
2007 EXECUTIVE SUMMARY

Integrated Natural Resources Appraisal, Monitoring and Desertification

Natural resource survey was extended to more tehsils of Jhunjhunun district. The normal annual rainfall of the district varies from 399 mm in 26 rainy days at Jhunjhunun to 556 mm in 32 rainy days at Khetri. Extreme annual rainfall records in the district varied from a lowest of 93 mm in 1901 at Jhunjhunun to a highest of 1252 mm in 1977 at Khetri. The long-term trends in annual rainfall showed either normal or marginal increase. The rate of increase over 100 years was 56 mm at Chirawa, 12 mm at Jhunjhunun and 30 mm at Udaipurwati. Moderate to severe drought occurred in 30 out of 105 years at Jhunjhunun and Chirawa tehsils and in 34 out of 105 years in Khetri tehsil.

The district has eleven major landform units. Seven soil series and their associations have been identified and mapped in twelve mapping units in Jhunjhunun district. Micronutrient deficiency is not a problem for agriculture here, except for deficiency in zinc. Dune complex soils are highly susceptible to wind erosion and best suited for silvi-pastoral system

Prosopis cineraria is the dominant tree on sandy plains whereas *P. cineraria* with *Acacia nilotica* occur on alluvial plains and with *Tecomella undulata* on hummocky areas. The dominant shrubs include *Capparis decidua*, *Calotropis procera*, *Leptadenia pyrotechnica*, *Aerva pseudotomentosa* and *Ziziphus nummularia*. Khejri tree density per hectare varied from 5-10 on sand dunes, 10-20 on sandy hummocks/plains in grazinglands and 10-20 trees ha⁻¹ in croplands. Of the 131 grazinglands, 23% were severely degraded, 34% moderately degraded, 40% slightly degraded and 3% were not degraded.

Average depth to groundwater is 60.55 m. Groundwater quality is generally good (mean EC 1.885 dS m⁻¹). Average water level decline in Jhunjhunun district is 1.46 m y⁻¹ for 2001-2006. Present groundwater balance is 274.61 mcm, and stage of groundwater development 525.84 mcm. Thus, there is a shortfall of -251.18 mcm (191.5%) in the district.

Cultivated lands including fallow lands cover 84.25% area of Jhunjhunun district, while wastelands cover 1.97%, notified forest 6.36%, permanent pasture/grazinglands 4.44% and settlement and water bodies occupy 2.98% area. The area under double cropping and settlement/built up has increased whereas the area under cultivable waste, permanent pasture, forest and barren lands has declined.

In the past three decades, irrigated area has increased 10 fold in Jodhpur district. Pasturelands have declined by 18.3% while the area under settlement increased by 24.3%. The area under rabi crops has increased by 110% in Churu district during 1980-2002. The area under forest has increased by 255%. In Ganganagar and Hanumangrah districts, irrigated area has increased by 334% after introduction of canal systems. About 15000 ha area is waterlogged.

Desertification mapping (1:1 million-scale) revealed that 176418 km² area of western Rajasthan and 72287 km² of western Gujarat is affected by different processes of degradation. Desertification-mapping at 1:50000 scale has now been undertaken in five districts of western Rajasthan.

Biodiversity Conservation and Improvement of Annuals and Perennials

Improvement in soil depth significantly enhanced the growth and leaf yield of *Aloe vera*. Guggal (*Commiphora wightii*) provenances Dantiwara and Mangaliawas were found suitable for Jaisalmer conditions. Guggul plants propagated through seeds had longer and more primary roots whereas plants raised through cuttings had better plant height and stem collar diameter. In henna, clone with high lawsone content has been identified. Accessions CZBHS-46 and CZBHS-39 of *Haloxylon salicornicum* had highest fruiting intensity and seed yield.

Variety Pant Manohar of karonda exhibited highest increase in plant height and canopy volume. In gonda, the highest fruit yield (9.1 kg) was recorded in accession G 2021. Goondi was unsuitable as a rootstock of gonda in the long run. Cultivar Deglet Noor of date palm produced the largest fruit. In *Salvadora oleoides*, accession from Navalgadh (Gujarat) showed maximum height. Amongst the seven provenances of *Acacia albida* the best accession was EC 2325 83 from Niger.

In forage clusterbean, entry AG-2-4 had maximum green yield (11.7 t ha⁻¹) as well as dry fodder (2.75 t ha⁻¹) and AG-2-5 had tallest plants (82 cm). In *Cenchrus ciliaris*, ICC 6 gave maximum green fodder (7 t ha⁻¹) and ICC 5 had maximum dry matter production (2.5 t ha⁻¹). Row spacing and N levels did not affect plant height and fodder yield of *C. ciliaris*, although number of tillers increased due to 40 kg ha⁻¹ N application at first cut. *Cenchrus setigerus* genotypes CAZRI 550, 419 and 758 were found promising. In Bhuj, genotype BH/CS-5 of *Cenchrus setigerus* and BH/DA-3 of *Dicanthium annulatum* performed better than other genotypes. At Jaisalmer, accession JSM 9 of *Lasiurus syndicus* consistently produced highest green and dry fodder yield.

Pearl millet crosses gave 17% and 5% higher stover yield than exotic and landraces, respectively. Cross 108x923 was best for simultaneous improvement of grain and stover. In participatory varietal selection farmers preferred varieties RHB 121, ICMH 356 and GHB 538 and showed strong liking for bristles, exposed and bold grains and early maturity. By crossing CAZRI inbred lines of pearl millet with male sterile lines, forty new hybrid combinations were made.

In clusterbean, early maturing varieties G-4 and G-5 had higher yield (390-392 kg ha⁻¹) and variety RGC 1030 (48%) and GAUG 0004 had highest endosperm and gum content, respectively. Early maturing lines exhibited better yield potential and seed size over medium and late maturing lines. In moth bean, variety (CZM-3) gave maximum yield (867 kg ha⁻¹), while CZM-2 possessed maximum clusters and pods plant⁻¹. In varieties HM-61 and RMO 225 narrow spacing of 30 cm resulted in significantly higher seed and straw yield than wider spacing of 45 cm. Urea spray treatments enhanced the seed and straw yield of moth bean significantly. This year 1685 kg breeder seed of released varieties and potential material of clusterbean, moth bean and cowpea was

produced. Under ICAR mega seed Project 251, 47 and 54 kg seeds of sesame cv. G-2 clusterbean cv. Maru guar and grass seeds were produced at Bhuj.

Three to four-year-old date palm offshoots were found good source of plant material for obtaining explants. The apical tip was most suitable for the initiation of callus. Activated charcoal was found essential for the survival of explants. Of the 44 *Bacillus thuringiensis* cultures isolated from local soil samples, two cultures showed promising insecticidal activity.

Integrated Arid Land Farming Systems Research

Continuous cropping of pearl millet without fertilizer application produced 735 kg grain ha⁻¹, in the fifteenth year, which was 59% lower than that with recommended level of N application. The practices of rotating pearl millet with clusterbean and fallowing in alternate years produced significantly higher grain yield than continuous cropping. Water use efficiency of pearl millet was significantly improved by rotation and fallowing. Soil organic carbon in surface soil rose from 0.12% to 0.20 and 0.24% after continuous application of 2.5 and 5 t FYM ha⁻¹ for fifteen years. Continuous cropping of pearl millet resulted in decline in available potassium whereas addition of FYM increased it.

Pearl millet yield was higher under reduced tillage as compared to tillage in clusterbean-pearl millet, mung bean-pearl millet, moth bean-pearl millet and pearl millet- pearl millet cropping systems. Significant enhancement of seed and straw yield of moth bean was recorded with the application of 2.5 t FYM+10 kg N+PSB. Intercropping of moth bean with pearl millet (2:1 or 3:1) significantly improved moth bean equivalent seed yield and net returns. At Jaisalmer sole crop of moth bean followed by intercropping of moth bean and pearl millet at 3:1 and 2:2 ratios resulted in higher pearl millet equivalent yield. Pearl millet (HHB 67) grown for second consecutive year after three years of senna cultivation yielded 36% higher grain yield. WUE of pearl millet genotype CZP 9802 was high under both rainfed and irrigated conditions and it also showed better drought tolerance at all the growth stages. Clusterbean+sesame in 2:1 row ratio gave significantly higher yield of clusterbean than 1:1 and 1:2 row ratios. Sesame performed better under intercropping system than sole stand. Among different farming systems moth bean-clusterbean system registered maximum clusterbean-equivalent yield.

The soil moisture remained higher when clusterbean was associated with older *Tecomella* than with younger seedlings. The height and canopy area of *C. mopane* were higher when grown in association with cowpea and grasses in strip cropping. The interaction effect of trees and grasses decreased green and dry fodder yield of *C. ciliaris*, *L. indicus* and cowpea up to 1 m distance from the 7 year old trees of *C. mopane* and *H. binata*. Beyond 1 m distance from trees, the yields were unaffected. Mustard intercropped with citrus gave the highest grain (385 kg ha⁻¹) and straw yield (3128 kg ha⁻¹) at 80% ETc irrigation level, whereas lowest yield of mustard was recorded under intercropping with shisham.

The fungus *Penicillium purpurogenum* hydrolyzes unavailable P and enhances production of pearl millet. The concentrations of Ca, Mg, Fe and Zn in cowpea, horse

gram, moth bean, mung bean, soybean and pearl millet seeds were increased during soaking and germination processes. Boiling decreased the Ca, Mg and Fe concentration.

Productivity of grass was the maximum in silvipasture, followed by agri-pasture, horti-pasture and sole pasture system. However, the highest system productivity (1829 kg ha⁻¹) was recorded with sole pasture under rainfed conditions. Maximum soil erosion occurred in arable cropping system whereas all the pasture based models except agri-pasture completely checked soil erosion and showed a net gain of SOC. *Pongamia pinnata* and *Jatropha curcas* plants under circular catchments showed the maximum growth.

Integrated Land and Water Resources Management

Catchment demarcation in three contiguous blocks of Beriganga Research Farm of CAZRI revealed 19 small catchments of first and second-order streams. Two high intensity rainfall events of 53 mm and 32 mm contributed the major volume of water in Agolai watershed. *Aloe vera* alone effectively reduced the runoff losses and prevented loss of important soil nutrients in the runoff. Application of irrigation water through drip equal to 60% cumulative pan evaporation (CPE) supported better growth and fruit yield in ber, pomegranate and aonla. Inter-cultural operation with tractor operated sweep for inter row water harvesting resulted in significant increase in henna dry leaf yield

In pearl millet+moth bean (2:2) intercropping system, the yield of pearl millet improved when grown in association with *P. cineraria* and *Z. mauritiana*, but the yield of moth bean reduced substantially. Land equivalent ratio (LER) was higher at 1.61, 1.43 and 1.29 in arable, agroforestry and agro-horticulture systems, respectively, for pearl millet+mungbean intercropping system.

Agro-horticulture system with ber gave the highest returns followed by agroforestry with khejri and arable farming. Among the dryland crops, net returns were higher (Rs. 9088 ha⁻¹) in clusterbean as compared to pearl millet/sesame based intercropping systems. The farming system model could sustain 3 milch cattle round the year with additional economic gains of Rs. 20,000 from animal component alone. Silvi-pasture system with *C. mopane* showed higher organic carbon (0.16%) followed by *C. ciliaris* pasture (0.13%), agroforestry with *P. cineraria* (0.127%) and agro-horticulture system (0.11%). The top feed production was the maximum (15 kg plant⁻¹) in *H. binata* followed by *P. cineraria* (12 kg plant⁻¹). The fuel wood production was higher in *P. cineraria* (26 kg plant⁻¹) and *Z. rotundifolia* (25 kg plant⁻¹). Pearl millet production was not affected by *P. cineraria*, significantly but other prominent leguminous arable crops exhibited a decline in production under it. Maximum yield reduction for various crops was recorded under canopy of *S. oleoides*.

Villages of Barmer district had maximum density of *P. cineraria* followed by *C. decidua* (9.67 shrubs ha⁻¹). Maximum basal cover was recorded for *P. cineraria* followed by *S. oleoides*. Studies indicated that *P. cineraria* and *S. oleoides* species are severely exploited and might disappear from the system in future.

Improvement of Animal Production and Management

Marwari breed is uniformly distributed in Luni Panchayat Samiti, in Jodhpur district whereas in Bilara Panchayat Samiti mixed phenotypes of Marwari, Sirohi, Barbari and Jamunapari breeds exist. The body weight of male kids at saleable age (6 month) ranged from 15 to 20 kg. Age of first kidding in Marwari goats ranged from 18 to 24 months. Daily milk yield ranged from 0.5 to 2.0 L with lactation period of about 7 months (October to April). Parbatsari kids registered higher weight and the average weight of dams at kidding was also higher in Parbatsari breed (35 kg) than Marwari (33 kg). Male kids were heavier than female kids in both the breeds. Lactation length and milk yield per day was also higher in Parbatsari breed (232 days and 0.85 L day⁻¹) than Marwari breed (23 days and 0.84 L day⁻¹). The elite group of Marwari goats produced 41% higher milk indicating a wide scope in improving milk yield traits through genotypes of elite Marwari goat. Goat kids receiving probiotics alone and in combination with multi-nutrient mixture had better body weights than kids not receiving probiotics. Similarly, the lactating goats yielded more milk

The increase in height at hipbone and the heart girth were significantly more in castrated Marwari goats than in non-castrated animals over a period of 14 months. The body length and height at withers were however more in non-castrated animals. The dressing percentage was higher (54%) in meat of castrated animals than in non-castrated (50%) animals. Castration increased fat deposition around intestine, kidneys and heart.

The age at first calving of Tharparkar cattle was 1340±75.8 days. The lactating cows yielded 2038 L milk in a standard lactation period of 305-days and 2225 L in a lactation period of 347 days. The feeding of urea molasses mineral blocks significantly improved average daily weight gain compared to the control group. The cost of feeding was Rs. 0.5 per day and net profit from the sale of block fed lambs was also higher by Rs. 125 as compared to control group. Fresh leaves of *C. mopane* could be given as feed of sub maintenance as the sole feeding of *C. mopane* leaves to growing Marwari and Parbatsari bucks was found to result in body weight loss of 3.36 kg, whereas the sole feeding of *H. binata* leaves resulted in body weight gain of 4.12 kg. Lactating Rathi cattle fed with lana (*Haloxylon salicornicum*) seed had higher values the fat, protein, of SNF and lactose in milk than the control group, respectively. Lana seed can be safely included in the concentrate replacing 25% til (*Sesamum indicum*) seed cake of the concentrate in the ration of lactating cattle. Feeding *Saji* powder, obtained from *Haloxylon recurvum* enhanced milk yield in Rathi cows.

Malnutrition and post partum reproduction diseases of the cattle in all the districts resulted in higher age at maturity (4-5 yrs), age at first calving (5-6 yrs) and inter-calving period (1.5-2 yrs), The young animals (upto 1-2 months) suffered from diseases like diarrhoea, pneumonia resulting in mortality. Mortality and morbidity was more for the kids than lambs. Analysis of blood samples of the animals for macro and microelement status revealed deficiency of different nutrients in different areas therefore, indicating need to formulate area specific mineral mixture.

Plant and Animal Products, Value Addition

Soap having good appearance and no adverse smell was prepared from bleached fat of *S. oleoides* seeds. Candles were also prepared from the bleached fat. Storage of

seeds of *Salvadora oleoides* for 2 years did not reduce its fat content. Air-dried leafless branches of *Acacia nubica* extracted with hexane and methanol yielded a flavonoid.

A method was standardised for purification of crude *Aloe vera* juice, which does not harm the active *Aloe vera* polysaccharide. A new and cheaper Aloe-based cream, suitable for dry skin, was also developed.

Squash was prepared from pods of *Prosopis juliflora*, which was approved in organoleptic tests. A coffee substitute was also made from *P. juliflora* pods. The flour of the pods was used in preparation of multi-nutrient feed block.

Methods have been developed for the preparation of chutney, pickle, jelly and toffee from the poor quality or damaged fruits of date palm. Kulfee, paneer and whey drink were prepared from goat milk.

Integrated Pest Management

Entomopathogens applied with FYM provided termite control at par with insecticide dust in clusterbean. In mung bean seeds no emergence of adults of pulse beetle *Callosobruchus maculatus* was seen with application of 1500-ppm azadirachtin and 10000 ppm neem oil. In surveys carried out in four districts, the infestation by the pod borer *Phycita clientella* was maximum in Barmer and minimum in Jaisalmer district. The maximum resistance to whitefly in henna was observed in accessions Wav, Khedbrahm, SKN and Sidhpur, while highly susceptible accessions were Ajmer, Pali and Panchotiya.

Of the 63 inbred and summer lines of pearl millet screened for resistance against downy mildew disease under field conditions, 23 entries did not exhibit disease symptoms. *Trichoderma viride* and *T. harzianum* enhanced both seed germination and seedling vigour of pearl millet. The least plant mortality due to dry root rot on cowpea was recorded in the treatment where seeds were coated with *Bacillus firmus* and sown in radish compost amended soil. Maximum colonization of *B. firmus* and *A. versicolor* in cowpea was recorded in the treatment where both the biocontrol agents were combined together. A heat-tolerant strain of *Aspergillus versicolor* has been developed which can withstand 75°C temperature.

Cotyledonary leaf explants initially cultured on callus induction medium and co-cultivated for 1-5 days with *Agrobacterium rhizogenes* showed maximum percent transformation for 2-4 days of exposure. When *M. incognita* infected seedlings were transplanted in soil infested with *Glomus fasciculatum* and *G. mosseae*, both the AM fungi reduced the average number of galls in the root system.

Choice trials indicated fairly good acceptability and palatability of the wax block bait of brodifacoum to *B. bengalensis*. Aluminium phosphide fumigation of rodent live burrows yielded good control success in different cropping systems.

Non-Conventional Energy Resources, Farm Machinery and Power

The use of 3-furrow (6-row) seed drill developed by the Institute resulted in 20 and 22% enhancement in yield of pearl millet and moth bean crops, respectively, compared to the crop sown by traditional method. The Pali local seed drill was improved by incorporating modifications in seed distribution system to drop the seeds adequately

and uniformly. An experimental harvesting device was designed and tested for cutting henna crop and is being improved with appropriate cutting mechanism and compatible engine. The drive system for metering mechanism of animal feed block-making machine was designed and fabricated.

Two low cost solar dryers, one made of bamboo with sirki and the other with bamboo and PVC have been designed and fabricated. A PV mobile unit for domestic and other applications was designed and developed. Some gadgets developed by the Institute were provided to farmers like integrated collector-storage solar water heater, low cost solar cooker for animal feed, etc. A three in one solar system, which can be used as solar water heater, cooker and dryer has been developed which can continue the dehydration process even during the night by the heated water.

Socio-Economic Investigation and Evaluation

In Jodhpur district a majority of landless and disadvantaged population find livelihood through wage labour within the village and in nearby urban areas especially from quarries, road constructions, share cropping and drought relief activities. These groups were vulnerable to drought for their annual income. Indebtedness was widespread in normal and drought years (60% indebted). Drought relief activities mitigate some of the miseries of the population through short-term employment. Workable indicators for measuring socio-economic vulnerability of local population to drought in this region were: disadvantaged population (weaker section including BPL), household income, land holding and access to secondary occupation.

In Rohat tehsil of Pali district, though farmers rear both cattle and buffalo for milk production, buffaloes had dominant share in the herd. Milch animals especially buffaloes alone accounted for about 56% share of fixed investment. The maintenance cost per buffalo per day was Rs. 56. Herd owners got higher price for milk in summer season than rainy and winter seasons. The major constraints perceived by the bovine rearers were uncertainty of monsoons, non-availability of green fodder round the year, lack of improved milch breed animals and high cost of feed and fodder.

Technology Assessment and Transfer

Bi-weekly weather based agro-advisory bulletins during kharif and rabi seasons were prepared and broadcasted to farmers of Jodhpur region for day-to-day agricultural operations. On an annual basis, the forecast success was 83% for rainfall, 50% for maximum temperature and 34% for minimum temperature

Various on-campus and off-campus training programmes and other extension activities were undertaken by the Institute for the benefit of farmers, farm women rural youth and extension personnel. A total of 169 training courses were organised at Jodhpur, which benefited more than 4000 farmers and 200 extension personnel. More than 50 training courses were organised at RRSs, which benefited about 1500 farmers. A total of 181 frontline demonstrations on fertilizer management, micronutrient management, weed management, bio-inoculation and improved varieties of arid legumes were organized by KVK, Pali. There was significant response of fertilizer application in clusterbean, cowpea, moth bean and horse gram.

The technology developed by the Institute to induce gum in kumat was demonstrated and handed over to the line department, Department of Science & Technology (Govt. of Rajasthan) and NGO (Thar Voluntary Health Society, Jodhpur) for adoption. Under the network project on rodents, six on-campus and three off-campus training courses were conducted on rodent pest management for farmers, agriculture officers and extension functionaries. CAZRI Regional Research Station, Bikaner organized two training programmes on pasture development, mixed and organic farming. Lana Field Day was organized at Regional Research Station, Bikaner in which research workers, NGOs, students and farmers from nearby areas participated.

Five group discussions were organized on high yielding varieties of kharif crops, compost techniques, rodent management, seed-treatment and multi-nutrient mixture, where 55 farmers were benefited. After exposure to the training course on rabi crop production majority of farmers moved from low knowledge category to medium and high knowledge category.

The ATIC had a good number of visitors (1425), including the Government personnel, farmers, NGOs, students, other stakeholders, etc. from across the state and country for various products evolved by the institute, technical know how and farm advisory services. During the year a good number of farmers (3120), farm women (363), students/trainees (1066) and officers (80) visited the Institute.

Nearly 20 exhibitions were organised at various places to popularize the technologies of CAZRI and to create awareness among the masses about the activities of the Institute.

Empowerment of Women and Mainstreaming of Gender Issues

Technological empowerment of the members of two selected Self-Help Groups was provided through a technology package of feeding and health management of dairy animals and cultivation of dual-purpose crop varieties.

Off-campus skill training programs were also organized on preparation of balanced concentrate mixture in Khokharia and Borawas villages for farmwomen. Continuous feeding of balanced concentrate mixture resulted in the increase in milk yield ranging from 0.5 to 0.75 L day⁻¹. The concentrate mixture was found economical compared to those available in the market leading to a saving of Rs. 10 cow⁻¹ day⁻¹.

Other Activities

Besides the Institute research projects, the scientists also executed many externally funded projects. The National Network Projects on Rodent Control and Arid Legumes operate from headquarters at the Institute. Two Krishi Vigyan Kenrdras, one at Jodhpur and another at Pali, serve to disseminate technologies to the farmers in these districts.

