



### 3. Research for Tribal and Hill Regions

The Indian Council of Agricultural Research (ICAR) through the Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora, the ICAR Research Complex for North-Eastern Hills Region, Umiam, Meghalaya, and the Central Agricultural Research Institute (CARI), Port Blair, evolves technologies to meet the needs of tribal and hill farmers.

These technologies are intended to improve the socio-economic status of the target group, and will help them to acquire special skills through vocational training in traditional and non-traditional crops, agroforestry, apiculture, sericulture, horticulture, animal husbandry, poultry and fisheries.

- Released 2 hybrids and 1 composite of maize for cultivation
- Identified varieties (4 in wheat, 2 in tomato, 1 each in maize, finger millet, field pea, lentil, soybean, horsegram, *toria* and vegetable pea) for their release
- Popularization of polyhouses in Uttaranchal opened possibility of year-round cultivation of high-value vegetables
- Designed and developed light weight, rust-proof, pedal-operated paddy thresher-cum-pearler
- Identified crop varieties suitable for organic farming
- A newly identified bacterium *Paenibacillus koreensis* possesses vast bicontrol potential for white grubs management in hill region

#### Crop Improvement

Two hybrids and one composite of maize have been released for cultivation. Besides, four varieties in rice, two varieties in

tomato and one variety each in maize, finger millet, field pea, lentil, soybean, horsegram, *toria* and vegetable pea have been identified for release in different parts of country.

#### New varieties of maize released

Variety	Adaptation region/agro-ecology	Yield (tonnes/ha)	Duration	Other salient features
Vivek Maize Hybrid 15	Zone I (Himalayan Region)	6.5	Extra early duration (85-90 days)	It is fairly tolerant to <i>turicum</i> leaf blight, and showed good response at lower doses of nitrogen
Vivek Maize Hybrid 17	Zone III (Eastern Uttar Pradesh and Eastern States of the country), Zone IV (Peninsular India) and Zone V (Central and Western India)	3.9 in Zone III, 5.9 in Zone IV and 3.6 in Zone V	Extra early duration (85-90 days)	It possesses moderate degree of tolerance against most prevalent diseases in zones III, IV and V
VL Baby Corn 1	For commercial cultivation across the country	1.2	First extra early babycorn	Prolific, baby corn composite Besides better baby corn yield, it gives 13.5% more green fodder than the check, VL Makka 42



Vivek maize Hybrid 15



Vivek Maize Hybrid 17



VL baby corn 1



### Seed Production

During the year, 13.8 tonnes breeder seed of 43 released varieties and inbred lines, 1.22 tonnes nucleus seed of 38 released varieties and 7.63 tonnes truthfully-labelled seed were produced. Around 11.4 tonnes breeder seed was supplied to meet the demand of various organizations for production of foundation and certified seed. About 7.20 tonnes truthfully labelled seed was supplied to farmers.

### Protected Cultivation of Vegetables

Popularization of polyhouses in Uttaranchal has opened up possibilities of year round cultivation of high-value vegetables. Three cropping sequences, viz. capsicum-tomato-spinach, squash-French bean-tomato and cucumber-French bean- French bean-spinach, suitable for growing vegetable round the year inside polyhouse, have been identified for the mid-hill conditions. These sequences gave net profit of Rs 515,000, 810,000 and 325,000/ha respectively.

### Varieties identified suitable for organic farming condition

A number of varieties of rice, finger millet, soybean, garden pea and wheat were identified suitable for organic farming condition. Of the varieties screened, VL 184 of rice, VL 149 of finger millet,

### LDPE Film lined Tank – A Supplemental Irrigation Source

In Uttaranchal, only 10% cultivated area is irrigated. The water requirement of the vegetables, which fetches more money, can be fulfilled by using low-density polyethylene film-lined tanks, developed by this Institute. This tank is being popular among hill farmers of the region for limited irrigation facilities. The farmers of an adopted village are harvesting water from low discharge springs in these tanks and using for cultivation of vegetables like, tomato, capsicum, cabbage, cauliflower, French bean etc.

VLS 21 of soybean, VL 802 of wheat and VL 3 and VL 6 of garden pea gave the highest yield with the application of farmyard manure.

### Biological control

**Soil-borne plant pathogens:** For biological control of soil-borne plant pathogens, a total of 60 isolates of *Trichoderma* spp., representing 45 locations in NW Himalayas, could be isolated from rhizosphere and non-rhizosphere soils of various crops grown in the hills. These were screened for their antagonistic potential against *Rhizoctonia solani*, *Sclerotinia sclerotiorum*,

### Genotypes of different crops found promising against diseases/insect-pests

Disease/insect	Genotype
<b>Rice</b>	
Blast disease	BG 367-7, Diwani, E 890715, E 890744, IR 4547-3-3-6, Milyang 47, Suweon 303, VL 88-971, VL 89-1193, VL 91-1190
Stem-borer and leaf folder	VL 4930, VL 30218, VL 4637, VL 4455, VL 7072, VL 779, VL 7220, VL 7314
<b>Wheat</b>	
Rusts and leaf blight	VL 867, VL 868
Powdery mildew	VL 824, VL 858, VW 0204, VW 0207, VW 0208 and VW 0472
Leaf blight	VL 829, VW 0401, VW 0417, VW 0418, and VW 0419
Loose smut	VL 614, VL 636, VL 639, and VL 646,
Hill bunt	VL 798, VW 0254, VW 0270, VW 0321, VW 0374, and VW 0375
Aphid	VL 829
<b>Barley</b>	
Stripe and leaf rust	VLB 91, VLB 93, VLB 97
<b>Maize</b>	
Turcicum blight	FH 3245, FH 3248, FH 3288, FH 3294, CM 129, V 336, V 338, V 340, V 354, and V356
<b>Finger millet</b>	
Leaf, neck and finger blast	VR 299, VR 301, VR 302, VR 169
<b>Barnyard millet</b>	
Grain smut	VB 287, GECH 71, VB 360, VB 366
<b>Soybean</b>	
Frog eye leaf spot	JS 75-46, PK 262, NRC 37, VLS 59, US 31, JS 98-63, MACS 985, PS 1392
<b>Lentil</b>	
Wilt	VL 120, VL 2115, IPL 208, PL 4, L 4597, VL 126,
<b>Rajmash/French bean</b>	
Fuscous blight	MFB 4, VLB 8, VLFB 2002, VLFB 9908
<b>Garden pea</b>	
Powdery mildew	DPP 9411, JP 15, JP 585, VP 8901, VP 9211, NDVP 250



### Design and Development of Pedal-operated Paddy Thresher-cum-Pearler

Engineering plastics (polycarbonate sheet) were utilized in development of pedal-operated paddy thresher-cum-pearler. The machine was basically designed and developed for hilly region where the weight of the machine is the major concern. Total weight of the machine is 40 kg and is rust-proof. The machine appears to be less noise producing during operation as compared to the machine of metal body. The probability of injury hazards is less during operation and transportation. The machine having, capacity 80-100 kg/hr and efficiency 98%, is operated by single man.

*Sclerotium rolfsii* and *Fusarium* spp. The *Trichoderma* isolates provided 48–70% growth inhibition against different soil-borne plant pathogens. Two isolates of *Trichoderma*, viz. *T. harzianum* and *T. viride*, also showed enhancement in seedling emergence and vigour index of tomato plants in nursery and checked damping-off incidence.

**White grubs and other insect-pests:** Out of 40 species of white grubs, *Anomala dimidiata*, *Holotrichia seticollis*, and *H. longipennis* are the major pests of upland rice, millets and many vegetables in Uttaranchal region. Of the 27 indigenous isolates of entomopathogenic bacteria tested against white grubs, an isolate, WGPSB 2, identified as *Paenibacillus koreensis* was found very effective against white grubs. A talc-based formulation of this bacterium caused mortality up to 90% of *A. dimidiata* grubs under laboratory as well as micro-plot field condition. This bacterium has vast biocontrol potential for managing white grubs in this region.

**Toxicity of *Bacillus thuringiensis* strains against lepidopterous insects:** *Bacillus thuringiensis* (Bt) strains were evaluated for the management of *Helicoverpa armigera*, causing extensive damage to chickpea and tomato, and of *Spodoptera litura*, *Plutella xylostella*, *Pieris brassicae*, *Spilartia obliqua* and *Trichoplusia ni* severe defoliators of cole vegetables. Most toxic Bt strain has been identified for each insect species for use in IPM. Four Bt strains have been isolated from diseased insects and were highly toxic against these insect species.

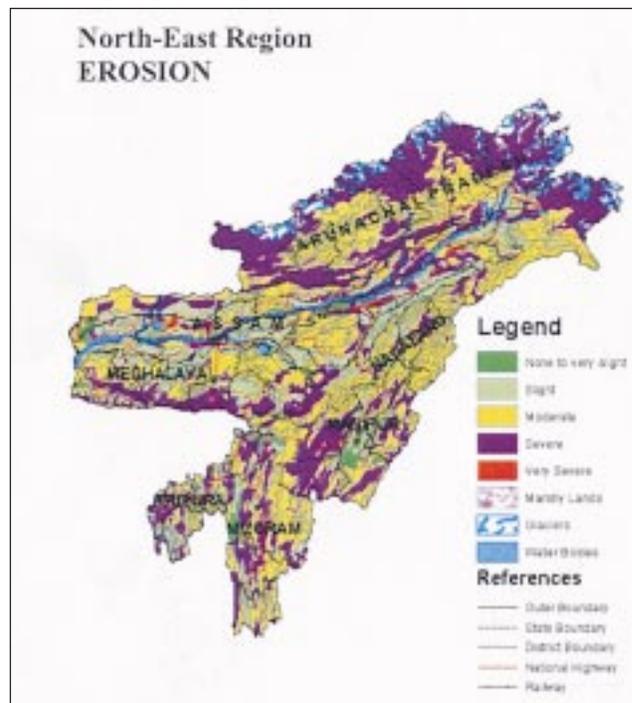
### Fodder Production from Sloping Wastelands

Growing improved grasses on the sloping degraded lands in hills is an important conservation measure for stabilizing these lands as well as for providing additional green forage. In view of fodder scarcity in hills, attempts were made to grow hybrid Napier on these lands to overcome the fodder scarcity as well as to help in soil conservation. Hybrid Napier produced the highest green forage 5-8 tonnes/ha during initial year and 30-50 tonnes/ha in the second year. Five to eight cuts can be taken during the growing season (May to mid-November).

### Soil Resource Characterization

Soil erosion map for NEH region has been generated. The map is useful for planning of suitable soil-conservation measures in the region.

- Developed protocol for *in-vitro* conservation and cryopreservation of wild rice
- Standardized soft wood grafting in Khasi mandarin
- Managed thrips in gladiolus
- Established hatcheries in 3 stations out of 7 to popularize Vanaraja birds in NEH region
- Developed DOT-ELISA-based diagnostic kit for identification of specific gastro-intestinal parasitic infection from serum samples of goat and cattle
- Detected and characterized pathogenic organisms from livestock and their products
- Developed cost-effective package of practice for commercial production of exotic ornamental fishes



Soil erosion map of North-eastern region

### Crop Improvement

**Protocol development for in-vitro conservation and cryopreservation of wild rice:** Protocol for *in-vitro* conservation of *Oryza rufipogon* and *Oryza officinalis* was developed. Clonal shoots were produced from young seedlings in MS medium supplemented with 8.9  $\mu$ M BAP and with 0.053 M Mannitol + 0.058 M sucrose + 4.4  $\mu$ M BAP for its maintenance.



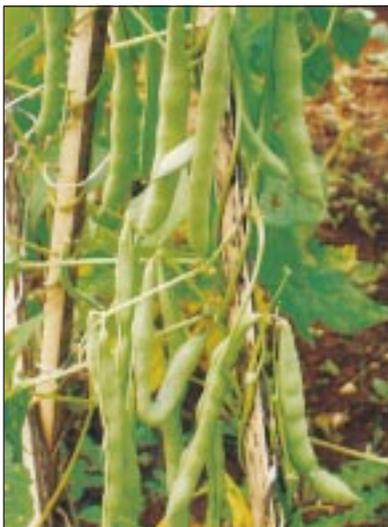
Similarly, protocol for cryopreservation of seed-derived calli of *O. rufipogon*, *O. officinalis* and *O. sativa* was also standardized. A common protocol worked for all the three species. N6C medium (N6 + CH + 18.1  $\mu$ M 2, 4-D) gelled with Phytigel® produced calli suitable for cryopreservation. A combination of PEG, DMSO and sucrose was used as cryoprotectant.



Plant regeneration of *Oryza rufipogon* from recovered calli (left) and regenerated plant transferred to pot (right)

**Soft wood grafting in Khasi mandarin:** Soft wood grafting in Khasi mandarin was standardized with a success rate of more than 90%. The Institute resorted to soft wood grafting because the T-budding technique of vegetative propagation gave a success rate of less than 50% only.

**Pole type French bean:** A promising pole type French bean (RCMFB 1) with yield potential of 11 tonnes/ha was identified and is being tested in multilocations under All-India Co-ordinated Research Project.



Pole type French bean

### Crop protection

**Isolation and bioefficacy of entomogenous fungus *Nomurea rileyi*:** Bioefficacy of locally isolated *Nomurea rileyi* indicated 100% control of *Spodoptera litura* in lichi, soybean and groundnut.

**Management of thrips in gladiolus:** Among the various botanicals and insecticides tested or tried to manage thrips in gladiolus, imidacloprid was found most effective (97%) followed by the botanicals Anonin (90%) and Karanjin (75%).

**Fruit feeders of passion fruit:** Passion fruit production and processing in the region has revolutionized the fruit sector development. Since it is relatively a new fruit crop, no major insect pest was reported. However, the fruit has been observed to be now attacked by *Xylotrupes gideon* and *Trigonophorus hookeri* inflicting 39.7% and 27.65% damage to Kaveri and Meghalaya local varieties respectively. Biological control of the insect through mass trapping with fermented jaggery was found most effective.

### Animal Science

**Piggery:** Around 30 members of piggery units with the improved species at farmers' fields were established. Pig ration could be supplemented by up to 25% with broken rice without any adverse effect on growth rate (353 g/day). Experimental results indicated that up to 40% weaner pig (56 days of age) could be fed with boiled sweet potato tuber for achieving a growth rate of 235 g/day. Artificial insemination in pig was also successfully carried out in the hill states of the region.



Artificial insemination in pig in a adopted village

**Poultry:** The Institute established hatcheries in 3 of the 7 stations to popularize the Vanaraja birds in the region for maximizing egg and chicken production. Their services were opened up to the beneficiaries who were given the 6-week-old Vanaraja birds. These also helped them in egg hatching, produced subsequently in their households. Around 300 farm families per centre have been benefited during the year. In addition to this, indigenous fowls of the region have also been collected for characterization, conservation and further use in the breeding programme.

**Rearing of rabbit:** A comprehensive technology package for rearing broiler rabbits was developed and transferred to farming



Vanaraja breed of poultry is being popularized in NEH region

community. On an average, they are getting 16 numbers of young ones per rabbit per year, each fetching Rs 150 after 90 days.

**Parasite diagnostic kit:** DOT-ELISA-based diagnostic kit for identification of specific gastro-intestinal parasitic infection (*Oesophagostomum* sp. and *Bunostomum* sp.) from serum samples of goat and cattle was developed particularly for the field veterinarians and master trainers for on the spot diagnosis of parasitic diseases and their subsequent control. The kit so developed is being released shortly.



DOT-ELISA based diagnostic kit developed for identification of specific gastro-intestinal parasitic infection

**Detection and molecular characterization of pathogenic organisms from livestock and their products:** PCR-based protocols for *Listeria* sp., *Campylobacter* sp., *Salmonella*

sp., *E. coli*, *Brucella*, *Bordetella bronchiseptica*, mesophilic *Aeromonas*, *Clostridium perfringens* Type A and *Pasteurella* sp., and RT-PCR for detection of Group C rotavirus were standardized. Isolation and molecular characterization of *Bordetella bronchiseptica*, a respiratory pathogen from pigs was carried out. Eight toxin genes, viz. *BvgAS*, *flaB*, *flaC*, *fim 2*, *fim 3*, *dnt*, *Ac-hlyA* and *tcfA*, were detected by PCR. Molecular typing and subtyping of all the *C. perfringens* isolates by multiplex PCR using 6 toxin specific primers amplified only the primer specific for alpha toxin (*cpa*, 324 bp fragment) indicating that all the cultures belonged to the genotype A.

### Fisheries

After successfully breeding cultivable carps, cost effective package of practice for commercial production of exotic ornamental fishes like gold fish and platty was developed to support ornamental fish rearing by local hobbyist.



Cost-effective package of practice developed for commercial production of gold fish (left) and platty (right)

### Horticulture and Forestry

Co 3, Anand, DT 2, DVRT 2, Arka Vikas, BT 120, BT 136, Sel 7, DT 1 and MDB No. 2-3 varieties of tomato; PB 64 of brinjal and JCA 283 of chilli recorded 100, 80.5 and 100% survival against bacterial wilt respectively. CHCP 1 cowpea, Contender French bean and JSGL 55 sponge gourd gave the highest yield. Application of *Pseudomonas fluorescens* @ 0.5% at 20 days interval from flower-bud initiation (May-June) up to final harvesting, resulted in profuse flowering simultaneously with control of anthracnose in mango. Mango fruits treated with *Pseudomonas* (0.5%) showed the highest shelf-life with quality characters. Technology



of composting coir pith and dried leaves using *Pleurotus* and urea was standardized. Nutritional analysis of underutilized indigenous fruits was carried out. Out of 54 species conserved, 16 were identified for commercial exploitation. *Morinda citrifolia*, *M. trimera* and *Annona glabra* were identified as saline resistant. Twenty-six indigenous species of underutilized fruits were allotted IC numbers by the NBPGR, New Delhi. The optimum spacing and vase-life for gerbera was standardized as 30 cm × 20 cm for production of more quality blooms. In gladiolus, sucrose (5%) + AgNO<sub>3</sub> (100 ppm) prolonged vase-life by 5 days. In *Eulophia andamanensis*, application of IBA 2000 ppm resulted in maximum number of suckers (5) and of 1.5% urea in maximum spike length with more duration of flowering. Fifteen indigenous orchids, 10 ferns and indigenous ornamental plants were allotted IC numbers. The *Eulophia andamanensis* was also registered. The peak biomass and yield of maize was greater when the leaves were applied green in both incorporated and surface conditions. *Gliricidia* as well as *Leucaena* provided nearly equal yield in maize.

Somaclones developed from brinjal BB 66C, SM 141 and BB 60C were evaluated at SC<sub>5</sub> and SC<sub>6</sub> generations for improved agromorphological characters. Of them, 16 promising lines were identified. Molecular characterization of three economically important endemic medicinal plant species, viz. *Alstonia macrophylla*, *Costus speciosus* and *Hernandia ovigera*; syn. *H. peltata* through RAPD analysis revealed ample genetic divergence among collections, which would be instrumental in devising sound conservation strategies.

The intercrops, *sowa* (*Anethium sowa*), kenaf (*Hibiscus sabdariffa*) and maize were found compatible with brinjal and also reduced fruit-borer damage. The crop diversity led to 8-fold increase in natural enemies. Tomato with intercrop of kenaf (4:1 rows), NPV application twice at 250 LE/ha at 15 days interval from 45 DAT led to 78% reduction in fruit damage. The NPV alone along with 2% jaggery as phagostimulant was effective in managing *Spodoptera litura* in cauliflower. Twenty-nine strains of *Pseudomonas* were collected and characterized. Local strains of *Pseudomonas* inhibited the growth of *Pythium* to varying degrees.

### Field Crop

In the very early group (superfast) rice variety Heera produced 1.8 tonnes/ha under direct seeded condition and 2.0 tonnes/ha under transplanted condition. Scope of double cropping involving a productive very early variety in conjunction with a medium-duration variety is distinctly discernible. Al and Fe toxicity tolerant lines developed in IR 72 and C 14-8 background showed appreciable field tolerance under constrained soil conditions. Microprojectile-based genetic transformation was optimized in Basmati 370 and Taraori Basmati involving diverse physico-chemical parameters.

- Standardized the technology of composting coir pith and dried leaves using *Pleurotus* and urea
- Allotted IC numbers to 26 indigenous species of underutilized fruits, 15 orchids, 10 ferns and ornamental plants
- Collected and characterized 29 strains of *Pseudomonas*
- Developed putative transgenics in rice
- Designed and fabricated coconut dehusker for Nicobar islands
- Achieved captive breeding of *A. ocellaris* in laboratory
- Assessed the impact of Tsunami on agricultural lands and suggested suitable technologies for rehabilitation of affected farmers in groups of islands

Putative transgenics involving *cryIA* (b), *cryIA* (c), Amsod and chitinase were developed. About 150 entries from F<sub>3</sub> population of IR 28 × Pokkali were phenotyped under artificially simulated saline soil condition and were molecularly profiled through RAPD analysis. Molecular tagging of salt-tolerant gene/s in a mapping population derived from IR 28 × Pokkali was carried out through RAPD analysis.

### Natural Resource Management

Both runoff loss and soil loss were less under forest canopy, being 3.9–31.8 mm and 2.8–13.2 tonnes/ha, respectively, depending on rainfall and followed by arecanut and other canopies except during September and October. In furrows, high-yielding varieties of rice-ratoon-pulses/sunflower and super rice-ratoon-ratoon could be recommended to achieve high yield. Quing Livan 1 rice registered high yield in main and ratoon crops compared to other varieties. Application of 50% N through *Gliricidia* and 50% N through inorganic sources was recommended for main crop and 40 kg N/ha to ratoon crop for high yield. *Sesbania aculeata* (*dhaincha*) and *Sesbania rostrata* could be recommended for intercropping in wet seeded rice under island conditions. Combination of cultural (intercropping) and mechanical (cono weeder) weeding method was found effective in bringing down the weed density, registering high yield. A study on 'System of Rice Intensification' using Taichung-sen-Yu variety revealed that this method resulted in higher grain yield (6,222 kg/ha) than conventional method of planting (4,347 kg/ha). Newly fabricated half and full cage wheels showed better performance than existing cage wheels. Puddling field capacity for one pass of tractor cultivator was maximum (0.1188 ha/hr), followed by power tiller (0.1152 ha/hr) and animal drawn puddlers (0.0144–0.120 ha/hr). Power tiller was found the best for puddling of rice field owing to highest puddling index. Aerobic direct seeders required less time (8–20 hr/ha) than anaerobic seeder (19.55 hr/ha). Conoweeder required 50–60 man-hr/ha compared to 120–150 man-hr/ha required in traditional method of weeding. A coconut



Dhaincha incorporation using conoweeder in rice + dhaincha intercropping reduces weed density and increases rice yield



CARI coconut dehusker



Low-cost solar dryer traps solar energy and improves copra quality

dehusker was designed and fabricated for Nicobari tribals. A solar dryer was designed and developed to trap solar energy and to improve the quality of copra. With two days of bright sunshine hours, with temperature of 28–52°C, 110 nuts copra could be dried.

### Animal Sciences

The turkey and guinea fowl birds were found well adapted to the island condition. In these islands, sera samples collected from cattle, goat, pig and poultry revealed the prevalence of brucellosis, infectious bronchitis rhinitis, leprospirosis in cattle; mycoplasmosis, brucellosis and leptospirosis in goat; and infectious bursal disease (IBD), salmonellosis and infectious bronchitis and mycoplasmosis in poultry. The parasitic diseases, humpsore, fascioliasis, strongyloides, taeniasis, trichuris and schistosomiasis were also prevalent in these islands. Detailed study on outbreak of foot-and-mouth disease was conducted and samples were examined for antibodies and it was found to be type 'O' FMDV. Efficacy of IBD vaccine was tested in poultry chicks @ 2 drops/bird through oral route and found to be safe and protective. Deficiency of mineral elements in dairy animals caused infertility at different places like Indiranagar, New Bimblitan and Namunagar, in South Andaman.



Turkey birds are well adapted to island climatic condition

### Fisheries

Evaluation of different mixed wet feeds showed that combination of 'green mussel + lam' resulted in best growth of lobster, *Parilurus versicolor*, and combination of 'sardine + stolephorus + common ingredients' in maximum growth of grouper, *Ephirephelus tauvina* and *Cephalopholis argus argus*. Captive breeding of *A. ocellaris* was successfully achieved under laboratory conditions. Feeding habit of clown fishes was studied. Walnes



media gave highest population growth for *Thoreckandra carteriformis*, *Chlorella pyrenoidosa* and *Phacodactylum tricorutum*.

### Social Sciences

Post-intervention impact of project 'Development of Integrated Farming System under different resource conditions in humid tropics of Bay Island' revealed that the application of chemicals in vegetables was reduced to 30–40%. Technologies like 'IPM in paddy' and 'Insect pest and disease management in vegetables' were adopted by 100 farmers with minor refinement. Significantly higher yield and net returns were realized using these technologies, as these were socio-economically viable and ecologically compatible in these islands. Dependency of farmers on broiler farm for more income reduced with the increase in farm size. The labour utilization pattern for broiler and layer farming revealed that with increase in farm size, the number of hired labour increased and that of family labour reduced. The IBD, heat-stroke, curled toe paralysis, visceral gout and *E. coli*, were common causes of mortality for broilers, and for layers main causes of mortality were fungal toxins, mycoplasma, heat stroke, visceral gout, *E. coli*, IBD and curled toe paralysis.

### Tsunami disaster

The CARI, Port Blair, constituted expert committees to assess the impact of Tsunami on agricultural lands. Based on the findings, the expert teams made the following recommendations for rehabilitation of affected farmers in various groups of islands such as South Andaman, Little Andaman, Car Nicobar, Nancowrie and Campbell Bay.

- Provision of adequate surface and sub-surface drainage
- Impounding and leaching of affected fields with rain water
- Construction of raised embankments along with one way sluice gates
- Biofencing through conservation of existing mangroves and planting new seedlings
- Planting of alternate trees like *Casurina*, sea mahua, *Pongamia*, *Pandanus*, *Thespesia*, *Ipomoea pes-caprae* etc. in the sea shores, if the site is not compatible for mangroves.
- Planting of trees/shrubs with higher evapotranspiration

requirement, viz. *Eucalyptus* sp. and *Acacia auriculiformis* to act as a bio-pump in waterlogged areas.

- Selection and raising of salt-tolerant crops like rice, sugarcane, sorghum, watermelon, castor and forage crops like karnal grass (*Diplachne fusca*) and para grass (*Brachiaria mutica*) and green-manure crop like *Sesbania*.
- Selection of suitable crop rotations like rice-watermelon, rice-maize, rice-sorghum, rice-vegetables, rice-sugarbeet and rice-forage crops
- Adoption of broad bed and furrow system of land manipulation in the affected areas to cope up with the problem of salinity and for increased profit
- Application of higher dose of farmyard manure and its incorporation in the field to improve the drainage
- Incorporation of blue green algae and azolla in rice fields
- Adoption of 25% higher seed rate than the recommended seed rate
- Sowing the seeds in the furrows or two-thirds from the top of the ridge
- Cultivation of rice followed by *dhaincha*, sunnhemp followed by safflower, castor, sugarbeet, watermelons during dry season. Replanting of coconut and other fruits like alligator apple and tuber crops like sweet potato in the lowlying submerged areas in the next rainy season.
- For wide spaced crops like vegetables, adoption of pit system of planting by replacing the salt-affected soil with mixture of normal soil and farmyard manure
- Adoption of drip irrigation or pitcher irrigation for high-value crops
- Application of higher dose of NPK than the recommended dose
- Promotion of jatropha and *Morinda citrifolia*, which are saline-tolerant crops
- Adoption of rice-cum-brackishwater-prawn and fish culture
- Adoption of auger hole technique for planting tree species in salt-affected areas
- Distribution of poultry birds (Nicobari fowl, Vanaraja, Turkey, Guinea fowl and ducks), goat and piglets to the affected farmers
- Culture of shrimps, mud crab, milkfish, mullet and sea bass
- Tambak system of aquaculture by planting mangroves and culturing shrimp/fishes in trenches