
CENTRAL ARID ZONE RESEARCH INSTITUTE

HIGHLIGHTS OF RESEARCH

2003

INTEGRATED NATURAL RESOURCES APPRAISAL, MONITORING AND DESERTIFICATION

Natural resources assessment of Taranagar (1811 sq. km) and Rajgarh (2202 sq. km) tehsils of Churu district was completed. Long-term rainfall analysis revealed an increasing trend in annual total at Taranagar by 0.8 mm year⁻¹, and by 1.2 mm year⁻¹ at Rajgarh. Taranagar experienced more drought and flood years than Rajgarh. Major areas in both the tehsils are under sand dunes and interdune plains (>85%), with sandy soils deficient in nitrogen (organic carbon 0.056-0.320%) and phosphorus (2-20 kg ha⁻¹), and poor surface and groundwater potentials. *Prosopis cineraria* is the dominant tree on all habitats but *Prosopis juliflora* has the potential to become a major weed. Among the herbaceous vegetation, *Eleusine compressa* is dominant. In comparison to Rajgarh, grazing lands in Taranagar tehsil are very severely degraded. Because of sandy terrain and low rainfall, surface water potential is low, but nadis can store during normal rainfall years 14.748 mcm water in Rajgarh tehsil and 7.764 mcm in Taranagar. Major hydrological formation is older alluvium, but groundwater quality is generally brackish to highly saline, with added problems of fluoride and nitrate. Only 0.13% area in the south-east of Rajgarh tehsil has potable groundwater. Despite limitation of sandy terrain >90% area is under cropland. Fallowing has declined by 36% (Rajgarh) to 68% (Taranagar). Double cropping has increased by >35% in Rajgarh tehsil, especially in the alluvial plains of the Kantli, where potable groundwater in the alluvium is being utilized. Because of high human impact 45% area of Taranagar tehsil and 11% of Rajgarh are affected by wind erosion.

Hydrological monitoring in the arid watersheds of Pundlu and Madpuria revealed greater runoff volume and lower sediment discharge from the former due to its rocky catchment. SWAMIN model predicted runoff from the watersheds satisfactorily.

Mapping of desertification processes in northern part of Pali district revealed 19.7% area under different degradation processes, largely due to human pressure. Salinization was the major process, especially in croplands (35%), followed by water erosion (25%), vegetation degradation (18%) and wind erosion (10%).

Multi-criteria evaluation of desertification in south Churu, involving co-evaluation of human and livestock densities, cultivation and animal pressures, and satellite-derived wind erosion pixels, suggested that 3% area had severe risk of desertification, 20% moderate and 62% slight. Moderate to severe risk of desertification was found in the western part and slight risk in large parts of central and eastern parts, with landscape stabilization.

Testing of some established satellite-derived vegetation indices to measure cover characteristics of arid rangelands in Shergarh area showed that the Australian method, PD54 best represented the low-density vegetation cover in Shergarh area. A regression

of PD54, Band 2, NDVI, Albedo, PCA3 and PCA4 with ground vegetation cover values of the test sites revealed that PCA3 was better correlated at higher cover levels. NDVI was variable throughout, while PD54 was less variable at lower cover values than at higher cover values. Band 2 performed similar to PD54 but more variable at lowest cover.

BIODIVERSITY CONSERVATION AND IMPROVEMENT OF ANNUALS AND PERENNIALS

Germplasm of 66 crops and 23 grasses were collected during the year and preserved.

Moth bean entry CZM-45, which was developed through hybridisation and evaluated for three years at 19 locations in All India Coordinated Trials, was released on November 2, 2003 for cultivation in 250-450 mm rainfall zone of the country as CAZRI-Moth-2. The variety matures in 62-70 days, and has an average grain yield of 570 kg ha⁻¹, which is 27% higher than that from CAZRI-Moth-1. Its optimum sowing time is 15-31 July, and suitable inter and intra-row spacing are to 35-40 and 10-15 cm, respectively. Due to medium early maturity it has a tendency to escape Yellow Mosaic Virus.

Among the pearl millet accessions evaluated, OPY 91, 108, 109, 118, 119 and 121 gave 10-20% higher grain yield over the check HHB 67, and also provided higher stover yield. Seven landraces took ≤ 45 days to flower. Among the population crosses developed, combinations ERajPop x ESRC, Jakharana x ESRC, Jakharana x BSEC and ERajPop x SRC proved very productive, while among the new experimental varieties, most notable was CZP-2006 for grain, and CZP-9802 for stover. Among the hybrids, top-cross hybrid 97333A x RCB-2 TCP provided highest grain yield. Under male-sterile line breeding programme, ICMB-95444 x ICMB-93333 was found to be free from downy mildew, while ICMA-93333 x CZ-IC-311 recorded highest grain yield.

Among the other crops, mung bean, cowpea and horse gram varieties were tested. In clusterbean, 5 early maturing lines performed better than early check variety RGC-936. Treating seeds of varieties HGS-365 and RGC-936 with gamma rays and EMS reduced germination percentage. In general, early maturing varieties performed better than the medium-late varieties. Testing of 41 clusterbean genotypes at Bikaner revealed maximum pod and biomass yield from RCM-113, while seed yield was maximum from HGS-365C.

Laboratory analysis of 70 accessions of *Calligonum polygonoides* showed higher germination (80%) in the dehusked seeds, as compared to the husked ones (69%). Analysis of *Haloxylon salicornicum* showed that the fruiting top of the shrub contained higher crude protein, total ash and ether extract than its twigs, but total carbohydrate, nutrient-detergent fibre and acid-detergent fibre were higher in twigs than in fruiting tops.

Studies on henna (*Lawsonia inermis* L.) accessions revealed that October cuttings had maximum dye content and June cutting the minimum. Colour of dried leaf powder changed from dark reddish brown (June cutting) to green (October cutting) in all the populations. Dry leaf yield of henna could be increased from 970 kg ha⁻¹ without fertilizer application to 1110 kg ha⁻¹ with 80 kg N and 40 kg P₂O₅ ha⁻¹. Application of

FYM at 5 t ha⁻¹ increased the dry leaf yield by 14% over no FYM. Row spacing at 45 cm, along with FYM application, gave the highest dry leaf yield.

Among the *P. cineraria* trees JU-5 was found best for growth and establishment. Among the *Salvadora oleoides* shrubs, those from Dhawa village performed better. *Cassia angustifolia* performed satisfactorily when transplanted in Jaisalmer. For micro-propagation of *P. cineraria*, nodal segments harvested from adult trees during January-February and July-August were most suitable for culture initiation. Explants obtained from pruned tree branches exhibited better response in bud break, multiplication and elongation of induced shoots.

Genotype CAZRI 2162 of *Cenchrus ciliaris* proved to be a promising variety, yielding 188 q green fodder and 61 q dry-matter per ha. Seed germination in the genotype CAZRI 30-5 of *Lasiurus indicus* was improved by pre-treatment with 0.2% KNO₃ solution at 25°C. Highest seed germination (54%) was recorded in the spikes harvested 25 days after emergence. De-husked seeds had more germination (53%) than husked seeds (36%).

Eight substrates were evaluated for cultivation of *Pleurotus sajor-caju* strain 1140, out of which maximum yield was recorded on mung bean stalk. Yield of oyster mushroom (*Pleurotus florida*) could be increased more through neem cake supplementation, than through wheat bran and rice bran supplements.

INTEGRATED ARID LAND FARMING SYSTEM RESEARCH

Continuous cultivation of pearl millet with 40 kg N ha⁻¹ application on a fixed site for 11 years led to yield reduction to ~40% of the initial value, although organic carbon remained constant at 0.13%. Rotation of pearl millet with clusterbean increased the grain yield to 1141 kg ha⁻¹ but was statistically at par with control. Application of FYM @ 2.5 and 5.0 t ha⁻¹ resulted in yield increase by 51% (1353 kg ha⁻¹) and 93% (1731 kg ha⁻¹), respectively, as compared to control, indicating benefits of organic sources of N. FYM also resulted in build-up of soil organic carbon from 0.12% in 1993 to 0.21% in 2003, and better moisture use.

At Pali, grain and stover yield of sorghum (CSV-17) were significantly higher with inter-row water harvesting, inter-pair row water harvesting and inter-triplet-row water harvesting than with conventional sowing. Application of tumba cake @ 1 t ha⁻¹, plus 20 kg N ha⁻¹ (through urea) and biofertilizer (*Azotobacter*) resulted in 40% higher cumin (RZ-19) yield over farmers' practice. Wider row-to-row spacing (45 cm) gave 19% higher seed yield in moth bean over closer row spacing (30 cm). At Kukma, cultivation of sesame or groundnut between two rows of castor decreased castor seed yield by 34.6 and 31.9% as compared to castor alone, but the yields of sesame or groundnut were satisfactory. A 15% reduction in the population of castor, sesame and groundnut increased the yield of sesame and groundnut by 10% and 40%, respectively, decreased castor seed yield and increased its biomass.

Sennoside, the active ingredient responsible for medicinal value of Senna (*Cassia angustifolia*) leaves, was found maximum during vegetative stage. Plant spacing of 30x30 cm produced higher amount of leaves. Application of 5 t FYM ha⁻¹ led to maximum dry leaf (1056 kg ha⁻¹) and seed (503 kg ha⁻¹) yield of senna.

Incorporation of senna stems in soil @ 2.5-5.0 t ha⁻¹ increased the growth and yield of pearl millet and wheat, possibly due to higher amounts of triconanol in the stems that triggered higher photosynthesis and plant growth. Application of organic wastes, composed of leaves of *Calotropis procera* and tumba cake, helped to mitigate the adverse effects of high RSC water on the yield of isabgol (plantago).

Application of P₂O₅ with seed treatment of thiourea @ 500 ppm, followed by two foliar sprays @ 1000 ppm thiourea at 25 and 40 DAS in clusterbean (RGC-936) mellowed down the detrimental effects of water stress due to their favourable effects on photosynthetic efficiency and nitrogen metabolism.

Relative drought tolerance of clusterbean (RGC-1002), moth bean (RMO-225), mung bean (RMB-12) and cowpea (RC-101) was assessed by subjecting them to water stress at vegetative (20 DAS) and flowering (40 DAS) stages separately by withholding irrigation for 9 days at each stage. Metabolic derangements were more pronounced at flowering than at the vegetative stage. Moth bean was the most drought-tolerant as decline in seed yield was the least (23%), while cowpea suffered the most with 56% reduction due to water stress at the flowering stage.

The evapo-transpiration rate of pearl millet changed from 1.2 mm to 8.3 mm day⁻¹ at initial stage to 2.2 mm day⁻¹ at maturity. The crop coefficients increased from 0.10-0.18 at initial stage to 0.56-1.07 at maturity. Water-use efficiency of the crop was 5.01 kg ha⁻¹ mm⁻¹.

Based on data of last 10 years, cv. Kanchan, Chakaiya, NA7 and Krishna of Aonla are recommended for cultivation in the irrigated areas of arid Rajasthan. Stock-scion relationship of gonda (*Cordia myxa*), budded on its own rootstock and goondi (*Cordia gharaf*), revealed that goondi had much vigorous rootstock as compared to gonda in respect of plant height and spread.

Nodulation and nitrogenase activity of clusterbean were significantly improved upon inoculation with bioinoculants. Maximum enhancement took place with dual inoculation of *Rhizobium* and PSB, alongwith the application of compost at 5 t ha⁻¹. Application of 20 kg N ha⁻¹ decreased nodulation and nitrogen fixing ability of the plants. Fruit yield of 3year-old pomegranate trees was enhanced with the use of nitrogen fixing bacteria and arbuscular mycorrhizal fungi. Maximum enhancement took place with the dual inoculation of *Azotobacter* and *Glomus mosseae*. *Glomus mosseae* was also found to improve the growth of aonla seedlings significantly.

Out of the four major agro-forestry systems, which were identified earlier in western Rajasthan, *P. cineraria* - *A. nilotica* based system in >400 mm rainfall zone is the richest in woody biomass, producing a B:C ratio of 1:2.43. *P. cineraria* - *Z. nummularia* based system is dominant in 200-300 mm zone.

Agroforestry with *Prosopis cineraria* provided maximum moth bean equivalent seed (523 kg ha⁻¹) and straw (1193 kg ha⁻¹) yield due to higher soil moisture. Yield of crops grown sole and in association with *Ziziphus mauritiana* (Ber) closely followed the seed and straw yield of crops grown with *P. cineraria*. At Pali, mung bean performed the best as inter-crop with pomegranate (Jalor seedless), followed by clusterbean.

Colophospermum mopane and *Hardwickia binata* were found to be more sensitive to water stresses than *Acacia senegal*, *Prosopis cineraria* and *Tecomella undulata*. Root excavation studies on one-year-old seedlings indicated better suitability of *T. undulata* as a companion tree in an agroforestry system because of its less roots in 0-60 cm soil depth compared to *C. mopane*.

At Bikaner, one supplemental irrigation through sprinklers in an agri-pasture system led to 6.21 q ha⁻¹ more grain yield for moth bean over its sole cropping without irrigation, but the clusterbean yield was almost at par with the unirrigated sole crop.

Phytase activity in the rhizosphere of investigated arid zone plants was found to vary widely. Among the crops legumes contributed more than pearl millet, while among the trees neem and among the grasses Sewan contributed more, thus increasing plant-available P in rhizosphere. Among the fungi, *Chaetomium globosum* had more potential to bring P in plant-available form.

Analysis of soils from key sites in CAZRI Farm at Jodhpur revealed that four decades of land utilization has changed the pattern of soil nutrient build up. Soil organic carbon in 0-5 cm depth was maximum under the forest trees, and lowest in fallow land, while available P was highest in crop field and available K under horticultural plants.

In Bikaner tehsil, irrigated agriculture has depleted soil micronutrients, the maximum depletion taking place in Fe (32%), followed by Zn (24%), Mn (23%) and Cu (12%), as compared to the contents in natural rangelands.

Another experiment showed that pearl millet roots exploited N from up to 60 cm depth whereas N exploitation by clusterbean and mung bean was limited to 40 and 20 cm depth, respectively.

INTEGRATED LAND MANAGEMENT

Out of 15 species of trees and shrubs planted in 20 ha back-fill area of lignite mine spoil at Giral, best survival was found in *Acacia senegal* (100%), followed by *Salvadora oleoides* (96.86%), *Parkinsonia aculeate* (95.49%) and *Colophospermum mopanae* (90.90%). *P. aculeate* had the best growth, followed by *A. tortilis*.

In the rocky habitat of Kailana, planting of *Cenchrus ciliaris* cv. 358 yielded about 120 kg grass seed and 15 q grass fodder from 2 ha area. Plantation of *Grewia tenax*, *Z. rotundifolia*, *Jatropha curcus*, *Agave americana* and *Aloe vera* were also taken up, for the survival of which a roof water harvesting system was established to collect 10,000 L rain water. Sediment deposition pattern in loose stone check dams across gullies in Jhanwar watershed near Jodhpur suggested the impact of catchment improvements that were carried out for several years. Land management practices were also carried out in four villages of Barmer district.

In the lower reaches of Darbari khadin near Jaisalmer stover production from pearl millet variety Gangotri-999 was higher than from HHB-67 that had higher grain production. Mung and clusterbean production were higher in middle reach than in higher reach.

Construction of subsurface barriers across ephemeral stream at Kalawas and Chauri Kalan improved fresh groundwater availability. The increase in water yield in wells in the zone of influence of the barriers was 80-92% at Kalawas and 38-59% at Chauri Kalan, prompting farmers to grow high-value vegetables and fruit crops.

Growth of jujube in farmers' fields degraded due to irrigation with high RSC water, was enhanced through the application of gypsum and FYM in soil.

IMPROVEMENT OF ANIMAL PRODUCTION AND MANAGEMENT

Studies revealed that average body weight and milk yield of Marwari and Parbatsari goats were more under semi-intensive management than under intensive and extensive management. Optimum productivity can be achieved by providing supplementary feeding during lean periods, shelter and health care. Fodder of clusterbean and moth were found more palatable to sheep than *Cenchrus* grass, leading to higher body weight gain. Marwari goats, which were given animal feed @ 250 to 400 g animal⁻¹ on alternate dates, performed better in terms of body weight than those fed similar quantity daily. Nutri-mix supplementation (150 g/d/animal) increased the wool yield and body weight in sheep.

Synthesized saline water containing different concentrations of nitrate, fluoride, chloride and sulphate, given to Marwari sheep and goats, did not adversely affect the body weight and wool production of the animals. Lambs and kids born to saline-water-treated parents were also not affected.

A new multi-nutrient feed block, using maize-extract and low-protein maize gluten, was formulated by replacing cane molasses and wheat bran. Also, mineralized salt licks, containing 35% common salt, 17.5% each of molasses, vitamin-mineral mixture and dolomite, 8.7% maize flour, 3.5% urea and 0.9% guar gum, were formulated, which weighed 2.78 kg.

No significant effect of multi-nutrient feed block was noticed in Tharparkar heifers. In case of Rathi calves, feed consisting of groundnut haulm plus wheat straw and concentrate mixture was found to be a good source of nutrients, but *loong* and wheat straw based diet did not perform well, particularly in respect of crude protein digestibility.

PLANT PRODUCTS AND VALUE ADDITION

Peelu (*Salvadora oleoides*), or Jal, is an economically important shrub of western Rajasthan, which grows abundantly in sandy habitat. Its fruit is normally eaten by the villagers to prevent heat stroke. Juice of its fruit was extracted and mixed with sugar solution and preservatives to prepare a natural drink that has a soothing taste.

Analysis of two varieties of *Aloe vera* (Meetha and Khara) showed that juice content in all samples of Meetha type was almost negligible but Khara variety with yellowish juice and pungent taste contained 10-15 g aloin per 100 ml yellow sap during August-September, which can be gainfully exploited for use in medicines and cosmetics.

Fresh and dried branches of guggal (*Commiphora wightii*), on extraction with petroleum ether (60-80°C), yielded 1.41% and 2.77% guggal extract, respectively, and

consisting of 64.13% resin. Mean seed oil content in 24 accessions of *Salvadora oleoides* collected from arid Gujarat was 47.5%.

An assay of Carotene content in desert tree revealed 101 to 227 mg per kg leaf. Highest content was found in *Albizia lebbek* (227 mg per kg leaf) and the lowest in *Salvadora persica* (22 mg per kg leaf). Air-dried leaves of *Prosopis juliflora* and *Cassia samia*, though unpalatable to most livestock, contained 162 and 155 mg per kg leaf.

INTEGRATED PEST MANAGEMENT

Good monsoon rains brought general improvement in the appearance of various fauna, including predators, parasites and insect pests. In Jodhpur, Nagaur, Bikaner, and Churu districts *Meriones hurrianae* was predominant rodent species, followed by *Tatera indica*. In CAZRI Farm at Jodhpur lower rodent population was recorded than during previous 3 years, *T. indica* being the major species, followed by *Funambulus pennanti* and *Rattus rattus*, but none were true xeric species. *Bandicota bengalensis*, which was reported earlier from new areas of Jodhpur city, spread fast in the old, walled city. Sex ratio was in favour of females. Body weight of Bandicoots changed with season and ranged from 158.75 g (December) to 312.75 g (July) for male and from 161.80 g (December) to 238.85 g (April) for female. In squirrel population two peaks were observed, one during September-October, and another during February-March. Population minimum was observed during November-December. Maximum fruit damage was noticed during February-March.

Neem emulsifier, when evaluated by residue film technique, was found effective against *Myzus persicae* at 2% dose rate, causing most insects to shrivel and dehydrated after 24-hour treatment. In case of *Spodoptera exigua*, emulsified neem oil (up to 1% concentration) gave 16.66 to 20% mortality in 4th instar after 48-hour treatment.

Broadcasting of neem emulsifier in fields during sowing, followed by two more weekly sprays 35 DAS, reduced the population of black weevil, *Cyrtogemia cognata* by 62.4 to 86.9% in mung bean plots and by 48.7 to 73.3% in moth bean plots. Population of leafhopper (*Empoasca kerri*) was reduced by 48.7 to 67.5% in moth bean and by 69.7 to 84.8% and mung bean crops.

Entomopathogenous fungi (*Metarhizium anisopliae* and *Beauveria barriana*) and organic amendments (tumba seed cake, 05 t ha⁻¹ and neem seed cake, 0.5 t ha⁻¹), along with phorate successfully controlled termites and white grubs in sesame crop.

Freshly plucked seeds of kaner (*Nerium oleander*) provided to Indian gerbils, *T. indica* resulted in 88.0% mortality. Of these, 33% died on 4th day and 50% on 5th day after eating the seed coat. Effect was more prominent in the treatment with whole seed as the mean consumption of treated food was only 0.89 g as compared to plain food (4.55 g). CAZRI's formulations of neem, viz., pellets, kernel powder, oil emulsion, etc., were found to possess deterrent properties against *T. indica*. A rodenticidal trial in irrigated field with zinc phosphide and bromadiolone suggested that rodenticidal baiting should be undertaken before sowing/at early stage of the crop for better results. Use of coumatetralyl (0.0375%) in baits was found to be effective in rodent control, as it led to 60% mortality in *T. indica* and 70% in *R. rattus* within 3-10 and 3-13 days, respectively. A new wax block formulation of bromadiolone (0.005%), containing 10 ppm denatonium

benzoate (DB), was found to cause 100% mortality in *R. rattus* in 3-13 days, even without the bittering agent.

Treatment of the seeds of Downey mildew-susceptible Nokha local variety of pearl millet with raw cow milk for 18 hour with *Gliocladium virens* in soil (10 g m⁻²) led to 73% control of the disease, while raw cow milk with *G. virens* seed treatment resulted in 70% control.

Studies on Downey mildew (DM)-susceptible pearl millet variety Eknath, and DM-resistant variety HHB-67, revealed that higher contents of phenols and O-dihydroxy phenols and their oxidizing enzymes such as PPO and PO, play major roles in downy mildew disease resistance in pearl millet.

Maximum control of cumin blight was possible through 2 sprays of mancozeb. Cumin seed yield was significantly higher than control in the treatments where compost water-extracts of weeds, neem, FYM and mancozeb were sprayed. In cowpea and clusterbean (guar) mortality due to dry root rot was reduced more by the compost-amended treatments than the non-amended control. Least mortality was through *P. juliflora* compost. Dry root rot incidence in cowpea was found to be minimum in *Aspergillus versicolor*-amended soil, while in case of sesame and clusterbean such disease was the least when the seeds were sown after treatment with *Bacillus firmus*.

Neem seed kernel ethanolic extract (NSKEE) was found most effective in reducing the population of root-knot nematode, *M. incognita*. It was established that leaf curl virus (LCV) was not seed-borne in nature. Calli raised from LCV-affected seeds were slow in callus initiation as well as growth after further subculturing. Research was also continued on tissue culture for producing die-back disease resistance in chilli.

NON-CONVENTIONAL ENERGY SOURCES, FARM MACHINERY AND POWER

An electro-mechanical type solar tracker has been designed and fabricated that turns a solar cooker or any such appliance towards the sun automatically during the day, and thus increases significantly the efficiency of the appliance being turned. The tracker comprises simple electronic circuit and a mechanical unit. The electronic circuit senses light through LDR and small PV cell and trigger circuit, which mobilizes tracking platform towards maximum light with the help of a 12 V dc motor and battery. On an average 25% higher output was obtained with tracked cooker.

An indoor storage solar cooker, capable to cook after sunset, has been designed and fabricated. Solar heat is gathered outside in a solar collector and transferred through a fluid medium to a storage-cum-cooking unit in the kitchen. The cooker is under test. A greenhouse, including fan and pad system for cooling and year-round production of off-season vegetables, is being developed.

Grain and stover yield of pearl millet, green gram, clusterbean and moth bean, sown with the recently-developed tractor-operated three-row multi-crop seed-cum-fertilizer drill were found to be higher than those sown using local method. Possible reason for increased yield is capability of the drill to sow on slanting surface of furrows while maintaining its shape and slope, which in turn helps more run off water in the

furrows, resulting in high moisture content for a longer time in the plant root zone. Also, crust formation is reduced.

The earlier-developed cool chamber was modified to ensure evaporation from sides and the bottom of the chamber, which led to reduction in temperature by 15°C, while maintaining relative humidity at 90-95%. This helped to increase the shelf life of vegetables. Performance testing of a recently fabricated solar photovoltaic winnower showed capability to winnow 35-50 kg grains of pearl millet and clusterbean within 1.5 hours. Performance test was also carried out on an earlier-developed solar dryer, animal feed solar cooker, a non-tracking storage solar cooker as well as a compact integrated solar heater cum solar cooker cum solar dryer.

SOCIO-ECONOMIC INVESTIGATION AND EVALUATION

A study on Raika graziers in five villages of Jodhpur district revealed that animal husbandry played an important role in their economy as most of them owned very meager agricultural land. Nearly 50% of the graziers practice long duration (8-10 months) migration with their herds to MP, UP and Haryana, but >90% of them want allocation by government of some fixed grazing areas to avoid long distance migration. Due to shrinking grazing resources and changing social conditions, many graziers are shifting to occupations like wage labourers, petty business, etc.

Henna cultivation was found to be more remunerative than arabe cropping in Sojat and Marwar Jn. tehsils, where area under henna has registered an annual compound growth rate of 7% during the last one decade, possibly at the cost of sesame, mustard and pearl millet area, which registered negative growth rates of -9.6%, -9.2% and -2.8%, respectively. The best B:C ratio for arable crop was for sesame (1.92:1), while that for henna was 2.07:1. Because of higher returns, henna cultivation can also be profitably taken up in Kachchh district.

TECHNOLOGY ASSESSMENT AND TRANSFER

Adoption of improved practices for wheat cultivation in Satheen village of Jodhpur district was found to be essentially for sowing time, seed rate, irrigation and sowing method. Improved practices on weedicide, fertilizer application, plant protection, etc. had little adoption due to knowledge gap and cost involved. Overall gap was 52%. The highest gap was for cotton cultivation (60%), followed by cumin (57%), mustard (56%), and groundnut (54%). Majority of farmers desired training in livestock health care, followed by breeding, feeding and management. They preferred one week training during the slack season of March to April.

Under Institute - Village linkage programme, a number of on-farm activities were carried out, especially to demonstrate the effects of improved varieties and nutrient management on mustard, cumin, pearl millet, mung bean, clusterbean crops, as well as their rotations, and livestock improvements. On-farm activities were also carried out in other villages also.

Based on weather predictions received from medium range weather forecasting center at New Delhi about 100 weather advisory bulletins were prepared and disseminated for farmers around Jodhpur during 2003. Monsoon forecast was successful on 70% occasions while cloud cover forecast had 88% success. High

humidity and drizzling rains during February 2003 affected the seed yield of cumin by a maximum of 50%, but those who followed the advisory could minimise the losses.

EMPOWERMENT OF WOMEN AND MAINSTREAMING OF GENDER ISSUES

A study of farm women in some sample villages revealed that women in age group of 15-45 years, doing moderate work, spent 1100 k cal per day on agricultural work out of their daily total energy expenditure of 2274 k cal. In contrast, women >45 years age spent their maximum energy (748 k cal) on activities related to household care.

A study on graziers, especially the Raikas, in five villages of Jodhpur district revealed that literacy among women was negligible, and majority of population did not realize the importance of women's education.