, organized by The Horticultural Society of India, New Delhi & NSFI, Gurgaon at National Physical Laboratory's auditorium, Pusa campus, New Delhi	Pradeep Kumar
November 18-21	4th Indian Horticulture Congress organized by Horticulture Society of India at New Delhi	Dheeraj Singh
November 20-22	23rd Conference of the Indian Institute of Geomorphologists and National Seminar on Global Environmental Change, Geomorphological Issues and Challenges at Gauhati University, Guwahati	Amal Kar
November 23-25	24th National Conference on Agricultural Marketing, Navsari Agricultural University, Navsari and Indian Society of Agricultural Marketing at NAU, Navsari	Khem Chand
November 24-25	National Conference on Biodiversity of Medicinal and Aromatic Plants: Collection, Characterization and Utilization, DMAP, Anand	N.K. Sinha Surjeet Singh
November 25-27	National Conference of Plant Physiology on Physiological and Molecular Approaches for Crop Improvement under	N.S. Nathawat

	Changing Environment, Deptt. of Plant Physiology, BHU and ISPP, BHU, Varanasi	
December 1-3	International Congress on Renewable Energy, Chandigarh	P.C. Pande
December 2-4	XIX National Symposium on Resource Management Approaches Towards Livelihood Security, Indian Society of Agronomy, ICAR and UAS, Bengaluru, at UAS, Bengaluru, Karnataka	Shiv Datt S.P.S. Tanwar S.S. Rao V.S. Rathore
December 7-8	Climate Risk Management in Agriculture, Palak Paradise, Jaipur	A.S. Rao
December 8-10	Workshop on Curriculum Development on Rodent Pest Management for Trainers to Farmers at NIPHM, Hyderabad	R.S. Tripathi
December 9-10	22nd National Seminar on Role of Extension in Integrated Farming Systems for Sustainable Rural Livelihood, Mumbai and Maharashtra Society of Extension Education, Mumbai Veterinary College, Mumbai	Bhagwan Singh M.L. Meena
December 10-11	Symposium on National Resource Management in Agriculture (Na-RMA-II) held at RCA, Udaipur	R.S. Mertia
December 10-12	5th Biennial International Conference, Sikkim University, Gangtok	R.N. Singh
December 13-15	Intersolar India Conference, Solar Promotion International GmbH, Mumbai	N.M. Nahar
December 14-16	National Symposium on Perspective in the Plant Health Management held at Anand Agricultural University, Anand	S.K. Lodha
December 20	GEF-UNDP- Inception and Launch Workshop held at Water Resource Centre, Jal Bhagirathi Foundation, Jodhpur	R.S. Mertia
December 22-24	5th National Conference on KVK-2010 and National Exhibition on Farm Innovations at MPUAT, Udaipur	Amal Kar A.S. Tomar D. Mishra M.C. Bhandari
December 27-29	International Conference on Clean Energy Technologies and Energy Efficiency for Sustainable Development, ENERSTATE-2010, Dehradun	P.B.L.Chaurasia
December 28-29	National Seminar on Precision Farming in Horticulture, organized by MPUAT, Udaipur, at College of Horticulture and Forestery, Jhalawar	Birbal

TRAINING COURSE

Date	Training course, organizers and venue	Name of the participant
February 22-26	Market Led Extension, National Institute of Agricultural Extension Management (MANAGE) Hyderabad, at CAZRI, Jodhpur	Amtul Waris Bhagwan Singh
March 1-April 30	Exposure to Method to Use Microbes as Bio Nano Factories, its Purification and Characterization at School of Engineering and Applied Sciences, Washington University in St. Louis, USA	J.C. Tarafdar
March 8-10	Technology for Plants and Dairy Ingredients based Formulated and Functional Foods Using Extrusion-Cooking, sponsored by Indian Council of Agricultural Research, New Delhi, Soybean Processing and Utilization Centre, CIAE, Bhopal	H.C. Bohra
March 8-12	Modern Library Management, Technical Education, Polytechnic College, Jodhpur	Tirth Das
June 15-16	Technology Demonstration for Harnessing Pulses Productivity, ZDP Zone VII, Jabalpur	R.R. Meghwal
June 28-July 9	DUS Testing and Plant Variety Protection, sponsored by NAIP, (ICAR) New Delhi, at National Institute of Agricultural Botany, Cambridge, United Kingdom	Suresh Kumar
August 2-7	Training Methods and Farm School, EEI, at Anand	R.R. Meghwal Subhash Kachhawaha
August 9-14	Application of PRA tools in Agril. Extension at EEI, at Anand	A.S. Tomar P.S. Bhati
August 12-13	Training programme on Quantitative Modelling Approaches for Economic Policy Analysis in Agriculture, NCAP, New Delhi	Khem Chand
August 16-18	Monitoring and Evaluation, EEI at Anand	Savita Singhal
September 6-7	Training Methods and Farm School, EEI at Anand	R.R. Meghwal
September 6-10	Climate Change and Carbon Mitigation, sponsored by DST, GOI, New Delhi at FRI, Dehradun	Suresh Kumar Anurag Saxena
September 22-27	Management Development Programme in Agricultural Research, National Academy of Agricultural Research Management (NAARM), Hyderabad	N.D. Yadava
October 15-November 4	Winter School on Designing Nutraceutical and Food Colorant Rich Vegetable Crop Plants: Conventional and Molecular Approaches, at Division of Vegetable Science, IARI, New Delhi	Pradeep Kumar

October 18-22	Cropping System Models-Applications in Land Management, ICRISAT, Hyderabad	A.S. Rao, D.V. Singh
November 8-12	Training on Developing Winning Research Proposals at NAARM, Hyderabad	Priyabrata Santra
November 9-18	Training on Biodiversity of Horticulture Crops, IIHR, Bangalore	Hari Dayal
November 9-29	Recent Advances in Plant Breeding Methodology held at Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana	H.R. Mahla
November 22-December 3	Creativity and Innovation Management in Research, at Administrative Staff College of India, Hyderabad	Sharmila Roy
November 24	Training on Kisan Mobile Advisory Service, organized by IFFCO/ ZPD-VI at RAU Bikaner	R.P. Singh
November 29-December 3	Climate Change and its Impact on Water Resources, IIT, Roorkee	H.M. Meena
December 27-31	Training on Extrusion: Process, Product Formulation and Fortification, Microbiological and Biochemical Aspects of Post-harvest Technology, organized by Central Institute of Post-harvest Engg. and Technology, Ludhiana & AICRP on PHT	P.K. Malaviya

HUMAN RESOURCE DEVELOPMENT

Staff members from Headquarter and Regional Research Stations who were nominated for various training programmes during 2010-11:

S. No.	Name, designation and place of posting	Name of the training programme	Duration	Organizers
Scientific Personnel				
1.	Dr. B.L. Jangid Sr. Scientist, RRS, Pali	Capacity Building Training Programme on Technology Diplomacy	May 31-June 4	CUTS International, Jaipur
2.	Dr. V.K. Manga, Principal Scientist (PS)	Management Development Programme in Agricultural Research	July 22-27	NAARM, Hyderabad
3.	Dr. Devi Dayal, Head, RRS, Kukma-Bhuj	Workshop on Leadership for Transition to NAIS	August 6-11	NAARM, Hyderabad
4.	Dr. Uday Burman, PS	E 2.0 Unlocking the Power of Knowledge, Management in the Smart Enterprise	August 16-18	IIM, Kozhikode, Kerala
5.	Dr. T.K. Bhati, PS	MDP Workshop on PME for Agricultural Research and Development Projects under NAIP	September 6-10	NIRD & NAARM, Hyderabad
6.	Ms. Seema Bhardwaj, Scientist, RRS, Bikaner	Winter School on System based Integrated Nutrient Management for Sustained Productivity and Soil Health	October 1-21	PDFSR, Modipurum, Meerut
7.	Dr. R.K. Bhatt Head, Div. III	Management Development Programme on Leadership for Innovative Agriculture	October 4-8	IIM, Lucknow
8.	Dr. P.C. Moharana, Sr. Scientist	GEF and UNDP Inception Launch Workshop	Oct. 20-21	Jal Bhagirathi Foundation Jodhpur
9.	Dr. P. C. Moharana, Sr. Scientist	MDP on Managing Quality in Agricultural Research	Oct. 25-29	IIM, Lucknow
10.	Dr. Khem Chand, Sr. Scientist, RRS, Pali	Managing Agricultural Innovations in the Era of Globalization	Oct. 25-30	IARI, New Delhi
11.	Dr. H.L. Kushwaha, Scientist (Sr. Scale)	Training Course on Knowledge Management	Nov.15-16	Institute of Secretariat Training and Management, Govt. of India, New Delhi

12.	Dr. B.L. Jangid Sr. Scientist, RRS, Pali	Market Led Extension Management	Dec. 6-11	EEI, Anand
13.	Dr. Arvind Kumar, Scientist, RRS, Bhuj	NAIP on Strengthening of Statistical Computing for NARS	Jan.10-15, 2011	MPUAT, Udaipur
14.	Dr. R. K. Goyal, Sr. Scientist			
15.	Dr. S.P.S. Tanwar Sr. Scientist RRS, Pali			
16.	Dr. Sunil Mahajan, Sr. Scientist			
17.	Dr. R. K. Bhatt Head, Div. III	Workshop on Management of Stress Related Disorders	Feb. 2-4, 2011	NAARM, Hyderabad
18.	Sh. H. M. Meena, Scientist	NAIP on Strengthening of Statistical Computing for NARS	Feb. 14-19, 2011	MPUAT, Udaipur
19.	Dr. P. Santra, Sr. Scientist			
20.	Dr. V. S. Rathore, Sr. Scientist, RRS, Bikaner			
21.	Dr. Khem Chand, Sr. Scientist, RRS, Pali	Institutional Changes for Inclusive Agricultural Growth	Feb. 15-March 7, 2011	IARI, New Delhi
Technical Personnel				
1.	Sh. J.C. Joshi, T-8, RRS, Bikaner	Capacity Building Training Programme on IPR, WTO Related Issues	May 25-29	CUTS, International, Jaipur
2.	Dr. Manish Mathur, T-5			
3.	Sh. S.K. Dasora, RRS, Pali			
4.	Dr. Har Dayal, T-6, KVK, Pali	Seed Spices Biodiversity and Production for Export Perspective	July 7	NRC on Seed Spices, Tabiji, Ajmer
5.	Dr. M.L. Meena, T-6, KVK, Pali			
6.	Sh. Ajay Maru T-4, KVK, Pali	Workshop on Training Methods and Farm School	August 2-7	EEI, AAU, Anand
7.	Sh. R. R. Meghwal, T-9, KVK			
8.	Dr. A.S. Tomar, T-7-8, KVK	Workshop on Application of PRA Tools in Agricultural Extension	Aug. 9-14	EEI, AAU, Anand
9.	Sh. P.S. Bhati, T-5, KVK			

10.	Dr. V.K. Soni, T-7-8			
11.	Sh. Ajay Maru, T-4, KVK, Pali	Summer School on Advances in Entomopathogenic Nematodes for Eco-safe and Economic Pest Management	Sep. 14-Oct. 4	MPUAT, Udaipur
12.	Dr. Har Dayal, T-6, KVK, Pali	Antioxidants Phytonutrient and Volatile Flavours in Horticultural Crops	Sep. 15-24	IIH, Banglore
13.	Sh. R.C. Bohra, T-6	Biodiversity Conservation in Agriculture	Sep. 27-30	AAU, Anand
14.	Sh. S.L. Sharma, T-5			
15.	Dr. A.S. Tomar, T-7-8, KVK	National Symposium on Food Security in Context of Changing Climate	Oct. 30-Nov. 1	CSAUA&T, Kanpur
16.	Sh. P.S. Bhati, T-5, KVK			
17.	Sh. B.K. Mathur, T-9	Information and Communication Technology in ICAR	Nov. 3-4	NASC Complex, New Delhi
18.	Sh. Vidyadhar, T-9	Sensitization cum Training Workshop for the Nodal Officers of PIMS-ICAR	Nov. 15	IASRI, New Delhi
19.	Dr. Rakesh Pathak, T-5	Detection, Molecular Characterization, Implications and Management of Plant Pathogens	Nov. 22-Dec. 12	AAU, Anand
20.	Sh. S.S. Bharath, T-5	National Conference on Biodiversity of Medicinal Plants, Collection, Characterization and Utilization	Nov. 24-25	DMAPR, Boriavi, Anand
21.	Sh. Bahadur Singh, T-5	Workshop on Mass Media in Agriculture	Nov. 29-Dec. 4	EEI, Anand
22.	Sh. Gaje Singh Jodha, T-5			
23.	Dr. R. P. Singh, T-6, KVK	International Seminar on Improving Access to Global Organic Markets	Dec. 8-9	Mumbai
24.	Sh. Gitam Singh, T-9 (Farm Supdt.)	Research Station Management	Jan.17-22, 2011	ICRISAT, Hyderabad
25.	Dr. Har Dayal, T-6, KVK, Pali	Workshop on Value Addition for Agri. Horticultural Crops	Feb. 3-5, 2011	EEI, AAU, Anand

26.	Dr. M. L. Meena, T-6, KVK, Pali	Workshop on Commodity Interest Group and their Federation	Feb.14-19, 2011	EEI, AAU, Anand
Administrative and Accounts Personnel				
1.	Sh. Sunil Chaudhary, AF&AO	Finance for Jr. Finance & Acounts Officers and Non-Executives (F&A)	Sept. 7-10	ICWAI, New Delhi
2.	Ms. Aruna Sharma, AF&AO	Financial Decision Making Using Excel	Sep. 27-Oct. 01	National Institute of Financial Management, Faridabad
3.	Sh. Sunil Chaudhary, AF&AO	Recent Trends in Financial Management including IFRS Convergence	Oct. 5-8	ICWAI, New Delhi
4.	Sh. S. Sugathan, AAO	Workshop on Reservation Policies for SCs, STs, OBCs, Ex-servicemen and Persons with Disabilities	Oct. 21-23	National Commission for ST at Regional Office, Vidyadhar Nagar, Jaipur
5.	Sh. Sujit Singh, AO	Training Programme in Administrative Vigilance-I	Dec. 6-10	ISTM, New Delhi
6.	Sh. Anil Bhandari, JAO, KVK, Pali	Finance for Jr. Finance & Acounts Officers and Non-Executives (F&A)	Jan.18-21, 2011	ICWAI, Mahabaleshwar
7.	Sh. Pawan Tiwari, AFO			

VISITORS

DISTINGUISHED VISITORS

January 2	Shri Rajendra Pareeka, Industrial & Mines Minister, Govt. of Rajasthan
	Hon'ble Smt. Chandresh Kumari, Member of Parliament, Govt. of India – visited Institute Exhibition Stall at Paschim Rajasthan Udyog Hastsilp Utsav-2010, Jodhpur
January 7	Shri Badri Ram Jakhar, Member of Parliament
	Smt. Sanehalata Panwar, Addl. Commissioner, visited Institute Exhibition Stall at Paschim Rajasthan Udyog Hastsilp Utsav-2010, Jodhpur
January 16	Dr. M.M. Anwar, Director, NRCSS, Ajmer
	Dr. Mana Ram Choudhary, Joint Director (Agril), Jodhpur
	Dr. R.G. Sharma, Project Director (ATMA) and Dy. Director (Agril), Jodhpur
February 20	Dr. Umesh Shrivastava, ADG (Hort.), ICAR, New Delhi
	Dr. S.A. Karim, Director, CSWRI, Avikanagar
	Smt. Nasim Akhata, MLA, Puskar – visited Institute Exhibition Stall at NRCSS, Ajmer
March 2	Padama Bhushan Prof. M.S. Swaminathan, Ex-Secretary DARE, GOI & Ex-DG, ICAR, New Delhi
April 30	Sh. Raj Ganguly, Food and Agriculture Organization, New Delhi
	Shri Rajiv Mehrishi, Secretary, ICAR, New Delhi
June 7	Sh. Rameshwar Dadhich, Mayor, Municipal Council, Jodhpur
June 10	Shri Sileshi Getahur, Director NRM, Directorate, Ministry of A. & R.D., Ethiopia
	Dr. Denial Denard, Program Manager, Sustainable Land Management, Ethiopia and team members
June 21	Dr. L.S. Rathore, Dy. Director General, Indian Metrology Deptt., New Delhi and Member, Earth Science
	Dr. J.R. Sharma, Director, ISRO, RRSC, Jodhpur
July 8	Prof. Madhu Goyal, SKRAU, Bikaner
July 8	Mr. Michael Willioms, BBC, World Services, London, UK
July 19	Dr. Raphael G. Wabome, Deptt. of Animal Production, University of Nairobi, Kenya
	Mr. James Tendwa, Ministry of Livestock Development, Kenya
	Mr. Richard Kyuma, Forestry Research Institute, Kenya
	Mr. Simon Tendwa, Forestry Research Institute, Kenya

August 28	Smt. Madan Kanwar Choudhary, Zeela Pramukha, Barmer visited Institute Exhibition Stall at Barmer
September 14	Shri G.C. Aggarwal, Divisional Railway Manager, Jodhpur
September 19	Dr. A.K. Singh, DDG, ICAR, New Delhi
September 29	Dr. T.S. Rathore, Director, AFRI, Jodhpur
	Dr. V. Harin, IFS (P), Dehradun
September 30	Mr. R. Senthil Kumaran, IFS (P), Dehradun
October 1	Prof. Naveen Mathur, Vice-Chancellor, JNVU, Jodhpur
	Dr. K.S. Ramchandran, Member, National Rainfed Area Authority, New Delhi
October 4-5	Dr. P. Rangnathan, Chief General Manager, NABARD, Mumbai
	Shri Ramesh Babu, ADG, NABARD team member
	Shri Sanjay Gosai, NABARD team member
	Dr. Deshraj Mauriya, NABARD team member
October 8	Dr. Y.G. Prasad, CRIDA, Hyderabad
November 9	Dr. Narendra Kumar, Director, Defence Lab, Jodhpur
November 19	Dr. Purnendu S. Kavoari, Institute of Development Studies, Jaipur
December 22	Visited CAZRI Exhibition Stall at MPUAT, Udaipur: Hon'ble Smt. Pratibha Devi Singh Patil, President of India Hon'ble Sarad Panwar Union Minister of Agriculture Hon'be Ashok Gehlot, Chief Minister, Govt. of Rajasthan Hon'ble Shri Shivraj Patil, Governor of Rajasthan Hon'ble Shri C.P. Joshi, Central Minister of Panchayat Raj Hon'ble Dr. S. Ayyapan, Secretary, DARE & Director General, ICAR, New Delhi Hon'ble Sh. K.V. Thomas, Central State Agril. Minister Dr. K.D. Kokate, DDG (Agri. Extn.), ICAR, New Delhi Prof. S.S. Chahal, Vice-Chancellor

VISITORS AT REGIONAL RESEARCH STATIONS

Date	Visitors	Farmers/ farmwomen	Extension functionaries	Dignitaries/ officials	Total
RRS, Kukma-Bhuj					
February 4	Dr. Panjab Singh, Ex DG, ICAR	-	-	1	1
December 22-23	Dr. Masood Ali, Ex. Director, IIPR, Kanpur & Member, QRT	-	-	1	1

RRS, Pali					
March 18	Trainee farmers under ATMA, Pali project	100	04	-	104
March 19	Students of class 9th and 10th from Government Secondary School, Sonai Mazi village in collaboration with DST	66	-	4	70
November 25	QRT Team	0	0	7	7

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		Students		Forest/University/ Central/State Officers etc.
	Male	Female	Boys	Girls	
Rajasthan	3166	596	790	458	240
Gujarat	220	20	15	-	8
Delhi	80	-	-	-	5
Punjab	-	-	20	-	2
Haryana	30	-	85	2	5
Uttarakhand	-	-	-	-	1
Himachal Pradesh	-	-	60	17	4
Goa	-	-	9	6	2
Uttar Pradesh	50	-	106	3	5
Bihar	-	-	-	-	14
Andhra Pradesh	-	-	16	-	2
Madhya Pradesh	44	-	85	3	11
Karnataka	-	-	24	-	2
Total	3590	616	1210	489	301

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	Occasion
January 2-11	Rawan Ka Chabutra, Jodhpur	Paschimi Rajasthan Hastsilp Udyog Utsav-2010
January 16	CAZRI, Jodhpur	Fruit Show on Arid Horticulture - Ber, Anar and Aonla
January 18	CAZRI, Jodhpur	Seminar on Arid Horticulture and Value Addition
February 2	CAZRI, Jodhpur	Training on Animal Nutrition
February 20	Village Tabiji, Ajmer	Kissan Mela
February 26	CAZRI, Jodhpur	National Science Day
February 27	Village Birai, Jodhpur	Kissan Mela
March 8	Luni Village	Women Day
May 1	CAZRI, Jodhpur	Summer Arid Legume Day
June 4-5	CAZRI, Jodhpur	World Environment Day
June 17	CAZRI, Jodhpur	World Desertification Day
July 8	CAZRI, Jodhpur	Seminar on Value addition in *Prosopis juliflora*
August 28-30	Village Chohtan, Barmer	Bharat Nirman Soochan Abhiyan Mela
September 8	Village, Agolai, Jodhpur	Field Day on Kharif Crops
September 15	Birami, Jodhpur	Field Day on Kharif Crops
September 14-20	CAZRI, Jodhpur	Hindi Week
September 29	CAZRI, Jodhpur	Kissan Mela
October 16	CAZRI, Jodhpur	World Food Day
November 29	CAZRI, Jodhpur	Mushroom Production
December 22-24	MPUAT, Udaipur	Vth National Conference on KVK, 2010

PERSONNEL

DIRECTORATE

1. Dr. N.V. Patil, Director I/c (upto 19.2.2010)
2. Dr. M.M. Roy, Director (from 20.2.2010)
3. Shri A. Angel, Private Secretary
4. Mrs. Sreedevi Mohanan, Private Secretary (from 26.6.2010)

RESEARCH COORDINATION AND MANAGEMENT

1. Dr. R.K. Kaul, Principal Scientist (Nematology)) & O I/c
2. Shri Vidyadhar, T-9
3. Shri B.K. Mathur, T-9
4. Dr. Y.N. Mathur, T-(7-8) (IPO)
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

DIVISION OF NATURAL RESOURCES AND ENVIRONMENT

1. Dr. Amal Kar, Head
2. Mrs. Pramila Raina, Principal Scientist (Soil Chemistry/Fertility)
3. Dr. H.A. Khan, Principal Scientist (Organic Chemistry)
4. Dr. A.S. Rao, Principal Scientist (Agril. Meteorology)
5. Dr. Praveen Kumar, Principal Scientist (Soil Chemistry/Fertility)
6. Dr. D.V. Singh, Sr. Scientist (Agronomy)
7. Dr. R.K. Goyal, Sr. Scientist (Soil & Water Cons. Engg.)
8. Dr. P.C. Moharana, Sr. Scientist (Geography)
9. Dr. Md. Mohibb-e-Azam, Sr. Scientist (Organic Chemistry)
10. Dr. Sharmila Roy, Sr. Scientist (Agril. Entomology) (from 28.5.2010)
11. Dr. Nav Raten Panwaqr, Sr. Scientist (Soil Science-Fert./Chem./Microbilogoy) (from 20.1.2011)
12. Dr. Mahesh Kumar, Scientist (Sr. Scale) (Pedology)
13. Shri Hari Mohan Meena, Scientist (Agril. Meteorology) (from 28.8. 2010)
14. Shri J.S. Chouhan, T-(7-8)
15. Shri V.C. Issac, T-9 (Retired on August 31, 2010)
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 Bajrang Lal, T-5 (Retired on 31.3.2010)
23. Shri A.K. Gehlot, T-5
24. Shri R.C. Bissa, T-5
25. Shri Laxmi Narain, T-5
26. Shri R.S. Mertia, T-5
27. Shri Murlidhar Sharma, T-5 (Retired on 1.8.2010)
28. Smt. Meena Manglia, T-5
29. Shri Surendra Poonia, T-5
30. Shri Rajendra Singh Rajpurohit, T-5
31. Shri Ganpat Singh Deora, T-5
32. Dr. Manish Mathur, T-5
33. Shri Mota Ram Arya, T-5
34. Shri Khem Singh, T-5

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. L.N. Harsh, Principal Scientist (Forestry) (Retired on 31.8.2010)
5. Dr. Uday Burman, Principal Scientist (Plant Physiology)
6. Dr. J.C. Tewari, Principal Scientist (Forestry)

7. Dr. Anurag Saxena, Principal Scientist (Agronomy)
8. Dr. P.R. Meghwal, Principal Scientist (Horticulture)
9. Shri A.K. Sharma, Scientist (Sel. Grade) (Agronomy)
10. Dr. Akath Singh, Sr. Scientist (Horticulture) (from 31.12.2010)
11. Dr. P. Ratha Krishnan, Sr. Scientist (Forestry) (from 31.12.2010)
12. Shri Pradeep Kumar, Scientist (Horticulture)
13. Shri S.P. Seth, T-(7-8)
14. Shri G.L. Meena, T-(7-8) (Retired on 28.2.2010)
15. Shri J.K. Lohiya, T-6
16. Shri Raj Kumar Mathur, T-6
17. Shri Shanti Lal Sharma, T-5
18. Shri Prahlad Singh, T-5
19. Smt. Aleyamma Varghese, Private Secretary (Retired on 31.1.2010)

DIVISION OF PLANT SCIENCES AND BIOTECHNOLOGY

1. Shri Arvind Henry, Principal Scientist (Plant Breeding) & I/c Head (upto 22.8.2010) and I/c PC (NNP on Arid Legume) (from 1.8.2010)
2. Dr. R.K. Bhatt, Head (from 23.8.2010)
3. Dr. Devendra Kumar, Principal Scientist (Plant Breeding) and PC (NNP on Arid Legume) (Retired on 31.7.2010)
4. Dr. Satya Vir, Principal Scientist (Agril. Entomology)
5. Dr. M.P.S. Rathore, Principal Scientist (Agril. Entomology)
6. Dr. V.K. Manga, Principal Scientist (Plant Breeding)
7. Dr. S.K. Jindal, Principal Scientist (Plant Breeding)
8. Dr. R.R. Bhansali, Principal Scientist (Plant Pathology)
9. Dr. S.K. Lodha, Principal Scientist (Plant Pathology)
10. Dr. Arun Kumar, Principal Scientist (Plant Pathology)
11. Dr. Om Parkash Yadav, Principal Scientist (Plant Breeding) (utpo 17.6.2010)
12. Dr. R.K. Kaul, Principal Scientist (Nematology)
13. Dr. S.K. Singh, Principal Scientist (Plant Pathology)
14. Dr. P.K. Roy, Sr. Scientist (Plant Breeding) (from 17.3.2010)
15. Dr. Anjaly Pancholy, Sr. Scientist (Genetics/Cytogenetics)
16. Dr. Nisha Patel, Sr. Scientist (Agril. Entomology)
17. Dr. M.P. Rajora, Sr. Scientist (Plant Breeding)
18. Dr. Sunil S. Mahajan. Sr. Scientist (Seed Technology)
19. Shri Bhagirath Ram, Scientist (Genetics) (from 12.7.2010 to 30.12.2010)
20. Dr. Arvind Kumar, Scientist (Genetics) (from 15.3.2010 to 5.7.2010
21. Shri Manohar Singh Solanki, T-5
22. Shri Puskar Singh Rawat, T-5
23. Shri Ramu Ram, T-5
24. Shri Rakesh Pathak, T-5
25. Shri Mohan Lal Sharma, T-5
26. Shri Rajan Lal, T-5

DIVISION OF ANIMAL SCIENCES AND FORAGE PRODUCTION

1. Dr. N.V. Patil, Head (upto 12.6.2010)
2. Dr. H.C. Bohra, Principal Scientist (Animal Nutrition), I/c Head (from 13.6.2010 to 19.10.2010)
3. Dr. A.K. Mishra, Head (from 20.10.2010)
4. Dr. M.S. Khan, Principal Scientist (Animal Biochemistry) (Retired on 31.3.2010)
5. Dr. B.K. Mathur, Principal Scientist (Animal Nutrition)
6. Dr. A.K. Patel, Principal Scientist (Livestock Prod. & Management)
7. Dr. Mavji Patidar, Principal Scientist (Agronomy)
8. Shri Dinesh Mathur, T-6
9. Shri R.C. Bohra, T-6
10. Shri R.S. Chouhan, T-5
11. Shri Hanuman Ram, T-5
12. Shri Bhudha Ram, T-5 (from 3.2.2010)

DIVISION OF AGRICULTURAL ENGINEERING AND ENERGY

1. Dr. Harpal Singh, Head (Retired on 31.1.2011)
2. Dr. P.C. Pande, Principal Scientist (Physics) & I/c Head (1.2.2011)

3. Dr. N.M. Nahar, Principal Scientist (Physics)
4. Dr. P.B.L. Chaurasia, Principal Scientist (Physics)
5. Shri Dinesh Mishra, Principal Scientist (Farm Machinery & Power)
6. Dr. P.K. Malaviya, Principal Scientist (ASPE)
7. Dr. A.K. Singh, Sr. Scientist (Farm Machinery & Power)
8. Dr. Harilal Kushwaha, Scientist (Sr. Scale) (Farm Machinery & Power) (upto 29.12.2010)
9. Shri Priyabrata Santra, Sr. Scientist (Soil Physics) (from 28.1.2011)
10. Shri Purshottam Sharma, T-9
11. Shri Safiullah Ansari, T-9
12. Shri Hans Raj, T-9
13. Shri S.K. Vyas, T-(7-8)
14. Shri M.M. Purohit, T-6
15. Shri R.C. Bissa, T-5
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 Babu Lal Prajapati, T-5 (Retired on 31.12.2010)
23. Shri Sodi Singh, T-5
24. Shri Bal Kishan Dave, T-5
25. Shri Madan Lal, T-5
26. Shri Bhanwar Lal Verma, T-5
27. Shri Kale Shailendra Rambau, T-5
28. Shri Vijay Kumar, T-5

DIVISION OF AGRICULTURAL ECONOMICS, EXTENSION AND TRAINING

1. Dr. Y.V. Singh, Head (upto 20.10.2010)
2. Dr. D.K. Saha, Principal Scientist (Agril. Extension), I/c Head (from 21.10.2010)
3. Dr. R.N. Singh, Principal Scientist (Agril. Extension)
4. Dr. B.L. Gajja, Principal Scientist (Agril. Economics)
5. Dr. Pratibha Tiwari, Principal Scientist (Home Science)
6. Dr. Raj Singh, Principal Scientist (Agronomy)
   Dr. A.W. Siddiqui, Sr. Scientist (Agril. Extension) (upto 1.10.2010)
7. Dr. Bhagwan Singh, Sr. Scientist (Agril. Extension)
8. Dr. Soma Srivastava, Scientist (Food & Nutrition) (from 9.9.2010)
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
6. Shri Surjeet Singh, T-5

K.V.K. SCHEME, JODHPUR

1. Shri M.C. Bhandari, Principal Scientist (Agril. Extension) and Officer-in-Charge
2. Shri A.C. Mathur, T-9
3. Shri R.R. Meghwal, T-9
4. Shri A.S. Tomar, T-(7-8)
5. Shri Vinod Kumar Badgujar, T-6
6. Mrs. Savita Singhal, T-6
7. Shri Ram Pal Singh, T-6
8. Dr. Manoj Kumar Gujar, T-6 (from 17.1.2011)
9. Shri P.S. Bhati, T-5
10. Shri Jagdish Rohlan, T-5
11. Ms. Kalawati, Asstt. Adm. Officer

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

C.R. FARM

1. Shri Gitam Singh, T-9

2. Shri Roop Singh Rathore, T-5

SECURITY SECTION

1. Shri Pramod Kumar, Security Officer
2. Shri Shyam Singh, T-5

ADMINISTRATIVE WING

1. Shri Shushant Saha, Sr. Administrative Officer (upto 14.9.2010)
2. Shri Sanjay Bakolia, Chief Administrative Officer (from 9.9.2010)
3. Smt. Annamma Varghese, Private Secretary (Retired on 31.8.2010)
4. Shri Atma Ram, Private Secretary (Retired on 30.6.2010)
5. Smt. Marriamma Mathews, Private Secretary (from 17.9.2010)
6. Shri Sujit Kumar Singh, Administrative Officer
7. Shri S. Sugathan, Asstt. Adm. Officer (Adm. I)
8. Shri Joy Varghese, Asstt. Adm. Officer (Adm. II)
9. Shri H.L. Pargi, Asstt. Adm. Officer (from 26.6.2010) and D.D.O (Adm. III)
10. Shri Dhan Raj, Asstt. Adm. Officer (Adm. IV)
11. Shri Ratan Lal Sunkariya, Asstt. Adm. Officer (from 24.1.2011) (Adm. V)
12. Mrs. Madhu Bala Charan, Asstt. Director (OL)
13. Shri Bhanwar Lal Balai, T-5 (Retired on 31.7.2010)

ACCOUNTING WING

1. Shri S.K. Pathak, Sr. Finance and Accounts Officer (upto 13.3.2010)
3. Ms. Aruna Sharma, AFAO
4. Shri Pawan Kumar Tiwari, AFAO
5. Shri Sunil Choudhary, AFAO

REGIONAL RESEARCH STATION, PALI MARWAR

1. Dr. P.P. Rohilla, Sr. Scientist (LPM), Officer-in-Charge (upto 17.4.2010)
2. Dr. Khem Chand, Sr. Scientist (Agril. Economics), Officer-in-Charge (from 18.4.2010 to 9.11.2010)
3. Dr. S.M. Deb, Head (from 10.11.2010)
4. Dr. P.K. Roy, Sr. Scientist (Plant Breeding) (upto 16.3.2010)
5. Dr. S.S. Rao, Sr. Scientist (Agronomy)
6. Dr. B.L. Jangid, Sr. Scientist (Agril. Extension)
7. Dr. Shiva Dutt, Sr. Scientist (Genetics/Cyto-Genetics) (upto 28.12.2010)
8. Dr. S.P.S. Tanwar, Sr. Scientist (Agronomy)
9. Shri Pannalal Regar, Scientist (Sel. Grade) (Soil & Water Cons. Engg.)
10. Shri B.S. Jodha, T-5
    Shri Sanjay Kumar Dashora, T-5
11. Shri Virendra Singh Nathawat, T-5 (from 3.2.2010)
12. Shri Pratap Singh Solanki, T-5 (from 3.2.2010)

K.V.K. SCHEME, PALI

1. Dr. Dheeraj Singh, Training Organizer
2. Dr. M.K. Choudhary, T-(7-8)
3. Shri Hari Dayal, T-6
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 (from 30.1.2009)
8. Shri Tara Ram, T-5

REGIONAL RESEARCH STATION, BIKANER

1. Dr. R.K. Beniwal, Head (Retired 31.5.2010)
2. Dr. N.D. Yadava, Principal Scientist (Agronomy) & I/c Head (1.6.2010)
3. Dr. Jai Prakash Singh**,** Principal Scientist (Economic Botany)
4. Shri Bhanu Pratap Singh, Sr. Scientist (Horticulture) (Retired on 31.1.2010)
5. Dr. Motilal Soni, Sr. Scientist (Soil Chemistry/Fertility)
6. Dr. Vijay Singh Rathore, Sr. Scientist (Agronomy)
7. Dr. Narain Singh Nathawat, Sr. Scientist (Plant Physiology)
8. Dr. Birbal, Scientist (Sr. Scale) (Horticulture)
   Ms. Seema Bhardwaj, Scientist (Pedology)
9. Shri N.P. Singh, T-9
10. Shri J.C. Joshi, T-9
11. Shri Rahu Ram Meghwal, T-5
12. Shri Pratul Gupta, T-5
13. Shri Jogeshwar Ram, T-5

REGIONAL RESEARCH STATION, JAISALMER

1. Dr. R.S. Mertia, Head (Retired on 31.3.2011)
2. Dr. R.N. Kumawat, Sr. Scientist (Agronomy)
3. Dr. Hansraj Mahla, Sr. Scientist

4. Dr. Nawlesh Kumar Sinha, Sr. Scientist (Seed Technology)
5. Shri Priyabrata Santra, Scientist (Soil Physics) (upto 27.1.2011)
6. Dr. P. Raja, Sr. Scientist (Pedology) (from 21.3.2011)
7. Shri Kana Ram Choudhary, T-(7-8)
8. Shri Daleep Singh, T-5
9. Shri Bhagirath Mal Yadav, T-5

REGIONAL RESEARCH STATION, KUKMA-BHUJ

1. Dr. Devidayal, Head
2. Dr. Deepesh Machiwal, Sr. Scientist (Soil & Water Conservation Engg.) (from 1.2.2011)
3. Shri Bhagirath Ram, Scientist (Genetcs) (upto 11.7.2010)
4. Dr. Arvind Kumar, Scientist (Genetics) (from 6.7.2010)
5. Shri M. Shamsudeen, Scientist (Pedology)
6. Shri M.L. Swami, T-(7-8)

CAZRI IN THE NEWS

NOTES