
CENTRAL ARID ZONE RESEARCH INSTITUTE

HIGHLIGHTS OF RESEARCH

2004

INTEGRATED NATURAL RESOURCES APPRAISAL, MONITORING AND DESERTIFICATION

Assessment of natural resources in Churu district revealed that despite >94% of its area being under dune-interdune sequence, with dominantly sand to loamy sand soils, 92% area is under croplands, and only 1% area is sandy waste. Pastures cover <5% area, and fallow lands have declined by ~44%. Consequently, 48% area is affected by wind erosion, the major increases being in the north-eastern and western parts due to increased human pressure. This is despite the fact that the long-term rainfall trend shows an increase of 72 mm in 100 years.

In Jodhpur district substantial decrease in soil organic carbon took place during the last 3 decades (4-14 g/m²/year), the higher losses being noticed in sandy soils, which, along with decline in P and K stocks may result in decreased productivity of soils. At the same time inorganic carbon is increasing due to irrigation with carbonate-rich groundwater.

Soils of CAZRI farm at Jodhpur were found to have been enriched in macro- and micro-nutrients due to scientific land uses, the maximum improvements being under silvi-pasture and agroforestry, especially due to contributions from tree component, and the lowest under sole cropping.

Watershed hydrological studies at Pundlu and Madpuria revealed that only 4 rainfall events contributed runoff in the former, compared to 7 in the latter, and suggested higher annual groundwater recharge and storage in the latter than in the former. At Agolai only one event could generate run off, where rainfall intensity of 5.5 cm h⁻¹ is needed to generate run off. At Jaisalmer maximum aeolian sediment discharge during summer was recorded between 21 June and 20 July (0.449-0.494 kg m⁻¹), while at Chandan the maximum was between 10 June and 12 July (0.219-0.369 kg m⁻¹). At Bikaner, maximum soil loss (341 t ha⁻¹) was observed in arable cropping system that had negligible plant cover after the harvest of kharif crops. Horti-pasture faced minimum soil loss (30 t ha⁻¹), followed by silvi-pasture, pasture and agri-pasture.

Mapping of desertification under different land uses in arid Gujarat revealed that out of the 158128 km² area mapped, 80.9% is affected by desertification, the largest being under water erosion (46%), especially in croplands, followed by salinity (21%). Studies in Sujangarh tehsil revealed that between 1972-73 and 2000-01 sand reactivation increased in 27% area, decreased in 33% area and no significant change took place in 40% area. Stability of aeolian landscape to irrigated agriculture in the eastern part took about 3 decades. At Shergarh, five sites were identified as suffering from extreme vegetation degradation due to low resilience to monsoon rainfall, mainly due to livestock grazing around village settlements.

BIODIVERSITY CONSERVATION AND IMPROVEMENT OF ANNUALS AND PERENNIALS

Multi-locational trial at 25 places in India has proved that CZM-99 of moth bean holds promises for cultivation in the 250-450 mm rainfall zone of arid lands in India. The crop matures in 65 days, and gives an average yield of 600 kg per ha. The plant can withstand drought and resists yellow mosaic virus and *Cercospora* leaf spot disease.

Three pearl millet varieties, CZP-212, CZP-215 and CZH-101 consistently performed better than the checks in coordinated trials, and are ready for release. One stock each of clusterbean (GDM-1) and cowpea (CAZC-13) were put in national register, while another stock of cowpea (CAZC-10) was allotted National Identity Number.

Different practices to enhance henna yield were tried. Seedling establishment, dry leaf yield and wood yield could be increased through application of *Azotobacter* and phosphatase solubilizing bacteria. Application of 80 kg N ha⁻¹ and 40 kg P₂O₅ ha⁻¹ increased dry leaf yield by 19.8% over control. Rows at 45 cm gave highest dry leaf and leaf dye yield. *In situ* moisture conservation technique resulted in 11% higher yield of henna dry leaves over conventional planting. The technique not only conserved moisture, minimised evaporation and enhanced the yield, but also helped to retain more leaves. Also, paired-row planting of henna provided higher yield of dry leaves (862.6 kg ha⁻¹), as compared to square planting (807.9 kg ha⁻¹). Intercropping of clusterbean with henna in Kachchh increased the net income by ~40%.

Forage evaluation trial on *Cenchrus ciliaris* for 4 years at Chandan Farm revealed higher dry forage yield of CAZRI-2285 (2868 kg ha⁻¹) and CAZRI-2224 (2548 kg ha⁻¹), suggesting their suitability for the region. At Jodhpur, CAZRI-2171 produced the highest green forage and dry matter. In *Lasiurus indicus*, CAZRI-30-7 yielded maximum dry matter (3686 kg ha⁻¹). Seed germination was highest from the freshly harvested and 3-month-stored seeds of 3rd harvest (25 DAE) (54.3% and 57.3%, respectively). To find out ways to propagate tumba (*Citrullus colocynthis* L.) cultivation, several methods were tested for its seed germination, but only a physical removal of seed coat caused higher germination. Seedlings should be transplanted to the field before 60 days of seedling growth. Yield of oyster mushroom was found to be higher on a substrate of Indian mustard (*Brassica* spp.) among the cultivated plants, and on kheenp (*Leptadenia pyrotechnica*) among the natural ones.

INTEGRATED ARID LAND FARMING SYSTEM RESEARCH

In pearl millet-based cropping system, taking legume crops in rotation with pearl millet, and incorporation of FYM along with inorganic N increased the yield and WUE of pearl millet. Similarly, incorporation of senna stems and their extracts in soil and foliar spray increased the yield of pearl millet. Maximum improvement took place with soil application of water extract of senna stems, followed by chloroform extract. Promotive effects were more pronounced at vegetative stage than at flowering stage.

Among mung bean, moth bean and clusterbean as leguminous inter-crop with *Prosopis cineraria* (agro-forestry), or with *Ziziphus nummularia* (agri-horticulture), the highest seed and stover yields were provided by mung bean, followed by clusterbean, the higher productions being obtained from agri-horticulture. Soil moisture was maximum under mung bean at all the crop growth stages.

Growing pearl millet and clusterbean with *Tecomella undulata* in two separate treatments revealed better compatibility of *T. undulata* with clusterbean than with pearl millet for soil moisture, as well as yield after 4 years. Lysimetric measurements of evapo-transpiration rates of unstressed pearl millet (cv. HHB-67) showed that the seasonal ET of the plant was 352 mm for 100% PET crop, 266 mm for 50% PET crop and 228 mm for rainfed crop.

Among horticultural crops, Bael accession No. PRMB2021 was more vigorous than accession No. PRMB 2022. At Kukma-Bhuj, direct-seeded horticultural plants like anar, aonla, ber, custard apple and mango performed better than the nursery-raised plants that were transplanted to fields. Among the date palm varieties grown in Kachchh, land race BHD-3 had better fruit size and TSS content. In the Khadi system of Jaisalmer, crop diversification through horticultural plants of Ber and Gunda ensured some production during the drought year, when traditional field crops failed.

Under the partially irrigated conditions at Bikaner, agri-horti system with ber + aonla, intercropped with wheat-gram/mustard-cumin, gave the maximum productivity and profits per unit area at 70% ET irrigation with micro-irrigation systems. Strip cropping of grass and crops in 1:3 ratio (4 x 12 m) was found best in terms of productivity and an insurance against complete crop failure during drought. FYM application influenced the growth and yield of the medicinally important plants, *Aloe barbadensis* and *Cassia angustifolia*, which were planted in 2-m wide strips alternating with 6-m wide strips of moth bean.

Among the four trees, *Acacia senegal*, *Prosopis cineraria*, *Tecomella undulata* and *Acacia tortilis*, maximum tree height and biomass production was from *T. undulata*. The traditional agro-forestry system in the south-eastern margin of the desert has been found to be dominated by *Azadirachta indica* - *Acacia nilotica* var. *cuppressiformis* - *Salvadora oleoides* trees/shrubs. At Bikaner, a silvi-pasture system with *Calligonum polygonoides*, *Acacia jacquemontii*, *T. undulata*, and *Prosopis cineraria* as tree components, and *L. indicus* and *C. ciliaris* as grass component, revealed better performance by *C. polygonoides* and *L. indicus*. Soil binding capacity was more in *C. ciliaris* than in *L. indicus* due to higher root volume and lower root radius of the former.

Azotobacter chroococcum was found to significantly improve height and dry weight of 5-month old pomegranate seedlings, the maximum being under dual inoculation of *Azotobacter* and AM-fungus. Similarly, dual inoculation of *Azotobacter* and AM-fungus enhanced the production from ber, aonla and anar, mainly due to synergistic action of nitrogen-fixing bacteria and AM-fungus.

Inoculation of soil with phosphatase solubilizing bacteria (PSB) along with AM fungus to pearl millet, and *Rhizobium* to moth bean increased the yields of both the crops. The production of til in kharif and cumin in rabi increased significantly when soil was inoculated with AM fungus and PSB. Likewise AM fungus and PSB increased the growth and yields of fruit crops like ber, pomegranate and aonla in the 4th year of transplanting.

INTEGRATED LAND MANAGEMENT

Jhanwar watershed, developed earlier by the Institute as a model watershed, is showing signs of degradation due to encroachments and mismanagement, as attested by a fast decline in plant cover and increased gully formation. However, farmers attested to increased cropland productivity due to soil and water conservation practices over the years, which included check dam construction and inter-plot water harvesting. At the developed silvi-pasture system at Bhopalgarh, the maximum herbage production was from *P. cineraria*-based system, and the minimum from *A. tortilis*-based system.

Monitoring groundwater recharge pattern in wells near a percolation tank revealed a rise of water level in the well in close vicinity of the tank, by 19 m within 9 weeks of a good rainfall event, while recharging of the well at 280 m distance from the tank was more gradual and retarded by 5 more weeks. Subsurface barriers across a sandy channel at Kalawas improved groundwater availability in upstream area by 68-109% that helped to improve crop cultivation.

Pearl millet yield could be increased by 27% through field bunding, while application of 5 t FYM + 50% recommended fertilizer (20 kg N + 20 kg P₂O₅ ha⁻¹) gave up to 28% higher yield of the crop than the recommended doses. Yield of clusterbean and moth bean were also higher by ~35% due to the water and nutrient management.

IMPROVEMENT OF ANIMAL PRODUCTION AND MANAGEMENT

Livestock in Barmer district were found to have lower levels of phosphorus, copper and manganese. Iron and zinc, on the other hand, were significantly higher. Low levels of copper reduce the reproductive efficiency of livestock.

Parbatsari goats performed better in kidding rate, prolificacy and body weight at and after kidding, and showed better feed-conversion efficiency into milk than the Marwari goats. Intensive management of Parbatsari goats resulted in 31% higher lactation milk than in Marwari goats. Marwari does consumed 1.506 kg DM animal⁻¹ day⁻¹, compared to 1.583 kg DM animal⁻¹ day⁻¹ by the Parbatsari. Daily water intake per animal was 1.5 times more in Parbatsari (3.81l) than in Marwari (2.03l).

Providing hyper-saline water, containing 60 mg fluoride + 12 g nitrate + 7 g chloride + 18 g sulphate animal⁻¹ day⁻¹ (i.e., in 3-5 L water) to sheep and goats did not have any adverse effect on growth of lambs/kids, wool yield or milk yield; also there was no stillbirth/abortion, suggesting that hyper-saline drinking water up to this concentration of salts is safe for the animals.

Marwari lambs reared on standard animal feed *ad libitum* in addition to standard grazing for 8 hours, attained 73% more growth and 67% more wool by the age of 6 months than the lambs reared solely on traditional grazing, while lambs that were allowed *ad libitum* feeding on local grains viz., guar churi, capasia or crushed maize, in addition to traditional grazing, gained 63% more growth and 64% more wool.

Incorporation of calcium oxide in multi-nutrient feed block improved the texture of the block. Rate of drying of the blocks was more when CaO was added at 3% level. Tharparkar cows, feeding on supplementary mineral mixture, yielded higher quantity of milk (6.9 kg animal⁻¹ day⁻¹), as compared to the control animals (3.4 kg animal⁻¹ day⁻¹).

It also increased their blood metabolites like haemoglobin, glucose, cholesterol and protein level.

Among the desert grasses, pro-vitamin A content was found higher in *Cenchrus ciliaris* (1.61 mg carotene/100 g dry matter) than in *Lasiurus indicus* (0.65 mg/100 g dry matter), while among the trees, *Azadirachta indica* contained the highest (9.15 mg/100 g dry matter). Overall, tree leaves contain highest carotene, followed by leguminous forages and grasses. Green foliage of Khara Lana (*Haloxylon recurvum*) was found to contain 13% crude protein, 63% total carbohydrate, 21% crude fiber, 58% neural detergent fiber, and 25% acid detergent fiber, and is palatable to goats. Mixing the leaves with other palatable roughages like groundnut haulm at 1:3 ratio, can meet the requirement of dry forage during periods of fodder scarcity.

PLANT PRODUCTS AND VALUE ADDITION

Improved recipe for preparing squash from peelu (*Salvadora oleoides*) fruit juice and jam from the fruit containing 90% of juicy pulp was prepared.

Aloin content in two-year old khara type of *Aloe vera* varied from 4.09 to 12.67 g/100 ml sap, while that in meetha type was found to be negligible. Five lines of khara were found to contain more than 7.0% of aloin. Gel content of the two-year old khara plants varied from 30 to 448 ml leaf⁻¹, while in meetha type it varied from 30 to 114 ml leaf⁻¹.

INTEGRATED PEST MANAGEMENT

Several new pests were recorded from the region. Henna crop was partly damaged during the year by semilooper *Achaea janata*. Among the rodents, *Meriones hurrianae*, *Gerbillus gleadowi* and *Tatera indica* were found to dominate the rain-fed crop fields of Jodhpur, Barmer and Bikaner districts, causing damage to crops, but the first two species have now been replaced by other species in the CR Farm of CAZRI at Jodhpur. The aggressive *Bandicota bengalensis* was found to have largely replaced the house rat, *Rattus rattus* in the Jodhpur zoo area. Canal-irrigated crop fields in Ganganagar district had a dominance of *Millardia meltada*, *Mus booduga* and *Tatera indica*.

In cowpea, maximum control of dry root rot, and maximum seed yield was in the *Aspergillus versicolor* amended soil, while in clusterbean, dry root rot was controlled more by *Bacillus firmus*, and seed yield was increased in *Trichoderma harzianum* amended plots. Spraying of neem seed palates and seed powder at the time of sowing controlled black weevils, *Cyrtogemia cognata*, in the mung bean fields by 33-57%, and in the moth bean fields by 19-53%. This also reduced the leaf-hopper (*Empoasca kerri*) population by 19-35%. Neem seed pallets also protected wood better from termites.

Dusting of fenvalerate (0.4%), in the clusterbean crop was found to have a longer effect in controlling *Cyrtogemia cognata* (up to 9 days), while spraying of imidacloprid (0.005%), fenvalerate (0.005%), cypermethrin (0.001%) and monocrotophos (0.04%) provided longer protection (up to 20 days) to black-seeded cowpea from pod borer *Lampides boeticus*.

B. bengalensis, when exposed to coumatetralyl powder (0.0375%) in pearl millet based baits for 3 days, survived for 2-5 days under no choice test, and up to 8 days in choice test. Exposing *Tatera indica*, *Rattus rattus* and *B. bengalensis* to bromadiolone bait (0.005%) in pearl millet for 1 day, led to 70%, 90% and 100% mortality of the above species, respectively. A wax block formulation of bromadiolone (0.005%), containing 10 ppm of a bitter compound, denatonium benzoate, proved more lethal (100% mortality) for *B. bengalensis* and *M. musculus*, both in laboratory and field, when they were exposed to it for 1-2 days. The bait was also 100% successful against squirrel, *F. pennanti*. Brodifacoum (0.005%) bait, either smeared on pearl millet grains as liquid, or as wax blocks, also caused 100% mortality to *F. pennanti*.

Downy mildew attack in pearl millet was contained by 96% when the seeds were treated with Apron (Metalaxyl) @ 5 g kg⁻¹ seed. This was followed by seed treatment with raw cow milk (50% diluted with water for 24 hours) and *Gliocladium virens* + *G. virens* soil application (10 g m⁻²).

In chilli, nematode disease was reduced by >70% when *P. penetrans* culture soil having spore encumbrance of 12.2 spores/larvae was applied @ 200 g kg⁻¹ soil, although application @ 50 and 100 g kg⁻¹ soil also provided success. This also resulted in better root and shoot growth. Dipping the roots of 45-day-old chilli plants to above *P. penetrans* culture also caused >70% reduction in the number of galls per root system. Combining different doses of *P. penetrans* with different doses of carbofuran also reduced gall number and nematode population, but this effect was less than the sum total of their individual effects.

NON-CONVENTIONAL ENERGY SOURCES, FARM MACHINERY AND POWER

A continuous type animal feed-block making machine was designed for making feed blocks of 25 x 15 x 5 cm size, weighing 2.2 kg. It intends to replace the batch type machines that are labour-intensive and time consuming.

The earlier-developed seed-cum-fertilizer drill was further improved by replacing wooden press wheels with C.I. wheel and providing seed box with slight slope at the bottom and additional rubber disc agitators for uniform distribution of seed inside the box. The earlier-developed electro-mechanical solar tracker was modified to reduce its power requirement and increase light sensitivity. In the modified version peak temperature could be achieved 2 hours prior to non-tracked cooker.

A solar PV based sprayer was developed which comprised 6.5 Wp PV module, 12 V, 7Ah battery, DC motor, plastic tank and a spraying nozzle fixed at extreme end of aluminium tube. A compact solar-based processor was developed which had a changeable cylindrical refill for various purposes, such as, melting wax for preparing polishes, butter for making ghee, etc. The design of the earlier three-in-one solar device was improved for enhancing water tank capacity to 50 litres, improved heat transfer, ease of operation while using it as cooker, proper ventilation for its use as dryer and enlarged top and vertical windows for sufficient energy gain with additional mirrors.

SOCIO-ECONOMIC INVESTIGATION AND EVALUATION

Studies on Raikas and Sindhi Muslims in 8 villages of Jodhpur district revealed that more than 53% of these sheep and goat raisers practiced long-distance migration. Those who did not own livestock practiced agriculture with meagre land holdings. Joint

families and large families with nine and above persons had higher migration than nuclear and small families. Majority of sample pastoralists (93%) perceived that grazing resources deteriorated due to poor rainfall and cutting of trees from grazing land, but few (9%) perceived excessive grazing as the cause of degradation.

Opinion survey on constraints in pearl millet production revealed that non-availability of seeds of high yielding varieties at proper time was the main constraint, followed by high cost of seed, lack of knowledge, and more fertilizer requirement. Lack of moisture was considered as main constraint at time of sowing, while lack of irrigation facilities was considered as major constraint for avoiding chemical fertilizers.

An assessment of farmers in Sar village on knowledge gained through communication on improved practices of pearl millet and mung bean cultivation revealed only 7% gain in knowledge from the education.

Decomposition analysis to find out the impact of tumba cake application for growing pearl millet (local, HHB-67 and MH-167) revealed that it contributed more than 85% to employment generation for different remunerative activities associated with it, while complementary inputs like fertilizer application had the rest of 15% contribution.

Economic analysis of henna cropping and marketing in Pali district revealed that about 70% of henna leaves was marketed through local middlemen to the Sojat City mandi, and sent from there to the processing units. Direct access of the farmers to the mandi, bypassing the middlemen, was only 20%, while direct access of farmers to processing units, bypassing the mandi, was 10%. Despite this, trade in henna in Sojat market is growing fast, the annual compound growth rate being 9%.

TECHNOLOGY ASSESSMENT AND TRANSFER

Full-package technology demonstration at Satheen village increased the yield of pearl millet by 50-96% over the local practices, moth bean by 75-78%, and clusterbean by 25-33%. Among the rabi crops, mustard yield was increased by 11-16%, and wheat yield by 34-40%. At Khudiala village application of senna residues to pearl millet and wheat increased the yield by 12-50%.

A number of improved practices were transferred to farmers under the Institute-Village Linkage Programme. These included crop varieties, agronomic practices, management of water and nutrient, pest management, alternate land uses, livestock management, etc., and led to higher yield and higher income.

Agro-meteorological advisory services were continued for the farmers of Jodhpur region, which helped them to take timely corrective measures and increase the crop yield and net income, especially during the rabi season (cumin and mustard), but also during the kharif season (clusterbean).

EMPOWERMENT OF WOMEN AND MAINSTREAMING OF GENDER ISSUES

Technology packages on feeding and health management of dairy animals and cultivation of dual-purpose crop varieties were demonstrated to women self-help groups. Also, off-campus trainings were organised for women on maintenance of kitchen gardens for nutritional security, animal health care, income generation, etc.