CENTRAL ARID ZONE RESEARCH INSTITUTE

HIGHLIGHTS OF RESEARCH

2002

INTEGRATED NATURAL RESOURCES APPRAISAL, ENVIRONMENTAL MONITORING AND DESERTIFICATION

Integrated natural resources assessment in Churu (1600 sq. km) and Sardarshahr (3852 sq. km) tehsils of Churu district revealed a slight, non-significant increase in annual rainfall over the last one century, despite periodic drought. Sand dunes and interdune plains, with a dominance of fine sand to loamy sand, cover >85% area, which are mostly low in N and available P, but medium to high in available K. *Prosopis cineraria* (khejri) is the dominant tree in all the habitats, *Acacia senegal* and *Tecomella undulata* being the dominant associates. *Calligonum polygonoides*, *Ephedra foliata* and *Maytenus emarginatus* are the major shrubs. In both the tehsils, 32 species of medicinal value, 20 of forage value, 6 each of food and fuel wood values, 3 of timber value, 11 grasses as fodder, and 7 of miscellaneous uses have been found, but grazing lands are mostly degraded. Surface water resource is limited in both the tehsils, although there are 251 nadis in Churu tehsil, which can store up to 7.445 mcm water, and 233 in Sardarshahr tehsil that can store up to 12.489 mcm water. Seven index catchments of 53 to 149 km^2 size have been identified for possible development. Depth to water in more than 65% area of the two tehsils is >40 m, and water quality is brackish to saline in about 95% area, high fluoride and nitrate being the major problems. Potential aquifers are the Tertiary and Nagaur Sandstone formations, covering only 6% area. Despite being largely dune-covered, croplands cover about 90% area in both the tehsils. Traditional agro-forestry is still followed, but long fallow practice has considerably declined over the last 3 decades. Gram has become an important crop on sandy landscape during winter, utilizing conserved moisture. There has been a phenomenal increase in groundwater-irrigated area and double cropping during last one decade. Wind erosion is dominant form of land degradation, but its severity declines from west to east due to lower wind energy. While Sardarshahr tehsil has 18% area under moderate to severe intensity, Churu has only 2% area under these categories.

Time series analysis of land degradation and pressure variables in south Churu revealed that during the last three decades western part of the region has become a focus for more population growth, higher cultivation and grazing pressures, and consequent high sand reactivation. A digital method for accurate identification of satellite-derived sand reactivation pattern has been found. Cultivation pressure explains spatial pattern of sand reactivation better than the grazing pressure.

In the sparsely vegetated Shergarh area of Jodhpur district, the Australian system of deriving vegetation index from bands 2 and 3 of satellite images (PD 54) was found useful. Villagers perceived that tractor use, less fallowing of land and oran degradation vis-à-vis increasing livestock population are the root cause of grazing land degradation.

Survey in 102 villages of Jaisalmer and Barmer districts revealed *Calotropis procera*, *Indigofera cordifolia*, *Boerhavia diffusa*, *Crotalaria burhia*, *Amaranthus viridis* and *Corchorus depressus* as the major medicinal plants that are traded, but *Commiphora wightii* and *Neurada procumbans* have become rare due to over-exploitation.

BIODIVERSITY CONSERVATION AND IMPROVEMENT OF ANNUALS AND PERENNIALS

Germplasm of 34 arid zone crops, 19 fruits and 11 pasture legumes were collected from different parts of Rajasthan. Seeds from 42 accessions of *Acacia jacquemontii*, 70 of *Calligonum polygonoides*, and 50 of *Haloxylon salicornicum* from Bikaner, Ganganagar and Jaisalmer districts were collected and evaluated. The highest organic C was measured under *H. salicornicum*.

Pearl millet variety CZP 9802, bred and developed at CAZRI, has been recommended for general cultivation exclusively for the scanty rainfall and drought-prone arid regions of Rajasthan, Haryana and Gujarat. It is a dual-purpose, tall variety with a potential to produce 33 q ha^{-1} dry stover, in comparison to 21 to 27 q ha^{-1} of checks Pusa 266 and ICTP 8203, and provide 28% higher dry stover than hybrid HHB 67, the most widely grown improved pearl millet cultivar in arid region. The variety flowers within 48 days of sowing and matures in 72 to 75 days, thus able to escape terminal drought. It is also resistant to downy mildew, smut and ergot diseases. Unlike single cross hybrids, farmers can use harvested seeds of CZP 9802 to grow next crop.

Among other crops, clusterbean genotype CAZG-97 and CAZG 90-2, and in early maturing group CAZG-60-1 were included in coordinated varietal trial. Among mung bean, genotype CZM-1 was promoted from initial varietal trial to advanced varietal testing, while genotype CZM-2 was included for testing in All India varietal testing.

In vitro micropropagation technique for *Capparis decidua* and *Lawsonia inermis* was developed through various tissue culture methods. Auxillary/terminal buds and seed explants were found successful for adventitious shoot regeneration of *Capparis decidua*.

Among the grasses, experimentations on seed testing procedures for *Lasiurus sindicus* showed that sand as a substratum, 25 to 30°C temperature and 0.2% KNO_3 application were the ideal conditions for its germination. Another experimentation revealed that less germination in husked seeds of *L. sindicus*, as compared to de-husked ones, was due to inhibitors present in the enveloping glumes of seeds. Seeds of the grass were found to attain physiological maturity after 15 days of spike emergence, and dormancy took place due to presence of enveloping structures (glumes).

INTEGRATED ARID LAND FARMING SYSTEM RESEARCH

Studies on agronomic practices for crop farming revealed that yield of mustard and isabgol, grown after taking guar crop with 20 kg N + 40 kg P_2O_5 (recommended fertilizer dose, RDF), was more than that after taking guar with 2/3 or 1/3 RDF. Guar-mustard system was found better than guar-isabgol system. In multi-nutrient trial for pearl millet yield, a combination of 5 t FYM ha^{-1} + 20 kg N + 20 kg P_2O_5 + biofertilizer gave highest grain yield (744 kg ha^{-1}), followed by 40 kg N + 40 kg P_2O_5 + biofertilizer application (698 kg ha^{-1}). At Pali, soil incorporation of mustard straw + FYM (1:1) @ 10 t ha^{-1} resulted in maximum increase (23.7%) in grain yield, followed by taramira straw + FYM (1:1) @ 10 t ha^{-1} (21.2%) and FYM @ 10 t ha^{-1} (15.3%) over control (2950 kg ha^{-1}).

Weed control efficiency in mustard crop was highest (75%) with 0.5 kg fluchloralin ha^{-1} + one weeding at 30 DAS, which was followed by one hand weeding (62%) and fluchloralin 1.0 kg ha^{-1} (53%). Highest seed yield (1593 kg ha^{-1}) was also recorded in fluchloralin + one hand weeding, followed by one weeding at 30 DAS. Among the N levels, 60 kg N ha^{-1} produced highest seed yield (1593 kg ha^{-1}), which was 13% and 35% higher than 30 kg N ha^{-1} and control, respectively.

Studies on physiological response of clusterbean (RGC-936) revealed that water stress drastically reduced net photosynthetic rate, total chlorophyll and soluble protein, but plants supplied with phosphorus and thiourea displayed higher photosynthetic and metabolic efficiency. Combined application of phosphorus and thiourea was most beneficial for all the parameters. Phosphorus and thiourea application markedly increased nitrate reductase activity in the plant, their combined application being most advantageous. Biomass production and seed yield of clusterbean could be improved by AMF inoculation and P application, maximum enhancement resulting from AMF inoculation with 5 t ha^{-1} compost.

Incorporation of senna stems in soils of wheat field @ 5 and 10 t ha^{-1}, alone or in combination with 80 kg N ha^{-1}, increased the rate of net photosynthesis in the plant, as well as levels of total chlorophyll and starch in the leaves. Wheat yield increased by 26-37%.

Neem cake application (1 t ha^{-1}) to soil helped to increase light interception by mustard crop at various growth stages and gave higher crop yield in comparison to other treatments. Light interception by cumin crop could be increased through tumba cake application (1 t ha^{-1}) to the soil, which was also translated into 37-50% increase in seed yield.

In studies on fruit crops, stock-scion relationship of Lasora, budded on its own rootstock was found best, with maximum budding success in August. The same scion variety budded on goondi started flowering and fruiting after 15 months of budding but not on lasora rootstock, indicating that goondi rootstock is precocious as compared to lasora. Growth in ber seedlings was improved through inoculation of the plants with *Arbuscular* mycorrhizal fungi, coupled with 20 ppm P application, which increased the uptake of N and P. Application of N-fixing bacteria plus 20 ppm N in ber plants helped to increase plant height and biomass production. At Kukma, 55% plants of pomegranate and 93% of custard apple could survive the severe drought, but other fruit plants like aonla, guava, date palm and ber could not. In pomegranate, plants raised from seedling performed better than those from cutting.

Studies on the effect of year 2002 drought on the performance of *Prosopis juliflora* (thornless) and *Acacia senegal* revealed severely curtailed current mean increment of height. In *P. juliflora* it was 4.2 cm $year^{-1}$, compared to 58.2 cm $year^{-1}$ in average years, while in *A. senegal* it was 4.6 cm year^{-1}, compared to 27.3 cm year^{-1} in normal years. Drought impact was also clear from measurements of seed weight, leafiness and gum production from different trees.

In the northern part of western Rajasthan traditional agroforestry system with *P. cineraria – A. nilotica – A. excelsa* was found to be more productive in terms of fuel wood and top feed resources.

To alleviate the impact of drought on Institute's livestock, fodder production through irrigation was carried out in limited area in the CR Farm, using different crop combinations. Highest green fodder yield (36.4 t ha^{-1}) and dry fodder yield (12.1 t ha^{-1}) were harvested from sorghum + cowpea intercropping, followed by pearl millet + cowpea intercropping.

In the studies on phosphorus and its availability to plants, it was found that the minimum soil solution concentration to start P mobilization due to different organic acids, irrespective of soil types, varied from 0.2 to 0.4 mM. The efficiency of different organic acids to mobilize P followed the order: Lactic acid > Formic acid > Citric acid > Malic acid. Phytase release was almost 30 times higher than the release of phosphatases by plant roots. On the other hand, about 40 times higher extracellular release of phytase than phosphatases by microorganisms was observed, as most of the phosphatases were locked inside the fungal cells.

To explain why dehydorgenase (DHA) is a reliable indicator of biological activity in arid soils of the region, bacteria, actinomycetes and fungi were cultivated and sprayed with 2, 3, 5-triphenyltetrazolium chloride (TTC). Fungi did not respond well to TTC, because it is not a major component of the ecosystem. Bacteria and actinomycetes being major components of microbial biomass in the region, responded very well, and explain why DHA provides reliable results.

INTEGRATED LAND MANAGEMENT

Rehabilitation work on lignite mine spoil at Giral was continued. Drought adversely affected natural regeneration of planted saplings, resulting in 75% decline in regeneration. The maximum survival was in *Salvadora oleoides* (94.6%) and minimum in *Ziziphus nummularia* (50%). Direct seeding of sonamukhi (senna) on backfill material was a success. Plant height was mostly over 20 cm, and yield of leaves 361.2 kg ha^{-1}, suggesting its potential on such substrata. On an average pH and EC of soils declined after plantation of trees on the backfill in 2001, and micronutrients above critical limits.

The most promising tree species on rocky/stony wastelands were found to be *Hardwickia binata*, *Acacia tortilis* and *Azadirachta indica*. In Kukma area of Kachchh, henna cultivation in farmer's field provided an average leaf yield of 277 kg ha^{-1} and wood of 202 kg ha^{-1}. The maximum leaf, wood and biomass were produced with a population of 50,000 plants ha^{-1}, giving highest economic returns.

A khadin at Darbari village (15 km from Jaisalmer town), with a catchment of ~4 km^2, was taken up for improved cropping practices. Despite severe drought, management practices led to survival and production from pearl millet in the lower reaches (15-17 q ha^{-1}). It suggested that short-duration varieties of pearl millet could be grown in the lower part of the khadin, even with a rainfall of 30 to 40 mm, and soil profile moisture of 200 mm m^{-1} depth. Survival of gonda (80%) and ber (52%) was notable in the upper reaches.

Experiment to avoid chlorosis and decreased fruit yield in ber due to saline water irrigation suggested that irrigating the individual plants @ 50 L water $tree^{-1}$ every 2 weeks in a ring around individual plant, and application of 1% KNO_3 + 2% $FeSO_4$ + 0.5% $CuSO_4$ solution, could lead to reduced chlorosis and increased fruit setting.

IMPROVEMENT OF ANIMAL PRODUCTION AND MANAGEMENT

Studies on productive potentials of arid goat breeds revealed that average body weight, reproductive performance and lactation yield were better under semi-intensive and intensive management than under extensive management. Parbatsari breed performed better than Marwari in all production aspects.

Multi-nutrient blocks produced at CAZRI were found to possess >6 times higher compressive strength, total soluble salts and total dry matter than the blocks from NDDB and RCDF. Sheep preferred CAZRI's blocks. In Tharparkar heifers, fed on CAZRI's blocks, blood haemoglobin, serum glucose and albumin levels were lower than in control animals, although the difference was not significant. An appropriate formulation was prepared for producing mineralized salt licks using combinations of common salt with vitamin mineral mixture, maize flour, guar gum, dolomite, molasses and jaggery solutions.

Tharparkar heifers, fed on til seed cake, had higher milk yield than those fed with mustard seed cake, although both the groups showed normal reproductive behaviour.

PLANT PRODUCTS AND VALUE ADDITION

Solvent extraction of *Salvadora oleoides* seeds from Jalor area yielded 48% fat, which when processed further, produced a fat having melting point of 60-61?C that could light a candle (12 g) for 1.5 hours.

In order to identify the most potential source of aloin in *Aloe vera*, meetha and khara varieties from different locations in western Rajasthan were tested. The narrow-leaved khara variety with pungent taste, yielded more sap than the meetha variety that produced higher biomass. February-March was found to be the best time for leaf collection for higher sap yield.

Senna stem, which has little or no economic importance, was incorporated in soil @ 5 and 10 t ha^{-1}, which increased the wheat yield by 26 and 37%, respectively. Triacontanol, a growth regulator in plants, was found to occur in its stems, and thus explaining the higher production.

Parazene blocks, which are used as air freshener and moth repellent, were prepared using solar system. Diffusion of parazene block decreased from August to January, indicating its temperature-dependence.

INTEGRATED PEST MANAGEMENT

Incidence of insect pests, rodents and plant diseases during the year were minimum due to severe drought. However, attack of anthracnose stalk rot was severe in sorghum varieties. Rodent attack in fruit orchard was more than in crop fields.

Neem oil was found to be more effective than other neem-based biopesticides in controlling pod borers, *Corcyra cephalonica* and *Cyrtozemia cognata*, which are noticed in crop fields. Mycelial growth of *Fusarium* was reduced more through the use of 8-day-old cell-free filtrate of *Aspergilus versicolor* and *Trichoderma harzianum* than through the use of older or younger filtrates. *Penicillium oxalicum*, a native bio-control agent parasitising *Fusarium oxysporum* f. sp. *cumini* and inhibiting *Macrophomina phaseolina*, was isolated from native soil. Bio-formulations Maru Sena 1 and Maru Sena 3 were prepared and sold through ATIC.

Five varieties of chilli were tested for disease resistance. Variety HC-44 (Hisar Shakti) was most resistant to leaf curl virus, followed by HC-28 (Hisar Vijay), New Chilli Hybrid (from PAU), CH-1 and Punjab Lal. Fruit size was largest (7.0 x 4.2 cm) in New Chilli hybrid and smallest in HC-44, but number of fruits per plant was highest in HC-44. In another study, least incidence of leaf curl virus infection of chilli was recorded when raw cow milk + *Trichoderma* seed treatments + *Trichoderma* spp. in soil was applied.

In another study, spraying of streptocycline was superior to extracts of compost from *Calotropis*, *P. juliflora*, weeds, neem and *A. nilotica* in controlling bacterial blight of clusterbean. Application of cold-water extract from the leaves of *Calotropis procera* and yellow juice from leaves of *Aloe vera*, containing aloin, was partially successful in causing mortality of *Meloidogyne incognita* larvae, which cause root knot. However, foliar spray of 50 ppm salicylic acid to chilli plant suppressed larval penetration of *M. incognita* by 26%.

At CR Farm of the Institute at Jodhpur, true xeric species of rodents, which were abundant 3 decades ago, have almost vanished, and are now replaced more by *Tatera indica* and *Funamabulus pennanti*. Data for last three years revealed higher rodent population from November to February, moderate from March to July and minimum from August to October.

Single-day exposure of freshly prepared baits containing difethialone yielded 100% mortality in *T. indica*, *Rattus rattus* and *Bandicota bengalensis*. In farmers' fields, a combination treatment, involving zinc phosphide and anti-coagulants (bromadiolone/brodifacoum/ difethialone), provided 50 to 60% protection to the crops from rodents from fourth day of treatment, which reached >90% on 40th day. Difethialone was found superior to other anti-coagulants, because it gave similar control success at half the dosage (0.0025%) than other anti-coagulants, which are recommended at 0.005% in baits.

NON-CONVENTIONAL ENERGY SOURCES, FARM MACHINERY AND POWER

The tractor-operated three row seed-cum-fertilizer drill, which was fabricated earlier, was improved upon and field-tested for sowing. In the new version each furrow opener was capable of forming 300 mm wide and 200 mm deep furrow. Metered seed and fertilizer were uniformly pressed at the slanting face of the furrow by press wheels, which helped early seed germination, even at low soil moisture.

An improved integrated solar device (ID-2) was fabricated and evaluated as a water heater, cooker and dryer. Testing of a solar PV winnower with 35 W peak panel and 12 v, 90 Ah battery, revealed that it could clean 168 kg h^{-1} mustard mixture, containing 50 kg grain and 118 kg straw. A solar PV dryer with PV-run fan was developed, and the earlier-developed cool chamber was improved upon. In order to increase PV output at early and late hours of day through extended length of reflector, a four panel-reflector system was fabricated and tested for PV modules.

SOCIO-ECONOMIC INVESTIGATION AND EVALUATION

Studies in six villages of Jodhpur district suggested that caste and land holding pattern did not relate significantly to the composition of population, level of literacy, family structure, cultural practices, etc. Farmers perceived that preference for male child and illiteracy were the most important factors of population growth, and that increasing population pressure had disturbed traditional land use. Irrigation facilities resulted in replacement of sheep and goat by cattle and buffalo. Studies on migratory Raika community revealed shrinkage of grazing land, and scarcity of food and water as their dominant problems. Although the graziers wished to lead a settled life, inadequate land holdings forced them to continue with present occupation.

Economic analysis of the impact of new technologies of crop farming revealed a benefit cost ratio of 8.35 for cumin, 6.67 for pearl millet and 1.68 for chilli. In Pali district henna has been found to fetch more income than the current crops, luring farmers to allocate more of their good land to its cultivation. The annual compound rate of growth in henna plantation was 7.2%.

High gaps in adoption of technologies for major kharif and rabi crops were found in Jodhpur, Jaisalmer and Pali districts, the maximum gap being recorded in case of fertilizer application, followed by plant protection measures. About 64% farmers preferred practical learning as the choicest method of technology demonstration, followed by crop trials, etc. Majority of farmers preferred a training of one week during March-April.

Despite severe drought, the institute continued its technology transfer programme in adopted villages and conducted training programmes, technology demonstration and Kisan Melas in its research farms as well as in villages. Agrometeorological advices were also provided regularly to the farmers through mass media.

EMPOWERMENT OF WOMEN AND MAINSTREAMING OF GENDER ISSUES

In sample villages of Jodhpur district, farm-women were found to participate more in post-harvest activities like cleaning of grain (90%), drying (79%), storage (82%) and care of stored grain (97%). In livestock farming, women's participation was higher in feed preparation (88%), feeding of animals (91%), care of expectant animals (65%), care of newborn calf (74%), feeding of calf (84%), milk product preparation (96%) and making dung cakes (83%). Farm-women perceived a greater need for training in animal health care, and income generation through milk product processing. Their access to technical information was hindered by low literacy and traditional system of seclusion from male Extension Officers. Mass media can play an important role in technical empowerment of the rural women.

Studies in sample villages of Bikaner district revealed an average fuel wood consumption of 15 kg day^{-1} $family^{-1}$. Phog (C*alligonum polygonoides*) and khejri (*Prosopis cineraria*) were the most popular fuel due to less smoke and good burning quality. These species were, therefore, over-exploited. Wheat and pearl millet were the staple food of women. Consumption of pulses and vegetables was below normal in rainfed areas, but normal to above-normal in irrigated areas.