
CENTRAL ARID ZONE RESEARCH INSTITUTE

HIGHLIGHTS OF RESEARCH

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INTEGRATED NATURAL RESOURCES APPRAISAL, MONITORING AND DESERTIFICATION

Natural resources appraisal in Jhunjhunun and Chirawa tehsils of Jhunjhunun district revealed that despite being in the eastern fringe of the desert the tehsils experienced 29 drought years and only 9 flood years during the last 104 years. Sandy landforms with light-textured soils cover >50% area, but cropping is practiced in >90% area, and double cropping 57%. Due to intensive cropping zinc availability has become a problem in many areas, while over-exploitation of groundwater for irrigation is being depleted by ~ 0.8 m year⁻¹. Narrow younger alluvial plains along the Kantli river are the best for agriculture. More than 80% grazing lands are moderate to severely degraded. In Jodhpur district cropping is practiced in >149% more land than the land quality permits. Too much cropping, over-grazing and clearance of vegetation cover during last 3 decades have depleted the stocks of soil organic carbon by 10%, P by 21% and K by 17%. Suitable agri-silvi-pastoral systems have been suggested for the district.

Hydrological studies on arid watersheds revealed inverse relationship between management practices and runoff. A fully treated watershed generated 17% runoff, while an untreated one generated 27%. Early peaks in hydrographs of untreated watersheds reflected quick runoff concentration, suggesting no soil and water conservation treatment.

Wind erosion studies at Bikaner showed maximum soil loss (48 t ha⁻¹) from arable crop fields because of negligible plant cover after the harvest of kharif crops during previous year. Among the pasture-based systems, horti-pasture showed maximum soil deposition (52.5 t ha⁻¹), followed by silvi-pasture (46.5 t ha⁻¹) and sole pasture (30 t ha⁻¹).

Analysis of the impact of year 2002 drought in 128 villages of western Rajasthan revealed that too much dependence on drought relief programmes and paucity of long-term assets is leading to increased vulnerability of the rural society to drought. Livestock farming and agro-forestry are more secured economic activities than rain-fed cropping, but need to be promoted, along with policy frameworks for land and water uses. Mapping of desertification under different land uses in arid southern part of western Rajasthan and the adjoining semi-arid tracts revealed that 52% area was affected by wind erosion, 9% by water erosion, 7% by vegetation degradation and 3% by salinity and waterlogging. Analysis of sequential AVHRR-NDVI images of NE part of western Rajasthan for February 1982 to 2001 revealed that the winter crop area during 2001 was higher than during 1982 in 38.6% area, while 54.4% area registered a decline and the rest 7% had almost no changes. About 18% area in the northwest registered 8-30% reduction, and the southern part registered an increase. The western-most part of the desert with finer soils has been found to be a major source of atmospheric dust, which is carried eastwards and gradually settles in the eastern part of Rajasthan and

adjoining parts of UP and MP. Scientific land use in the CR farm of CAZRI has been found to improve soil quality, including water-holding capacity and infiltration rates in soil, the maximum being under silviculture, followed by agroforestry and silvi-pasture.

BIODIVERSITY CONSERVATION AND IMPROVEMENT OF ANNUALS AND PERENNIALS

Evaluation of the germplasm of important local shrub species at Bikaner and Jaisalmer yielded encouraging results on *Calligonum polygonoides*, *Acacia jacquemontii*, *Commiphora wightii*, *Cassia angustifolia* and *Haloxylon salicornicum*. Success rates for *Capparis decidua* and cactii were poor. In *Citrullus colocynthis* the fruit sizes and stages of harvest had remarkable influence on the number of viable seeds per fruit, germination, shoot length, root length and seedling vigour. Effect of spacing was prominent on average fruit weight per plant and dry fruit and seed yield, while FYM application had more beneficial effect on ratios of seed, rind and pulp to total fruit weight. At Jodhpur, evaluation of *Cenchrus ciliaris* grass germplasm revealed higher green fodder and dry matter yield in CAZRI 2162 and CAZRI 657.

CZM-99, which was developed from RMO-40 through mutation breeding, was released as CAZRI-Moth-3 for cultivation in the arid and drought-prone areas. It flowers in 35 days, has good resistance to Yellow Mosaic virus, and matures in 68 days, providing an average yield of 600 kg ha⁻¹. A new moth bean genotype mutant, CZM-12, with early synchronous maturity, was also registered during the year. In pearl millet some promising experimental varieties were identified, which provided up to 38% higher yield than the earlier-developed CZP-9802. Pearl millet hybrids 841A x CZI 2000/3 and ICMA00222 x TCP-I-6 were promoted to advanced hybrid trials. Four clusterbean and one cowpea genotype were contributed to coordinated varietal trials. In general early-maturing clusterbean varieties gave higher seed yield. A total of 1796 kg breeder seeds of different crop varieties were produced.

In henna, application of farmyard manure at 5 t ha⁻¹ increased dry leaf yield by 9% over no farmyard manure, and by 25% when fertilizer was applied @ 80 kg N and 40 kg P₂O₅ ha⁻¹. Row spacing of 60 x 30 cm produced 20% higher dry leaves than in triple row planting and 9% higher over paired row planting due to efficient use of water. Integration of in-situ moisture conservation techniques produced 90% higher yield over triple row planting. Under inter-cropping systems, water use efficiency and henna-equivalent yield of clusterbean and mung bean were higher under strip cropping, and needs encouragement. In Kachchh, dry leaf yield was the highest with 50 x 40 cm spacing, followed by 40 x 40 cm and 60 x 40 cm spacing. Henna germplasm from Kothara performed better than those from Khedbrahm and Sojat. Alley cropping of henna and senna reduced henna leaf yield by 28%, but produced 586 kg additional dry leaf of senna, thus providing additional net income of Rs. 6652 ha⁻¹.

In date palm, terminal and lateral bud meristems-segments taken from the suckers during August-December were found most suitable for proliferation of leaves than callus initiation. Callus initiation was extremely low and slow in Sadami, Shamaran, Khadrawy and Halawy than Umshock and Muscut cultivars on callus induction medium containing high levels of auxins. Maximum callus induction was observed after 90 days of incubation. In mushroom, seeds of pearl millet and wheat were found most suitable substrates for spawn production of *Pleurotus florida* and *P. sapidus*.

Relationship of dry fuel yield of *Prosopis cineraria* with tree height, its collar diameter, DBH, dry stem weight, dry branches and $DBH^2 \times$ height was positive and significant. Ninety one percent of the variation in dry fuel yield per tree was associated with $DBH^2 \times$ height

In *C. ciliaris* contribution of primary spikes for seed yield and its components was much higher than the secondary spikes. Seeds of primary spikes had higher seed germination (43.7%) than secondary spikes (32.7%). In *Lasirus sindicus* intact spikes can be harvested on 20th day after emergence during kharif season. During spring, it is ideal to harvest spikes 20-25 days after emergence (in March). At Jaisalmer, accession JSM-9 showed very high germination percentage (52%) and vigour index (642), followed by JSM-7. Application of Ethrel (100 ppm), GA_3 (200 ppm) and kinetin (50 ppm) significantly reduced the dormant seeds and thus increased the germination percentage of spikelets and caryopsis. The institute produced during the year >13 kg nucleus grass seeds and 1000 kg seeds of pasture grasses.

INTEGRATED ARID LAND FARMING SYSTEM RESEARCH

Application of N, FYM, adoption of rotation of pearl millet with legumes, and keeping land fallow during alternate year improved the grain yield, yield attributes, stover yield and WUE of pearl millet. Even after 12 years of pearl millet cultivation not much change was recorded in levels of SOC, and micronutrients Mn, Fe and Cu. Available Zn recorded about 4% decline.

In senna crop the leaf yield at pre-flowering stage was maximum at 30 cm row spacing, while at maturity it was the maximum at 45 cm row spacing. The sennoside content in the leaves was maximum at the vegetative stage and decreased progressively with crop age. Both N (20-30%) and P (12%) application increased the leaf yield. Yield increase was maximum when N and P were applied together. Senna stem extracts. increased the growth of wheat (RJ-3077), both under low and high soil fertility. Senna-treated plants maintained higher levels of chlorophyll and N in leaves and grain yield.

In moth bean, application of FYM 2.5 t + (10 kg N + 20 kg P_2O_5 by fertilizer) + bio-fertilizer inoculation (*Rhizobium* culture + PSB) provided maximum seed yield. At Jaisalmer, sole cropping of moth bean, followed by its intercropping with pearl millet at 2:1 and 2: 2 ratio was superior to other crop combinations. In clusterbean row spacing of 45 cm increased the CO_2 assimilation rate, activities of enzymes of N metabolism and the levels of chlorophyll and protein in canopy, leading to higher seed yield. In Kachchh growing of sesame – clusterbean in 2:1 ratio with N_{40} + FYM was found better for maximum sesame seed yield. At Bikaner deep ploughing and conjunctive use of FYM @ 5 t ha^{-1} and $\frac{1}{2}$ RDF increased the productivity of cropping sequence by 5-15% over conventional ploughing.

At Pali, highest grain yield of sorghum (CSV-17) was obtained with sole sorghum, followed by sorghum + moong in 2:1 row ratio with 50 kg N ha^{-1} and 75 kg N ha^{-1} and sorghum + moong in 3:1 row ratio with 75 kg N ha^{-1} . The intercrop yield of moong was maximum under sole crop, followed by sorghum + moong in 1:1 row ratio. Paired row water harvesting produced 62.7, 13.5 and 4.8% higher yield of sorghum

than conventional, triple row water harvesting and inter row water harvesting, respectively.

In *Casia angustifolia* (senna), a spacing of 30 x 30 cm at pre-flowering stage produced 37.7% and 51.6% higher dry leaf yield over 45 x 30 and 60 x 30 cm spacing, respectively. Sennoside content in leaf was higher (2.6%) at pre-flowering stage. Also, application of 40 kg N ha⁻¹ increased the dry leaf yield by 26% and 36% and seed yield by 9% and 24% over 20 kg N ha⁻¹ level and control, respectively. Soil application of water-extract of senna stems to crops improved the plant production functions and grain yield of wheat and pearl millet.

In *Aloe vera*, application of FYM @5 t ha⁻¹ and irrigation at ID: CPE ratio 0.4 sharply increased the leaves and the suckers. At Jaisalmer leaf yield was higher in deep soils. In Kachchh, GA-2 variety of *Amaranthus cadutus* L. (Rajgira) was grown successfully with application of 90 kg ha⁻¹ N and 200 mm water applied at four stages, producing 1206 kg ha⁻¹ seed and 8382 kg ha⁻¹ total biomass.

P application to clusterbean grown under 45 cm row spacing significantly increased net photosynthetic rates, levels of certain leaf metabolites and nitrate reductase activity at vegetative and flowering stages. Pre-sowing thiourea treatment of clusterbean seeds led to higher RWC, net photosynthesis, NR activity and chlorophyll concentration as compared to control plants. Post-drought application of thiourea as foliar spray also improved the leaf metabolism and photosynthetic efficiency, leading to higher seed yield. Irrigation of pearl millet and mustard at 50% PET rate were found more efficient than irrigation at 100% PET rate, as yields were marginally higher with doubling of the irrigation rate. At Bikaner the highest plant height and canopy cover of *Citrus aurabtiifolia* and *Colophospermum mopane* were recorded at 80% ETc irrigation level. Trees and irrigation levels also influenced the yields of intercrops grown under sprinkler.

In Gonda, seed treatment with GA₃ (250 and 500 ppm) enhanced germination per cent significantly while KNO₃ treatment failed to affect germination irrespective of concentration and duration of treatment. Tomato grown in multi-tier pots yielded 2.3 kg pot⁻¹ against 0.62 kg pot⁻¹ in single tier pots, as the multi-tier pots provided 37% more area for aeration and 18.3% faster CO₂ diffusion than under conventional pot for the same amount of soil. In Kachchh growth of fruit trees like mango, aonla and custard apple was more when plants were raised in saucer shaped pits as compared to ring and shelved trench type pits. Softwood cuttings (6- month-old growth) of pomegranate were better in root production than hardwood cuttings (1-year-old growth). Similarly FYM-based nursery soil supported higher rooting of cuttings than those of vermicompost-based nursery soil.

At Jaisalmer the maximum increase in height of *Acacia jacquemontii* was noticed between 2nd and 4th year and thereafter it became static. Deep soils registered maximum increase and maximum number of stems. Length and thickness of spines was more in coppicing plant as compared to those in non-coppicing plants.

Introduction of *L. purpureus* in the inter-row spaces of *C. ciliaris* produced higher grass seed and total dry fodder. Up to 30 cm depth the root dry weight of *C.*

ciliaris was higher than that of *L. purpureus*, but at 30-100 cm depth, the dry root weight of *L. purpureus* was higher than the grass, suggesting that grass was more active to extract nutrients and water from surface soil while legume extracted nutrients and water from both surface and sub-surface soils. About 90% of grass height was attained in 40-50 days, whereas legume crop took 70-80 days to attain the same height. In mixed pastures of *C. ciliaris* + *L. sindicus* at Bikaner, population of *C. ciliaris* was more than *L. sindicus*.

In *Prosopis cineraria* and pearl millet based agroforestry system the per unit productivity, gross return (GR) and B:C ratio were highest in khejri + HHB-67. In ber-based agri-horticulture system, maximum NR and B:C ratio were in ber + mung bean system. The net returns and B:C ratio were markedly higher in integrated farming system as compared to that in arable farming. *T. undulata* was found to be more compatible with the under-story crops. *A. senegal*-based agroforestry system is more economical, if gum is extracted after 8 to 10 years of initial establishment. In Kachchh cultivation of brassica after castor, sesame or groundnut in the preceding kharif season reduced the seed yield of brassica.

In Bikaner district three rain-fed micro-farming situations were identified as (1) sandy plains having hard sub-surface barrier, (2) sand dunes with undulating interdune plains, and (3) sandy plains with limited rabi cultivation. The last one has the maximum net returns, while maximum milk productivity is from the second farming system.

Soils under long fallow, pasture, crops and trees in the CR Farm of CAZRI revealed poor status of available P. Maximum P was present under NaOH-extractable fractions, followed by HCl-extractable fractions. Rhizosphere soils had higher water-soluble P and NaHCO₃-extractable P. Inoculation of soil with *Azotobacter* or AM-fungus, alone or together significantly increased the rooting of cuttings of pomegranate. Rooting was maximum when IBA treated cuttings were planted in inoculated soil. Urea application increased the conc. of DTPA-extractable micronutrients Mn, Fe, Cu, Zn from 21 to 180% in arid zone soils due to replacement of micronutrients from exchangeable and non-exchangeable sites by NH₄ formed by urea hydrolysis. The threshold urea concentration ranged from 750 to 2500 µg N/g soil. HCl-hydrolysable-N has been found to be sensitive and able to detect changes in N build up due to legumes.

INTEGRATED LAND MANAGEMENT

In the sandy tract of Kalyanpur residue incorporation in the soil, after composting, increased the grain yield of pearl millet by 21% and straw yield by 11%. Clusterbean showed 33% and 20% improvement in seed and straw yield, respectively, due to compost application @ 4 t ha⁻¹. Studies on the effect of old shelterbelts at different sites in the tube-well-irrigated areas of Jaisalmer district revealed that the double-row tree shelterbelts of 18 years' age cooled the temperature on the leeward side. Changes in soil properties were also noticed up to a distance of 20 times the height of shelterbelt (H), which were more pronounced up to 15 H distance. Appropriate application of bio-fertilizer and nutrient management helped to increase the crop yields, including pearl millet, mung bean, clusterbean, cumin, wheat and mustard in farmers' fields.

At Jodhpur, sloping gravelly surfaces were found less suitable for *C.angustifolia*, but *Aloe vera* had excellent survival. Growth of *Cenchrus ciliaris*, *Lasiurus indicus* and *L. purpureus* was not significantly influenced by tree species, cropping system and fertilizer application. However, fodder yield was influenced by cropping system and fertilizer application. At Bhopalgarh, herbage production in inter-space of silvi-pasture was the lowest with *A. tortilis* and maximum in plots without trees.

Artificial groundwater recharge studies during the year revealed that the annual water inflow in a percolation tank having 62,100 m³ storage capacity from 69 ha upland catchment was 1,38,269 m³ over a ponding area of 22,200 m². The threshold rainfall for generating runoff was 22 mm. De-silting of percolation tank hastened the percolation of the first water inflow to tank. With the settlement of fine soil on wetted area the percolation rates during subsequent events were reduced. The annual total recharge through percolation accounted for 67% of the total water intake in tank. Water build up in the wells in immediate vicinity of tank was instantaneous, but delayed by 15 days in wells 280 m away from the tank. Subsurface barriers across sandy beds induced groundwater recharge in upstream at least by 50-80%.

At a farmer's field in Khodyala village, foliar application of water extract of senna stems (400 kg ha⁻¹) at 40 DAS under irrigated conditions and at Berai village at 35 DAS under rainfed condition markedly increased the grain yield of pearl millet. At Satheen village, the influence of thiourea on clusterbean, moth bean and mung bean revealed increased seed yield by 12.8, 13.5 and 12.2%, respectively over control. At farmers' fields in Bikaner, maximum spread of aonla plant in E-W direction was with application of 600 g nitrogen + 200 g phosphorus per plant. Application of N 450 g + P 300 g resulted maximum spread in N-S direction. FYM application (2.5 and 5 t ha⁻¹) on different medicinal plants in the CR Farm of CAZRI resulted maximum survival in *Aloe vera* (80-93%) and *Cassia angustifolia* (80-100%). In *O. sanctum* (Tulsi) most of the vigour and yield parameters performed better under FYM application of 2.5 t ha⁻¹ than 5 t ha⁻¹.

IMPROVEMENT OF ANIMAL PRODUCTION AND MANAGEMENT

Plasma carotene and retinol levels were significantly higher in cattle followed by goats and sheep as majority of dietary carotene is absorbed and circulated in cattle whereas in sheep and goats it is converted to retinol and stored in liver. Sheep milk contained maximum carotene, followed by Marwari does and least in Tharparkar cows.

Male Marwari kids had a significantly higher birth weights and gain in body weights till 2 years of age. The body weights of single born kids were higher than twin born kids up to 12 months age but thereafter the body weights of both type of kids were similar indicating compensatory growth in twin born kids.

No adverse effect of salt-rich water was noticed on body weight of adult Marwari sheep and goats, as well as lambs and kids. Intake of higher concentrations of salts (80 mg F + 16 g NO₃ + 10 g Cl + 20 g SO₄ animal⁻¹ day⁻¹) for six months also had no adverse effects on growth and blood physiological and biochemical constituents. Reproductive performance of the does was normal.

Lani (*Salsola baryosma*), a shrub of arid region, has been found to be palatable, though non-conventional, and can be fed to adult goats up to 900g daily without any adverse effect on their growth and health. Also, Lana (*Haloxylon salicornicum*) seeds (DM-96%, CP-18.6%) can be included as a source of protein in the diet of adult goats up to 25% of the concentrate mixture without any adverse effect on growth and health.

Lactation performance of Tharparkar cows calved during the rainy season was higher, followed by the cows calved in winter, summer and autumn due to favorable environment and adequacy of grazing resources.

During grazing in fields sheep and goats preferred to graze/browse the weeds present in the field first, followed by *L. indicus* and *C. ciliaris* grass and *L. pyrotechnica*.

PLANT AND ANIMAL PRODUCTS, AND VALUE ADDITION

Analysis of 65 accessions of *Aloe vera* revealed that 14 accessions had 3 ml or more sap leaf⁻¹. Saps of 17 accessions had aloin content higher than 10 g/100 ml sap. Leaf of 11 accessions produced higher than 250 g gel leaf⁻¹.

A dry, edible product from matured leaves of *Aloe vera*, called Aloe candy, and having active ingredient of 0.20 to 0.35%, and an oil-based skin cream, which acts as a moisturizer, were developed from *Aloe vera*.

The shelf life of goat milk was found better than cow milk due to better lactoperoxidase systems. The enzymes responsible for stability, texture and oxidative degenerative changes, were lower in goat milk than in cow milk.

Composition of fat, protein, SNF and total solids was found higher in sheep milk than in camel milk, but keeping quality of camel milk was better (13 h) than the sheep milk (4 h) at 34°C and 51% RH.

Activation of lactoperoxidase system in the milk of Marwari and Parbatsari goats by exogenous addition of hydrogen peroxide: thiocyanate at 20:20 and 30:30 ppm increased the shelf life by 1.5 and 4 h, respectively, compared to control. Hydrogen peroxide concentration is a limiting factor in enhancing the shelf life of goat milk.

INTEGRATED PEST MANAGEMENT

Due to delayed rains and poor crop conditions pest incidence was low. Use of selective BSP resulted in the virtual absence of pests at Soyla. *Lampides boeticus* damaged 27-36% pods of cowpea cv. CAZC-B. In henna, incidence of defoliators, whiteflies, blister beetles and termites was recorded. Heavy infestation of castor semi-loopers (*Achaea janata*) was observed at Pali and Sojat. Among the rodents, *Tatera indica* was predominant in heavy-textural soils of irrigated areas in Merta tehsil, whereas *Meriones hurrianae* was predominant in sandy soils. In rainfed crops *M. hurrianae* was predominant, followed by *T. indica*. In CR Farm of CAZRI truly desertic rodent fauna, *M. hurrianae* and *Gerbillus gleadowi* have been replaced by other species. *F. pennanti* was mainly trapped from ber and pomegranate orchards, while *T. indica* was trapped from all habitats. Bandicoots continued to be a major colonizer of Jodhpur railway station, zoo and nearby localities. Commensalisation of field rodent, *T. indica*, was noticed in Basni Grain Mandi, Jodhpur. In the rocky habitat of Bhopalgarh 4

rodent species, viz., *Tatera indica* (49%), *Meriones hurrianae* (19%), *Mus platythrix* (6%) and *Funambulus pennanti* (26%), were abundant.

Cowpea cultivars DCP-8, DCP-10, GC-9737, GC-3 and RC-101 were identified as least susceptible to the attack of *C. maculatus*. In mungbean, 8 varieties were found resistant to bruchid, 3 moderately resistant, 2 moderately susceptible and 6 susceptible. In henna, accession Khedbrahma was most resistant to whitefly infestation, while accession Panchotiya was the most susceptible. Seed extracts of neem, prepared using methanol, ethanol, ethyl acetate and hexane as solvent, were effective in controlling pod borers.

Effect of difethialone on *Rattus rattus* was found reduced with vitamin K₁ supplementation for 15 days. Application of zinc phosphide (2%), followed by bromadiolone (0.005%), to rodent burrows provided >60% protection from rodent in crop fields on 4th day of treatment and up to 83% on the 14th day.

A combination of *B. firmus* seed coating and soil amendment with radish compost proved as the best treatment against dry root rot of cowpea. Downey mildew (DM) incidence in pearl millet cultivar Nokha local could be controlled the best with a combination of seed treatment with raw cow milk (RCM, 50% diluted with water for 18 hours) + seed treatment of *Gliocladium virens* (6 g kg⁻¹ seed) + treatments of the above two.

Studies revealed that free proline was 8-9 times higher in tufting and malformed ear heads of DM necrotic leaves in comparison to healthy ones. Free amino acids were 14-16 times higher in tufted and completely malformed ear heads. Chlorophyll-a, Chlorophyll-b and total Chlorophyll contents were reduced by 47.1, 97.8 and 58.8 per cent, respectively, in necrotic leaves in comparison to healthy ones. Activities of polyphenol oxidase (PPO), per oxidase (PO) and IAA oxidase (IAAO) were much higher in the DN-infected necrotic leaves.

Maximum control of leaf curl disease in chilli was possible through seed treatment of raw goat milk (RGM) in 1:1 ratio for 24 h and *Trichoderma viride* (T2). Amounts of total reducing and non-reducing sugars and starch were higher in resistant chilli cultivars (HC-44, HC-28 and New Chilli Hybrid) than in susceptible cv. Mandoria. Econeem, followed by Growneem, caused maximum increase in the shoot and root weights in chilli over the nematode check while nimbicidine was least effective in increasing the plant growth. Exposure of second stage juveniles of *M. incognita* larvae for 72-h in 1000-ppm Neem EC resulted in 100% loss in nematode activity, while the same was true for 96-h exposure in 500 and 250 ppm concentration.

Induction of rooting in chilli for aseptic establishment of *M. incognita* was the maximum from root segments in 1 mg L⁻¹ conc. of IAA. Culturing hypocotyl and cotyledonary leaf segments on kinetin and BAP-supplemented medium resulted in poor induction of callus. In tomato the best response for root induction was recorded from cotyledons on 3 mg L⁻¹ IAA. 2,4-D did not induce any root formation. Treatment of *M. incognita* larvae with 0.1% streptomycin sulphate for 15 minutes was sufficient for surface sterilization of the nematode inoculum. Roots established from different explant

tissues of chilli and tomato, when inoculated with the axenized larvae, were susceptible to nematode irrespective of their tissue of origin and hormone treatment.

NON-CONVENTIONAL ENERGY SOURCES, FARM MACHINERY AND POWER

The earlier-developed experimental light sensitive solar tracker was further improved to orient solar devices towards the sun more efficiently for maximizing solar energy gain. A two-stage mixer was designed and experimentally developed for mixing different ingredients delivered by a metering unit and then to feed it to block-making machine. A cleaner-cum-grader (capacity 250-300 kg h⁻¹) for value addition to cumin was also designed. A framed structure was fabricated to measure force and energy requirement for cutting henna branches by a pruner. A second order polynomial relationship was found between the force required to cut the henna branch and cross-section area of the branch. The maximum energy required for cutting a branch of 2 cm² was found to be ~2 joules. A new wind erosion sampler, having an opening cross section of 1000 mm² that would adjust its opening area towards the wind using a vane attached at its backside, was designed and fabricated.

A PV generator was developed, which could be used to run pump, operate small machines, illuminate farm building and carry out other agricultural activities, including post-harvest operations. Moreover, a mobile PV system, having a maximum power unit with two 70 Wp multi-crystalline silicon based PV modules fixed on a stand with inclination of 26° from horizontal, was developed. An integrated collector storage (ICS) solar water heater (capacity 100 L) was developed and fabricated by combining collector and storage tank as a single unit.

Evaluation of the earlier developed tractor drawn, three-furrows (six rows) and multi-crop improved seed-cum-fertilizer drill for mustard cultivation revealed that it performed better and yielded higher than the CIAE-developed drill and local method. Testing of the earlier developed PV dryer showed that it took two days to dehydrate 11 kg chillies with 26% moisture (wet basis) to 7%, while in the open sun the moisture content could be reduced to 10% after 7 days.

Performance evaluation of the ID-3 revealed that rice (250 g) with 500 ml water and soft lentil (250 g) with 750 ml water could be boiled within 2 hours in summer. As a dryer, grated carrot (2.5 kg) could be dehydrated from 86% to 5%, within 60 hours in winter. It can also save about 230 kWh during winter as a water heater and 70 kWh as a solar cooker during a year. The design of the cool chamber was further improved by incorporating cross air channels at bottom side to enhance water evaporation, enabling to attain maximum depression of temperature by 15°C and maintain humidity >90% for a longer duration.

SOCIO-ECONOMIC INVESTIGATION AND EVALUATION

In four studied villages of Phalodi and Bilara tehsils the pastoralists follow a traditional way of life with prevalent social and economic backwardness, but there has been attitudinal change towards education of children. Literacy among children is increasing gradually.

Assessment of the economic impact of shelterbelts in the tubewell-irrigated croplands of Chandan area revealed that the shelterbelts protected crops better, and

encouraged the farmers to invest more in cultivation to get higher net profit. This in turn improved their life style and helped them to spend more on better education of their children.

The annual compound growth rate of livestock population in Pali district was found to be 0.32%. Negative annual compound growth rate was noticed in case of cattle and camel, while the maximum positive rate was in case of buffalo, although goats and sheep continued a steady growth rate, suggesting their importance in the farming system.

TECHNOLOGY ASSESSMENT AND TRANSFER

In Satheen village of Jodhpur district the overall adoption of improved practices of mustard cultivation was 59%, the maximum being irrigation practices. Evaluation of watershed development projects run by NGO and govt. departments showed improvements in resource conservation and natural resource asset creation, as well as gain in knowledge and skill of the villagers. In Luni Panchayat Samiti the family members were found to be the major source for communicating improved agricultural practices (55%), followed by neighbours (53%), friends (48%), relatives (45%), progressive farmers (45%), input dealers (37%) and Sarpanch (27%). Evaluation of the impact of farmers' training courses by KVK at Jodhpur revealed that the training courses improved the knowledge of farmers by an average of 45%.

Crop and livestock production demonstrations in villages led to significant improvement in yield, and more farmers were motivated to adopt improved practices.

Agro-meteorological advisory services to farmers of Jodhpur region helped farmers to get higher economic returns from their kharif and rabi crops.

EMPOWERMENT OF WOMEN AND MAINSTREAMING OF GENDER ISSUES

A study on psychological empowerment of women indicated that the members of self-help groups (SHG) had a higher self-perception than the non-members. Analysis of demographic attributes revealed that in beneficiary families of SHG the size of family was small and the literacy status was better. Improved practices for cultivation of pearl millet, mung bean, sorghum and *C. ciliaris* were demonstrated on fields of farm-women for technological empowerment of women in agriculture, and off-campus training programme was organised for the SHGs.