17. Research for Tribal and Hill Regions

The Indian Council of Agricultural Research (ICAR) through its institutes located in North-west Himalayas, North-east Himalayas and Islands evolved 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 acquire special skills through vocational training in traditional and non-traditional crops, agro-forestry, apiculture, horticulture, animal husbandry, poultry and fisheries.

NORTH-WEST HIMALAYAS

Varietal release: Four varieties, namely Vivek Sankul Makka 35, Vivek Sankul Makka 37, VL Gahun 907 and VL Gahat 19, were released for various agro-climatic regions of the country.

Registration of genetic stocks: One genetic stock of wheat, VL 876 was developed for high bread loaf volume and quality bread. Similarly, Kagazi Madira B 29, an easy de-hulling type barnyard millet was identified. It is dehulled by the dehulling machine at least 40 to 141.4% faster over other popular varieties. Both these genetic stocks were registered.

NORTH-EAST HIMALAYAS

Rice: Four genotypes of rice found promising for Meghalaya were proposed for release by SVRC. Bhalum 3 and Bhalum 4 were recommended for rainfed upland, including *jhum* lands up to 1,250 m above mean sea-level in main *kharif* (May/Jun to Sep/Oct). Both varieties mature in 130–150 days, depending on the altitude. Besides, RCPL 1-76 and RCPL 1-60 were recommended for the mid-altitude rainfed lowland (up to 1,000 m above mean sea-level) in main *kharif*. In all the four genotypes, seeding can be delayed up to 15 July at lower elevations. The genotypes give substantial yield advantage over traditional aromatic varieties like Joha, and are slightly aromatic.

RCM 21, recommended for cultivation in valley and terraced areas of Manipur and Meghalaya up to an elevation of 1,000 m above mean sea-level, has been handedover to the Central Variety Release Committee. It is resistant to leaf blast and brown spot with maturity duration of 130–135 days.

Maize: Two composites of maize, namely RCM 75 and RCM 76, were also found promising. Out of two variants of RCM 76, one variant produces one cob/plant while the other produces two cobs/plant.

A few maize inbred lines with tolerance to excess moisture were identified. DA 61A has also been identified as a potential maize line.

SDS-PAGE protein profiling of guava genotypes: Four varieties of guava developed are at various stages of release. SDS-PAGE protein profiling indicated that the varieties RCG 11, RGCH 4 and RGGH 7 are

Varieties released

Variety	Adaptation region/ agro-ecology	Duration	Salient features
Vivek Sankul Makka 35	Uttarakhand, Himachal Pradesh, Jammu & Kashmir and NEH region	Early (90-95 days in hills)	Yellow flint synthetic cultivar of maize yielded 15.39 and 7.40% higher than best check Surya and double-cross hybrid HIM 129. Better responded to lower and higher doses of nitrogen
Vivek Sankul Makka 37	Maharashtra, Andhra Pradesh, Karnataka and Tamil Nadu	Extra-early (85-90 days)	Yellow flint synthetic cultivar of maize outyielded the best check Surya by 13.5%. Showed better response to lower dose of nitrogen
VL Gehun 907	Rainfed and irrigated timely sown conditions of hills of Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Manipur and West Bengal	160-165 days under irrigated, 175-180 days under rainfed situation	It showed an overall yield superiority of 18.0, 24.2 and 16.4% under rainfed and of 15.9, 11.0 and 5.9% under irrigated conditions to the checks HS 240, VL 738 and VL 804. It is highly resistant to brown and yellow rusts. Also possesses higher degree of resistance against the most virulent yellow rust pathotypes 46S119 and 78S84 under natural as well as artificial epiphytotic conditions. It has very good *chapati*-making quality
VL Gahat 19	Northern India	90-100 days	It showed significant yield superiority of 14.39% to the best check AK 42. Moderately resistant to anthracnose, collar rot, powdery mildew and leaf spot diseases (< 10%) and resistant to root rot. It also has better digestibility than AK 42, PHG 9 and AK 21

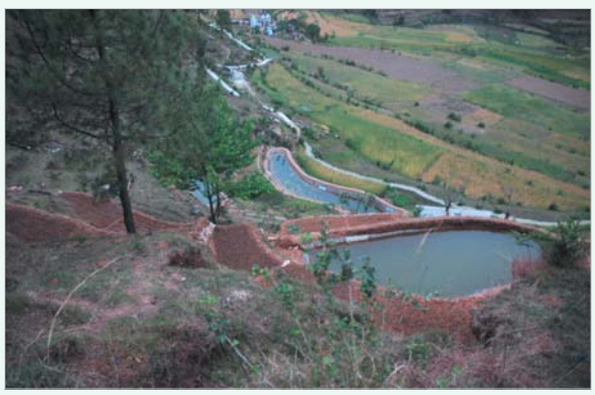
SUCCESS STORY

Water Harvesting and its Utilization

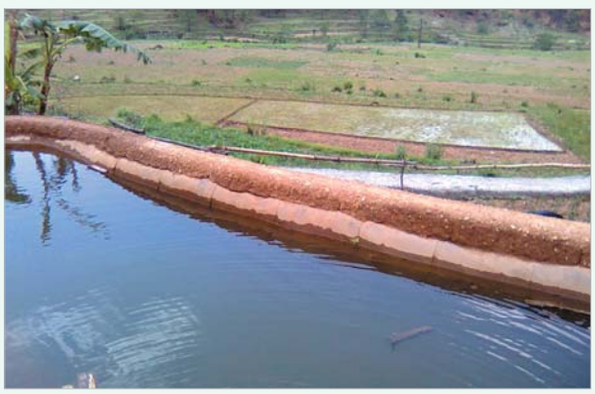
Two pronged strategy was adopted for water harvesting and its utilization, under a project funded by the Central Water Commission, Ministry of Water Resources, to develop the water harvesting structures in farmers' fields with lowest possible cost and highest efficiency and demonstration of high-yielding crops under rainfed conditions for higher benefits.

A total 67 LDPE lined tanks were developed on farmers' fields including a community based tank in three districts, namely Almora, Bageshwar and Nainital, with a total capacity of about 14,758 m^3. Micro Irrigation System (MIS) was installed in 4.7 ha in farmers' fields, which is connected to these tanks. Based on normative assumption, about 14.1 ha of land can be irrigated by these tanks.

For showing ability to produce more than local varieties, demonstrations on high-yielding varieties in crops like rainfed rice, finger millet, barnyard millet in *kharif* and wheat in *rabi* were carried out at 314 farmers' fields. Significant increase in yield was observed, i.e. 36% in rice, 20% in finger millet, 29% in barnyard millet during *kharif* and 36% in wheat during *rabi*. Other farmers of the area were highly influenced by these technologies and showed their interest in high-yielding varieties and construction of water tanks in their fields.



LDPE tanks suitable for hill agro-ecosystem



Paddy transplantation through LDPE tank

genetically different from other varieties. The seed content of RCG 11 is much lesser than the commercial varieties like L 49 and Allahabad Safeda. However, TSS: acid ratio and ascorbic acid content of this variety are much higher than the other varieties.

Tomato variety for Meghalaya: The Meghalaya State Variety Release Committee recommended tomato variety Megha Tomato 3 for release. It is tolerant to bacterial wilt and contains a fairly good amount of ascorbic acid, lycopene and β-carotene.

Organic production of turmeric and ginger: Integrated application of farmyard manure 10 tonnes/ha + vermicompost 5 tonnes/ha + rock phosphate 150 kg/ha resulted in profitable yield in turmeric and ginger.

RC seed bin: A low-cost medium-term storage RC seed bin for small farmers was developed using charcoal as desiccant. This can extend seed viability of all kinds of orthodox seeds up to 20 months. The cost of one RC seed bin is approximately ₹ 3,000. Its performance has been validated at the farmer's field.

Organic turmeric production under rainfed terrace

Shelf-life extension of strawberry and peach: The shelf-life of strawberry and peach could be increased up to 30 and 40 days, respectively, if the fruits are packed in 200 gauge PP with 2% $KMnO_4$ under refrigerated condition. The shelf-life of the same fruits is only 3–4 days at ambient condition. This technology will help the traders in marketing of these fruits.

Ready-to-cook minimally processed jack fruit slices during off-season: Jackfruits are used as vegetables when the fruits are at tender stage and the availability of the same is limited for 1–2 months only. A protocol was developed to prepare ready-to-cook minimally processed jackfruit slices as vegetables. This finding will help the growers to utilize the jackfruit as vegetables during off-season.

Genetic diversity in ginger: Fifty cultivars of ginger, comprising both improved varieties and local cultivars/ land races, were used to assess the allelic diversity using RAPD markers. High polymorphism of 92.85% was detected with 18 RAPD primers, and 4 genotypes from Meghalaya showed distinct molecular pattern.

Detection of *Babesia bigemina* infection in cattle of Meghalaya: Detection of *Babesia bigemina* infection in crossbred cow along with presence of tick *Babesia microplus* in this hilly region is significant because

all epidemiological factors of spread of babesiosis like host, environment, parasite and vectors are present in this hilly region also like plains area of India, and there may be a chance of spread of infection among cattle. Blood samples collected from cattle of organized farms of Meghalaya, were processed for detection of *Babesia* spp. infections by examination of Giemsa stained blood smears and PCR. *Boophilus microplus* ticks were identified from these farms. *B. bigemina* infection was also diagnosed. No parasite was detected either by examination of Giemsa stained blood smears or PCR in treated animals 48 hr post-treatment.

Stress encountered by endangered chocolate mahseer during captive rearing: An attempt was made to assess the activity of alkaline phosphatase in different organs of chocolate mahseer (*Neolissochilus hexagonolepis*) and its significance in counteracting stress due to captivity or confinement. Nutritional profile of chocolate mahseer was also studied. The activity of alkaline phosphatase was more in kidney followed by liver, intestine and muscle. The increased activity in kidney may be due to the fact that the phosphatase is very important for regulation of various metabolic processes, which occur by phosphorylation and dephosphorylation with kinase, especially during stress condition to meet the energy requirement in the animal. The chocolate mahseer is rich in crude protein, calcium and phosphorus.

Endangered chocolate mahseer

Introduction of improved common carp in NEH region: Common carp is one of the ideal fish species for aquaculture and is one of the most sought after species, especially in the North-Eastern Hill states. However, the growth of the existing variety *communis* is not encouraging due to several factors. Moreover the species attains early maturity resulting in low flesh content. Considering the importance of common carp, stock of both breeder and grower seeds of this new and improved carp were procured and introduced for quality seed production and to meet the requirements of the NEH states, both for composite as well as paddy-cum-fish culture.

Inclusion of state fish of Manipur in aquaculture fold: The medium carp, pengba (*Osteobrama belangeri*) endemic to the Chindwin drainage, has high food value and is in great demand in Manipur. The species has become endangered and extinct in wild. To conserve the species, it has been declared *State Fish of Manipur*. To augment its production, initiation of its culture along with other Indian and Chinese carps have been undertaken by DCFR, Bhimtal in collaboration with ICAR Research Complex, Imphal. A series of earthen ponds having an area of 62.5 m³ were stocked with

Pengba (*Osteobrama belangeri*)—State fish of Manipur

Indian and Chinese major carps plus pengba @ 15,000 no./ha in different combinations and ratios. The ponds were regularly fertilized with organic manure plus inorganic fertilizers at 12-day interval. The pengba showed net gain of 499 g in monoculture compared in one year rearing period to net gain of 274 g in polyculture thereby showing that monoculture of pengba may be more suitable for Manipur region.

ISLANDS

Crops

Of the 183 early and medium early lowland rice lines evaluated. Karjat 3 (6.66 tonnes/ha), IR 78555-3-2-2-2 (5.69 tonnes/ha) and IR 78581-12-3-2-2 (5.40 tonnes/ha) were found promising. Out of 74 long-duration rice cultivars/improved lines collected from different sources, 14 genotypes were selected for further evaluation and improvement. The highest yield was recorded for Jagbandhu (4.49 tonnes/ha), followed by MTU 2067 (4.39 tonnes/ha) and MTU 1075 (4.32 tonnes/ha). Of the 99 salt-tolerant rice lines were evaluated under soil having electrical conductivity 4–5 dS/m and pH 8.7 wherein IR 759418-7B-21-3, IR 7646-B-B-10-1-1-1 along with check variety CSR 28 were found most promising with yield of 4.34 tonnes/ha.

Under rainfed lowland condition, the maximum Gundhi bug incidence was recorded in late maturing lines of rice, followed by medium duration, but it was very low in very early, early and medium early lines. There was 44–49% yield reduction in medium and late duration lines compared to early and medium early. Out of 375 lines of rice, 29 were found tolerant to major insects and diseases under natural field condition.

A complete package of practices for table- purpose groundnut cultivation was standardized with seed production in coconut plantations during wet season and crop cultivation in dry season with information on time, method of sowing, varieties, irrigation and mulching practices for dry season with an objective to develop production to consumption chain for table-purpose groundnut in the Islands. Variety TG 37A recorded higher pod and kernel seed yield (1,652 and 858 kg/ha respectively) compared to ICGS 76 (1,245 and 740 kg/ha) with application of 10 tonnes FYM/ha. Comparison of net returns and benifit:cost ratio in terms of pod and kernel seed yield indicates 45–55%

increase in returns owing to sale of kernels for seed instead of pods for seed due to increased value of kernels over pods.

Horticulture: An exploration trip undertaken for collection of coconut germplasm accessions from South Andaman resulted in identification and collection of 18 accessions which included three dwarfs and a *makapuno* type. The *makapuno* type with soft endosperm is the first report and collection from the Andaman and Nicobar (A&N) Islands. The high-yielding arecanut selection (CARI Sel 1), made from local population, has 94 nuts/bunch compared to Mangla (81.6) and Samridhi (82.0). The *chali* weight is also higher (9.8 g) than 8.5% of Mangla. Evaluation of *Morinda citrifolia* accessions revealed that TRA 2 is the best accession having highest amount of phenolics (300 mg/100 g), while JGH 1 contained higher anthocyanin (91.8 mg/ 100 g), than the other accessions.

Molecular characterization of 21 different samples of wild *jamun* (*Sizigium claviflorum*) was carried out. Twenty RAPD and 30 ISSR markers were used to infer genetic similarity among 23 different collections of wild *jamun*. The dendrogram differentiated all the samples of wild *jamun* at 67% similarity with RAPD primers and 44% similarity with ISSR primers. The rigorous screening of the 80 isolates from Neil and Havelock Islands for biocontrol and plant-growth promoting (PGP) attributes finally led to the selection of 27 isolates. The dominating organism was *Bacillus* sp. Of the 12 *Trichoderma* spp. studied, *T. erinaceum*, *T. ovalisporum*, *T. asperellum* and *T. brevicompactum* are the first report from India. Twenty-one *Colletotrichum* spp. studied for morphological and molecular level indicated that the variation in *Colletrotrichum* was more in Islands. A total of 43 PGP bacterial isolates from banana and rice rhizosphere were characterized by PCR-RFLP using 7 different restriction enzymes. 16s rRNA gene sequencing and BLAST similarity search identified these isolates as *Bacillus* sp. and *Pseudomonas* sp. Fifteen antagonistic isolates of *Trichoderma* sp. were characterized by PCR-RFLP using three different restriction enzymes. 16s rRNA gene sequencing and BLAST similarity search result identified these isolates as *Trichoderma ovalisporum*, *T. viride* and *T. harzianum*.

Module consisting of combination of cultural practices, biocontrol agents and fungicides were most effective in per cent reduction of disease incidence and increasing yield of tomato. The chloroform and acetone extract of *Morinda citrifolia* leaf and fruit showed antibacterial activity against two different isolates of *Ralstonia solanacearum* (RSN 6 and RSN 12). The potential of the *Morinda citrifolia* extracts was better than most of the antibiotics and the same may be useful against the treatment of *Ralstonia* infection in plants.

Fourteen isolates of *Trichoderma* were evaluated against *Phytophthora capsici* and *Colletotrichum capsici* causing foot rot and anthracnose disease in black pepper by dual-culture test. The highest per cent inhibition of *P. capsici* was recorded with Tv-CARI-27, whereas *C. capsici* was the most parasitized with Tv-CARI-27. The isolates of *Trichoderma* Th-CARI-37, Tv-CARI-32 and Th-CARI-27 were most compatible with Copper oxychloride, Mancozeb, Moximate and Krilaxyl Gold. Greenhouse evaluation of *Trichoderma* spp. against foot rot of black pepper revealed that the isolate Th-CARI-33 was most effective with 63.9% reduction in disease incidence, followed by Tv-CARI-32, Tv-CARI-14 and Tv-CARI-16, and the isolate Th-CARI-27 was noted with least reduction in disease incidence of foot rot (42.6%). Leaf extracts of clove, amomum and noni were very effective against fruit fly (*Bactrocera cucurbitae*), based on LC_{50} (median lethal concentration) values. In okra, number of fruits was highest in 100% N applied through vermicompost, but the fruit weight was highest in 100% N applied through inorganic source. However, application of 100% of N through inorganic recorded at par yield to that of application of 100% of N through inorganic + vermicompost @ 50 : 50, indicating a possible 50% replacement of inorganic N by vermicompost.

A bacterial wilt-resistant line 'CARI Brinjal 1' was identified showing score of 1 for bacterial wilt and 3 for shoot and fruit-borer.

Animal and Fisheries

Microsatellite analysis of indigenous goats revealed 50 genotypes across the 15 loci. The number of genotypes varied between 1 (MAF70; SRCRSP3) and 6 (SRCRSP15). The effective number of alleles (Ne) varied from 2 to 6.98 in Teressa goat and 2 to 4.31 in local goats. All the values of FIS obtained for the Teressa and Andaman local goats were negative which is indicative of no inbreeding within the populations and the animals were outbred. The mode-shift test indicated the genetic bottleneck in Teressa and Andaman local goats and needs greater attention towards *in situ/ ex situ* conservation. Zinc in the existing diet of grower showed higher average daily weight gain of 365 g. The performance of the pigs, reared by the tribal, was much better than those by non-tribal farmers.

Investigation on sponge biodiversity in Andaman and their significance in nutrient cycling, maintaining reef health and as potential producers of future drugs, was initiated to document the marine sponge resources in the coastal waters of North Bay and Pongi Baalu in South Andaman. The sponges were identified taking assistance from Zoological Survey of India, Port Blair.

Four sponges collected from Pongibaalu, namely *Crella cyathophora, Oceanapia sagittaria*, *Plakortis* sp. and *Monanchora* sp., are being studied. More than 200 sponge associated bacteria have been purified from them, which were assigned to *Neisseria villonella, Micrococcus* sp., *Staphylococcus* sp., *Clostridium* sp., *Corynebacterium* sp., *Bacillus* sp., *Pseudomonas* sp., *Enterobacteria* sp., *Lactobacillus* sp., *Vibrio* sp., *Aeromonas salmonicida, Mycobacterium smagmatis, Sterptococcus pneumonia* and *Streptococcus mitis* based on their morphological, physiological and biochemical


Crella cyathophora


Monanchora arbuscula


Plakortis sp.


Oceanapia sagittaria

Sponges collected from North Bay and Pongi Baalu

properties. A preliminary qualitative dual-culture assay revealed that in *Oceanapia sagittaria* and *Monanchora* sp., the antimicrobial activity was primarily due to the host metabolites. In *Crella cyathophora* and *Plakortis* sp., over 75% of the associated bacteria exhibited significant antimicrobial activity against the selected pathogens.

The biodiversity of marine sponges from North Bay and Pongi Baalu has been documented.

Integrated farming

In brackishwater-based integrated farming system, ducks can serve as an important component as no mortality was observed when introduced gradually to saline water of different concentrations up to 15 ppt. The body weight recorded at different week intervals does not pronounce much difference in different concentrations of salinity for one, two and three weeks interval. A return of ₹ 4,000 from 600 m^2 pond area can be obtained from the duck component within four months through sale of eggs.

Water balance approach was used to design the optimal size of lined tank fed from impermeable rooftop or plastic mulched vegetable area. In case of 50 m^2 rooftop area to harvest rainwater in lined tank, 361 m^3 and 322 m^3 capacity tank can provide supplemental irrigation at irrigation water: cumulative pan evaporation (IW : CPE) ratio 0.5 to 18 coconut plants or 160 arecanut plants in 1,000 m^2 in 8 out of 10 years during the dry period. In case of plastic mulched area of 1,000 m^2 to harvest rainwater, 290 m^3 capacity tank can provide supplemental irrigation at IW:CPE ratio 0.5 in the same area with 2,778 capsicum plants. ❑