
EXECUTIVE SUMMARY (2008)

Integrated Natural Resources Appraisal, Monitoring and Desertification

Natural resource survey of two tehsils of Sirohi district showed an increase in annual rainfall of 78 and 66 mm/100 years at Sirohi and at Sheoganj, respectively. In Sheoganj tehsil, the major landforms are older alluvial plains (56.6%), hills with intermontane valleys (24.8%), younger alluvial plains (14.4%), pediments (3%), sand dunes (0.8%) and river beds (0.4%). Coarse-to-medium textured soils cover the maximum area. Invasion of *P. juliflora* in all the habitats and land use units is a concern. The major opportunities for watershed development were identified as *Nala* bunding, contour bunding, grading and terracing at higher slopes. The average depth to groundwater is 24.18 m and about 84% area has groundwater level at <40 m. In Sheoganj tehsil, cultivated lands constitute 52.2%, forest 20.3%, wastelands 12.2%, pastures/grazing land 6.7%, water bodies (river and tanks) 3.5%, settlement/built-up land 2.8% and plantation 2.1%. Between 1985-86 and 2006-07 the net irrigated area has increased by 44.4% and double cropped area by 144.5%. LISS-IV data has shown that in Ajitgarh area of Sikar district, the irrigated double cropped area has increased by 306.1% and rainfed mono-cropland has declined by 58.9% between 1967-68 and 2004-05. Contrary to it, irrigated area in Sojat (Pali district) has declined by 38.55% from 1970-71 to 2005-06 due to sharp decline in water table and drying of wells. In Makrana, the area under pasture has declined by 64.1% because of rapid expansion in mining activities. In Sodakor, the sandy waste has declined by 79.0% and gravelly waste by 10.9% due to increased use of groundwater for origination. Medium-resolution satellite data has shown substantial increase in cultivated area in Jaisalmer and Bikaner districts, increase in irrigated area in Nagaur district and decline in irrigated area in Pali district.

Land degradation mapping of Ganganagar, Hanumangarh and Churu districts based on IRS P6 LISS-III data revealed that out of the 34683 km² mapped area, 62.7% is under different kinds of degradation. The most dominant process is wind erosion (21398 km²; 61.7% area), especially in the form of sand sheeting (12864 km²), followed by partially stabilized sand dunes (5751 km²), stabilized sand dunes (2318 km²) and unstabilized sand dunes (464 km²).

Survey of 21 villages in 6 districts of Rajasthan revealed the problems of late maturity in heifers and post partum anoestrus in older animals. Infertility due to infection was reported in 20-45% animals. Major nutritional problems noticed in animals were deficiency of protein (43-78%), energy (24-36%) and major minerals i.e. Ca and P (23-47%).

In soils of Sikar district, organic carbon ranged from 0.015 to 0.560% but about 70% soil samples had <0.2% organic carbon. Available phosphorus and potassium ranged from 1.57 to 78.24 and 90 to 1023 kg ha⁻¹, respectively. In Ganganagar district, organic carbon ranged from 0.09 to 0.560% but 56% soil samples had <0.20% organic carbon and 32% samples had 0.2-0.3%. Available phosphorus and potassium ranged from 3.2 to 58.50 kg ha⁻¹ and 112 to 956 kg ha⁻¹, respectively.

Analysis of soil samples from different land uses in Bhopalgarh revealed that the soils under silviculture had the highest organic carbon (0.4%), available P (11.2 kg ha⁻¹) and available K (386 kg ha⁻¹). At RRS, Bikaner, soil organic carbon was highest in pasture and silvi-pasture systems (0.17%) followed by horti-pasture (0.16%). Minimum organic carbon was recorded in sole cropping of pearl millet (0.09%). In major grasslands of Kachchh region of Gujarat, the soil organic carbon stock in upper 5 cm layer was 2.57 to 4.67 t ha⁻¹. The carbon stock in different date palm growing eco-regions ranged from 2.17 to 2.83 t ha⁻¹ in top 5 cm layer.

Biodiversity Conservation and Improvement of Annuals and Perennials

A large number of experimental hybrids, testcrosses and varieties of pearl millet were tested. Hybrids based on landrace-derived material and dual-purpose male sterile line 93333A were evaluated against checks. The crosses on pollinators 2-6, 2-35 and 2-37 significantly out yielded the highest yielding check HHB 67 (2395 kg ha⁻¹) with their yields ranging from 3166 to 4388 kg ha⁻¹. In the evaluation of new testcrosses fifteen hybrids outperformed the best check HHB 67 by at least 10%.

Phenotyping for drought tolerance of pearl millet crosses produced by crossing 232 progenies on 93333A revealed that biomass, grain yield and stover yield were independent of flowering time. The association between grain and stover yield was slightly positive suggesting that grain and stover productivity in these materials were not antagonistic entities and one trait can be increased without causing any decline in other. Variation in biomass appeared to explain a significant amount of variation for both stover yield (79%) and grain yield (53%).

From the clusterbean varietal evaluations, the promising varieties were identified as GR-1, GR-5, GR-7 and GR-15. From fifty progenies from four crosses the progenies no. 5, 39, 47, 52, 69 were the most promising. Out of fifty stabilized progenies from cross of PNB x Suvidha, the progenies no. 3, 26, 35 and 60 with early flowering (25-27 days) were high yielding.

In the performance trial of mung bean varieties, KM-8-208 and KM 8-219 gave the highest yield (560-597 kg ha⁻¹) and were also early in maturity (61-62 days) with better 100-seed weight (4.3-4.7 g).

In varietal evaluation trials of *Cenchrus ciliaris* genotypes CAZRI 393 and CAZRI 288 were most promising with better fodder yield and plant height. In station trial of 18 genotypes of *Cenchrus setigerus*, the highest green fodder yield and dry matter production was recorded in genotypes CAZRI 175 (7916 kg ha⁻¹) and CAZRI 76 (2888 kg ha⁻¹) followed by check CAZRI 76 (6958 kg ha⁻¹, green) and CAZRI 175 (2375 kg ha⁻¹, dry). From 15 accessions of *Clitoria (Clitoria ternatea)* the accessions EC 15331-1, IGFRI 173-1, IGFRI 23-1 and CAZRI 1440, CAZRI 1441 yielded more than 2 t ha⁻¹.

From among 65 accessions of Lana (*Haloxylon salicornicum*), CZBHS-39 at 15 months after planting (MAP) and CZBHS-46 at 30 MAP and 45 MAP recorded maximum plant height.

The morphological characteristics of 8-year-old plantation of guggul (*Commiphora wightii*) showed a significant variation in plant height (135-171 cm), crown size (208-253 cm), shoot

diameter (65.0-78.6 mm), number of primary branches (5.2-10.5 per plant, and mean collar diameter of primary branches (32.8-42.9 mm).

From 24 accessions of *Salvadora oleoides*, the best progeny accession 214 showed significantly better height than the population means height during all the six years of growth. It was also established that selection for plant height will be most effective from second year onwards.

Performance of distinct types of *khejri* budded *in situ* showed that 20-30% of plants have also started flowering and fruiting just after one and half year of budding.

Date palm maintained at Jaisalmer showed that spathe emergence was first in cv. Migraf and Umsok and last in cultivar Khadrawy and Medjool. Cultivars Khadrawy, Umsok and Saidy produced nine bunches per plant. Maximum fruits/strand was in Hayani followed by Khalash. The overall yield was maximum in Khalash followed by Deglet Noor.

In seed production programme, 6306 kg seed of different crop varieties and 492 kg of grass seed was produced. Also, 8810 and 58,515 saplings of horticulture and forestry trees, respectively were raised. Total 1050 kg breeder seed of moth bean and pearl millet was produced.

Molecular characterization of 48 specimens of mushrooms growing in wild form in arid regions and also of the native *Bacillus* cultures was accomplished.

Integrated Arid Land Farming Systems Research

Effect of tillage and compost application on arid zone crops was studied during 10th consecutive year. Lowest pearl millet yield was obtained in control plots under reduced tillage. Incorporation of residues or compost (4 tons ha⁻¹) increased pearl millet yield both under conventional tillage and reduced tillage treatments. The effect of residues on grain yield of clusterbean and moth bean was very small. Compost had a positive effect on yield of all the legumes. In another long-term study, application of 40 kg N ha⁻¹ gave significantly higher yield (879 kg ha⁻¹) of pearl millet as compared to yield without fertilizer application (483 kg ha⁻¹) in the fifteenth year.

Clusterbean genotype GUAG-309 gave maximum seed yield (459 kg ha⁻¹) at Bikaner whereas cv. RMO-64 of moth bean was highest yielder (392 kg ha⁻¹). Sowing in rows 45 cm apart gave higher yield of both the legumes compared to 30 cm row spacing.

In clusterbean-cumin cropping system, application of 50% N through FYM and 50% N through urea gave highest seed yield (703 kg ha⁻¹) of clusterbean while application of 100% N through FYM to clusterbean gave highest seed yield (466 kg ha⁻¹) of succeeding cumin crop. In moth bean - pearl millet intercropping system, moth bean equivalent seed yield was highest (730 kg ha⁻¹) in 2:1 row ratio of moth bean and pearl millet intercropping, followed by 2:2 and 3:1 row ratio. At Bikaner, maximum clusterbean equivalent yield was registered with moth bean - clusterbean cropping system followed by pearl millet + clusterbean cropping system and least in pearl millet - pearl millet cropping system.

There were marked variations in yield and water use efficiency of 12 pearl millet genotypes assessed for drought tolerance. High yielding genotypes displayed 78.2% higher net photosynthesis, 57.6% higher chlorophyll content and 36.7% higher nitrate reductase activity as compared to low yielders at the flowering and maturity stages.

Application of TGA @ 250 ppm increased mustard seed yield by 32.76% over untreated control when crop was grown under limited irrigation condition at Bikaner. At Pali, cotton yield declined linearly with decreasing water supply from ET 100 to ET 50, while cumin yield decline from no-deficit to 70% water deficit was 79%. In wheat, deep tillage significantly increased yield by 12.6% over control.

Fruit yield of ladyfinger was maximum (9.77 t ha⁻¹) at 20x25 cm spacing followed by 20x30 cm (9.19 t ha⁻¹) under drip irrigation. Fresh root weight of carrot was maximum when crop was given 75% of recommended dose of nitrogen through fertilizer and 25% nitrogen through vermicompost.

Mushrooms gave highest yield on wheat straw followed by moth bean substrate. The fruit body yields of *P. sapidus*, *P. florida* and *P. sajor-caju* on wheat straw substrate were statistically at par when spawning was done in October. In gladiolus, variety snow princess (white coloured) was found best with respect to spike length (45-50 cm), total number of florets per spike (15-18), floret size (7.2 cm) and duration of flowering (14 days).

Under silvi-pastoral system, growth of *Colophospermum mopane* was better than *Hardwickia binata*. Maximum green and dry fodder yields were recorded with sole *Lasiurus sindicus* followed by sole *Cenchrus ciliaris*, which were significantly higher than grass-legume strip cropping. In another study, application of 45 kg nitrogen and 60 kg P₂O₅ kg ha⁻¹ gave the highest production of fresh weight (3883 kg ha⁻¹) and dry weight (1617 kg ha⁻¹) of clitoria. Under limited irrigation conditions, maximum green fodder yield was given by sole pearl millet, that was at par with pearl millet + cowpea intercropping.

In an agro-forestry system, no clear-cut effect of age of *Tecomella* trees or its distance from plant was observed on the variable-to-maximal fluorescence (Fv/Fm) of dark-adapted clusterbean leaves. However, the Fv/Fm ratio was more in tree + crop than sole crop system.

Clusterbean, cowpea and moth bean were intercropped with three fruit trees viz., aonla, ber and pomegranate at Kukma, Bhuj. All three arid legumes as intercrops performed better under the fruit plantations in terms of plant height, number of pods per plant, number of seeds per pod and 1000-seed weight than their sole crops. However, seed yield of arid legumes was maximum under sole cropping because of higher plant population.

In *Aloe vera*, green leaf yield was 19.9 t ha⁻¹ under rainfed condition. Irrigation at ID:CPE ratio of 0.2 and 0.4 gave 141 and 198% higher leaf yield compared to rainfed crop. At Bikaner, canopy area and number of branches per plant of *Haloxylon recurvum* were found to decrease with increase in plant density from 2500 to 4000 plants ha⁻¹. In another study, maximum germination of *Acacia jacquenmonti* was registered at 20°C followed by 25, 30, 15 and 35°C, While, in *Haloxylon*

recurvum maximum germination was registered at lower temperature (15 and 20°C) and it got inhibited at higher temperatures.

Lignin content of stover of cumin, sesame and mustard, and residues of *Amaranthus* and *Acarynthus* decreased after treating them with ammonia and the efficacy of NH₃ treatment was much better when moisture content of stover and residues was high.

Carbon input of arid zone crops during kharif season was found to vary between 500 to 1193 kg ha⁻¹. In another study, strongly basic anion exchange resin in Cl⁻ form was the best to extract more available phosphorus from the arid soils, which was strongly correlated with the P uptake of pearl millet and clusterbean. A new method for estimation of labile P in arid soils was developed and HCl was found to be the best extractant at 1.0 N concentration. A new P mobilizing organism, *Aspergillus wentii*, was isolated from arid soils. It can mobilize P from unavailable inorganic and organic sources.

Integrated Land and Water Resources Management

Repeated measurement of long profiles at Agolai showed symmetrical changes in channel hypsometry in the middle reach and a marked asymmetry in the erosion/deposition pattern in the lower reach. On an average >75% of the total particles moved >150 m while 5% moved more than >300m. In the upper reach, a maximum bank cut of 16 cm was recorded on August 2 along the left bank, and 8 cm deposition on August 14, but there was no marked change in the channel bed. In the middle reach, there was more incidence of aggradation with 3-8 cm cut and 4-5 cm deposition on August 14. In the lower reach, there was 49 cm erosion on August 14 and 41 cm deposition on August 2. The rainfall of 1 July caused initial erosion, but higher deposition took place during rains of July 17. The next rain of August 2 eroded the bed and flushed out most of the sediments, which was further accentuated during the rain storm of 13-14 August. The higher discharge (7-12 m³ s⁻¹) at L1 in the lower reach was responsible for high erosion, followed by bedload deposition in the lower reach.

Six rainfall events of >15 mm each at Beriganga farm effectively contributed to the runoff in Block-I, which varied from 8.1 to 11.2%. Out of the total runoff of 14685.8 m³, the three masonry check dams retained 1839.5 m³ (12.53%). Also, 0.2-0.5 m thick sediment was deposited upstream of the dams. Impounded water in check dams sustained for more than 3 weeks which helped tree growth along the banks.

Madpuria and Pundlu watersheds received 378.1 mm rainfall in 22 rainy days, while Baorali-Bambore watershed received 407.0 mm. The fully treated Baorali-Bambore watershed showed average runoff of 18.74%, followed by the partially treated Madpuria watershed (23.36%) and the untreated Pundlu watershed (24.24%). Highest average sediment load of 4.51 g l⁻¹ was observed in Pundlu watershed, followed by Madpuria (3.85 g l⁻¹) and Baorali-Bambore (3.2 g l⁻¹) watersheds. At Madpuria, the groundwater recharge was estimated to be 26.8532 ha-m. For Pundlu watershed recharge was estimated to be 28.9573 ha-m.

Effect of tree species on physical properties of arid soils was studied. Dispersible silt+clay of control soil was significantly higher than that of cultivated soil as well as soils below the tree

species. Hydraulic conductivity (HC in cm h⁻¹) of surface 0-10 cm undisturbed soil layer differed significantly under different tree species of similar age but only in older plantation.

Production potential of *Pongamia pinnata* and *Jatropha curcas* was studied for culturable wastelands at Pali. Spacing and moisture conservation treatments in *Jatropha* had no significant effect on plant height, collar diameter, branches per plant and canopy spread. In *P. pinnata*, maximum plant height and collar diameter of 144.6 cm and 3.4 cm were observed under circular catchment.

Continuous trenching treatment resulted in a maximum plant height (72.5 cm) of two year old plantation of *Acacia nilotica* followed by staggered trenching (59.4 cm) and no-trench (43.6 cm) on sloping wastelands at Jadan. Similarly, bunding increased henna dry leaf yield (232.3 kg ha⁻¹) over control (190.6 kg ha⁻¹).

Improvement of Animal Production and Management

An evaluation study with varying levels of dietary crude protein on production and reproduction performance of lactating goats of Parbatsari and Marwari breeds showed that the production and reproduction performance with 20% lesser crude proteins was as good as that with full protein supplementation. Similarly, effect of supplementation of mineral mixture on milk yield of Rathi cattle showed that milk yield, during lean period (November to February) when the availability of biomass is scarce, can be increased by feeding balanced concentrate having 2% mineral mixture. Thornless cactus (*Opuntia ficus indica*) was explored as alternate fodder source for Tharparkar cattle and it showed good acceptability, palatability and dry matter intake with higher body weight gain in cattle.

Experiments conducted on Marwari kids indicated that feeding of probiotics (1.4x10⁹ cfu day⁻¹) and nutrient mixture (100 g day⁻¹) resulted in 47% higher growth over control group and net returns of Rs. 2079 kid⁻¹. Similarly, Marwari goats offered probiotics (2.8x10⁹ cfu day⁻¹) and nutrient mixture (250 g day⁻¹) resulted in 48.2% greater milk yield than control group and net returns of Rs. 1170 goat⁻¹.

Growth performance of castrated and un-castrated male kids fed on supplementary Multi-Nutrient Mixture having 5% urea showed that castrated kids had slightly higher body weight gain than the un-castrated animals. Carcass traits as the shrinkage %, dressing %, weight of commercial cuts, offal weights etc. were also similar in the castrated and un-castrated kids and also in the un-castrated ram except the visceral and mesenteric fat content and its proportion to the fasted weight which was higher in the castrated kids.

Lana (*Haloxylon salicornicum*) seeds were utilized as 25% replacement of concentrate mixture for camel. The seeds can replace partially conventional concentrate feed without any effect on daily DM intake, average body weight gain and digestibility of nutrients. A grazing study on *Cenchrus ciliaris* and *Lasiurus syndicus* for Tharparkar cattle indicated that carrying capacity can be increased up to 1.56 ACU ha⁻¹, thereby resulting in increased livestock productivity.

The analysis of milk samples of cattle, goat and sheep indicated that Marwari goat milk contained highest level of β -carotene (23.87 \pm 2.13 μ g 100 ml⁻¹); while Marwari sheep milk had

lowest contents. Similarly, highest level of retinol was recorded in Marwari goat ($32.42 \pm 1.81 \mu\text{g } 100 \text{ ml}^{-1}$) and lowest in Tharparker cow milk. Parbatsar goat milk lipids contained maximum vitamin-A activity ($1397 \pm 155.4 \mu\text{g } 100 \text{ g}^{-1}$). Proximate analysis of the milk samples revealed that during summer, the density of sheep milk was highest and that of cattle milk was lowest. Sheep milk contained highest solids-not-fat ($10.17 \pm 0.11\%$), total solids ($17.32 \pm 1.16\%$) and lipid contents ($7.15 \pm 1.06\%$); while goat milk recorded lowest respective values of three parameters.

Plant and Animal Products and Value Addition

The fruits of *Salvadora oleoides* (Peelu) were procured (52 kg) from Araba area in Barmer district and Uttesar in Jodhpur district for preparing Peelu squash and extracting fat. The seeds available as by-product in the process of making Peelu squash were used for extracting inedible fat. The fat content in the assorted fruits was 39.9%. Analysis of 3-year-old seeds of *Salvadora oleoides* showed almost no difference in fat content even after three years' of storage.

A total of 91 landraces of *Aloe vera*, belonging to two groups, were analysed for AVPS content, fresh leaf weight and AVPS (g leaf^{-1}). The first group contained bitter (45) and non-bitter Aloe (15) of more than 4 year old plants and the second group had 31 landraces of over one year old plants. From first group, five landraces having leaf biomass of $>500 \text{ g}$ and AVPS content of 0.40%, were selected. Three superior landraces of non-bitter Aloe were also selected in the same manner. Their leaf biomass and AVPS content were $>360 \text{ g}$ and 0.200%, respectively. From second group, two landraces were selected which have leaf biomass more than 500 g and AVPS content above 0.250%. Aloe shampoo from *Aloe vera* juice was prepared by cold process without harming the active principle of the Aloe juice. The product is viscous and transparent.

Seven thousand trees of *Acacia senegal* were treated with gum inducer in the selected district of Barmer where 10 to 50 trees ha^{-1} occur naturally on dunes. To enhance the gum production, a small hole of 1" deep and $\frac{1}{4}$ " in diameter was made in the main stem. After that 4 ml solution of CAZRI gum inducer was applied through syringe and covered with the clay soil or bee wax. Gum exudation started within 10 to 15 days which was 10 to 100 g tree^{-1} whereas, with CAZRI's technology it ranged from 100 to 2000 g tree^{-1} with an average of 500 g tree^{-1} .

Mint leaves were dehydrated in three-in-one solar integrated device with an efficiency of 27%. The watermelon candies prepared by using the device in cooking and drying modes in succession could be stored without any obvious deterioration. Five kg mint leaves were dehydrated from 85 to 7% moisture content within 22 hours during June with maximum air temperature of 50°C and thermal gradient varying from $2-6^\circ\text{C}$. During the month of September, 5 kg spinach was dehydrated within 24 hours, quite uniformly with thermal gradient of $1-2^\circ\text{C}$ only. The system was also used for dehydrating 30 kg semi-dried pods of *Prosopis juliflora* within 8 hours. In all the experiments the thermal gradient was less initially but increased subsequently as the moisture content of the product reduced.

Integrated Pest Management

Effect of neem formulations on the incidence of pest complex and grain yield of mung bean showed that all the treatments were found significantly superior to control with maximum increase of 30.65% in grain yield in treatment having 200 kg ha⁻¹ neem pallets with 10 kg N + 20 kg P₂O₅ followed by neem pellets @ 400 kg + 20 kg P₂O₅ (25.96%).

Three entomopathogenic fungi viz., *Metarhizium*, *Beauveria* and *Verticillium* were tested for their effectiveness against termites. Cellulose bags (20 g) were put in pits in moist soil to attract termites. Entomopathogenic fungi formulations in saw dust (200g) were separately mixed in the pits having termites *Odontotermes obesi*. *Metarhizium anisopliae* consistently accorded the maximum protection.

Population dynamics of *A. versicolor*, a native bio-control agent, was studied for 12 months at 0-5, 6-10 and 11-20 cm soil depths. Maximum population of *A. versicolor* was estimated at 6-10 cm soil depth, but population density tended to decline at 0-5 cm followed by 11-20 cm soil depth. At 6-10 cm soil depth, population of *A. versicolor* remained higher after 12 months compared to initial level, while at 0-5 cm soil depth it remained almost similar to that of initial counts in the same period. At 11-20 soil depth, 80% increase in the viable propagules of *A. versicolor* was estimated in a 12-month period of study. Evaluation of 29 guar genotypes of guar against bacterial blight showed that genotypes GR 6 (30%) and on GR 25 (37.5%) recorded the least disease incidence.

In screening of *Bacillus thuringiensis* strains for nematode toxicity, second stage juveniles of *M. incognita* were exposed to eight isolates of *B. thuringiensis* for 24-96 hours. None of the isolate was observed toxic against the larvae. Two of the isolates initially caused loss in the motility of the larvae but larvae regained activity within 48 hours of exposure.

Monthly trappings of rodents in Institute farm indicated presence of five rodent species in different habitats. *Tatera indica* (73.9%) continued to dominate the species composition followed by *Funambulus pennanti* (10.4%), *Mus musculus* (9.13%), *Rattus rattus* (5.21%) and *Millardia meltada* (1.3%). The habitat preference of rodents towards horticultural, silva and cropfields/grasslands was at par with 33.0, 29.6 and 37.4% abundance in respective cropping systems. *F. pennanti* was mainly trapped from ber and pomegranate orchards, whereas *T. indica* was trapped from all the three habitats almost uniformly.

The effect of temperature on bait shyness behaviour was studied in *T. indica* and *F. pennanti* at higher (31°C) and lower (21°C) temperatures. The shyness period in both the test species was reduced at lower temperatures. In *T. indica* it took 50 days to overcome the shyness behaviour and 20 to 22 days in *F. pennanti*.

Non-Conventional Energy Sources, Farm Machinery and Power

Evaluation of solar thermal devices showed that average maximum stagnation temperature inside cooking chamber was 83.5°C, 71.7°C, 83.5°C, 76.4°C and 70.3°C in solar cooker made of

clay, vermiculite, vermiculite with reflector, brick and stone slab, respectively at ambient temperature of 26.2°C. The average hot water temperature was 53.4°C and 58.1°C in integrated collector storage solar water heater and natural circulation type solar water heater, respectively when tap water temperature was 24.0°C.

PV Mobile unit fabricated for providing a moveable self sustaining power system to contemplate domestic, agricultural and rural-oriented tasks was tested for charging the battery by 140 Wp PV modules through a charge regulator and maximum power tracker. The charging current while operating the different loads varied from 4 A to 10 A, depending on the load, irradiance and battery condition. The lowering in voltage was 2.3-5.2% when different base materials were used as compared to no-base material while ambient temperature varied from 31-34°C.

The performance evaluation of PV array attached to PV pump and generator revealed that the PV output, especially the short circuit current, has come down to more than 20% of that of initial values after 14 years indicating an average yearly fall of 1.5%.

The three-furrow (six-rows) seed drill (CAZRI seed drill) was extensively evaluated. Mustard seed yield was 2133 kg ha⁻¹ when crop was sown with CAZRI seed drill in comparison to 1633 kg ha⁻¹ from sowing with modified Pali-seed drill. Pearl millet seed yield was 1378 and 1200 kg ha⁻¹ when crop was sown with CAZRI seed drill and Modified Pali seed drill, respectively. A new seed drill was fabricated from cultivator, with tyne type furrow opener, by incorporating appropriate mechanized seed distribution system and press wheel assembly for effective and uniform seed germination. The device was tested with pearl millet crop and field capacity was found to be 0.63 ha h⁻¹. The crop yield was 1025 kg ha⁻¹.

The experimental unit of animal feed block making machine was perfected for its scaling-up purpose. All three components of the machine like metering mechanism, mixing unit and block making unit were synchronized to work as a single complete unit.

A cutter bar type reciprocating cutting unit for harvesting henna was designed and developed. The width of the cutting bar was 500 mm. The unit could cut the stem with thickness up to 25 mm from about 70-80 mm above the ground.

The 25 mm thick, 10 high speed carborandum grinding wheels (A-24 grade) each of 300 mm diameter were used to process pearl millet seed. Preliminary analysis revealed that at 9% pearling, there is a reduction in the fat content by 0.48% at 9% moisture content. The fraction of grain consisting grits (brokens) was having 14.1% fat indicating that germ portion of the grain has highest fat content.

Performance evaluation of cumin cleaner-cum-grader revealed that the screen effectiveness was 78%. The cleaning index was 0.93 and cleaning efficiency was 75%. In order to make the machine more versatile and economically viable, screen perforation size of 4 mm (frame size 1500 x 800 mm) was made to clean and grade grains of other crops also.

Socio-Economic Investigation and Evaluation

Empirical studies on drought vulnerability were carried out in three villages in Shergarh tehsil of Jodhpur district which revealed that wage earnings from nearby stone quarries and other labour activities are the major ones in the sample villages. The marginal, small and landless farmers who are mostly vulnerable to drought conditions depended on daily wage earnings from mines within a distance of 30 to 40 kms.

Two micro farming situations viz., well irrigated sandy undulated plain (MFS-1) and well-irrigated hard pan plain (MFS-II) were identified in irrigated area of district Bikaner. Groundnut and clusterbean are major kharif season crops in MFS-I and constitutes 70.7 and 21.3% of total cropped area, respectively. Clusterbean is major crop in MFS-II with coverage of 85.5% of cropped area. Chickpea and wheat are major *rabi* season crops in MFS-I and constituted 56.7, and 38.0% of cropped area. Mustard and wheat covers 76.0 and 15.4%, respectively of cropped area in MFS-II. Standard animal unit (SAU) per household is 6.7 and 5.3 in MFS-I and II, respectively. Cattle and buffalo have 70.4 and 17.4% share in total livestock in MFS-I. Cattle and buffalo have 65.2 and 15.1% share in total livestock in MFS-II.

In MFS-I, groundnut is more remunerative than clusterbean. In *rabi* season wheat is more remunerative than chickpea. Shortage of electricity for irrigation and high price of inputs are major constraints in production of groundnut and wheat. Pest and disease infestation is major production constraint in production of clusterbean and chickpea. In MFS-II, mustard fetches maximum net return (Rs. 6004 ha⁻¹) followed by wheat and clusterbean. Shortage of electricity for irrigation is major production constraint in clusterbean and wheat whereas frost is major production constraint in mustard.

Economic analysis of livestock production systems in Pali district was showed that composition of bovine was found to be changing in favour of buffalo species with 1.93 percent growth rate during 1966-2003. Importance of ovine in the livestock of the district was revealed by its population density of 124 ovine per sq km and positive growth rate of both the species (sheep 0.82% and goat 0.75%).

Camel marketing analysis of camel production system in arid Rajasthan indicated Pushkar and Jhalrapatan fairs held trade of diverse animal species, where, beside camel other animal species like cattle, buffalo, horse, sheep and donkey etc. were also traded. Gogamedi fair was found to be the most important fair with arrival of about 22,000 camels (2008) followed by Pushkar fair where around 12,000 camel arrived for sale.

Technology Assessment and Transfer

Bi-weekly weather-based agro-advisory bulletins during *kharif* and *rabi* seasons were disseminated to farmers of Barmer, Churu, Jalore, Jodhpur and Pali districts for day-to-day agricultural operations.

Farmers participatory action research programme was initiated in four agroclimatic zone of western Rajasthan. At farmers' field improved cultivars of wheat (Raj 3077), mustard (Pusa

Jaikisan) and cumin (GC-4) along with improved package of practice provided 29, 25 and 52% higher yield over local cultivars under conventional practices, respectively with a net profit of Rs. 8646, Rs. 7175 and Rs. 22080 with wheat, mustard and cumin, respectively.

In an attempt to popularize high yielding varieties of crops, improved varieties from institute were evaluated in Jodhpur district. The yields varieties of pearl millet (CZP 9802), moth bean (CZM 3) and clusterbean (RGC 936) provided 30-37% higher yield than that of local cultivars.

Improved package of practices provided 84% and 24% higher yield of pearl millet and clusterbean with clusterbean-pearl millet and pearl millet-clusterbean cropping system in comparison to conventional cropping system in villages of Jodhpur district. The integrated nutrient management comprising FYM @ 5 ton ha⁻¹ + 50% RDF in pearl millet (CZP 9802) and 100% RDF (100 kg N and 60 kg P₂O₅ ha⁻¹) in wheat (Raj 3077) provided 35.9% and 20.8% higher yield of pearl millet and wheat, respectively over conventional practices.

The mustard equivalent yield of sprinkler irrigated mustard in clusterbean- mustard cropping system was 27.3% higher than local varieties of both the crops. The improved cultivars were RGM-112 of clusterbean and Pusa Jaikisan of mustard. It resulted into 42.9% higher WUE than local cultivars. Though the yield of sprinkler irrigation was 3.58% lesser than that of check basin but it resulted into 22.6% higher WUE due to 25% saving in total water use by crop.

To identify factors constraining attainment of potential yield level of particular crop in the prevailing farming situation in Pali district, a project was undertaken in villages of Rampura, Denda and Dari. Varietal intervention in wheat (KRL 19) for saline/sodic soil and irrigation water improved the grain yield by 11.4% and 30.2% over Raj 3077 and local cultivars, respectively.

Maru sena 3 (*Bacillus firmus*) was tested as seed coating against dry root rot of guar and moth bean at farmers field at Dantiwada village of Jodhpur. It resulted in reducing the incidence of dry root rot and enhanced the seed yield 10-15% in guar and moth bean tested cultivars.

Empowerment of Women and Mainstreaming of Gender Issues

A survey of 15 Women Dairy Cooperative Societies (WDCS) operational in Jodhpur district, was undertaken to analyze the facilities, inputs and services of veterinary doctor and other dairy officials being availed by members of WDCS. It was observed that the training component is almost non-existent. However, trainings were organized as and when funds were provided by other agencies like Agricultural Technology Management Agency (ATMA). The visit and advice provided by veterinary doctor was found to be inadequate in some WDCS. As per the norms of the Rajasthan Cooperative Dairy Federation, the inputs were being provided to the members on payment basis and there was no provision for free inputs.

The capacity building needs in dairy related aspects were identified from randomly selected members and non-members by conducting focused group discussions in fifteen WDCS. The findings indicated that for breeding activities, the members did not perceive a need as the WDCS were providing Artificial Insemination and other breeding services for dairy animals to the members. However, the non-members felt a need for this activity. Both members and non-

members felt necessity for capacity building in feeding and health management of dairy animals. The need for training in clean milk production was perceived by non-members, while it was not reported by members due to the close monitoring by route supervisor of the dairy federation for following clean milk production practices. The need for improved varieties and seeds of dual purpose crops was expressed by both members and non-members reiterating the fact that most of the farmers face the problem of non-availability of good quality seed. The need for technical guidance in entrepreneurship development was perceived by both members and non-members.