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ICAR NEWS

A SCIENCE AND TECHNOLOGY NEWSLETTER

RESEARCH UPDATE

PROMISING TECHNOLOGIES

Detection of spontaneous haploids in oilpalm

Haploids (Hs) are extremely valuable in plant breeding when they are converted to fertile doubled haploids (DHs) as they are 100% homozygous, and may be used as parental lines to produce uniform F_1 hybrids. To date, H/DH production *via* androgenesis, gynogenesis and by aberrant pollination either fails repeatedly or is limited to a small number of species, and has yet not been reported in oilpalm. Frequency of spontaneous haploids in nature is too low in oilpalm, which has necessitated the development of an effective high-throughput screening system for detection of haploids.

An alternative strategy has been to seek undefined atypical phenotypic features that may arise from reduced cell size and/or hemizygous state of H individuals and may manifest at the seedling stage when high-throughput visual assessment is plausible. However, a more direct approach is a high-throughput flow cytometry (FC) method that detects naturally occurring Hs/non-euploids in oilpalm by measurement of DNA content of the cell nuclei when released into an analyte containing a DNA-specific dye.

First time in India, three spontaneously formed haploids have been detected—one each from exotic germplasm collection,

Haploid plant from exotic germplasm collection

Haploid plant from indigenous germplasm collection

Haploid plant (encirled), detected at the primary nursery, raised from abnormal seeds

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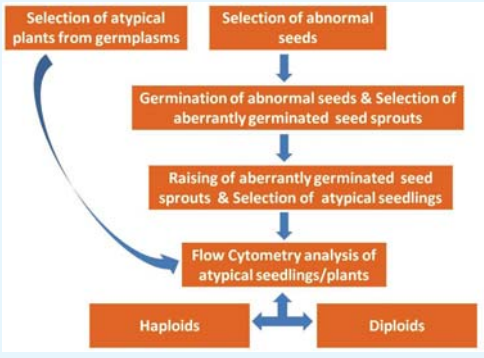
Identification of Hs Sub-populations



Stages in identification of haploids in oilpalm

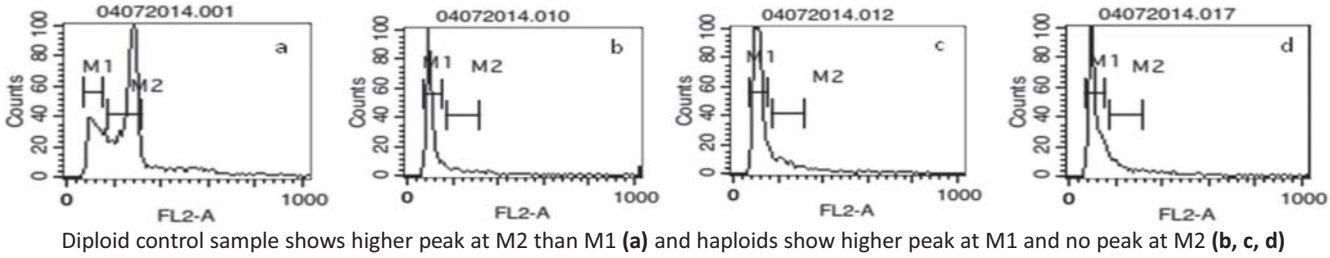
Bunch failure in the identified haploid plant

- Selection of atypical plants in the field was carried out by observing one or more of reduced growth plant organs—slower vegetative growth; reduced leaflet width and length, frond width and length, internode distance of leaflets and fronds; change in leaf colour and aborted female inflorescence (bunch failure). The key element in selection of Hs is in the logical differentiation of Hs from the diploids, based on the phenotypic morphology.
- Choose atypical seeds based on their size and shape.
- Choose atypically germinated seeds on the basis of delayed germination, under developed plumule and/or radicle, altered radicle and plumule lengths and their ratio, changed plumule to radicle angles and colour, twin embryos (doublet), three embryos (triplet) and four embryos (tetrad) per seed.
- Raise aberrantly germinated seeds in the nursery and select 'off-type' seedlings (weaklings, reduced leaflets and leaf numbers, change in leaf colour/shape and precocious flowering).
- Sub-population selected from an atypical phenotype at every stage progressively improves probability of Hs selection. Hs are identified through ordinate approaches by identifying those traits that are most important in discriminating Hs and are used to redesign search criteria. This process progressively improves accuracy of phenotypic screen as increasing number of Hs enhances statistical power and as uniformity traits are discarded from consideration.
- Ploidy of these populations is determined using flow cytometry.

indigenous germplasm collection and from a primary nursery, raised from abnormal sprouts.

Haploids have been deducted using FACS Calibur (Becton Dickinson Bio Sciences) flow cytometry facility. Nuclei suspension of oilpalm is prepared using hypotonic nuclear lysis buffer solution containing propidium iodide (PI). About 1 cm^2 unopened young leaf samples were chopped with a sharp scalpel blade in a glass petri-dish containing 1- ml of isolation buffer. The suspension was mixed thoroughly by pumping in and out from the pipette tips before filtering through a 30- µ sieve into tubes. The PI-fluorescence peak histogram of about 5,000 nuclei per sample was measured at 585 nm using diploid *dura* as a control for deduction of haploids.

The results suggest that practical approach of selecting morphological 'off-types' can be used to secure a large number of spontaneously formed oilpalm haploids for producing doubled haploids by somatic doubling. The seedlings selected can be grown, thus making method directly applicable to production of Hs and DHs for genetic studies and plant breeding. DHs can be formed from these Hs through spontaneous chromosome doubling of Hs or selfing of Hs or treating them with external stimuli such as colchicine under *in vivo* (root dipping) or *in vitro* (tissue culture). The flow cytometry can be used 'aggressively' in screening ploidy level of off-types and for classification of oilpalm cultivars (*tenera, dura* and *pisifera*) at the nursery stage,and 'defensively' to assess and control seedling quality.



Diploid control sample shows higher peak at M2 than M1 **(a)** and haploids show higher peak at M1 and no peak at M2 **(b, c, d)**

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Cost-effective tomato-powder-making — a farm-woman-friendly technology

Tomatoes are of low calorific value, and are an excellent source of antioxidants, dietary fibres, minerals and vitamins. They are rich in lycopene (60 – 90 mg/kg), a flavoured antioxidant; vitamin C (160-240 mg/kg); vitamin A; polyphenols (5-20 mg/kg) and flavonoid antioxidants α and β carotenes, xanthin and lutein. Fresh tomatoes are also rich in potassium— its 100 g contains 237 mg of potassium and just 5 mg of sodium; contains moderate level of vital B-complex (folate, thiamin, niacin, riboflavin) as well as essential minerals like iron, calcium, manganese and other trace elements.

Drying of tomatoes (*inset:* Tomato powder)

Generally, when the price of tomatoes is high, their consumption is markedly reduced, and during the glut, farmers don't get the remunerative price from selling them immediately after the harvest. To regulate their price and consumption, a sun-drying technology for them has been standardized.

Whole ripe- tomatoes are washed thoroughly and wiped with muslin- cloth to remove excess of surface moisture. They are cut into 6-8 pieces vertically and dried on the wooden trays or sheets. After complete drying,they can be stored in powder-form or in the form of pieces in polyethylene cover or in a perforated cover. One kilogram of tomatoes yields only 50-55 g of pieces/powder, depending on the tomato variety.

If a consumer wants 100 grams of tomatoes for use, a teaspoon (5 g) of the powder would be sufficient, and there would not be much loss of nutrients in that compared to the fresh tomatoes.

Days required for drying at different temperatures

Temperature (°C)	Days required for sun-drying
34	5-6
38	3-4
40 and above	2-3

Nutritive value of tomatoes

Nutritive value	Fresh tomatoes	Dehydrated tomatoes
Vitamin C (mg/100g)	27	26.7(mg/100g)
Lycopene (mg/100g)	50-70	63.04
Total bacterial count (cfu/g)		BDL
Total microbial count (cfu/g)		BDL

BDL: (below detectable level)

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Tongue colour as a marker, distinguishing Murrah and Nili-Ravi buffaloes

Murrah and Nili-Ravi breeds are considered the best buffalo breeds of India and of the world. Murrah is available in larger numbers, but Nili-Ravi population is dwindling due to preference of farmers for the former. There is a rampant crossing of Nili-Ravi with Murrah, and this is diluting genetic purity of Nili-Ravi,and is also leading to mixing in Murrah germplasm from the adjoining areas.

During 2013 and 2014, the study on 954 Murrah and 447 Nili-Ravi buffaloes from fields and organized farms of Haryana and Punjab has revealed that colour of the tongue is an important determinant in checking genetic purity of the breed vis-a-vis other phenotypic traits, which indicate purity of the breed.

Murrah/Nili-Ravi

Murrah is recognized by jet-black colour, short face, long neck and characteristic curled horns. Nili-Ravi is usually black in colour with white markings on the forehead, face, muzzle, feet, tail switch and has walled eyes, popularly known as "PanchKalyani" or "PanchPhuli" or "Pakhali", and it may have pink markings on the udder and brisket; white markings extending above hock and knee and over neck and body are considered as disqualification.

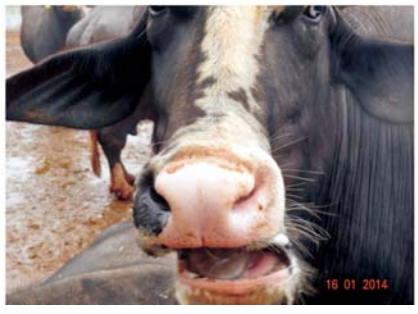
Based on the data on the phenotypes of the tongue colour in Nili-Ravi and Murrah buffaloes, apparently there is a possibility of two forms of

Pure Nili-Ravi calves with pink tongue

Pure Murrah with black tongue

Graded Nili-Ravi (no walled eye) with

Graded Murrah with mixed tongue



Graded Nili-Ravi (one walled eye, black front feet) buffalo with black tongue

Graded Murrah with pink tongue

genes controlling the basic tongue colour. Pink and black tongue colour gene pattern of inheritance reveals epistatic or incomplete dominance. An animal with one of each "heterozygous" would be grey or with spotted tongue, while homozygous will be either black or pink.

Frequency of tongue colour in Nili-Ravi and Murrah buffaloes

Tongue colour/ pattern	Nili-Ravi Buffalo genotype	Nili-Ravi Buffalo pheno-type/No.	Murrah Buffalo genotype	Murrah Buffalo pheno-type/No.	Total
Black	b^1b^1	26	b^1b^1	865	891
Mixed /Spotted	b^1b^2	125	b^1b^2	74	199
Pink	b^2b^2	296	b^2b^2	15	311

The genotypic frequency of tongue colour in Nili-Ravi buffalo was observed at 0.66, 0.28 and 0.05 for pink (b^2b^2), grey / spotted (b^1b^2) and black (b^1b^1), respectively. The corresponding data for Murrah buffalo were 0.02, 0.08 and 0.90, respectively. The gene frequency for pink colour gene (b^2) in Nili-Ravi and Murrah buffalo was calculated as 0.80 and 0.05, respectively. The corresponding black colour gene (b^1) frequency was 0.20 and 0.95 for Nili-Ravi and Murrah buffalo, respectively.

Tongue colour pattern has revealed that pink colour indicates purity for Nili-Ravi and black tongue for Murrah buffalo, governed by homozygous genes. The mix type or grey or spotted colour of tongue may be due to breed impurity, incomplete dominance or gene interaction, which dilute basic tongue colour.

Punjab farmers were not much aware about Nili-Ravi buffalo breed vis-a-vis Haryana farmers . Some buffaloes purchased from Punjab / adjoining areas showed pink or mixed tongue colour pattern in Murrah buffaloes; indicating some mixing down the line.

The mixed tongue colour (pink and black), grey, pink in Murrah and black tongue colour in Nili-Ravi indicate inter-mixing in Murrah and Nili-Ravi buffalo breeds. Some otherwise pure animals of either breed had divergent tongue colour, and were found to have some characters deviating away from the typical breed characters and their calves also showed divergent breed characters as well – e.g. calf of the pink tongue Murrah buffalo having star on forehead, or tail of such Murrah buffalo having longer white switch. In majority of the cases, mixed (black and pink) tongues or black tongues were observed in Nili-Ravi buffaloes, which did not have walled eye, which is a characteristic of Nili-Ravi breed (92%) or without one or more white markings out of the five (forehead, face, muzzle, leg and tail). Calves or dams of such buffaloes were also missing one or more phenotypic characters. Murrah buffaloes with pink tongue were either having longer white-tail switch or some other white markings on the body. In some cases, calf or dam of such buffaloes did have additional white markings or white-tail switch.

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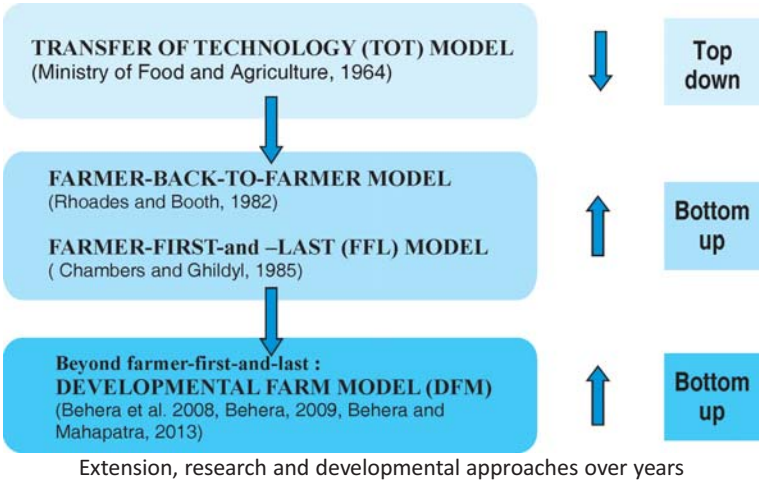
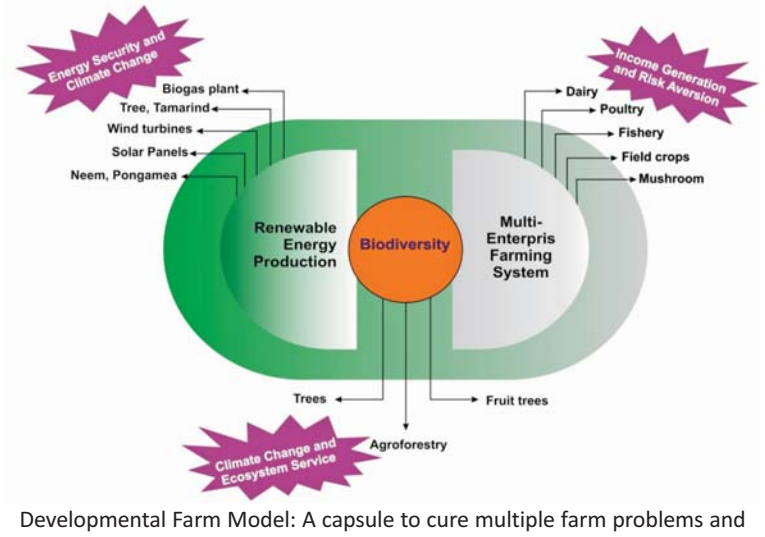
Developmental Farm Model for revolutionizing agricultural growth

Economic limitation for different operations in a small-sized land is the main challenge of the 21st century for sustainability of farming systems. The important concern is how to develop institutional mechanism that help farmers in earning more through beneficial technologies, aggregation of inputs and outputs, value-addition and marketing. Considering this, a concept, Developmental Farm Model (DFM), has been developed, which would address problems simultaneously with redesigning of the farming systems.

Farmer-back-to-farmer (Rhoades and Booth, 1982 and **farmer-first-and-last** (FFL) models (Chambers and Ghildyal, 1985) were the two models, which operated on farmers problems and farm situations for agricultural research, transfer of technology and other agricultural developmental efforts. These approaches could not prove to be much use in reducing poverty and hunger in most developing and under-developed countries. The Indian Council of Agricultural Research (ICAR) was also popularizing agri-cultural technologies through FFL. Keeping in view the millennium goal of the World in reducing poverty by 50% by 2020, and to bring agricultural growth in the rural areas, a model "Developmental Farm Model (DFM)" has been proposed. This model emphasizes in developing and transferring holistic farm model, which would assure adequate farm income and employment for farmers, particularly resource- poor, small and marginal farmers. The model is based on the bottom-up approach, and would be suitable for all classes of farmers.



Extension, research and developmental approaches over years



Developmental Farm Model: A capsule to cure multiple farm problems and improve livelihood

Developmental Farm Model

In this, a developmental farm model has to be given to each and every farmer of the country. The DFM has the following important characteristics.

Holistic: The major focus is to project holistic view of the farms to farmers and to provide them with chain of activities round- the -year or enterprise combi-nations, which would ensure adequate income and employment to small and marginal farmers. In practical sense, whole farming system would serve as a framework for analysis, but specific components, sub-systems or interactions would be targeted for interventions. The models which have been developed and implemented take into consideration farmer's resource availability, various bio-physical, socio-economic, insti-tutional factors influencing the systems etc.

Participatory 'bottom-up': The model aims to redesign farming systems keeping farmers' ecological, economic and family goals, and the design would be in close partnership between researchers/other agencies and farmers. Instead of starting with knowledge, problems, analysis and priorities of the scientist, it would start with the

knowledge, problems, analysis and priorities of the farmers and the farm-families. Instead of research station as the main focus of action, it would be farm-centred. Instead of scientist as the central experimenter, it would be the farmer.

Accounting/budgeting of farm operations: This model focuses on accounting and budgeting as an integral part of the farming system, and emphasizes that to develop entrepreneurship, this is very important. It has been observed that on an average more than 90% of the farmers did not keep proper records of their farm expenditure and income.

Entrepreneurship: The DFM has the core underlying emphasis on how a farm can be converted into an entrepreneurship, so to create wealth and employment opportunity at the farm level.

DFM will touch actual farmers: The DFM approach will include all actual farmers, who practice farming. DFM will avoid middleman and village politicians.

DFM — A Case Study in Eastern India

A study was undertaken in a farm in Balasore district (Odisha) of a young man of 25 years old, who had farm area of 1.25 ha and a family of 4 members. He was a graduate and migrated to Calcutta (Kolkata) city to earn. He longed to be in farming if only he could earn ₹ 100,000 from farm activities.

During 2011-12, he was disappointed from his farm as he earned only ₹ 19, 390 (study–1). His circumstances were properly studied, and a DFM was applied considering his situations, and that resulted him to earn a net profit of ₹ 104,579.

Different farming system components with corresponding income and employment generation

Components of farming systems in eastern India	Area allocation (ha)		Production cost (₹)		Labour requirement (man-days)		Net returns (₹)	
	Study-1 (2011-12)	DFM (2012-13)	Study-1 (2011-12)	DFM (2012-13)	Study-1(2011-12)	DFM (2012-13)	Study-1 (2011-12)	DFM (2012-13)
Rice	1.0	0.79	20,000	19,535	80	79	20,000	27,529
Wheat	0.1	0	2,100	0	7	0	150	0
Mustard	0	0.15	-	2,550	-	12	0	3,150
Greengram	0.01	0.10	160	1,700	2	7	40	1,500
Vegetables	0.1	0.19	5000	11400	17	49.4	3000	9500
Marigold	0.01	0.01	500	600	2	2.4	200	400
Dairy (2 units+2 calves)	0.01	0.01	12,000	44,000	50	72	-4000	20,000
Goatery (25 in number +1 buck)	0	0.005	-	45,000	-	50	0	42500
Total	**1.23**	**1.255**	**39,760**	**124,785**	**158**	**272**	**19,390**	**104,579**

Treating farm as an industry: Farm needs to be managed on the same principles as any other industry, and then only the subsistent farm can be developed into an entrepreneurship. The farmer as an entrepreneur, managing farm, can be compared with the professional manager.

Scale neutrality and wider applicability: The DFM is an approach which can be applied to all types of farmers in the country.

Not one size fitting all: In DFM, different farm models will be developed for different farmers based on their knowledge, skill, wisdom, opportunities and constraints, instead of developing one technology and fitting it to all, in spite of varying situations, needs and objectives of farmers.

In DFM, new enterprise, new crops, improved varieties and management practices were introduced, which enhanced productivity and net profit, thus the income of the farmer increased around 5 times, along with additional employment of 114 man-days and additional income by the family (₹ 17,100) by engaging family in farm activities.

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Indigenous Sikkim rice cultivars

Explorations, during April to June 2013, for local rice diversity in the North, East, West and South districts of Sikkim resulted in the collection of fifty landraces. These landraces dominate in the rice-production systems of the state, occupying over 80 % of the area. They were evaluated for fifty quantitative characters during *kharif* 2013, and are being maintained at the Regional Centre for genetic improvement.

Indigenous rice germplasm

The landraces mainly belong to tall *indica* group, and have shown variability with respect to grain colour, grain quality, plant habit and adaptation to different agroclimates. Among them, Attey is the most popular and is grown widely in Sikkim at elevations up to 1,500 m amsl. Krishna Bhog, Kalo Nunia and Champey are popular as aromatic rices. Tulasi Dhan, reasonably popular, is used as a puffed rice. Takmaru Dhan is the only cultivar grown as a direct-seeded one and is adapted to water-stress conditions. Landraces seed colour varies from straw, brown to purple-black. The highest 1,000 seed-weight has been recorded in Anandhi (28.83 g).

Six cultivars have been reported with awned panicles; awns vary in length. Majority of the cultivars belong to late-maturing group and are prone to lodging. Panicle length ranges from 18.5 cm to 29.0 cm. Timburey and Yedehi have characteristic node colouration. These landraces are threatened to be extinct. They are being evaluated for mining climate resilient traits.

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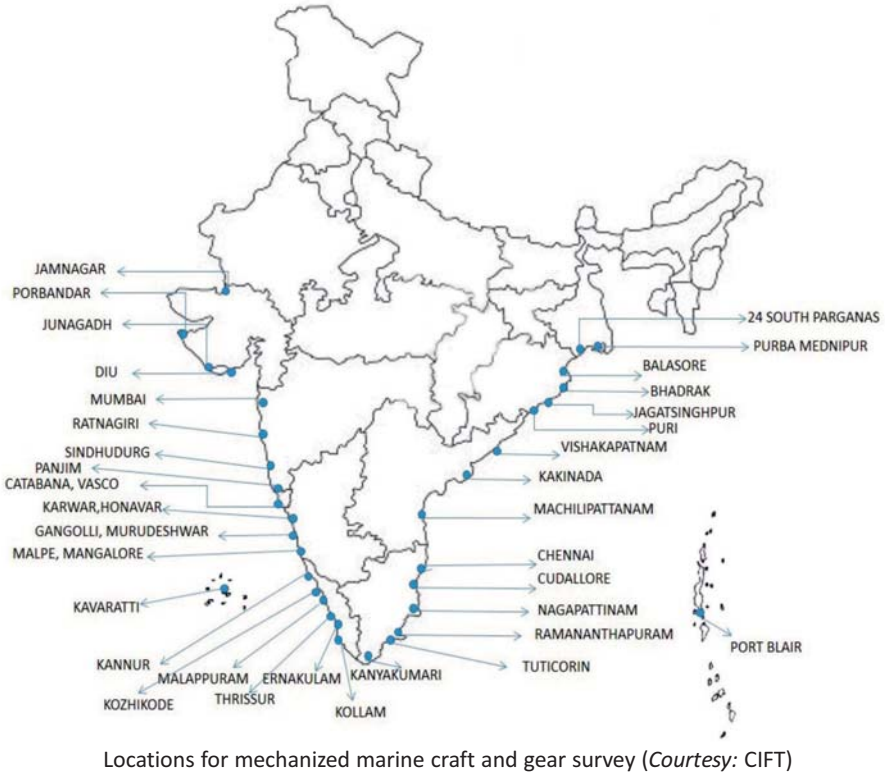
Mechanized marine fishing crafts and gears — An all-India base-line survey

Marine fisheries have undergone significant changes since fifties. To build a database on mechanized fishing crafts and gears and on the use of energy by the fishing sector in India, a base-line survey was conducted from 1 October 2012 to 30 September 2013.

The study covered main fishing harbours and important landing centres all along the Indian coast, including Lakshadweep and Andaman and Nicobar Islands. Twenty-two maritime districts from the west coast and 15 maritime districts from the east coast and one typical centre each from the island territories were identified as survey locations based on the maximum number of fishing units operated as per the CMFRI Marine Fisheries Census 2010, India. Three to five fishing villages were covered under each identified location. Secondary data were collected from state departments, fishermen cooperative societies and log books maintained on on-board fishing vessels.



Locations for mechanized marine craft and gear survey (*Courtesy:* CIFT)

The most popular fishing vessels were identified based on the type of fishing, number of units operating and the region of operation. Detailed line plans and structural drawings of 35 selected designs for fishing vessels were also documented. The details of the engine power, fish hold capacity, number of crew on-board, type of fishing done from the boat and the average fuel consumed during the trip were also documented. The classes of vessels encountered were trawler, trawler-cum-long liner, purse-seiner, gillnetter, gillnetter-cum-long liner, ring seiner and long liner.

Fuel being a major contributor to operational expenses, the data on engine power, and types of engines, and approximate fuel consumption by different classes and sizes of vessels were also analysed. The engine powering was not commensurate to the size of the fishing vessels.

The structural, operational and design differences in common fishing gears used by different coastal states, dimensions, materials, accessories like floats, sinkers, operational parameters, were also evaluated. Different types of gears operated from mechanized/motorized craft were trawl nets (pelagic and demersal), gillnets (drift gill net, set gill net, trammel nets and surrounding gill nets), surrounding nets (purse-seines and ring seines) and hooks and lines (hand lines, long lines and troll lines).

The base-line survey data would benefit fishing industry, researchers and policy-makers for quantifying and evaluating characteristic parameters and operational efficiency of the existing fishing craft and gear designs and for implementing effective management measures.

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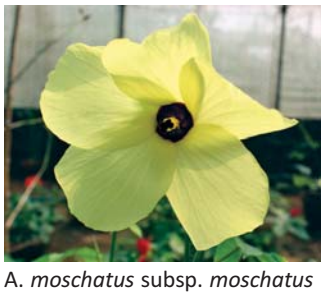
Abelmoschus hybrids as potential ornamentals

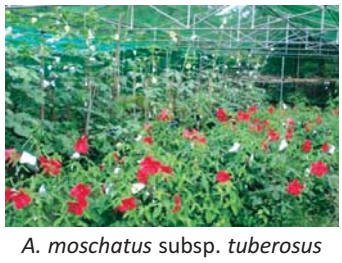
Abelmoschus in India comprises nine species, including cultivated okra and a newly described peninsular Indian endemic, *A. enbeepeegeearense*. While majority are yellow flowered, *Abelmoschus moschatus* subsp. *tuberosus* is unique with its brick -red petals and dwarf habit. This is more known by its synonyms,*A. sagitifolius* and *A. moschatus* subsp. *rodophyllus,*and its natural distribution ranges from grasslands and open-forest areas of Myanmar, Malaysia, Thailand, Vietnam, China and Australia, and in India it extends to north-eastern region. It is an introduced ornamental in Kerala with weak bi-annual habit and small-red flowers.

A. moschatus subsp. *tuberosus*

F_1 of *A. moschatus* subsp. *tuberosus* x *A. moschatus* subsp. *moschatus*



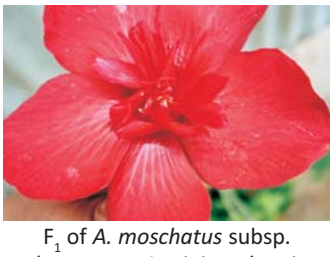
A. *moschatus* subsp. *moschatus* ('Kasthurivenda')



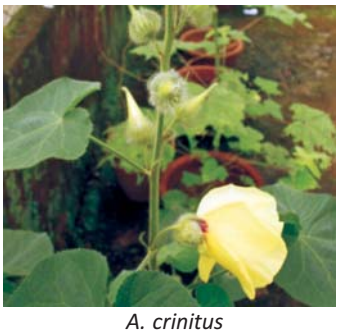
A. moschatus subsp. *tuberosus* x *A moschatus* subsp. *moschatus* in 4th year of flowering

Rooted cuttings of the hybrid

Flower colour variability in F_2 of *A. moschatus* subsp. *tuberosus* x *A. moschatus* subsp. *moschatus*



F_1 of *A. moschatus* subsp. *tuberosus* x *A.crinitus* showing modified stamens



A. crinitus

F_1 hybrids involving *A. moschatus* subsp. *tuberosus,A. crinitus*, *A. enbeepeegeearense* and *A. moschatus* subsp. *moschatus* were produced and evaluated along with their parents for ornamental traits. They were found mostly dominant with red flower colour and perennating nature. The hybrids between *A. crinitus* and *A. moschatus* subsp. *moschatus*, exceeded both the parents for such traits as prolificacy of flowering, vigour, extended life-span, flower colour, shape, flower yield per day and adaptability. These hybrids perennated owing to their tuberous tap-root, and could be multiplied by stem-cuttings; and they hardly needed any care, and could easily grow throughout the year in tropical climate, both as a plant for flower-beds and as potted plants. Known for their adaptability to varied seasons, contrasting leaf, flower and anther colour, prolificacy and perennation, they are found ideal for ornamental-gardens. Intraspecific cross between *A. moschatus* subsp. *moschatus* and *A. moschatus* subsp. *tuberosus* segregated for flower colour and shades in F_2 generation, offering further scope for selection of ornamental types, but hybrids of *A. crinitus* were found sterile; they were however most versatile for their multi-petaled red flowers, formed by modification of stamens. *A. enbeepeegearense* hybrids were weak and were poor in adaptability but flowers were with bright- red velvety petals.

Propagation of all the three hybrids is through vegetative stem-cuttings. Terminal stem- cuttings rooted in a medium of sand kept in mist chamber showed nearly 100% sprouting, and the transplanted rooted cuttings established into a full bloom within 45 days in monsoon season in Kerala. Treatment of cuttings with commercial formulations of rooting hormones enhanced number of roots and rooting.

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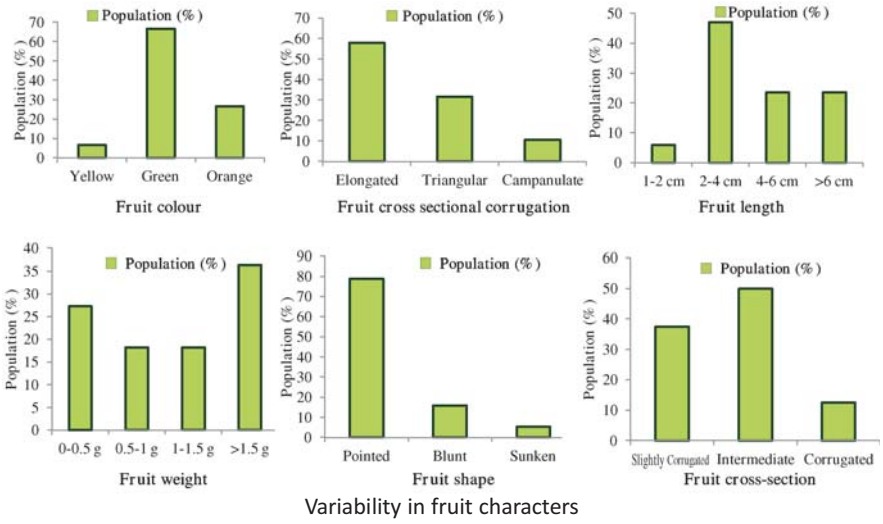
Mizoram: Habitat for diverse indigenous bird's eye chillies

Bird's eye chilli (*Capsicum frutescens*L.) is a perennial crop,common in north-eastern India, Mizoram, and some areas of Manipur, with small-sized fruits, which are blood-red and are highly pungent. It is extensively used as a spice in curried dishes in tribal areas. As a medicine also, it is used as a counter-irritant in Lumbago, Neuralgia and Rheumatic disorders. Not much was known about it morphology, biochemical properties and genetic diversity.

Fruit morphology of landraces of bird's eye chilli



Variability in fruit characters

A state-wide survey in Mizoram was conducted to collect its diverse landraces. Out of the seventy landraces, district-wise entries are as follows: Kolasib (9), Aizawl (4), Serrchip (7), Lunglei (21), Lawngtlai (3), Saiha (14), Champhai (8) and Mamit (4). Out of all, 67% of the population was found green, 27% was orange and 6% was yellow in immature stage. Fruit cross-sectional corrugations were 58% elongated, 32% triangular and 10% campanulate. Fruit length was categorized into 1-2 cm (6%), 2-4 cm (46%), 4-6 cm (24%) and more than 6 cm (24%) groups. Average fruit weight was classified into 0-0.5 g (27%), 0.5-1 g (18%), 1-1.5 g (18%) and more than 1.5 g (37%). Fruit shape was pointed in 79%, blunt in 16% and sunken in 5%. Fruit cross-section exhibited slightly corrugated (38%), intermediate (50%) and corrugated (12%) shape. Collected germplasm is under mass multiplication, and will be deposited in the National Gene Bank, NBPGR, for a long-term conservation.

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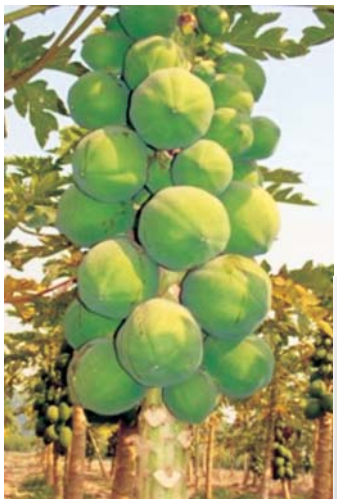
PL-13/96 — A new papaya selection

Papaya is cultivated throughout the tropical and subtropical regions of the world. Wide genetic variability noticed in the crop in papaya-growing regions is due to its propagation by seeds and also due to its cross-



Fruit-bearing tree

Pink-coloured flesh of PL-13/96

pollinated nature. Owing to high degree of variability in economic characters, several selections were made from the existing populations.

According to the international codex and market preferences for the following characteristics of the crop:fruits weight (0.5-1.0 kg/fruit), red/pink flesh, richness in β-carotene, high TSS and better shelf-life (of moderate keeping- quality), a new solo type, which is dioecious and with small-fruits, has been selected. It is a selection from Pune Selection-3 (seedling). Its plant is of medium height and bears fruits heavily on the trunk in the first year itself. Its fruits with small central cavity are round, smooth skinned with less prominent ridges and with pink flesh of soft/melting type; fruits are juicy with good flavour, and the fresh seeds are of jet black colour. The highest fruit yield (53.40 kg/plant) with TSS 13.50° Brix was obtained during autumn transplanted crop. Pune Selection-3 (67.02 %) was most sensitive to fruit deformity, while PL-13/96 has been found most tolerant (3.26%) under the agroclimatic conditions of the NEPZ.

Carpological traits of different papaya germplasm

Germplasm line	Fruit yield/ plant (kg)	Fruit weight (kg)	Fruiting zone (cm)	Flesh thickness (cm)	TSS (°Brix)	Flesh colour
Pusa Majesty	33.10^{d}	0.90^{c}	76.80^{c}	2.50^{c}	10.20^{b}	Yellow
Pusa Delicious	36.30^{d}	1.20^{b}	73.40^{c}	2.70^{bc}	10.30^{b}	Yellow
Pusa Dwarf	43.60^{c}	1.00^{bc}	51.00^{d}	3.00^{abc}	10.00^{b}	Yellow
Pune Selection-3	63.70^{a}	1.70^{a}	136.80^{a}	3.30^{a}	12.50^{a}	Pink
PL-13/96	**53.40^{b}**	**0.75^{d}**	**115.20^{b}**	**3.10^{ab}**	**13.50^{a}**	**Pink**

Note: Means with the same letter (superscript) in the columns showing germination and number of days taken to germination do not significantly differ (P=0.05), based on Duncan Multiple Range Test.

Papaya germplasm against different diseases and disorders

Germplasm	Bumpiness (%)	Collar-rot (%)	Leaf curl (%)	Bud drop (%)	Mosaic (%)	Papaya ring spot virus severity (%)
Pusa Majesty	10.17^{c}	15.79^{b}	0.00	28.33^{a}	90.63^{a}	78.00^{a}
Pusa Delicious	27.04^{b}	17.02^{b}	0.00	13.83^{bc}	49.26^{b}	77.05^{a}
Pusa Dwarf	18.97^{c}	29.14^{a}	4.40^{a}	14.08^{b}	14.90^{d}	72.06^{b}
Pune Selection-3	67.02^{a}	12.25^{c}	0.00	14.86^{b}	26.05^{c}	50.45^{c}
PL-13/96	**3.26^{d}**	**6.30^{d}**	**0.00**	**12.31^{c}**	**22.56^{c}**	**47.61^{c}**

Note: Means with the same letter (superscript) in the columns showing germination and number of days taken to germination do not significantly differ (P=0.05), based on Duncan Multiple Range Test.

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Burmese fish-tail palm — A wild ornamental with domestication potential

Caryota mitis, Burmese fish-tail palm or cluster fish-tail palm, closely allied to fish-tail palm (*Caryota urens*), has shown potential to be domesticated as an ornamental plant and also as a source for elephant fodder. *C. mitis* differs from *C. urens* in multiple-clump -forming habit, being dwarf and with early reproductive maturity; it is a native to evergreen forests of South-East Asia and grows wild in Andaman Islands.

Seven trees of accession IC 553772 of this palm, collected from Hutbay Island of Andaman and Nicobar islands, have been established at the Field Genebank (FGB) of the NBPGR, Regional Station, Thrissur. The palm multiplies through seeds.

Its plants form narrow clumps at the base and crowd together forming a luxuriant crown at the top. The plant grows to a height of 3-6 m with a slender trunk. Its fronds are 1.8-3.0 m in length and 1.2 m in width with an average of 10 pairs of branches, each bearing 18-20 fan-like pinnae, including the terminal fin. Trees come to bearing in 4-5 years. Single-seeded fruits are borne in clusters on long spadix, and they are recalcitrant in nature. Civet cats feed on ripe-fruits and the defecated seeds germinate in wild. Fallen fruits from mature ripe bunches can be collected, de-skinned, and seeds can be

planted in poly-bags. For artificial regeneration, three-month-old hardened seedlings raised in poly-bags can be planted without injuring root system.

Caryota mitis

The plant has an immense potential for domestication. It can be grown as an ornamental palm; both as an indoor and as an outdoor for landscape beautification. It is a non-thorny, non-toxic, non-staining and non-allergic, shade-loving plant, and because of being dwarf, is a good choice for indoors. Its leaves do not litter; only lower fronds needs to be pruned annually. As its crown permits penetration of sunlight, it is ideal for lawns also. However, one has to be careful in extracting seeds for planting as fruit- skin causes itching on human-skin. The basal clump- forming nature and compactness make it a suitable choice for cultivation as elephant fodder also; fronds can be easily harvested without a tree climber.

In the South-East Asian countries,palm-heart is used as a delicacy vegetable. Good quality palm-wine (toddy) is extracted by tapping inflorescence, which is also used for jaggery -making. Palm-toddy is cooling, refreshing and rich in minerals and vitamins. Food-grade starch, equivalent to sago, is extracted from the pith of the bunching palms. Its flowers are also a good source of bee- forage.

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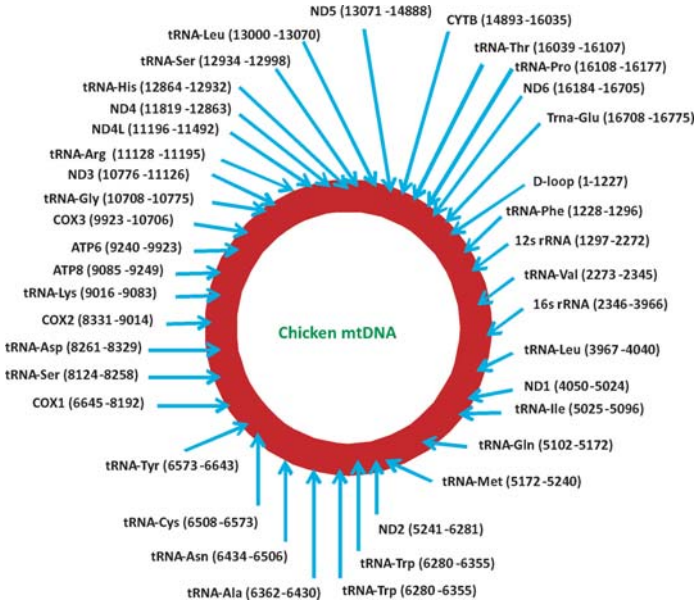
Sequenced whole mitochondrial genome of indigenous chicken-breeds

Chicken (*Gallus gallus*) was domesticated about 5,400 years ago through purposeful breeding and extensive use of wild Jungle Fowl in South-east Asia, including India. Origin and domestication of chickens have been of enormous interest to researchers and breeders as distribution of chickens has been observed to be enrouted from Asian domestication centres to Middle East and Africa, and subsequently to Europe and America. Archeological evidences and other historical findings were not able to confirm precise distribution route of chicken -breeds across the Globe. Herein, advent of the modern biotechnological tools helped decipher precise evolutionary relationship among species/breeds/clans/lines/strains. Of the several molecular technologies, mitochondrial DNA sequence- based method has been one of the most authenticated tools. The mtDNA molecule is associated with the onset of several diseases and stresses, and also with important cellular functions for climate resilience. Indigenous breeds are well adapted to unfavourable climate making them popular in tropical hot humid weather. India harbors 18 native breeds of chicken, including Red Jungle Fowl as wild ancestor of modern chickens-breeds. The whole mitochondrial sequence of seven Indian native chickens—Aseel, Ghagus, Nicobari (Black and Brown), Tellicherry, Kadaknath, Haringhata Black and Red Jungle Fowl— has been explored through Ion PGM Sequencer and analyzed with Torrent suite v 3.6. In chicken mitochondrial genome, there are 37 genes, encoding 13 proteins, 2 rRNAs and 22 tRNAs encompassing 16,775 bp circular DNA. The sequence variabilities among the breeds have been determined in terms of SNPs, insertions and deletions in the genome. The SNPs have been observed in D-Loop (1-1227), rRNA (1297-2272), rRNA (2346-3966), ND1 (4050-5024), ND2 (5241-6281), tRNA-Cys (6508-6573), COX1 (6645-8132), tRNA-Ser (8124-8258), tRNA-



Asp (8261-8329), COX2 (8331-9014), ATP6 (9240-9923), COX3 (9924-10706), ND3 (10776-11126), ND4L (11196-11492), ND4 (11486-12863), ND5 (13071-14888), CYTB (14893-16035), tRNA-Pro (16108-16177) and ND6 (16184-16705) genes of the mitochondrial genome. The insertions of nucleotides have been detected in D-Loop (1-1296), 12s-rRNA (1297-2272), tRNA-Val (2273-2345), 16s-rRNA (2346-3966), tRNA-Cys (6508-6573), COX1 (6645-8192), ATP6 (9240-9923), COX3 (9923-10706), ND3 (10776-11126), ND4L (11196-11492), ND4 (11819-12640), ND5 (13071-14888) and CYTB (14893-16035) genes in native breeds. Certain deletions have been observed in 12srRNA (1297-2272), 16srRNA (2346-3966), ND1 (4050-5024), ND2 (5241-6281), COX2 (8331-9014), ND3 (10776-11126) and ND4 (11486-12863) genes in Aseel, Ghagus, Nicobari Brown and Black, Tellicherry and Red Jungle Fowl; and Kadaknath and Haringhata Black did not show any deletion of nucleotides in the Mt genome. There were no nucleotide variabilities in other genes such as tRNA-Phe (1228-1296), tRNA-Leu (3967-4040), tRNA-Ile (5025-5096), tRNA-Gln (5102-5172), tRNA-Met (5172-5240), tRNA-Trp (6280-6355), tRNA-Ala (6362-6430), tRNA-Asn (6434-6506), tRNA-Tyr (6573-6643), tRNA-Lys (9016-9083), ATP8 (9085-9249), tRNA-Gly (10708-10775), tRNA-Arg (11128-11195), tRNA-His (12864-12932), tRNA-Ser (12934-12998), tRNA-Leu (13000-13070), tRNA-Thr (16039-16107) and tRNA-Glu (16708-16775). These nucleotide variations in the mitochondrial genome can be used further for determination of genetic markers for disease and stress resilience traits, and for phylogenetic relationship among chicken-breeds and other animal species to commensurate domestication process in the evolutionary lineage.

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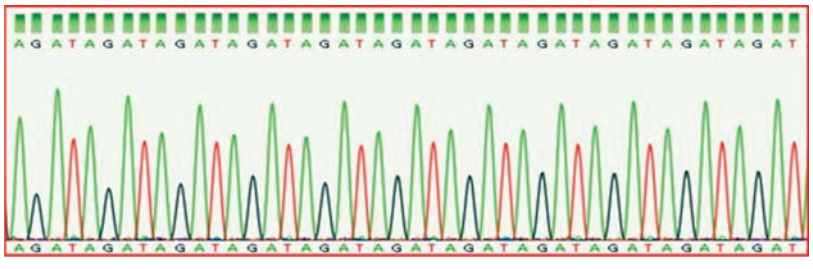
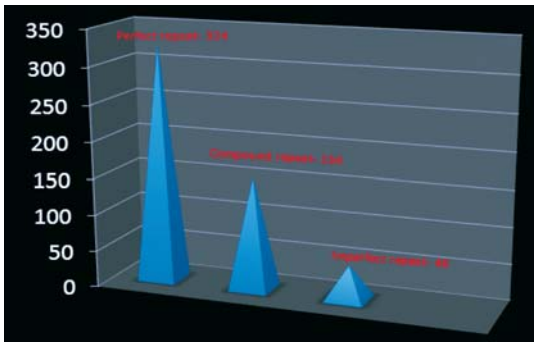
Novel microsatellite loci in great snakehead, *Channa marulius,* isolated

Snakehead fishes or murrels are old world fishes, belonging to family Channidae and order Perciformes. Among murrels, great snakehead, *Channa marulius,* is a commercially important fish of the South East Asia, valued as a table-fish, and is also of ornamental value. It has been assessed as lower risk-near threatened (LRnt) status. There was no information available using the Simple Sequence Repeat (SSR) loci on the genetic variability assessment of *Channa* species due to lack of information on these markers. And cross priming tests also did not yield polymorphic microsatellite loci. Hence, genomic library was constructed of *C. marulius* to identify polymorphic microsatellite loci.



Tetra nucleotide repeats in *C. marulius*

Isolation of species-specific *de novo* microsatellite loci in great snakehead was done through construction of microsatellite enriched genomic library. Enrichment was done using biotin labeled oligos, and the PCR product was cloned with TOPO-TA cloning kit. While sequencing recombinant plasmids, a total of n=524 repeats containing sequences were obtained; containing dinucleotide repeats, 383 (73%); tri, 73(13.9%); tetra, 53 (10.1%); penta, 9 (1.71%); hexa, 4(0.76%); and octa, 2(0.38%). Perfect repeats were found in 324 (61%) sequences, 154 (29%) were compound, while 46 (8.7%) were imperfect repeats. A total of 14 microsatellite polymorphic loci found would be useful for quantification of genetic variability and differentiating wild populations of *C. marulius.*



Types of repeats in *C. marulius*

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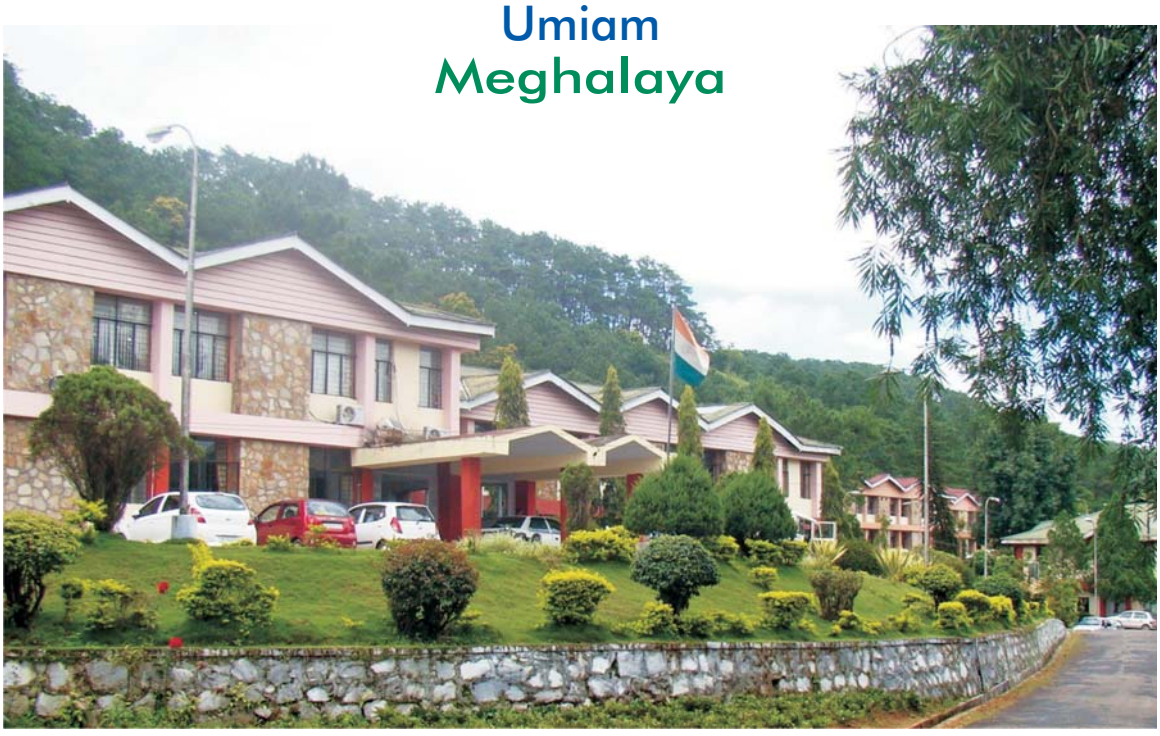
ICAR Research Complex for NEH Region

Umiam
Meghalaya



To establish an ICAR Institute in the North- Eastern Hill region was conceived during a seminar on *'Research and Training Needs in Agriculture and Animal Husbandry of the North East Himalayan Region'* at the Central Library Hall, Shillong, organized from 23 to 26 October 1973 under the Chairmanship of Dr M.S. Swaminathan, the then Director-General, ICAR, New Delhi. During the deliberations, the potential of the region as well as the long-felt need for research and development in Agriculture, Animal Husbandry and Fisheries in the North-Eastern Hill Region were highlighted. The ICAR RC NEH was established on 9 January 1975 under the aegis of the Indian Council of Agricultural Research. Initially, its Headquarters was at a private building in Shillong. In 1992, it was shifted to Barapani.

This institute is **the first of its kind,** which encompasses all disciplines of agriculture, horticulture, animal sciences, agricultural engineering, agroforestry, fishery and social sciences to cater to the needs of the tribal areas of the NEH Region, including Sikkim. Its headquarters is located in Barapani(Meghalaya), while regional centres are at Basar (Arunachal Pradesh), Imphal (Manipur), Kolasib (Mizoram), Jharnapani (Nagaland), Lembucherra (Tripura) and Gangtok (Sikkim). The institute has 15 Krishi Vigyan Kendras (KVKs).

Considering entire NEH Region as one unit, research centres are so located to represent varying altitudes (60-1800 m above msl) and agroclimates of the region.

Regional Centres

Basar, Arunachal Pradesh, it is spread over 40.5 ha at Gori research farm, and one KVK is attached to this centre.

Imphal, Manipur, its campus is at Lamphelpat. Its farm area is spread over 108 ha. It has a plant-health clinic, besides fish and poultry hatcheries.

Kolasib, Mizoram, it has farm area of 32 ha, and is located at altitude varying between 750 and 800 m. One KVK is now attached to the centre.

Jharnapani, Nagaland,it has farm area of 84 ha.

Tadong, Sikkim,it has farm area 21.2 ha and is at an altitude of 1,200-1,400 m.

Lembucherra, Tripura, it has farm area of 48 ha, comprising mostly *tilla* land; with only about 2 ha of lowland.

MANDATE

- To improve and develop sustainable farming systems for different agroclimatic and socio-economic conditions of the region.
- To improve crops, livestock, fishery and to impart training for developing local competence for management of resources to enhance agricultural productivity.
- To maintain, analyse and project database resources for perspective planning.


Gene gun


Biochar


Gas chromatography

- To collaborate with the state departments of the region for testing, and for promotion of improved farming technologies.
- To act as a repository of information on different farming systems of the region.
- To collaborate with national and international agencies in achieving the above.

INFRASTRUCTURE

Its laboratories are well-equipped with advanced instruments/equipments like automated sequencer, growth chamber, biochar, portable photosynthetic system, gene gun (Biolistic particle delivery system); all kinds of thermal cyclers (normal, gradient and real time); vertical and horizontal gel electrophoresis systems; gel documentation system; ELISA reader; spectrophotometer; nanodrop, phase contrast microscope; stereo binocular microscope; normal and deep freezers (–20°C and –70°C); BOD; laminar air- flow chamber; nitrogen analyzer; leaf area meter; SPAD50; shaker incubator etc.

Moreover, a well-established tissue-culture laboratory and bio-safety cabinets of BSL2 and BSL3 for animal disease diagnostic works and a well-equipped Agro Processing Centre (APC) have also been established. A phenomics lab has also been established to carry out functional genomic works and phenotypic evaluation under the regulated environment.


Phenomics facility

Farms: Research farm is equipped with an automatic weather station, a number of screen- houses and polyhouses, Free-Air Temperature Enrichment (FATE) and Carbon dioxide and Temperature Gradient Chamber (CTGC) facilities and a rain-out shelter. Animal husbandry farm is equipped with artificial insemination facility.

Library: The library has been connected with NKN network. Besides, providing SDI services to scientists by accessing various national data- bases, the institute is also linked to CeRA project.

IT facilities: An AC lab with computers (installed with SAS) along with projector and a UPS back-up of 2.30 hr with internet facility has been developed. A general purpose Statistical Software Package SAS (Stand-alone


Rain-out shelter


Automatic weather station


CTGC facility

Knowledge Innovation Repository in Agriculture for North- East (KIRAN)

KIRAN is an umbrella arrangement to harness power of scientific knowledge and technology innovation for strengthening food production system in the NE Region through dynamic partnership and convergence among the stakeholders. It is a knowledge database of NE India having variety of information, starting from divisional profile to technology bouquet.

KIRAN has initiated agricultural messaging service to share agricultural knowledge and innovation among farmers, researchers, students and industries of the region.

as well as internet- based), consisting of all modules for perpetual use by different NARS organizations, is available. An online system, established for NET/ARS Prelim Examination for ASRB, ICAR, has also been started from March 2014.

SALIENT ACHIEVEMENTS

Varieties identified/developed

- Developed/ released 11 rice varieties in last five years.
- Identified submergence tolerant rice:RC Maniphou7.
- Developed two composites of maize of 100-110 days duration, RCM75 and RCM76, for the NE Hills with a yield potential of 5.0-5.5 tonnes/ha.
- Identified one OPV maize genotype showing QPM character (tryptophan 0.86, lysine 3.87g/16gN).
- Released field-pea varieties TRCP8 and TRCP9 for Tripura.
- Rapeseed variety, TRC T-1-1-5-1, has been released for Tripura.
- Released tomato varieties Megha Tomato 3 and RC Manikhamenashinba1 and Brinjal varieties Bholanath and Singhnath.

Varieties in pipeline for release

- Six composite maize varieties; of which RCM 1-3 is high in lysine and tryptophan (close to Shaktiman)
- Guava cultivars — RCGH 1, RCGH 4, RCGH 7 and RCGH 11
- Papaya cultivar, RCTP 1, tolerant to ring-spot virus
- Two genotypes of tomato (Megha Tomato 1 , 2) proposed
- Two genotypes developed of brinjal (RCMB 1 and Sel 5), and are in the last year of AICVIP trial
- One genotype of Frenchbean (RCFB 1)
- Two genotypes of ash-gourd (RCAG 15 and RCAG 28).
- 17 crop varieties: of rice (9), maize (1), mungbean (1), urdbean (1), sesame (1), papaya (1), pineapple (1), elephant foot-yam (1), *Dioscorea alata* (1), submitted for release through the State Variety Release Committee (SVRC), Govt of Tripura

Patents filed/sent for filing

- Process for producing tuity-fruity from chow-chow
- Method for producing an effective vaccine against salmonellosis
- Hypo-card: Product containing parasitoid, *Hyposoterebeninus* G. Cocoons
- Artificial diet of citrus trunk-borer grub (*Anoplophora versteegi* Ritsema)
- Mass-rearing of citrus trunk-borer grub (*Anoplophora versteegi* Ritsema)

Important technologies/findings

- Developed and disseminated package of practices of 12 crops for organic production.
- Mulching with rice-straw standardized for improving productivity of *rabi* crops under lowlands.
- Identified crop varieties for acid tolerance, and developed liming technology and soil- testing kits.
- Soil-organic carbon (SOC) map and SOC density/stock map at the regional scale prepared and reported for the first time from the NE India.
- A total of 46,000 insects were collected from NE region, and 1,300 insect species have been identified.
- Sequenced and assembled complete mitochondrial genome of India's first insect (*Henosepilachna pusillanima*).

- Reported for the first time from NE India infection of *Chilli veinal mottle virus* (ChiVMV) in Naga chilli and also full genome characterization of a distinct isolate of *Banana bunchy top virus* (BBTV).
- Characterized 15 plant pathogens and 3 hyper-parasites.
- Collected 57 indigenous ornamental fishes from different parts of Manipur.
- *Porcine reproductive and respiratory syndrome virus* (PRRSV) infection in porcine tissues detected and reported for the first time from India.
- *REV* (retroviral gene) insert in turkey-pox virus reported for the first time.
- PCR -based detection standardized in blood samples of bovine and canine for three species of *Babesia—bigemina, canis* and *gibsoni.*

Intensive integrated farming system (IIFS) model

Micro-rainwater-harvesting structure (*Jalkund*)

Micro-watershed based farming system model

Innovative integrated low-cost pig pen

- First time in India, boar semen cryopreservation protocol was developed, and piglets have been produced after insemination of sow with frozen-thawed semen.
- Under mid-hill conditions, standardized captive breeding protocols for exotic ornamental fishes, Gold fish and Koi carp.
- For the first time an endemic and endangered fish species of Manipur, Pengba (*Osteobrama belangeri)* has been bred under mid-hill conditions of Meghalaya.
- Bred successfully grass carp (*Ctenopharyngodon idella*) under mid-hill conditions of Meghalaya.

Mechanization

- Meat processing centre, water-harvesting structures (438), rice mill (10), *dal* mill (4), oil mill (2), mini tractor/power tiller (3), custom hiring centre (7), deep tube wells, fish-feed mill, turmeric-processing unit (2), poultry hatchery, aerator, bee-hives, etc. have been established in remote NEH districts.

Production technology

- Technologies for zero till pea, lentil, *toria* in rice fallow and Frenchbean in maize fallow have been standardized and disseminated in more than 1,000 ha in farmers' fields.
- Among 8 micro-watershed-based farming system models (32 to 52% slope) for sloppy land, *Agri-horti-silvi-pasture system* has been found most remunerative (₹ 140,000/ha/yr), which reduced soil loss to 2.46-3.45 tonnes/ha compared to 42.9 tonnes/ha under *Jhum,* and retained about 90% rainfall. And Agro-pastoral based farming system gave ₹ 1.25 lakh/annum with B:C ratio of 2.45:1.
- Intensive integrated farming system (IIFS) model *crop-fish-dairy-MPTs-fruit trees-hedge rows-vermiculture-liquid manure-broom* was found most remunerative with a B:C ratio of 1.76 for valley land.
- Micro-rain water harvesting structures such as *jalkund* (30,000 litres capacity) and roof water-harvesting technology with agri-film lining (250 micron thickness) for hill ecosystem have been standardized and disseminated in more than 1,000 farmers' fields.
- Innovative integrated low-cost pig pen (shelter) has been designed and developed with locally available natural resources for climate resilience (humidity, cold, high temperature etc.).
- A DOT-ELISA based diagnostic kit has been developed for two cattle parasites, viz. *Oesophagostomum* sp. and *Bunostomum* sp.
- Upgraded pig variety developed, including 75% to 87.5% genetic inheritance of Hampshire, 25% and 12.5% genetic inheritance of Khasi local indigenous pig.
- Three-breed- cross pig has been developed, including 25% genetic inheritance of Hampshire, 25% genetic inheritance of Khasi local indigenous pig and 50% genetic inheritance of Duroc.
- Artificial insemination technology in pig has been standardized and popularized.
- Complete feed-blocks developed with locally available grass/roughage for cattle.

PROMISING FARMING SYSTEMS FOR 7-DISADVANTAGED DISTRICTS

Fish-based farming system: In South Garo Hills (Meghalaya), almost 150 households were benefitted from fish- based farming system (fish+ duck/pig + vegetables). The pond size was 0.15 ha, and average productivity of fish was 2.98 tonnes/ha/year. The farmers could earn a net income of ₹ 30,000. Average productivity of fish under fish-vegetable- fruit farming system was 2.6 tonnes/ha /year compared to 0.35 tonne/ha without integration.

Fruit-based farming system: Strawberry- based farming system with drip irrigation was introduced in Saiha(Mizoram) and 30 farmers (0.1 ha each), who adopted this could generate a net income of ₹ 225,000/ ha/year. Pineapple cultivation was popularized in Dhalai in about 41 ha and the net income generated was ₹ 164,450/ha.

Strawberry cultivation in Saiha, Mizoram

Zero-till rapeseed (var. M27) in rice fallow: In Tamenglong of Manipur with zero-till cultivation of rapeseed in 576 ha of rice fallows, an average productivity of 0.85 tonnes/ha was realized. Farmers could earn a net income of ₹ 11,125/ha from rapeseed cultivation. At least, 1,000 ha of rice fallow is under zero-till rapeseed in and around Tamenglong. Apiculture (4 bee-hives/ha) integrated with rapeseed cultivation recording an average income of ₹ 4,500/ unit/year, as an additional income.

Improved shifting cultivation for sustainability: Improved *jhum* farming activities were implemented in 17.85 ha in Upper Subansiri (Arunachal Pradesh), and the net returns of the farmer were ₹ 31,454/ha with a benefit: cost (B: C) ratio of 1.33. In Mon district of Nagaland, improved *jhum* cultivation was introduced in 106 ha, and farmers fetched a net income of ₹ 22,140 from the *jhum*.

Upper Subansiri

SRI and ICM rice culture: The System of Rice Intensification (SRI) and Integrated Crop Management (ICM) increased rice productivity with high-yielding varieties to 4.22 tonnes/ha as against 1.96 tones/ha with local rice variety under the farmer's practice. Farmers earned a net profit of ₹ 30,100/ha by adopting SRI/ICM methods of rice cultivation compared to

Good crop of rice under SRI in Dhalai

- First time in NE India, genetically improved common carp (Hungarian strain), *Cyprinus carpio*. var. Amur, has been successfully introduced.
- Introduced two important indigenous fish species of NE region, *Tor putitora,* (Golden mahseer) and *Osteobrama belangeri* (Pengba) .

THRUST AREAS

- Soil and water conservation
- Integrated Farming System (IFS) for food and nutritional security
- Conservation agriculture
- Organic agriculture
- Agroforestry for rehabilitation of degraded lands
- Identification of efficient rice- and maize- based cropping systems
- Identification of stress- tolerant crops, livestock, fish
- Aquaculture, including cold- water fisheries
- Addressing Trans-boundary diseases
- Medicinal and aromatic plants
- National Mission on Sustaining Himalayan Agriculture—New programme
- Towards an agricultural policy for NER—collaboration with NEC—New programme
- Temperate horticulture

Flagship programme

- ***Jhum*** **improvement for livelihood security:** Development of varieties of major crops and crop

OF THE NORTH-EASTERN REGION

₹ 12,700/ha under the conventional practice. Realizing the potential of rice varieties, Ranjit in South Garo Hills and Naveen and Gomati in Dhalai, about 240 ha every year (2008-14) have been covered under the SRI and ICM.

Polyhouse technology for year- round vegetables: Year-round cultivation of high-value vegetables, tomato, cauliflower, broccoli under low-cost polyhouse substantially increased farmers' income of North Sikkim and Upper Subansiri. In Upper Subansiri, net income from a single polyhouse (100 m^2) was ₹ 21,250 in a year compared to about ₹ 750 from open cultivation; whereas, in North Sikkim, the increase in net income was realized to the tune of ₹ 7,000 to ₹ 18,000 per household over baseline income.

Vegetable cultivation in poly-house at Upper Subansiri

CMU members monitoring year-round vegetable cultivation at North Sikkim

Organic large cardamom production: Large cardamom (varieties ICRI Sikkim I, ICRI Sikkim 2) -based farming system using organic inputs was developed in North Sikkim and Mon, covering 226 ha. Also ICRI improved *bhatti* was introduced for improving curing process and quality of processed products. The net income of farmers was ₹ 35,000/ha as compared to ₹ 20,000/ha earlier.

Large cardamom nursery raised at Dzongu, North Sikkim

ICRI improved *bhatti* for curing large cardamom

Organic ginger cultivation: Improved organic ginger cultivation was introduced in North Sikkim. The net returns of the farmers were ₹ 698,000/ha and ₹ 45,000/ 0.10 ha.

Seedling production of Sikkim mandarin: Nucellar seedling production unit of Sikkim mandarin was established, covering 6 beneficiaries and 6 SHGs. The net returns were about ₹ 130, 000 from selling 65,000 saplings.

Nutritional kitchen-garden: Nutritional kitchen-garden concept was introduced in South Garo Hills, Mon and Dhalai, covering 762 beneficiaries and 39.6 ha area. The net income of the farmers from the kitchen-gardening was ₹ 91,254/ha and ₹ 4,575/ 500 m^2. Almost all the vegetables like chilli, tomato, cabbage, cauliflower, beans, coriander, okra, amaranth, broccoli, knol-khol, lettuce, mustard (laipatta), onion etc. were cultivated in about 500 m^2 area.

management practices for improvement of productivity of *jhum* lands.

Development of technology for faster restoration and rehabilitation of *jhum* lands through mechanical and biological measures; to cover about 50 ha *jhum* in each NEH states.

- **Temperate horticulture:** In Arunachal Pradesh, about 50,000 ha and 200 ha in Sikkim have been identified for research on the performances of different varieties, INM, pests, diseases etc.

Kiwi, pear, walnut, chestnut, star-anise, apricot, cherries and off- season vegetables and floriculture have been recommended.

- **Trans-boundary plant and animal diseases:** Evaluation and development of innovative technologies relevant to location-specific conditions.
- **Farmers' first**: Evaluation and development of innovative technologies relevant to location- specific conditions in a participatory approach. To cover at least 50,000 farmers annually under various schemes is planned.

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New vegetable varieties/hybrids

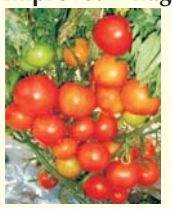
In the recent years, vegetable sector has emerged as an important component of Indian agriculture. India is the second largest producer of vegetables in the world, contributing to about 14 % of world's vegetable production. The AICRP (vegetable crops) has added the following seven new high-yielding open-pollinated cultivars, four hybrids and one resistant variety, identified and recommended for release and notification for different agroclimatic zones of the country during the XXXII Group Meeting, organized at the IGKV, Raipur, from 24 to27 June 2014.

Open-pollinated cultivars

Crop	Varieties	Recommended Agro - climatic Zones	Characteristic Features
Tomato (Indeterminate)	**DARL68** 	III (Sikkim, Meghalaya, Manipur, Nagaland, Mizoram, Tripura, Arunachal Pradesh and Andaman & Nicobar Islands) and IV (Punjab, Uttar Pradesh, Bihar and Jharkhand)	It is a selection from the segregating lines of EC386023 x BL342. Its fruits are long, oval, red-coloured with thick pericarp, good keeping quality, and are suitable for long transit. Edible fruits contain 6.0% total soluble solids (TSS) and 4.67% dry matter content. It is tolerant to powdery mildew in the fields. In open fields, its yield potential is 32 tonnes/ha, and is suitable for cultivation in open as well as in protected conditions
Tomato (Determinate)	**Punjab Ratta** 	IV(Punjab, Uttar Pradesh, Bihar and Jharkhand)	Its fruits are oval-shaped, medium-sized, firm and deep-red, and are suitable for processing. Average fruit length ranges from 4.87 to 6.43, girth from 12.38 to 18.29, and fruit weighs from 57.0 to 97.33 g. Its TSS ranges from 4.94 to 6.43%. It has average yield of 56.2 tonnes/ha.
Chilli	**LCA 620** 	V (Chhattisgarh, Odisha and Andhra Pradesh)	Its plants are tall, erect and has bold and medium long (8-9 cm) fruits of medium pungency. It has excellent dry fruit colour. Fruit maturity ranges from 170 to 190 days (seed-to-seed). It has average fruit (red ripe) yield of 13.8 tonnes/ha. In fields, it is moderately tolerant to fruit- rot and thrips. It has colour value of 50-55 ASTA and pungency of 22,000-25,000 SHU.
Cauliflower (Early)	**SBECF 102 (Sabour Agrim)** 	VII (Madhya Pradesh, Maharashtra and Goa)	It has been developed through selection from material collected from Chakwara village, near to Hazipur city, Vaishali, Bihar. It is an early variety; forms curd at an average temperature of 22-27°C;its plants are erect to semi- spreading with light- green leaves. It takes 48 - 54 days for 50% curd initiation and 65 -68 days for 50% curd maturity from the transplanting day. It has round, white and compact curds with average curd weight ranging from 450.0 to 482 g. The variety has a yield potential of 15-20 tonnes/ha.
Cauliflower (Early)	**DC 31** 	IV(Punjab, Uttar Pradesh, Bihar and Jharkhand)	This is an early-group cauliflower variety. Its curd initiation and development occurs at an average temperature range of 22-27°C. It is suitable for transplanting during July and reaches marketable maturity during October. Its curds are compact with retentive white colour. The average curd weight is 500-600g with a yield potential of 16-18 tonnes/ha.
Ash- gourd	**DAG12** 	VIII (Karnataka, Tamil Nadu, Kerala and Puducherry)	Its vines are medium-long (average length 7.0 m) and its fruits are cylindrical, and can be easily transported to long distance. The fruit has greenish white- rind and white-flesh. Its average fruit weight is 3.5 kg. And its national average yield is 36.1 tonnes/ha.

Kale	**KTK64** 	I (Jammu and Kashmir, Himachal Pradesh and (Uttarakhand)	This is the *first-ever variety of vegetable-kale,* identified for release in India. It has highly serrated, purplish green leaves, 40-50 cm in length and 15-20 cm in width.Its plant height is 50-60 cm. Its leaves are available throughout winter with multiple harvestings and can be consumed as cooked green vegetable like *methi* or mixed with other leafy vegetables; for preparing soup and as a salad also. It has higher content of phenols, anthocyanin, ascorbic acid, chlorophyll-α, chlorophyll-β, total chlorophyll, lycopene and total carotenoids (6,120 µg gallic acid/ gfw, 3,284 µg/100 g, 80,832 µg/100 g, 244 µg/g, 162 µg/g, 413 µg/g, 8,018 µg/100 g and 52,820 µg/100 g, respectively) than other varieties of brassica vegetables. It has high tolerance to cold and frost. Its average leaf yield over locations is 35 tonnes/ha.

Hybrid cultivars

Crop	Hybrids	Reccomended Zone	Characteristic Features
Tomato	**Improved Bhagya** 	IV (Punjab, Uttar Pradesh, Bihar and Jharkhand) and VII (Madhya Pradesh, Maharashtra and Goa)	It is a determinate hybrid. It has jointed pedicle, flat-round fruits with good firmness, suitable for transportation; fruit colour is deep- red at ripening, 3-4 fruits are per cluster, and pericarp thickness is 5-6 mm and fruit weight is 90-100 g. It is tolerant toToLCV. Fruits are ready for harvest in 65-70 days after transplanting.Its yield potential is 35-40 tonnes/ha.
Tomato	**2011/TODHyb2** 	I (Jammu and Kashmir, Himachal Pradesh and Uttarakhand)	It is a determinate hybrid with vigorous plant habit. Its fruits are oval and deep-red at ripening. Average fruit length is 3.71 - 4.8 cm, girth is 14.6-17.89 cm and fruit weighs 59.3-81.98 g, and its TSS is 3.5 - 5.0 %.Its fruits are firm and suitable for transportation. Its yield potential is 35-45 tonnes/ha.
Brinjal	**PBHL 52** 	IV (Punjab, Uttar Pradesh Bihar and Jharkhand)	It is an early- maturing long-group brinjal hybrid. Its plants are medium in height, are compact, thornless with green foliage. Its flowers are purple, borne in clusters. Fruits are long, medium-sized, shining-purple with green calyx. Its average yield is 67.50 tonnes/ha.
Okra	**JOH 0819** 	VI (Rajasthan, Gujarat, Haryana and Delhi) and VII (Madhya Pradesh, Maharashtra and Goa)	It is a medium height plant with vigorous growth. Its fruits are medium-long with attractive light-green colour with good shining. Its average fruit length is from 10-15 cm, fruit girth is 2-5 cm and fruit weight is 10-150g. It has average fruit yield of 16 tonnes/ha.

Resistant variety

Okra	**VRO 25** 	IV (Punjab, Uttar Pradesh, Bihar and Jharkhand)	It is an early, medium-tall (120-125 cm) variety with short internodes with single or double branches; attached at a narrow angle with the main branch. It takes 42-44 days for first flowering. Flowering starts after 5-7 nodes. Each plant has 19-21 fruits of dark-green colour. The length and the width of the fruit are 10-11 cm and 1.65 cm, respectively, at marketable stage. The fruits are available from 47to-100 days after sowing and the total yield is 15-16 tonnes/ha. It is found resistant to yellow vein mosaic virus and okra enation leaf curl virus in fields.

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Growth promoters' foliar sprays for quality seed production of anjan grass

Anjan or buffel grass (*Cenchrus ciliaris*)is widely adapted to sub-humid to semi-arid tropical/subtropical areas. It often occurs on the sandy soils in wild, and is also well adapted to deep, freely draining sandy -loam, loam and clay-loam soils. It is mainly used as a permanent pasture, but can be used for hay or silage and for controlling soil erosion. Its dry fodder yield ranges from 2 to 9 tonnes/ha with 8-12 % crude protein and 50-60 % digestibility. Many of the *Cenchrus* spp. produce higher percentage of empty seeds due to poor seed-setting. There are some physio-chemical manipulations that help diverting source to sink,and thus increasing proportion of filled seeds.

In IGFRI 3108 variety of *C. ciliaris* at the panicle initiation stage, effects of foliar sprays of Thiourea (0.25, 0.50 and 0.75%), GA_3 (50 ppm, 100 ppm and 150 ppm) and KNO_3 (2, 4 and 6%) were studied as compared to water spray as control. The experiment was conducted during *kharif* 2011 to 2013. Seed yield and its contributing traits were observed on 5 randomly selected tussocks; and for germination and quality traits, seeds were evaluated as per the ISTA (1993). X-ray photography was used for observing proportion of filled seeds. Pooled analysis of three years data was subjected to analysis of variance also.

Application of 0.50% Thiourea, 100 ppm GA_3 and 4% KNO_3 significantly increased seed yield by 39, 31 and 50%, respectively, over the control. The seed yield may have enhanced through 1,000-seed weight, which increased by 26, 19 and 36 %, and the spike length, which increased by 13, 12 and 17%, respectively, over the control.

The proportion of the filled seeds increased significantly with the use of 0.25% Thiourea, 50 ppm GA_3 and 2% KNO_3 by 12, 17 and 24% respectively, over the control. To achieve significant increment in germination, application of 0.50% Thiourea, 100 ppm GA_3 and 4% KNO_3 was repeated, which increased germination by 17, 25 and 21 % and seedling length by 18, 21 and 18 %, respectively, over the control.

Spraying 0.50% Thiourea, 100 ppm GA_3 and 4% KNO_3increased dry fodder yield by 30, 49 and 41 % through increased plant height by 14, 29 and 16 % respectively, over the control.

It was found that the foliar spray of all the three was equally effective in enhancing quality seed yield as well as fodder yield. By considering the low cost, availability and easy handling, use of Thiourea has been recommended.

Growth promoters' effects on *Cenchrus ciliaris* seed yield and quality (pooled data, 2011 to 13)

Treatment	Seed yield (kg/ha)	Filled seeds (%)	1,000-seed weight (g)	Germination (%)	Seedling length (cm)	Spike length (cm)	Dry fodder yield (tonnes/ha)	Plant height (cm)
Control	46.4	62.6	1.183	16.9	6.3	13.9	4.4	93.7
Thiourea 0.25%	57.0	69.9	1.350	18.0	6.6	15.0	5.1	102.6
Thiourea 0.50%	64.3	74.0	1.494	19.7	7.4	15.6	5.7	106.5
Thiourea 0.75%	67.4	75.6	1.545	21.1	7.3	15.9	6.2	108.2
GA_3 50 ppm	53.4	73.2	1.295	18.8	6.8	14.9	5.6	108.0
GA_3 100 ppm	60.7	76.5	1.404	21.1	7.6	15.5	6.5	121.2
GA_3 150 ppm	63.0	79.3	1.405	21.4	8.0	15.8	6.8	121.8
KNO_3 2%	59.4	77.6	1.453	18.4	6.6	15.4	5.3	103.3
KNO_3 4%	69.6	79.0	1.612	20.5	7.5	16.2	6.2	108.1
KNO_3 6%	76.9	80.3	1.641	21.9	7.3	16.4	6.1	106.7
Mean	61.8	74.8	1.438	20.0	7.1	15.5	5.8	108.0
SEm (±)	2.5	2.3	0.042	0.7	0.2	0.3	0.2	2.8
CD (5%)	6.95	6.6	0.120	2.1	0.7	0.75	0.61	8.0

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Hampered pollination results in abnormal litchi-fruits

Litchi is a highly cross-pollinated fruit-crop. During the peak-flowering season, a variety of insects from Hymenopteran, Coleopteran, Lepidopteran, Dipteran and Hemipteran group visit litchi-crop. Among bees, *Apis* and *Melipona* spp. represent around 98-99% of the visitors; *Apis mellifera* has been recognized as the principal pollinator. Foraging activities of pollinators are governed by temperature, relative humidity, light intensity, solar radiations and nectar/sugar concentrations. Optimum pollination resulted in healthier fruits as was evident with the placement of *Apis mellifera* colonies in the litchi- orchard, which yielded more of healthy and heavier fruits. With the change in the climate, a decline in pollination activity has been observed, which led to the development of abnormal fruits and also reduced crop yield. Thus, there is a need to address effect of climate change on the pollinators' activities through measures that would enhance their population, by providing them congenial environment during their peak hours of visit to the litchi-orchards.

Effect of honeybee pollination on litchi yield

No. of bee-hives/ha	Yield/plant	Percentage of fruit retention
10	80 kg	0.9-1.4
08	70 kg	0.6-0.8
05	50 kg	0-4-0.7
00 (Natural pollination)	25 kg	00
Cased (No pollination)	00	00

Different pollinators on litchi-plant

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Jalkund stimulated agri-preneurship in Sikkim through winter vegetable production

Nandok village in East district of Sikkim, situated at a latitude of N 27° 17.818', longitude of E 88° 36.678' and at an altitude of 1,135 m above mean sea level makes it ideal for cultivation of important horticultural crops. This village used to receive normal annual rainfall of 3,057.3 mm in *kharif* and 269.1 mm during *rabi*.




However, during the last decade, the village has become highly vulnerable due to drought, erratic rainfall, and wind and hailstorms. There is also an acute shortage of irrigation water, especially for *rabi* vegetable crops, due to absence and/or drying of perennial natural water streams. Winter precipitation during the last decade has also reduced significantly. The farmers showed their willingness to grow *rabi* vegetables if water is made available.

During benchmark survey, PRA and focused group discussions (FGDs), rainwater harvesting and storage in farm- ponds were identified as suitable interventions for efficient rainwater utilization. Climate resilient technologies to enhance productivity and income and sustained livelihood of the farmers in the village were also prioritized.

Shri Gokul Rai volunteered for adopting pond technology (capacity of 40 cu m and size of 5 m × 4 m × 2 m)in his farm. He constructed a *jalkund* for rainwater harvesting to collect runoff from the village streams; to be used as a supplemental irrigation to grow organic cabbage, cauliflower, broccoli and vegetable seedlings under low-cost structures. Before this, he was confined to only a single crop of rice or maize during *kharif*; leaving field fallow during *rabi*. The returns were very nominal. Increased availability of water through farm-pond encouraged him to diversify cropping system with organic cabbage, cauliflower, broccoli cultivation and vegetable seedlings production. This increased cropping intensity from 100 to 216%, and his net returns multiplied from ₹ 16,500 to ₹ 85,250 from his 0.45 ha.

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Bioacoustics to reduce damage by birds to crops

Any sound that we hear is acoustics, and bioacoustics is the sound that originates from biological objects. Human audible frequency ranges from 20Hz to 20,000Hz. Sounds below 20Hz, called infrasonic, are audible frequencies for birds like Rock Pigeons. But no bird can hear above 20,000Hz, called ultrasonic, as also human-beings.

Bird calls of importance were recorded from fields – alarm, distress calls—of predatory birds, and the songs were sequenced in a row or were layered vertically to form constructs. Three such constructs, each with increasing efficiency, were developed, and have been experimented with. The call construct used for protecting crops from depredatory birds is Call Construct-3. Equipments were developed to produce sounds in the field.

Call Construct-3 is of 14.46 min duration and uses multiple layering techniques to create a scene of danger naturally at the broadcasting site. This has proven effective in preventing distress feeding by birds, and especially by major depredatory birds, like Rose-ringed Parakeets. The effectiveness of Call Construct-3 has gone up from 52-59% (Call Construct -2) to 66.3-89.7%. And with this, the labour requirement for guarding crops has become almost obsolete. In earlier Call Constructs, one or two labour augmentations were needed in the later stages of crop per acre. This saves about ₹ 16,000 per acre per season, and farmers can use this time for other productive works.

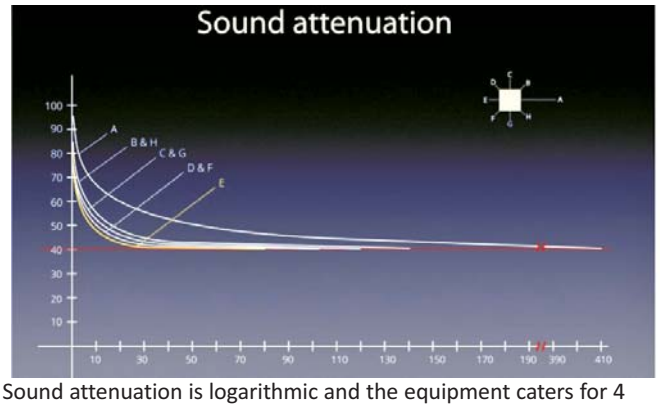
Sound attenuation from broadcasting source has been worked out. At 24-26°C and calm wind conditions, a

single device could cover 3.51 to 4 acres, when ambient sound was 48dB. This would increase to 19 acres if the ambient sound used was 40dB.

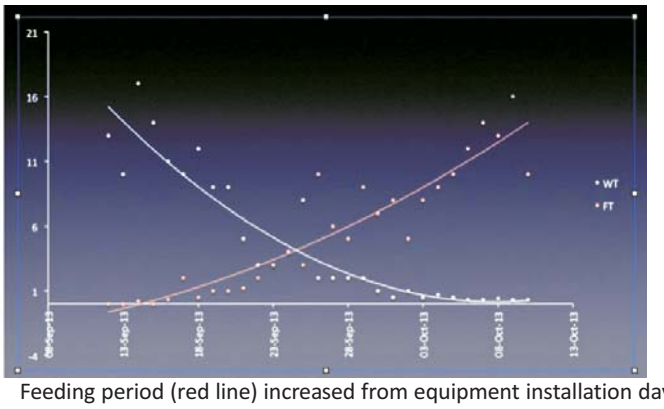
A library of birdcalls has been developed, and their present count is 28. Out of these, three calls of Common Myna distress, Rosy Starling distress, and Baya Weaver alarm and distress were recorded last year that proved very effective for dispersal of birds from agricultural holdings. These calls have been augmented in Call Construct-3, and have contributed in increasing equipment efficiency.

Acoustic equipment installed at sunflower field (Sira taluk) Bengaluru

experimental area, and it was sustained throughout the duration of the experiment. Parakeets completely avoided feeding on the plot. There was no distress feeding observed in relation to food scarcity (distress feeding). However, breeding birds could not be dispersed effectively with Call Construct-3. The effect on dispersing breeding birds was up to 32%. Combined dispersal potential for breeding and non-breeding birds was 66.3%. On non-breeding birds, the sequence was effective 89.7%. Acclimatization by non-breeding birds did not happen till the crop was harvested. There was 95% damage in



Sound attenuation is logarithmic and the equipment caters for 4 acres (distance in metres on x axis and decibels (dB) on y axis)



Feeding period (red line) increased from equipment installation day to 25 day. Waiting period (white line) on trees decreased as days progressed

Two sets of experiments were conducted in Karnataka on sunflower and in Hyderabad on sorghum. In one set, Call Construct -2 was used, and in another, Call Construct -3 was used. Call Construct -2 was tested for multiple-season acclimatization. This enabled to find whether the birds were attuned to the same set of calls season after season. During the experiment, distress feeding by Parakeets was observed. Line transects 5 km around experimental plots revealed no food available to birds. Despite distress feeding, Call Construct-2 was 52.5% effective in dispersing birds. This score is slightly lower than the earlier results from the previous experiments in Andhra Pradesh (59%), during which there was no distress feeding. There was 50.5% damage in control plot without human interference compared to 2.56% damage in the experimental plot. Crop yield in control plot was 237.5kg/acre versus 616kg/acre (both plots were irrigated).

Experiment involving Call Construct-3 lasted for 29 days. Flying route of Parakeets immediately changed to avoid control plot without human interference, compared to 1.06% damage in the experimental plot. Crop yield in control plot was 30 kg/acre versus 317kg/acre (both plots were rainfed).

The time spent by depredatory birds gradually increased from 0 min to more than 2.4 min on an average in the experimental plots compared to 3.1 min feeding time from the beginning at control plots. Number of feeding birds at the control plots was 2-3 times more than birds feeding on the experimental plots.

Similarly, time spent on waiting over trees by depredatory birds before descending down on crops was more than 5 minutes in experimental plots compared to 1.75 minutes in the control plot.

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Improved pull-type rice transplanter

Three-row manual pull-type transplanter has been developed by modifying functional components of the six-row IRRI rice transplanter. The unit is capable of planting seedlings at 250- mm row spacing. Its picker mechanism is designed in such a way that planting operation is performed simultaneously as the equipment is pulled with the handle. The elimination of push-pull mechanism in this improved model reduces drudgery of the operator. Drive from two ground wheels actuates seedlings pushing down mechanism through cam. Speed reduction gears are fixed in between the ground wheel shaft and the seedling picking arms to maintain intra-row spacing of 250 mm, and the two skids enhance ease of floating and pulling.

The unit has been evaluated in different puddling conditions as well as textural conditions. Draught requirement to operate equipment is 261.7 N. Energy requirement was reduced by 24.8% with the modified transplanter as compared to the IRRI manual transplanter. The missing hills (9.61%) observed with modified transplanter with optimized growing density of seedlings of 600 g/m^2 were below the allowable limit. The planting arrangement of the modified transplanter consists of 12% single seedlings per hill, 30% double seedlings, 32% triple seedlings, and 26% multiple seedlings. The operation of equipment registered 81 % cost and 91% time saving as compared to manual transplanting. This improved transplanter has a good scope for introduction in the marginal farms.

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Seed-cum-ferti-drill with differential-depth-fertilizer-application system

A tractor-operated multi-row seed-cum-ferti-drill developed, can apply seeds and fertilizers at different depths as per the requirement of the crop.

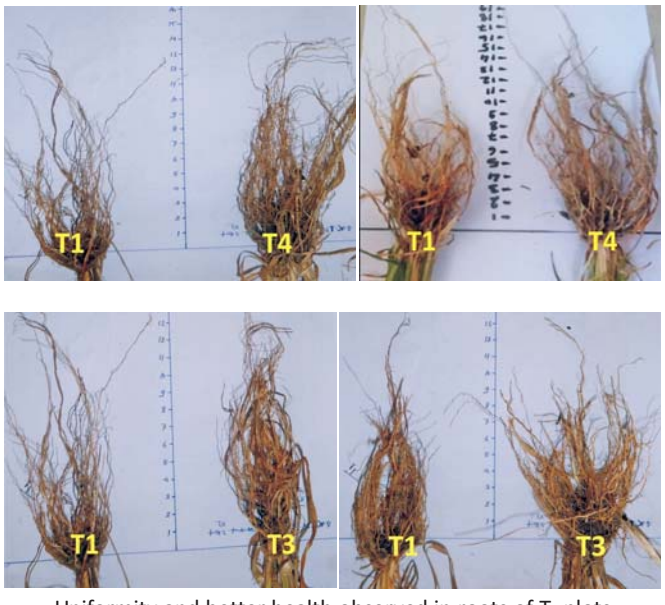
This drill is mainly used to apply phosphorus and potash at the root zones of different crops to enhance fertilizer-use efficiency during peak requirement. Furrow openers selected for seeding and fertilizer application are of shovel type, and fluted- roller type mechanism has been employed for metering seeds and fertilizers. The machine weighs about 200 kg.

Split- plot design experiments for wheat (aestivum HI1544 and durum HI8663) sowing using this drill were conducted for two

Effects of differential depths fertilizers application on the wheat-crop attributes

Treatment	Plant ht, cm	Plant wt, g	Root wt per plant, g
Main plots			
Triticum aestivum	96.73	47.3	10.29
Triticum durum	94.94	51.89	15.38
LSD (p=0.01)	NS	NS	6.68
Sub plots			
T1, 0 mm depth	96.17	50.51	11.40
T2, 50 mm depth	97.50	47.50	11.58
T3, 100 mm depth	88.0	38.03	16.01
T4,150 mm depth	98.0	57.68	15.55
T5, 200 mm depth	99.50	54.54	9.63
LSD (p=0.01)	3.39	5.63	1.77

Treatment	Seed wt per ear-head, g	Grain yield q/ha	Straw yield q/ha
Main plots			
Triticum aestivum	1.90	52.75	67.4
Triticum durum	2.85	51.70	65.9
LSD (p=0.01)	0.24	NS	NS
Sub plots			
T1, 0 mm depth	2.26	47.39	60.6
T2, 50 mm depth	2.41	52.23	65.0
T3, 100 mm depth	2.45	56.11	72.4
T4,150 mm depth	3.32	60.48	69.0
T5, 200 mm depth	2.45	44.93	66.3
LSD (p=0.01)	NS	2.39	2.4



Uniformity and better health observed in roots of T_4 plots

consecutive years. Aestivum and durum wheats were grown in the main plots, and fertilizer application (phosphorus and potash) at depths of 0, 5, 10, 15, 20 cm from soil surface was done in sub -main plots.

The data analysis revealed that main treatments were significant for root weight per plant and seed weight per ear-head at 5% level of significance. However, plant height, plant weight, grain and straw yields of main treatments were not significantly different at 5% level of significance.

The application of fertilizers at different depths significantlyaffected plant height, plant weight and root weight per plant, grain and straw yields of sub -main treatments at 5% level of significance. The study clearly indicates that with the machine about 15% higher wheat yield could be observedwhen fertilizerswere placed at an appropriate depth of 15 cm below the ground level as compared to placement at 5 cm below the ground level.

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WAY FORWARD

GROWING demand of fish in the domestic and export markets indicates good prospects for 'looking to the sea' for large- scale sea- farming and coastal mariculture. As per the FAO (2014) statistics, mariculture has contributed to 37.5% of the global aquaculture production. In India, in 2012, 4.21 million tonnes of fish production (6.32% of the total global production) was through aquaculture. It is clearly evident that to augment seafood production in the context of declining catch rate from capture fisheries, development and expansion of mariculture is needed. Mussels, oysters and clams are much sought-after and widely consumed throughout the world as a gourmet food. In India, these have, so far, not received much acceptance. Nonetheless, farm production of mussel and oyster in India is between 15,000 and 20,000 tonnes per year. Although ever-expanding internal market for fish and fishery products has recorded highest jump among all the food products, still in the global scenario, India is in infancy as far as mariculture production is concerned.

Recent research interventions in mariculture have enhanced growth rate, adaptability to captive breeding, low-cost of production, good meat quality and high market demand, which have made cobia, *Rachycentron canadum* and pompano, *Trachinotus blochii, T. mookalee* excellent species for mariculture. The ICAR institutes have developed appropriate technologies for mussels, oysters, clams, seaweeds, finfishes and shellfishes, and the first-ever technology for broodstock development, induced breeding and larval rearing of cobia and pompano. Development of brood bank, Re-circulatory Aquaculture System, hatchery rearing and grow- out facilities, including open -sea cage rearing, provides opportunities and assistance in mariculture of commercially important sea-fish and shellfish species. For public awareness, demonstration of open -sea cage culture technology all along the Indian coast, including its transfer to tribal communities, has been a great booster for all the stakeholders.

In the recent years, a lucrative global opportunity as marine ornamental fishes and pearl trade has emerged, which is a low- volume and high-value industry. While techniques for breeding, seed production and culture of 16 species of marine ornamental fishes — Clown fish (*Amphiprion percula, A. ocellaris, A. perideraion, A. ephippium)* and damsels *(Dascyllusaruanus, Pomacentrus caeruleus* and *Chrysiptera cyanea)*—are available, hatchery production of marine ornamental fishes in indoor tanks with copepods and rotifers as larval feed gave an average survival of 40% for damsels and 70% for clown fishes. The wide resource of ornamental fishes in vast water- bodies and coral- reef ecosystems along the Indian coast, if judiciously used, can be a significant foreign- exchange earner.

Dr S. Ayyappan, Secretary (DARE) and Director General (ICAR)

Besides, fish resources, around 60 species of commercially important seaweeds, growing along the Indian coast, which are the source of agar, algin, carrageenan and liquid fertilizer, are in great demand in the global market. Among the species, production of *Gelidiella acerosa* from culture amounted to 5 tonnes dry matter per hectare, while *Gracilaria edulis* and *Hypnea* yielded 15 tonnes dry weight per hectare. Recently, culture of carrageenan- yielding seaweed *Kappaphycus alvarezii* has become popular due to its fast growth and low susceptibility as a fish -food.

Along with the guidelines and protocols for Good Management Practices (GMP's) in the hatcheries and Better Management Practices (BMP's) in the farming would help finfish hatchery operators and farmers. The Council has introduced *m-krishi* Fisheries Advisory Service to provide information on the oceanic environment and also PFZ advisories.

To promote mariculture, a national -level policy for leasing out potential sites, bank finance, insurance and governmental support through subsidy assistance activities is also imperative. Promotion and availability of logistic support for cage- farming should be given careful consideration if a profitable business has to be established. With an inclusive vision to manifest Blue Revolution in the country, the Council has identified a few R&D programmes to address broodstock development of selected marine finfishes and shellfishes, larval rearing of marine fin-fishes, live-feed and grow-out technologies, development of cage-farming, coastal farming protocols and Integrated Multi Trophic Aquaculture (IMTA). It is our strong hope that in India, field testing, demonstrations and transfer of technologies through farmer's participation on these issues would enable mariculture to contribute significantly to the fisheries sector.

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