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ICAR NEWS

A SCIENCE AND TECHNOLOGY NEWSLETTER

RESEARCH UPDATE

PROMISING TECHNOLOGIES

Biofloc-based shrimp farming technology

Specific-pathogen-free Pacific white shrimp *Litopenaeus vannamei* introduction in India has resulted in high economic returns to shrimp-farmers. Delivering high productivity with sustainability through eco-based approaches, this shrimp is evincing keen interest among all stakeholders. One such eco-based approach for this is biofloc- and -periphyton technology (BFT), which is based on the concept of retention of the waste and its conversion into biofloc as a natural food within the culture system.

Recently, an intensive aquafarming system has employed this technology using some kind of biomats and supplementation with carbon addition to manipulate C : N ratio. Biofloc is a conglomeration of heterotrophic bacteria, algae (dinoflagellates and diatoms), fungi, ciliates, flagellates, rotifers, nematodes, metazoans and detritus, which act synergistically to maintain quality of the water in aquaculture units, thus reducing water exchange need and production cost, and the feed also is reutilized.

Biofloc-based *L. vannamei* harvest

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Biofloc Advantages

- Biosecurity of the system can be maintained.
- Heterotrophic bacteria can reduce toxic metabolites (NH_3, NO_2).
- An environment-friendly approach with reduced protein requirement, fish-meal usage and water / nutrient discharge.
- Probiotic action—reducing pathogenic bacteria (Vibrios).
- Reduces cost, including saving on the feed.

A very high survival of 98-99 % of *L. vannamei* was achieved in a periphyton-and-biofloc- based nursery-tank- based rearing system compared to 91-92 % in the conventional system. One nursery-tank of 100 tonnes could generate revenue of ₹ 50,000 – ₹ 100,000 per year. Following this successful nursery-rearing; in the same system, grow-out culture was completed under biofloc- based rearing. A final weight of 22-23g in 110 days culture could be observed. This indicates scope for developing a tank- based grow-out culture system also, which can result in a production of 20-25 tonnes of shrimps per hectare.

An advanced biofloc-production technology with emphasis on the sustainable intensive farming will be disseminated after further standardization and demonstration of the technology with the involvement of stakeholders.

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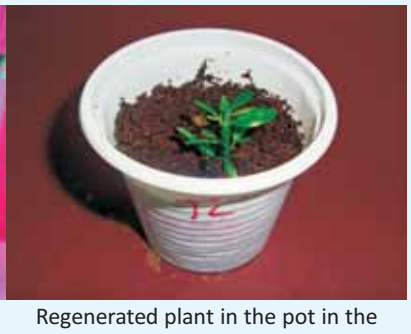
In-vitro propagation of Troyer citrange

In citrus species, success of the scion depends largely on the rootstock on which it is grafted. 'Troyer' citrange (*Citrus sinensis* (L.) Osbeck ×*Poncirus trifoliata* (L.) Raf.) is an important rootstock used worldwide for high-density citrus planting. It is one of the promising rootstocks for many of the commercial citrus species, due to its inherent genetic tolerance to *Phytophthora* disease, citrus tristeza virus and nematodes, which mainly contribute to citrus decline.

The commercial rootstocks are mostly propagated by seeds; and seeds of many citrus varieties are moderately recalcitrant and loss viability within a short period. Also plants grown from seeds exhibit extended juvenility (4 - 10 years); this indicates vegetative propagation and/or micropropagation a desirable propagation method for citrus species.

In-vitro generated plantlets of Troyer citrange



Regenerated plant in the pot in the greenhouse

Calli were initiated on epicotyls, cotyledons, root segments and shoot-tips of 4- week- old *in- vitro*- grown nucellar seedlings of Troyer citrange on different concentrations of callus- inducing growth regulators, individually and/or in combinations. The optimal callus induction response was obtained on Murashige and Skoog medium (MS) supplemented with 80.55µM NAA and 4.65 µM kinetin from all types of the explants; epicotyl showed the highest response. Maximum shoot regeneration was observed in MS medium supplemented with 8.8 µM BA, which was also the highest in epicotyl callus. Root initiation occurred within 14 days; 90% shoots rooted on the rooting medium containing IBA. The best root growth, earliness in length with new shoot emergence occurred on the full MS supplemented with IBA 9.8µM. Rooted young plants were transplanted when they were 5-cm high in the small plastic containers with the sterilized peat-mass.

The method of regeneration in Troyer citrange can be used to provide a system of multiplication in rootstock-screening studies and also in gene transfer.

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Pusa *Pearl* Pasta

Popularity of the pasta in India is growing at a fast pace; pasta market in India is expected to be around ₹ 250-300 crore. Pasta craze has led to FMCG companies in launching of instant pasta variants — Nestle's Pazzta, ITC's Sunfeast Pasta Treat, Bambino's Passta and the likes. Traditionally pasta is produced from durum wheat (*Triticum durum*) semolina and water by forming a homogeneous mixture. There are two major types of pasta—pasta *fresca* (fresh) and pasta *secca* (dried). Over 75% of the market is dominated by dry pasta segment.

Soy incorporated pasta

Carrot incorporated pasta

Mango-peel incorporated pasta

Moringa-leaf incorporated pasta

Owing to rapid industrialization and improved socio-economic status, people are becoming more health conscious, and are keen on high fibre and low fat diet. Thus, use of pearl millet (*bajra*) in preparation of pasta-like products can be advantageous, as *bajra* is rich in vitamin B (especially niacin, B_6 and folic acid), calcium, iron, potassium, magnesium and zinc, besides carbohydrates (67.5%), proteins (11.6%), fat (5%) and fibres (1.2%).

Thus, ready-to-cook "**Pusa pearl pasta**" based on pearl millet and semolina was developed. It was prepared through extrusion processing, and the product has 10.96% protein content, 0.81% ash, 0.65% fat, 71.7mg phenols/100g, 175 g water/100g swelling index,2.08 swelling capacity and 5.57% cooking loss, and is also low in gluten. On organoleptic evaluation, the product has been found of acceptable qualiy.

In the product, functional ingredients (to combat diseases), moringa-leaf, carrot-powder, mango-peel powder and defatted soy flour, were also incorporated. These ingredients not only added functionality but also imparted natural attractive colour to the product. Soy-flour reduces cholesterol, inhibits bone deterioration, relieves menopause symptoms and possesses anti-cancer activity. And carrot possesses following properties: cleanses intestines, is diuretic, remineralizing, antidiarrheal, and is an overall tonic and is antianemic. Some compounds in mango-skin help fight diabetes and also some form of cancer; moringa-leaf supports in healing of the body.

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Cotton-wheat system: a potential alternative to rice-wheat system

A study was carried out with three major non-rice cropping systems—maize-wheat, cotton-wheat, pigeonpea-wheat—and different conservation agriculture practices to replace rice with suitable alternative crops during *kharif* in the north-western plains zone.

All the three systems performed better when were grown on the zero-till broad-bed, narrow-bed or flat-bed with residue than on the conventional-till (CT) flat-bed. The cotton-wheat system under the zero-till broad-bed with residue gave higher system crop productivity, water productivity, energy productivity and efficiency, and net returns than the pigeonpea-wheat or maize-wheat system. Zero-till broad-bed with residue also resulted in significantly higher soil-organic carbon, particularly at the surface (0-5 cm) layer of the soil. Cotton-wheat system out-yielded rice-wheat system, and can be a potential alternative to rice-wheat system.

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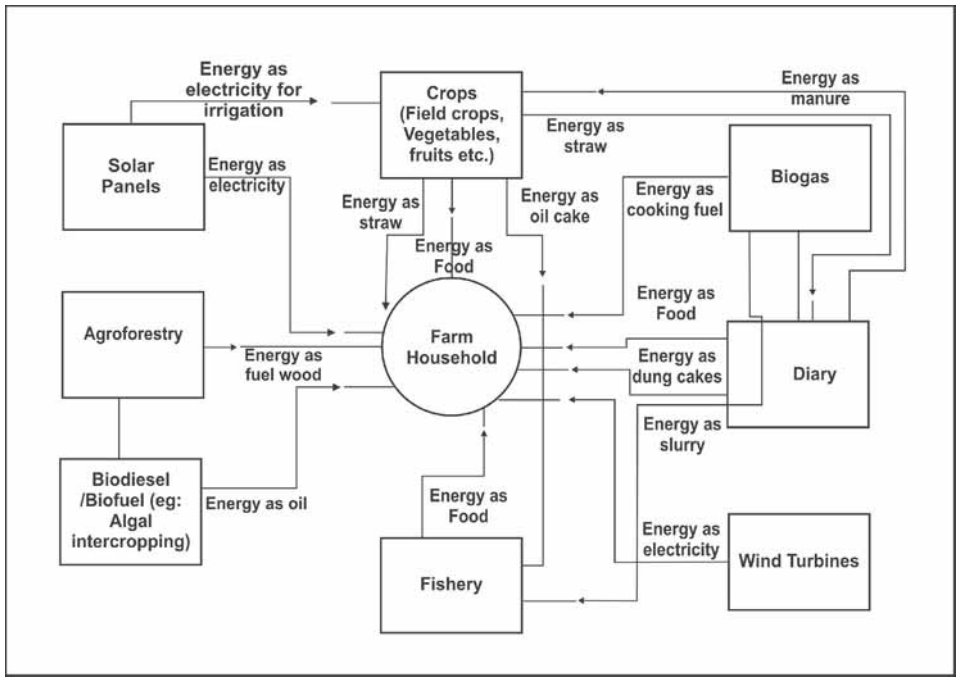
Energy self-sufficient integrated farming systems for livelihood security

Farming systems have to meet multiple demands — supporting livelihood, conserving biodiversity, producing energy, offsetting emissions and adapting to climate change. An energy self-sufficient integrated farming system (E-IFS) that may satisfy/fulfill many of these conditions has been conceptualized in Indian context as well as for global relevance. As a traditional way of farming in India, an integrated farming system represents multiple crops (cereals, legumes, tree crops, vegetables, etc.) and enterprises (animal farming, bee keeping, fish farming, etc) in a single farm. The concept of E-IFS that could make farms energy self-sufficient (or even surplus), especially with modern forms of energy, was studied. Such farms can mitigate large amount of carbon emissions, and can offer resilience to probable climatic changes.



Energy flow among different components of the proposed E-IFS

In the E-IFS concept, the objective is to integrate all direct and indirect sources of energy, which have so far been never explored and thought of in the context of the IFS, though they have potential and utilize-resource recycling and resource conservation options to reduce energy embodied in inputs, such as fertilizers, pesticides and irrigation water.

The E-IFS concept was tested in a small farm (1.25 ha) in Anantpur village of Balasore district of Odisha in eastern India, involving crop-livestock-fishery-agroforestry during 2012-13.

Nine members of the farm-family (6 adult and 3 children) were dependent on the IFS for their livelihood. The IFS model generated an income of ₹ 136,161 from 1.223 ha with a cost involvement of ₹ 68,985. Energy output of the system was 251,854 MJ, with energy inputs of 149,427 MJ from farm activities. Energy requirement of the farm household was 165,170 MJ; out of which energy consumption for the needs of the household through burning of fuel-wood, cowdung-cake and rice- straw was 98,550, 9,592 and 31,937 MJ, respectively. The total energy requirement involving farming and household was 314,597 MJ, and there was net deficit of 62,743 MJ (5,259 Kwh). This energy requirement could be met by exploring renewable energy production from biogas, solar panel and windmill. With these energy sources, burning of fuel-wood, cowdung-cake and rice-straw, which needed 140,079 MJ, could also be avoided, thus making IFS energy self-sufficient (or even energy-surplus).

The integration of modern energy sources with conventional wisdom of the integrated farming as suggested by the concept is presented in the above Figure. The study is a novel attempt to bring energy security in rural India while addressing climate change and biodiversity concerns. It can potentially lead to ensuring sustainable livelihood options to small farmers in India. Whole idea is to produce modern form of energy at the farm itself by linking various interdependent enterprises to bridge energy deficit and to meet future energy demands, and also for offsetting emissions.

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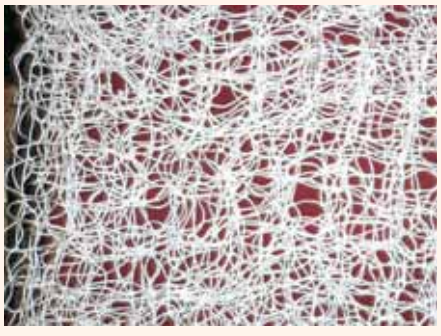
CIFT- GWRL- DSM introduces a wonder fibre to Indian fisheries

The strongest fibre of ultra high molecular weight polyethylene is being introduced into the Indian fishing industry through a collaborative initiative of the Central Institute of Fisheries Technology (ICAR), Cochin; Garware Wall Ropes Ltd (GWRL), Pune; and DSM India Ltd, Mumbai, under the PPP mode. This material developed by the DSM, Netherlands, christened Dyneema and patented by the GWRL under the trade name Plateena is set to make new waves in the Indian fishing industry, choked by rising fuel prices. With one- third the diameter of nylon and one- fourth of its weight, this wonder fibre renders 30-40% fuel saving and has 4-5 times more life, and reduces carbon footprint considerably. The fishing gears made out of this new material promises conservation of aquatic biodiversity and also fuel saving through efficient water filtering.

The ultra high molecular weight polyethylene (UHMWPE) is a type of polyolefin synthesized from the monomer of ethylene. Its fibres made by gel spinning have a high degree of molecular orientation resulting in very high tensile strength and have extremely long chains of polyethylene.

Netting of single knot, double knot and knotless, viz., raschel, can be made with the UHMWPE fibres. The UHMWPE is 15 times stronger than steel on a weight-to-weight basis. The material has high strength, low density and no water absorption, low elongation at break, high abrasion resistance, high resistance to UV radiations and also high resistance to degradation by micro-organisms and to most chemicals except oxidizing acids.



UHMWPE webbing

UHMWPE rope

The most important property of the UHMWPE fibre is its being of thinner material compared to PA and HDPE; thus it develops less drag, resulting in saving on fuel. In addition to drag reduction, the trawls made with Dyneema fibres, especially in the cod-end, maintain their shape and facilitate better filtering, reducing by-catch.

In purse seines, use of the UHMWPE facilitates faster sinking due to better filtering and reduced drag. The netting twines made with Dyneema fibres can be reduced by up to a factor of 2 on thickness (diameter) basis and by a factor of 4 on the weight basis. The UHMWPE is 3 times stronger than nylon of equal dimension and its abrasion resistance is also very good. Nylon purse seines last only for about 2-3 years while UHMWPE netting ensures 2-3 times more life for the net. The Dyneema netting is very resistant to abrasion, tearing and cutting. From the safety point of view, if UHMWPE rope breaks there won't be any backlash unlike steel-wire rope, in which the backlash on snapping can be fatal. Mending and repair of PA and PE nets during fishing often consumes lot of time and money, besides losing fishing days. As this new material is strong and abrasion resistant, the damage during fishing would be minimum.

However, compared to the nylon monofilament,the UHMWPE twine cuts deeper into the fish body, making deep injury giving less chances of survival of the released catch.

Aquaculture sector

On a weight-to-weight basis, cages made with Dyneema netting weighs only up to a third of the weight of a cage made of nylon twine, thus reducing drag. As the twine diameter is less, it improves water flow through meshes resulting in a better exchange of nutrients and filtering out of excreta, making a cleaner and healthier environment for fishes inside the cage. The material resists fish bites when farming is of biting fish species like cod and sea-bream etc. and also prevents attack of predators.

The material in the form of netting and rope is manufactured in India by Garware Wall Ropes Ltd, Pune, under the trade name 'Plateena' with the raw material supplied by the DSM, Netherlands. The only report from Indian waters has been on the use of 'Plateena' rope as the warp lines on a trawler based at Visakhapatnam, and it is reported that it resisted stormy

weather for eight hours without any damage when the net was stuck on the seabed.

Though the material is claimed to have many advantages, the very high cost involved is a major disadvantage. However, more webbing for the same weight is expected to nullify increased cost, besides advantages of better durability, lower maintenance and fuel saving. The Central Institute of Fisheries Technology has taken up the initiative of testing suitability of plateena netting and ropes in the Indian context. Designs of plateena trawls and purse seines have already been made for testing.

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Green fishing to save on fuel

Modern fishing is one of the most energy-intensive methods of food production in the world. Motorized and mechanized fishing operations are dependent on the fossil-fuel, which is non-renewable and limited. Fossil-fuel produces increased levels of carbon dioxide in the atmosphere and contributes to greenhouse effect and other pollutants detrimental to environment and human-health. The upper safety limit for atmospheric CO_2 is 350 parts per million (ppm), and since 1988, its level is found higher than 350 ppm. In May 2013, the atmospheric CO_2 reached 400 ppm at one of the monitoring sites.

World capture fisheries (2005)
(Tyedmers *et al.,* 2005)

- Consumes 50 billion litres of fuel annually
- Releases about 134 million tonnes of CO_2
- 1.7 tonnes of CO_2 released per tonne of live-weight fish landed

Indian capture fisheries (2010)
(Vivekanandan *et al.,* 2013)

- Consumes 1,378.8 million litres of fuel annually
- Releases about 3.60 million tonnes of CO_2
- 1.02 tonnes of CO_2 released per tonne of live-weight of marine fish landed

According to the Marine Fisheries Census of 2010, the marine fishing fleet of India consists of 194,490 fishing vessels; out of which 37% are mechanized, 37% are motorized and 26% are non-motorized.

Modification to the vessel technology, fishing gear modification and adoption of energy- saving operational interventions are the three main approaches, which can make a visible impact to conserve energy during fish harvesting.

The novel features of the new vessel envisaged to be constructed are for optimized hull design with bulbous bow, fuel-efficient propeller design, use of alternate energy for auxiliary purposes and improved sea- keeping characteristics. Modern tools and techniques like software simulation and model testing are being used for designing of the vessel.

A baseline study on the existing mechanized fishing craft and gear has been completed. The benchmarking of the energy consumption parameters of the existing fishing vessels have also been carried out. Data on the gear designs and construction, operation and economic details have also been collected and digitized. This database is the first of its kind.

Components of green fishing systems

Substitution of the conventional synthetic materials like High Density Polyethylene (HDPE) and Nylon (Polyamide) used for fishing gear manufacture with the new generation materials, Ultra High Molecular Weight Polyethylene (UHMWPE), of thinner twines will reduce drag and save energy significantly. Research on design and development of the efficient otter doors, by-catch reduction devices, optimized purse seines and new types of gillnets and lines will also reduce gross energy requirement.

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Myrothecium roridum LG7 delignifies paddy-straw

A new lignolytic micromycete fungus, *Myrothecium roridum* LG7, isolated from decayed wood, was investigated for biological delignification of paddy-straw(agro-residue) and herbaceous weed *Parthenium* sp. Physical and chemical modifications in the biomass following pretreatment with *M. roridum* LG7 for 7 days in terms of structural modifications and lignin removal, changes in lignin skeleton and alteration in cellulose crystallinity were observed through SEM-EDXA, FTIR and XRD analysis techniques, respectively. Colonization of the fungus led to high amount of lignin removal (5.8-6.98 mg/gds) from the pretreated biomass, which can be used as a value-added product. Enzymatic hydrolysis of pretreated biomass by *M. roridum* LG7 released significantly higher amount of sugars (455.81-509.65 mg/gds) on saccharification as compared to respective raw biomass within 24 hr.

Structural changes associated with delignification process through *Myrothecium roridum* LG7

M. roridum LG7 is most suitable for biological pretreatment of biomass as it creates alkaline environment that prevents growth of other contaminants during delignification.

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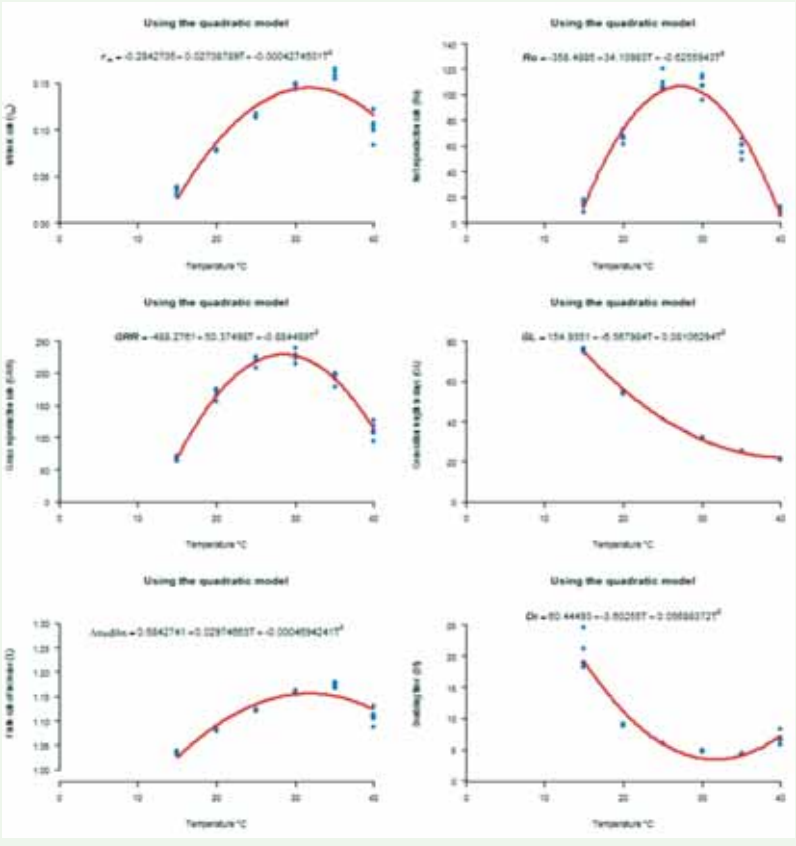
Temperature-based phenology model for mealybug *Phenacoccus solenopsis*

Temperature-dependent population growth potential of *Phenacoccus solenopsis* was studied on the sprouted potatoes in laboratory conditions at six temperatures (15, 20, 25, 30, 35 and 40 °C). Several non-linear equations were fitted to obtained data to model temperature-dependent population growth and species life history. The established equations for each life age/stage of species were compiled to obtain an overall temperature-dependent phenology model. The life-table parameters of *P. solenopsis* were estimated using stochastic simulation centred on a rate summation and cohort up-dating approach.

The developed phenology model was employed in a geographic information system (GIS) for mapping its population growth potential in different geographical regions. The three risk indices — establishment risk index, generation index and activity index—were computed using interpolated temperature data from worldclim database for the current (1950-2000) and the future (2050) climatic conditions. The daily temperature data from four selected weather stations in India — Ludhiana (Punjab), Hisar (Haryana), Junagadh (Gujarat) and Akola (Maharashtra)—were used for analyzing within-year variations of pest population due to seasonal climatic fluctuations.

The developed model predicted temperature between 25 and 35 °C as favourable for *P. solenopsis* development, survival and reproduction. Population attained a maximum net reproductive rate of 107-108 females/female/generation and a total fecundity of 216.6-226.5 individuals/female/generation. The mean length of generation decreased from 75.6 days at 15 °C to 21 days at 40 °C. The maximum finite rate of increase (1.12 - 1.16 females/female/day) and shortest doubling time (4.3 - 6.1 days) were also observed between 25 and 35 °C.

Risk maps indicated that under the current temperature,



Life-table parameters of *P. solenopsis* estimated through model prediction over a range of six constant temperatures: Intrinsic rate of natural increase, rm (a); net reproduction rate, Ro (b); gross reproductive rate, GRR (c); mean generation time, T (d); finite rate of increase, λ (e); and doubling time, Dt (f).

Mealybug *Phenacoccus solenopsis* Tinsley (Hemiptera: Pseudococcidae) is a highly invasive and polyphagous pest, widespread in more than 24 countries in tropics and subtropics. Its outbreak on cotton in Indian subcontinent during 2005-09 devastated cotton economy, due to 30-40% yield losses and increased cost of crop protection. The pest is likely to spread to many other parts of the world in due course due to predicted global temperature increase by 1.5–5.8 °C by the end of 21st century.

P. solenopsis can complete > 4.0 generations per year on ~ 80 % of the global cotton- production areas. The economic losses are likely to occur in areas where at least 8.0 generations of *P. solenopsis* can develop in a year; under current climate ~ 40 % areas fall under this category. The geographical range expansion at higher latitudes, additional 2.0 generations per year and increase of abundance by 4.0 fold are predicted for *P. solenopsis* in tropical and sub-tropical cotton areas due to climate change. Analyses of the within-year variations of population dynamics indicated maximum potential population increase during main cropping season, which reduced considerably during off-season and cooler winter months.

In India, in the present climatic conditions, the risk for *P. solenopsis* establishment and damage is moderately high for the North Zone and high for the Central and South Zones. Entire cotton-growing belt of India is likely to be severely affected with a very high risk of *P. solenopsis* incidence by 2050. Major setback will be to the Central Zone that contributes ≥ 60 % of the total cotton production. With the establishment of the pest in new areas and increased abundance and incidence in the already established areas, the average yield losses in cotton may increase from 54.40 lakh bales (million ₹ 365.97) under current conditions to the tune of 96.0 lakh bales (million ₹ 574.98) by 2050.

The study facilitated a detailed analysis of climate change impact on the activity of *P. solenopsis*. The predictions on the future distribution, survival and abundance of *P. solenopsis* clearly indicate that invasiveness of this pest will be aggravated under the projected climate change.

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Late-maturing mango Clone 77

During the variability survey in the population of mango-seedlings, a very late- maturing seedling-plant (Clone 77) in Bhuskaul village of Samastipur district was identified. Its tree is about 50 years old and bears big-sized fruits (308g/fruit). The farmer could never harvest its tree-ripened fruits (*Tapka*—naturally ripened fruits falling from the tree first), because of late- ripening. Its fruits were analyzed for physico-chemical characteristics, which were excellent; almost similar to Malda cultivar, and recorded TSS of 19.64.4° Brix, which was on a higher side for the season.

Fruits of the seedling-plant are very much similar to Malda, but mature two months later than Malda. These

Physico-chemical characteristics of fruits of the selected clone and mango cv. Malda

Cultivar/clone	Fruit wt (g)	Pulp wt (g)	Seed wt (g)	Pulp (%)	TSS (°Brix)	Pulp colour	Maturity period
Clone 77	234.00	141.00	40.00	60.26	17.20	Light yellow	Mid July
Malda	308.00	201.00	49.00	64.20	19.64	Dark orange	End of August

Whole and cut fruit of Clone 77 showing pulp colour

late-maturing fruits can be sold at the premier market price, besides widening the season of the availability of mango-fruits.

One-hundred- and- fifty grafted plants have been made from this clone for detailed evaluation in replicated trials and for distribution among farmers of Jagdishpur, Mahamda, Murliyachak and Dhobgama villages (Samatipur).

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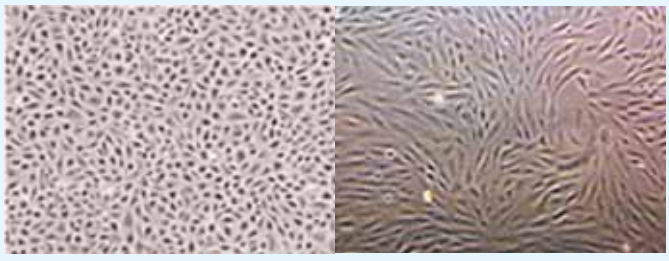
National Repository of Fish Cell Lines

A National Repository on Fish Cell Line has been established to characterize and conserve fish cell lines as well as to provide support for training and education to stakeholders, and to serve as a National Referral Centre of the Indian and exotic fish cell lines in the country.

Currently, the repository is maintaining 27 fish cell lines; deposited by the various research organizations along with the cell lines developed at the Cell Culture Facility at the NBFGR, Lucknow. The cell lines have been successfully cryopreserved in the repository, and have been characterized cytogenetically as well as with molecular markers. The cell lines were authenticated with sequence analysis of mitochondrial genes, *i.e.* 16S ribosomal and cytochrome C oxidase sub-unit I. Further, cell lines have been characterized by chromosomal analysis, transfection efficiency and immune cytochemistry.



Photomicrograph of cell lines. NRFC004 (developed from fin of *Cyprinus carpio*) (*left*), NRFC007 (developed from fin of Koi carp) (*right*)

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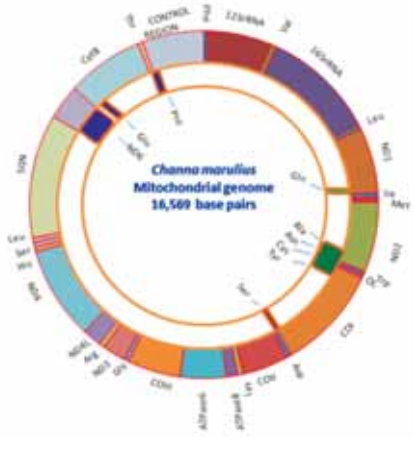
Mitochondrial genomes sequenced of three important fish species

The whole mitochondrial genomes of three commercially important Indian fish species, *Channa marulius,* great snakehead (NCBI accession no. KF 420268), *Clarias batrachus,* walking catfish (accession no.KC 572134), and *Pangasius pangasius,* yellow fin catfish (accession no. KC 572135), were sequenced and found to have 16,569 bp, 16,511 bp and 16,476 bp, respectively.



Gene map of mitochondrial genome of the great snakehead, *Channa marulius*. Genes encoded on the heavy or light strands are illustrated outside or inside the circle gene map, respectively

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Directorate of Water Management, Bhubaneswar

It is a premier institute for research excellence in the field of agricultural water management, and is committing to the welfare of farming community

The Directorate of Water Management (formerly Water Technology Centre of Eastern Region, WTCER) came into existence in May 1988. In April 2009, the WTCER was upgraded as the Directorate of Water Management to cater to research and development needs in the agricultural water management at the national level along with its two All-India Co-ordinated Research Projects on Water Management and Groundwater Utilization. The Directorate is engaged in on-farm water management activities through basic, applied and strategic research in the area of rainwater, canal water, groundwater and waterlogged area situations. The Institute has developed various technological options for different agro-ecological regions of the country to address on-farm water management issues with adequate institutional linkages, infrastructural support and capacity-building.

MANDATE

- To undertake basic and applied research for developing strategies for efficient management of on-farm water resources to enhance agricultural productivity on sustainable basis.
- To provide leadership role and co-ordinate network of research with the state agricultural universities in generating location- specific technologies for efficient use of water resources.
- To act as a centre for training in research methodologies and in technology update in agricultural water management.
- To collaborate with the national and the international agencies in achieving above objectives.

Earth surface's 70 % is covered with water but only 2.7% is available as freshwater. About 77 % of the freshwater is locked up in glaciers and permanent snow, 11 % is available as extractable groundwater (within 800-m depth) and about 1 % is available as surface water in lakes, reservoirs and river systems. The global renewable water supply is about 7,000 m^3 per person per year. A renewable water supply of at least 2000 m^3 per person per year is necessary for a standard living, as in the western and industrialized countries. Globally, therefore, renewable water supply is enough to meet requirement of the present world population. In India, with 4,000 billion cubic metres (BCM) of annual rainfall, average runoff generated is only 1,869 BCM. About 1,123 BCM of this is utilizable water resource — 690 BCM is through surface water and 432 BCM is through groundwater. Out of the surface water, so far about 213 BCM of the storage has been built through major irrigation projects. Another 184 BCM of storage is under construction. Similarly, out of 432 BCM of groundwater resource, 360 BCM is available for irrigation; out of which present usage is only 135 BCM.

VISION

Sustainable development of on-farm water management technologies for enhanced agricultural productivity and improved livelihood under different agro-ecological regions.

INFRASTRUCTURE

Laboratories: The Directorate has state-of-the-art infrastructural facilities and has four well-equipped laboratories— soil-water-plant relationship laboratory; irrigation and drainage laboratory; hydraulic laboratory; and plant science laboratory. There is also an engineering workshop and photographic laboratory. Besides, four field laboratories are at the farm: meteorological laboratory; pressurized irrigation system; solar photovoltaic pumping system; and agricultural drainage system. The institute has its own web server and regularly updated website (www.dwm.res.in). The entire network administration of computers, internet and website management is looked after by the ARIS Cell,which also accommodates a fully developed GIS laboratory.

Academic: The Directorate has a main office-cum-laboratory building with museum, conference hall, cartographic room, library hall, 50- seat- capacity air-conditioned committee room with video-conferencing facility, and one air-conditioned conference room of 150 sitting- capacity. It also has a training hostel. **The Directorate has been recognized by the Indira Gandhi National Open University as a study centre to conduct diploma course on Watershed Management and also recognized as a nodal centre for pursuing Ph.D programme by Utkal University.** The Directorate conducts M.Sc dissertation courses in Environmental Sciences, Biotechnology and Life Science from different recognized Universities.

Library: It has more than 1,800 reference books and subscribes to 24 international and 17 national journals. It also maintains a CD-ROM Server with a bibliographic database from the AGRIS, AGRICOLA and Water Resources Abstracts. These databases are accessible to an individual scientist through LAN.

Farm: The central research farm (63.71 ha of farm land), located at Deras, Mendhasal (20°30' N and 87°48' E), is 30-km away from the main complex, and has a slope of 1-3% ,representing all land types — upland, medium land lowland and waterlogged area. A canal system

PROGRAMMES AND ACTIVITIES

Research: They are five main programmes: 1. Rain-water management, 2. Canal water management, 3. Groundwater management, 4. Management of waterlogged area, and 5. On-farm Research and Transfer of Technology.

Different centres operating under the All-India Co-ordinated Research Project on Water Management are engaged in evaluation of pressurized irrigation system; management of rains and other natural sources of water; basic studies on soil- water- plant relationships and their interactions; water management in different agricultural production systems including horticultural and other high-value crops. Similarly, centres operating under the All- India Co-ordinated Research Project on Optimization of Groundwater Utilization undertake research work in regional groundwater assessment and modeling; conjunctive use of surface and groundwater; artificial groundwater recharge; and groundwater pollution.

The initiative of "Water Platform" will focus on emerging researchable issues like agricultural water management under changed climate scenario, aquacultural water management and water management in animal husbandry to give further boost to land-and-water productivity.

Extension and training: Farmers participation in the irrigation management has taken the centre stage. **Transfer of irrigation management responsibilities from government agencies to farmers under water-user association (WUA) umbrella is now an important policy.**

Under the scheme "Scaling up of Water Productivity in Agriculture for Livelihoods" aim was to train farmers and trainers with the help of on- station and on-farm demonstrative units on different water management technology models at the different locations.

Through another outreach programme "Farmers' Participatory Action Research Programme", multiple use of water, use of recycled water for irrigation and application of Treadle pump technology for irrigation were demonstrated at 100 locations in 5 agroclimatic zones. Application of these technologies saved water from 8 to 33 % and increased crop yields up to 38%.

To strengthen computing skills, scientists and researchers of eastern region were trained in the application of advance statistical tools and techniques using SAS software.

Education: The Directorate serves for dissertation work for M.Tech. in Soil and Water Conservation Engineering; M.Sc degree in biotechnology, environmental sciences; B.Tech. training courses for students from different basic universities as well as from the State Agricultural Universities. It regularly holds training programmes, summer and winter schools, and frontier-level advanced training programmes, including use of remote sensing and GIS, for scientists, officers and teachers from the basic and agricultural universities and other Institutions.

Policy support: With back-up of repository of information and faculty, the Directorate serves as a platform for deliberations on various national issues related to agricultural water management through brainstorming sessions and other high-power committee meetings.

TECHNOLOGIES DEVELOPED BY THE DIRECTORATE

Rubber-dam for watersheds

A rubber-dam is an inflatable and deflatable structure used for regulating water flow. When it is inflated, it serves as an agricultural weir (low-level dam) and when it is deflated it functions as a flood mitigation device. This technology has a potential to create an additional water storage capacity of about 52,000 m^3 to 80,000m^3 for irrigating about 30-40 ha of paddy in *kharif* and 6 ha of pulse, oilseed and vegetable crops in *rabi*. The productivity of rice in *kharif* was found enhanced up to 62% and productivity of vegetables in *rabi* enhanced up to 47 % due to installation of rubber-dams in watersheds. In addition, it has potential to enhance net returns of farmers up to ₹ 48,000/ ha.

Rainwater conservation for rice-fish integrated system

In rice-field (8-10% of its total area), a small dugout pond of 2.0 to 2.5 m depth and 1:1 side slope is beneficial at downstream. The pond is used for short-duration aquaculture during monsoon, and its embankment can be used for growing horticultural crops. Conserved rainwater is used for supplemental irrigations for *kharif* paddy and for irrigating *rabi* crops. The *kharif* paddy yield increased from 1.8 tonnes/ha for 4.9 tonnes/ha and fish yield was 1.4 tonnes/ha. The output per unit area was ₹ 67, 000/ha. The technology helps in *in-situ* conservation of rainwater for drought-proofing and bringing crop diversification in the rainfed ecosystem.

Raised- and- sunken bed technology for canal command

Out of the total land area of the eastern region, about 48 % (12.9 mha) is under rainfed lowland and only 21.3 % (5.7 mha) is irrigated. For food and livelihood, farmers of this region heavily depend on the rainfed and irrigated medium and lowland ecosystem.

Raised beds, each of 30- m length and 5 m- width and 60- cm height than the adjacent sunken beds, are raised by placing dugout soil over the adjacent strip. The top 20-30-cm soil of the raised bed remains unsaturated and can be used for cultivation of vegetable crops. Rice or crops like *Colocasia* can be grown simultaneously in the adjacent sunken beds where soil remains submerged. Fish spawn can also be raised up to fingerling stage in the sunken beds together with rice within 90 days. Practice of raised- and -sunken bed technique for crop diversification improved productivity of water in lowlands over the conventional system of rice cultivation.

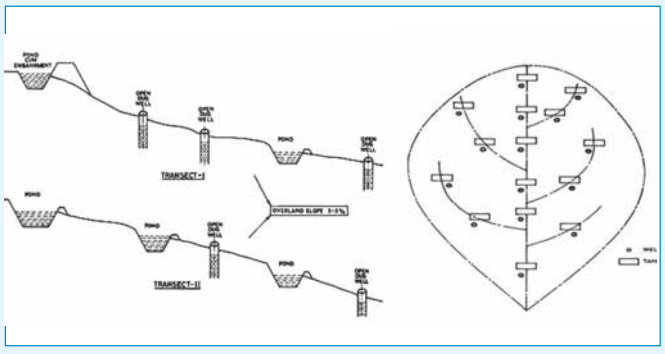
Sub-surface water-harvesting structures for coastal areas

Below the sub-surface profile, freshwater floats above the saline water in the coastal waterlogged areas. This

could be tapped through sub-surface water- harvesting structures (SSWHS). The system is helpful in mitigating early drought during *kharif* and provides irrigation for *rabi* and summer crops. To lift water from these structures, 1-2-hp pumps are recommended to avoid ingression of saline water into freshwater layer. The depth of the structure should be restricted up to 5 m (i.e. within sandy zone). These structures act as an off-season source for increasing cropping intensity and crop productivity.

Micro- level water resource development through tank-cum-well system

The tank-cum-well system technology along the drainage line in a watershed is recommended for plateau areas with slope of 2 to 5%. The well is constructed about 100 to 300 m downstream of the tank to tap water that is lost by seepage from the tank. The technology has the potential to generate ₹ 50,000 extra gross income / year with additional employment generation of 115 man days/ha, and can increase cropping intensity to 166%.



Crop diversification with *in-situ* rainwater conservation for drought mitigation

The technology is suitable for rainfed upland ecology where rice productivity is low (<1 tonne/ha) and unstable. Crop diversification by adopting maize, groundnut, pigeonpea, cowpea through sole or intercropping following ridge-and-furrow methods of sowing will generate stable and higher income (₹ 20,000 – 25,000/ha/annum).

Biological drainage for reclamation of waterlogged lands in high-rainfall areas

In the deltaic region of Odisha with flat topography with slope of around 0.02% in the upper reaches, decreases to about 0.01% in the coastal proximal areas, makes drainage difficult, especially in the high-rainfall situation. The use of bio-drainage vegetation appears feasible in deltaic areas in the inland topographical depressions and in the areas where natural drainage is incapacitated by sea- water intrusion.

Eucalyptus was planted at the inland sites and *Casuarina* was selected for raising biodrainage plantation because of its salt-tolerance ability in coastal waterlogged sites.In topographically depressed areas *Eucalyptus* plantations tolerated both surface waterlogging during monsoon and sub-surface waterlogging during rest of the season. Even under severe waterlogging, *Eucalyptus* plants could survive.

Pond -based farming system for deep waterlogged areas

Due to poor drainage, saucer-shaped topography and high monsoon rainfall, some parts of east coast of India remain waterlogged (> 1m surface waterlogging) and unproductive. To stabilize and enhance net income from such a waterlogged ecosystem, pond-based farming technology (deep water rice in *kharif* + salt tolerant vegetables like watermelon, lady's finger, spinach, chili

in winter + on-dyke vegetables-fruits + fish inside pond) was conceptualized and implemented in the deep-waterlogged areas (1-2.5- m water depth) of Puri district, Odisha. The technology can generate additional net returns of ₹25,000-30,000/ha/annum with increased water productivity of ₹7.2/m^3 from the system.

Integration of water chestnut cultivation and aquaculture technology

Aquatic crop like water chestnut (*Trapa bispinosa*) has natural adaptability to grow under the environment especially in areas where water stagnation above the ground extends for more than six months in a year. Due to aquatic habitat, water chestnut has resurrection ability despite exposure to brief submergence or flash flood. The crop gradually adjusts itself with rise in water level to keep its leaf crown afloat. In fish-water chestnut integration, highest growth was obtained when cat fish like Magur (*Clarius batrachus*) was reared with water chestnut. Under this co-production system fish gets natural food, even in the presence of supplemental feed. Thus under controlled condition, 25-30% feed can be reduced during each meal. It also results an increase in gross and net water productivity and net water productivity

Enhancing productivity of seasonal deep waterlogged areas of coastal region

To enhance productivity of seasonal coastal waterlogged area (occurs due to poor drainage, saucer-shaped topography and high monsoon rainfall), soil resources, hydrological parameters and agro-climate were analyzed and pond- based farming technology (deep water rice in *kharif* + watermelon, lady's finger, spinach, chili in winter + on-dyke vegetables-fruits + fish inside pond) was conceptualized and implemented in the representative deep waterlogged areas (1-2.5 m water depth) of Puri district, Odisha.

With the implementation of the technology, the net water productivity enhanced from ₹1.4/m^3 in rice to ₹7.29/m^3 and net returns of ₹22,100 to 26,735/ha were obtained from the system.

runs within the farm periphery from the Deras minor irrigation project and facilitates research programmes on the canal water management. The farm is equipped with all farm machineries, automatic weather station, Bowen ratio tower with automatic data logging facilities for measurement of various soil and weather related parameters.

ACHIEVEMENTS

- Designed and developed rubber-dams for watersheds.
- Designed raised- and- sunken bed system for medium and low lands to achieve crop diversification and higher cropping intensity.
- Micro- level water -resource developed through tank-cum-well system.
- In the rainfed agro-ecosystem, increased dyke height for *in-situ* conservation of rainwater, nutrients and sediments in leveled rice- lands with light- to medium-textured soil.
- Two-stage rainwater conservation and multiple- use management of conserved rainwater in the rainfed rice- lands.
- Designed secondary reservoir for efficient storage and utilization of rainwater.
- Planned and designed soil-and-water conservation structures in the watersheds for sustainable crop production
- Integration of System of Rice Intensification (SRI) method of rice with fish culture.
- Development of regional groundwater recharge and flow-simulation model using soil-water balance approach and MODFLOW.
- Standardization of designs and evaluation of sub-surface water harvesting structures in coastal waterlogged areas.
- Standardization of design of surface drainage structure in Kushbhadra-Bhargavi *doab* for enhancing drainage intensity.
- Standardization of package of practices for bio-drainage in waterlogged areas.
- Package of practices for cultivation of aquatic and semiaquatic crops with integrated aquaculture, and of medicinal plants for productive utilization of waterlogged areas.
- Developed contingent crop planning for post- flood situations in the waterlogged areas.
- Developed strategies for suitable use of brackishwater shrimp farming interfaced with paddy growing coastal area.

- Standardization and transfer of technologies on water-use efficiency for 52 crops across different agro-ecological regions.
- Assessed irrigation performance of Water User Associations (WUA) under the Participatory Irrigation Management (PIM).
- Assessment of water demand and supply at distributary/minor/sub-minor levels in different reaches in 14 major command areas of India.
- Development, refinement and standardization of drip fertigation technology for major cash crops and vegetables for different agro-ecological regions.
- Conjunctive use of freshwater and poor quality water in canal commands.

THRUST AREAS DURING XII PLAN

- Development and management of on-farm water resources for sustainable crop production, efficient use of irrigation water per unit area and promoting multiple use of water in agricultural production to enhance water productivity.
- Development and evaluation of location-specific rainwater-harvesting techniques and their impact on hydrology and agriculture.
- Promotion of basic research on soil-plant-water-atmospheric-environment relationship.
- Development and promotion of water-saving technologies for sustainable crop production.
- Design and evaluation of canal irrigation system and development of strategies for performance improvement.
- Assessment of groundwater development, energy-use patterns and dynamics of groundwater market for optimal utilization.
- Development of mathematical model to address groundwater planning issues, including suitability of areas and identification of location-specific structures in hard-rock areas.
- Coastal waterlogged and salinity area management and checking of further degradation of water resources.
- Development of mitigation and adaptation strategies on water management for meeting climate change challenge and evolving strategies for climate resilient agriculture
- Promotion of basic and strategic research on agricultural water management using frontier tools like remote sensing, GIS, information technology and nanotechnology for sustainable water productivity and farm profitability.

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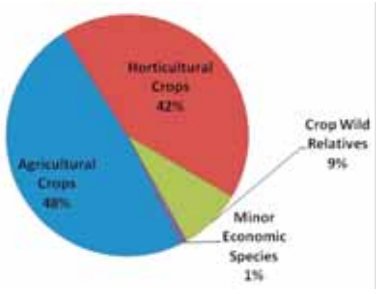
Plant genetic resources from NEH region involving KVKs

The North-Eastern Hill (NEH) region as the 'gateway' for much of India's flora and fauna is with a high level of endemism. The prevalence of rich diversity, high endemism, availability of rare, endangered and threatened taxa have made this region a potential site for the collection of desired germplasm.

During 2011-2013,the NBPGR launched a special drive for collection, involving KVKs, crop-based institutes and SAUs.Mainly coarse-grid surveys were conducted since most of the areas were part of the previously unexplored/ or underexplored regions and little or nothing was known about ecotypic or agricultural variation patterns. Efforts were made to collect landraces of known trait(s) with the help of KVKs from the household stores located in remote and disturbed areas. Thirty-one explorations were carried out in 69 districts of Arunachal Pradesh, Asom, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. In vegetables, rich diversity was collected of leafy mustard (73), chilli (59) and cucurbits, mainly ash-gourd (42), bittergourd (29), bottlegourd (37), cucumber (72), *Luffa* (68), pumpkin (82), teasle-gourd (96), and vegetable cowpea (28). Since NEH region is the centre of diversity for cucurbits, efforts were made to enrich species/ taxon diversity in *Cucumis* (5), *Cucurbita* (4), *Momordica* (4), *Solanum* (7), *Trichosanthes* (8), etc. In paddy, besides collecting germplasm of known landraces, efforts were made to collect trait-specific germplasm (scented, deep-water and cold tolerance) and their wild genepool from the ecologically diverse regions.Rare deep-water paddy landraces — *Batu*, *Indi*, *Mia*, *Dol*, *Jul*, *Idulia*, *Ad*, *Dhepa*, *Tulsi*, *Dubari*, *Ikarasali* and *Dhusuri* from Asom; cold-tolerant landraces, *Lahi*, *K.Botha*, *Sikota Lahi* and *Dal Boradhan* from the eastern parts of Arunachal Pradesh and good-to-taste landrace '*Signal*' from Tripura were collected.



First-time collected rare species confined to the NEH region are: *Citrus ichangensis* (Nagaland), *Trichosanthes truncata* (Arunachal Pradesh), *T. himalensis* (Sikkim) and *T. cordata* (Manipur and Asom); besides collection of *Cucumis hystrix* (Mizoram), wild *Citrus medica* (Asom) and *Allium hookeri* (Sikkim).

Among the wild relatives of crops, rich diversity was collected of *Allium hookeri* (7), *Cucumis hystrix* (8), *Oryza rufipogon* (46), *Trichosanthes tricuspidata* (30), *T. wallichiana* (21) and *T. lepiniana* (11).

In the NHCP, 26 taxa, not earlier represented, were added. Some salient herbarium specimens collected include: *Boehmeria penduliflora*, *Camellia kissii* var. *confusa*, *Capsicum baccatum*, *Cucurbita ficifolia*, *Elaeagnus conferta*, *Machilus edulis*, *Nostolachma khasiana*, *Parkia timoriana*, *Piper boehmeriifolium*, *Setaria palmifolia*, *Solanum lasiocarpum* and *Swertia bimaculata*.

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Bundel lobia 4 fodder cowpea for the North-Eastern Zone

This fodder cowpea variety was approved for the North-Eastern Zone by the Varietal Identification Committee at the annual group meeting of the All-India Co-ordinated Research Project on Forage Crops held at the BAIF, Development Research Foundation, Urulikanchan, Pune (Maharashtra) on4-6 May 2012. The variety showed superiority of 10.20% and 14.10% for green fodder and 10.00% and 10.70% for dry matter yield over the zonal check (UPC 622) and the national check (UPC 5286), respectively. For per day productivity of green fodder and dry matter yield in q/ha/day, its superiority was 9.34% and 14.20% for green fodder and 10.63% and 12.90% for dry matter yield over the zonal check UPC 622 and the national check UPC 5286, respectively.

Bundel lobia 4 also appeared resistant to biotic stresses: was found free of diseases; yellow mosaic virus; showed least incidence of aphid and flea beetle, and was better than the checks in agronomical experiments, grain quality and adaptability.

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Productivity potential of Bhimal, Dehra Dun

High-yielding provenances (HYP) of Bhimal(*Grewia optiva)* (IC Bhaintan, IC Chamba and IC Malas) were multiplied in the polyhouse to raise 1,200 healthy saplings. The saplings were transported to four different sites (Almas, Ranigaon(middle elevations); Sabhawala, Selakui(valley locations) for multilocation testing. Plant height, collar diameter, crown length and width were recorded at the time of planting of saplings; average plant height ranged from 103.1 (Sabhawala) to 140.7 cm (Ranigaon). After first year of planting, marked differences of locations were reflected in respect of the growth parameters, which could be directly attributed to genotype × location interactions. Initial trends of Bhimal-plants showing faster growth in valley locations, recorded in the first year of planting (2007) in respect of the plant height and other growth parameters in comparison to the middle elevations, were consistent in the fifth year. Fresh fodder productivity ranged between 0.392 and 0.612 kg/ plant at the valley locations (Sabhawala, Selakui) in comparison to the middle elevations (0.150 to 0.225 kg/ plant) at Ranigaon and Almas, respectively. Similarly, dry fuel-wood productivity ranged from 0.286 to 0.510 kg/ plant at the valley locations with an average of 0.407 kg/ plant, which was 1.73 times higher than at the middle elevations.

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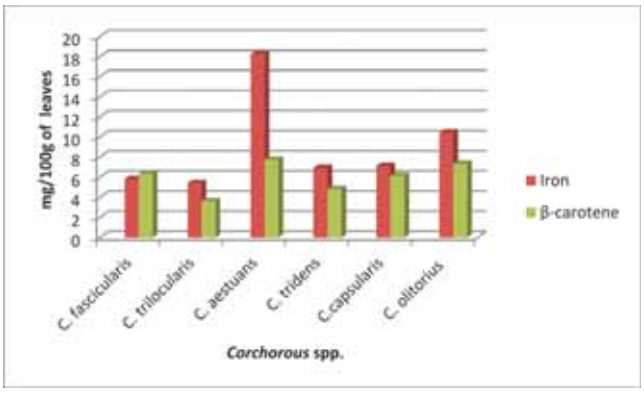
Tossa jute: A nutritive leafy vegetable

Jute is an important bast-fibre crop, traditionally grown in India and Bangladesh. In African and Asian countries, including India and Bangladesh, tender stem and top leaves of jute are being consumed. Despite such traditional use of jute as leafy vegetable, there is no information regarding its nutritional status , in general, and cultivated species, in particular.

Seventeen jute genotypes, representing two cultivated (*Corchorus olitorius* and *C. capsularis*) and four wild (*Corchorus fascicularis*, *C. trilocularis*, *C. aestuans* and *C. tridens*), were evaluated for growth (leaf area, foliage yield) and nutritional (crude protein, potassium, iron and β-carotene content) parameters. Tossa jute (*C. olitorius*) has been identified nutritionally superior to rest of the jute species for most of the growth and nutritional parameters except iron; for which *C. aestuans* outperformed. Given the nutritional superiority of *C. olitorius,* which is the most popular cultivated species grown in almost 90% of jute- growing areas, importance of jute in food security of the region can be well understood. Moreover, Tanganayika- a tossa jute exotic accession from Africa, which has been extensively used in tossa-jute breeding programme (for fibre), also recorded high content of iron, potassium



and β-carotene. The finding highlighted importance of exotic collection of crop species in breeding for diversified uses. Among tossa jute varieties, JRO 204, JRO 8432, JRO 524 and S 19 have been identified as better source of leafy vegetable than the rest of the varieties due to their higher foliage yield and nutritional superiority. Paradoxically, *C. aestuans,* which has poor culinary values and lower foliage yield, contains very high iron and β- carotene in leaves. Hence these species can be effectively used as donor parents for introgression of genes in iron-and- β-carotene deficient lines, which otherwise exhibit high foliage yield potential.

Further, all these traits are being governed by additive type of gene action. Hence, directed selection may be effective for improvement of these traits.

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New vegetable varieties/hybrids

The AICRP (VC) has added four new high- yielding open-pollinated varieties and seven hybrids of vegetables. They have been identified and recommended for release and notification for different agroclimatic zones of the country during the XXXI st Group Meeting, organized at the CSK, HKPVV, Palampur (Himachal Pradesh).

Open-pollinated cultivars

Crops	Varieties	Recommended Agroclimatic Zones	Characteristic Features
Tomato	**VRT 0801 (Kashi Aman)** 	IV (Punjab, Uttar Pradesh, Bihar and Jharkhand)	This is a determinate tomato variety. Its fruits are round and firm with pericarp thickness of 0.52-0.57cm. Average fruit weight ranges from 80 to110 g with 3-4 locules. The fruits are attractive red with an average total soluble solid content of 4.6° Brix at red- ripe stage. The yield potential of the variety ranges from 50 to 60 tonnes/ha. This variety is resistant to ToLCV
Capsicum	**DARL 70** 	I (Jammu and Kashmir, Himachal Pradesh and Uttarakhand)	It is derived from an introduction and pure-line selection from Garampani region of district Nainital (Uttarakhand). Its fruits are uniform, green in colour with smooth, thin and bright skin. Fruit bearing is pendent with 3-4 lobes per fruit. It is field tolerant to *Fusarium* wilt and powdery mildew, and its yield potential is 20-22 tonnes/ha in the field
Bittergourd	**Sel 1 (Pusa Aushadhi)** 	VI (Rajasthan, Gujarat, Haryana and Delhi)	This is suitable for cultivation in spring-summer in the north Indian plains. Its fruits are light-green, medium long (16.5 cm) and medium thick (6.0 cm) with 7-8 continuous narrow ridges; average fruit weight is 85 g. The crop is ready for harvest in 48-52 days after sowing. Its average yield potential is 20-22 tonnes/ha
Brinjal	**HABR 21** 	IV(Punjab, Uttar Pradesh, Bihar and Jharkhand)	Plants are intermediate in growth habit; with semi-upright stems and leaves are green. Fruits are round (18-20 cm), black with dark-purple calyx. The average fruit weight varies from 300 to 350 g. The yield potential ranges from 55 to 60 tonnes/ha

Hybrids

Crops	Hybrids	Recommended Agroclimatic Zones	Characteristic Features
Chilli	**Vidya** 	IV (Punjab, Uttar Pradesh, Bihar and Jharkhand)	This hybrid has medium plant height (70 cm); green leaf colour; and intermediate branching habit. Its fruits are long (12–14 cm), light- green, mildly pungent with very strong calyx attachment, and their surface is wrinkled. The yield potential of green-fruits ranges from 20 to 22 tonnest/ha. It is tolerant to *Fusarium* wilt

Crops	Hybrids	Recommended Agroclimatic Zones	Characteristic Features
Tomato	**Bhagya** 	VI (Rajasthan, Gujarat, Haryana and Delhi)	Its plant growing habit is determinate type. Fruits are flat, round, bright-red with uniform green on fruit-shoulders, have sour taste, and good firmness; are suitable for transportation. The average fruit weight is 80-90 g. This is an early hybrid, ready for harvest after 60-65 days after transplanting. Its yield potential is 30-35 tonnes/ha. This is tolerant to ToLCV
Bottlegourd	**Anurag** 	IV (Punjab, Uttar Pradesh, Bihar and Jharkhand)	This is a high- yielding, early-maturing hybrid with uniform and continuous fruit-bearing characteristic. Vines are vigorous, glossy green. Fruits are tubular, 35-40- cm long, glossy green with average fruit weight of 800-1000 g and fruits are suitable for long distance transportation. Crop is ready for harvest in 50-55 days after sowing. Its yield potential is 30-35 tonnes/ha. This is tolerant to powdery mildew
Ash-gourd	**DAGH 16 (Pusa Urmi)** 	VI (Rajasthan, Gujarat, Haryana and Delhi) and VIII (Karnataka, Tamil Nadu and Kerala)	This hybrid is suitable for growing in both spring-summer and *kharif* seasons. Vines are medium-long (average length: 7.5m) and fruits are oblong ellipsoid with greenish- white rind and white flesh. Average fruit weight is 8-10 kg and average number of fruits per plant is 4.60. Its average yield is 47.5 tonnes/ha. Seeds are creamy- white
Ash-gourd	**DAGH14 (Pusa Shreyali)** 	IV (Punjab, Uttar Pradesh, Bihar and Jharkhand)	This hybrid is also suitable for spring-summer and *kharif*. Vines are medium-long (7.0 m) and fruits are cylindrical with white rind and white flesh. The fruits weigh 10.5kg and are ideal for easy packing and long distance transportation. Its average yield is 52.0 tonnes/ha. Seed is creamy-white
Capsicum	**PRCH 101** 	I (Jammu and Kashmir, Himachal Pradesh and (Uttarakhand)	The hybrid is intermediate in branching habit; on an average 4 primary branches/plant are observed. Each plant bears 9-10 fruits. The fruit shape is blocky with 3-4 lobes; is 10-cm in length and 16 cm in girth; pedicel is 3.38 cm and average fruit weight is 80 g with mild pungency. It takes 60-65 days for first fruit harvest. Average yield potential of this hybrid is 30-32 tonnes/ha
Cabbage	**KTCBH 81** 	I (Jammu and Kashmir, Himachal Pradesh and Uttarakhand)	This is the second F_1 hybrid of cabbage released from the public sector. The hybrid has dark-green, 12-14 non-wrapping waxy leaves at harvest. Plant height is 22-25 cm; head is round shaped; compact and covered with outer leaf. It is ready for harvest in 60-65 days after transplanting and has very good field staying capacity (20-25 days) after head formation. Its average yield of potential is 40-45 tonnes/ha

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Seeds of pole-type Frenchbean landraces

In Mizoram, Frenchbeans are grown for green pods, to be used as fresh vegetable; and dried seeds are used as a pulse and for seed purpose, while foliage is consumed as fodder and also for restoring soil fertility.

Twenty-eight landraces of pole-type Frenchbean were collected from the different districts of Mizoram, and their seeds were multiplied and evaluated for qualitative and quantitative traits. Genotype MZFB 84 seeds are dark blue, MZFB 92 has purple seeds and MZFB 100 has orange-coloured seeds. Majority of the landraces showed cuboid- or kidney-shaped seeds, except MZFB 82 and MZFB 93 (Truncate fastigate). Collected germplasm are under mass multiplication, and will be deposited in the National Gene Bank, NBPGR, for long-term conservation.

Seed morphological characteristics of pole-type vegetable Frenchbean landraces

Local reference name	Place of collection (District)	Seed traits		
		Seed size (mm)	Seed colour	100-seed wt (g)
MZFB 80	Serrchip	17.25×8.39	Brown	46.1
MZFB 81	Serrchip	13.77×7.26	Black	30.2
MZFB 82	Serrchip	12.67×7.35	Brown	36.1
MZFB 83	Lunglei	14.78×7.80	Brown	33.7
MZFB 84	Lunglei	14.67×7.78	Dark blue	38.0
MZFB 85	Lunglei	14.57×7.60	Brown	30.8
MZFB 86	Lunglei	17.06×8.38	Brown	42.4
MZFB 87	Lunglei	16.55×7.73	Brown	40.8
MZFB 88	Lunglei	16.25×7.56	Light brown	42.7
MZFB 89	Lunglei	17.13×8.43	Brown pale dark	38.2
MZFB 90	Lunglei	17.78×6.38	Dark brown	31.7
MZFB 91	Lunglei	15.94×7.91	Brown pale dark	41.3
MZFB 92	Lunglei	16.61×7.72	Purple	40.5
MZFB 93	Lunglei	14.98×8.76	Brown	36.1
MZFB 94	Saiha	14.80×6.97	Black	26.1
MZFB 95	Saiha	16.73×8.54	Light brown	40.8
MZFB 96	Saiha	13.81×8.40	Dark brown	33.4
MZFB 97	Lawngtlai	16.17×7.76	Dark brown	50.3
MZFB 98	Lawngtlai	15.36×8.14	Black	41.4
MZFB 100	Lawngtlai	17.12×7.56	Orange	50.15
MZFB 101	Lawngtlai	12.16×6.51	Black	25.3
MZFB 102	Lawngtlai	15.48×7.15	Light brown	32.14
MZFB 103	Aizawl	12.95×7.41	Brown	31.4
MZFB 104	Saiha	17.04×10.04	Light brown	42.5
MZFB 105	Saiha	15.35×6.79	Black	32.6
MZFB 106	Lunglei	14.16×7.77	Black	36.7
MZFB 107	Lunglei	12.53×6.46	Dark brown	31.1
MZFB108	Lunglei	12.84×7.72	Dark brown	31.3


MZFB 80


MZFB 81


MZFB 85


MZFB 86


MZFB 90


MZFB 91


MZFB 95


MZFB 96


MZFB 101


MZFB 102


MZFB 105


MZFB 106

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from Mizoram


MZFB 82

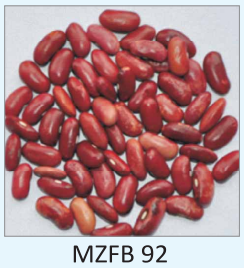

MZFB 83

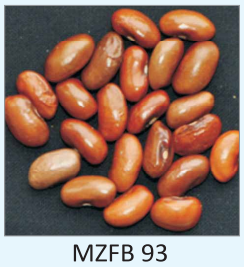

MZFB 84


MZFB87


MZFB 88

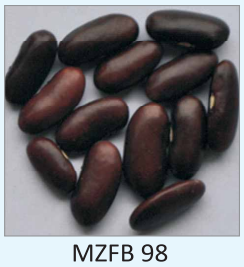

MZFB 89


MZFB 92


MZFB 93

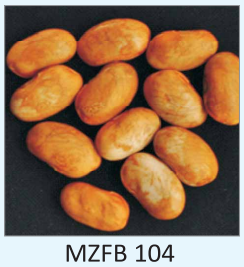

MZFB 94


MZFB 97

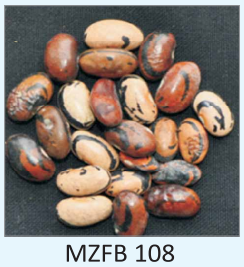

MZFB 98


MZFB 100


MZFB 103


MZFB 104


MZFB 107


MZFB 108

Diversity in morphology of seeds of Frenchbean landraces

Power-weeder for mound cassava

A power-weeder suitable for cassava planted in mounds at row spacing of 75 cm× 75 cm and intra-mound spacing of 30-40 cm has been developed by improvising a commercial light-weight mini roto-tiller.

The prototype consists of a petrol engine (0.5-hp; 4-stroke), central weeding assembly, offset weeding rotor, handle, and a depth control-cum-resting lever. Four blades are mounted on the central axis of the weeding assembly. The main rotor removes weeds on the flat-bed in between rows while offset rotor removes effectively weeds spread over the mounds.

Width of coverage is 35 cm and depth of operation extends up to 5 cm. The weeder is found to be effective in removing all major types of weeds in cassava-plot in hilly terrain without damaging geometry of mounds as well as tubers. The unit is very handy, weighs only 15 kg and hence any women-operator can work easily without fatigue with this. Hand-arm vibration and sound pressure are under acceptable limits.

Cost of the prototype is estimated at ₹18,000. It is economically viable with fuel consumption limited to 0.55 litre per hour and requires two labourers with desirable rest pause. The machine performs well between rows on both the directions with acceptable weeding efficiency of 93% and with negligible damage to tubers (0.68%), field capacity of 0.16 ha/day, and field efficiency of 70%. The weeder fulfills agronomical requirement of weed control in mound cassava. The power-weeder would be very useful for cassava-farmers as well as marginal and small farm holders.

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Swarna Vaidehi — The First *Makhana* variety of India

Euryale ferox, an important aquatic crop, commonly known as Makhana, Gorgon-nut or Fox- nut, is grown in the stagnant perennial water-bodies like ponds, land depressions, oxbow lakes, swamps and ditches. Its commercial cultivation is limited to North Bihar, Manipur, parts of West Bengal and Madhya Pradesh.

Keeping in view its commercial importance, a makhana (*Euryale ferox*) variety Swarna Vaidehi has been developed through pure-line selection. It has production potential of 2.8-3.0 tonnes/ha in the farmers' fields, which is almost 2-fold higher than the traditional cultivars. The Institute Variety Release Committee has approved its release for Bihar, Asom, Chhattisgarh and Odisha.

Makhana cultivation technology in cropping-system mode has also been developed, wherein makhana is grown at a shallow water-depth of 30 cm. After makhana, wheat / berseem or other *rabi* crops like lentil, chickpea or vegetables could be cultivated in the same field. Swarna Vaidehi could be grown successfully in the stagnant water- bodies and also in the field.

Makhana-fish-water chestnut cultivation in the integrated mode is also gaining popularity among stakeholders. Makhana is being grown commercially only in approximately 13,000 hectares with approximate seed yield of about 21,000 tonnes in Darbhanga, Sitamarhi, Madhubani, Saharsa, Supaul, Araria, Kishanganj, Purnea and Katihar districts of Bihar.

Field method of makhana cultivation (extreme *left*), harvesting of nuts (*centre*) and wheat cultivation in Makhana-growing fields (extreme *right*)

Approximately, 80% of total production of the processed makhana, however, comes from Darbhanga, Madhubani, Purnea and Katihar districts alone. The technology on makhana cultivation in cropping system mode has the scope of adoption in 1.1 million hectares of waterlogged areas, located in Bihar and adjacent states. This particular variety produces biomass of about 10.6 tonnes/ha (dry-weight basis); and is being grown by about 50 progressive farmers and cooperative groups located in Darbhanga, Purnea, Madhubani, Katihar and Sitamarhi districts of Bihar.

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MAKEFEED software for poultry-birds feed formulation

Poultry industry has emerged as the most dynamic and fast expanding segment in animal husbandry, and feed is the most important and major input in poultry production, and the major mean of making production system profitable.

MakeFeed Poultry version 3.0 is easier, user-friendly and efficient to formulate balanced poultry ration and is an updated version of earlier *MakeFeed Poultry*. Its exhaustive database provides the user information on nutritive values for a wide range of feed ingredients along with the maximum inclusion level for each ingredient. The users also have the complete control in modifying database according their own requirements. The software has more a comprehensive information on 'Ingredients Database'. It has option for searching whole database according to appropriate options using two criteria. Clicking 'Edit Record' button one can edit the database. Adding and deleting records from the database are also much simpler. There is also scope for updating. Any number of ingredients with its composition and cost can be added in the database. There is a provision to include enzymes, preboitics and probiotics in the feed additive database. The nutrient requirements (ME, CP, Ca, P, Lys, Met) values for any species can be changed as per the need or choice.

It also includes detailed help option for troubleshooting guidance in formulation of ration as well as an exhaustive list of ready-made rations, which could be used at the click of the mouse. The *Help* documentation has searching facilities through content or index. One can also search *Help* documentation by entering specific keywords. It has A to Z of help information on balanced ration formulation in poultry. Result window gives exhaustive information on the computed ration along with the information on model, criteria and constraints used for formulation of the ration. This helps in fine-tuning ration with changed criteria and constraints. Some ready-made rations, mostly proven for their efficacy, have been given for reference use. The rations include broiler starter, broiler finisher, broiler breeder, chick starter egg type, chick grower egg type, layer, layer breeder, quail layer starter, quail broiler starter,

quail layer/breeder, ducks, turkey, guinea-fowl for various age groups as well as in various concentrates for broiler and layer chicken. If the user does not have any exposure in the feed formulation, he can choose a suitable ready-made ration, depending upon the available ingredients for practical feeding. *MakeFeed Poultry* version 3.0 has also facilities regarding password protection and modification facility, opening or saving your result file and all other advantageous features of the earlier version. The software is being used in different parts of our country by farmers, industry, co-operative societies, NGOs and other entrepreneurs.

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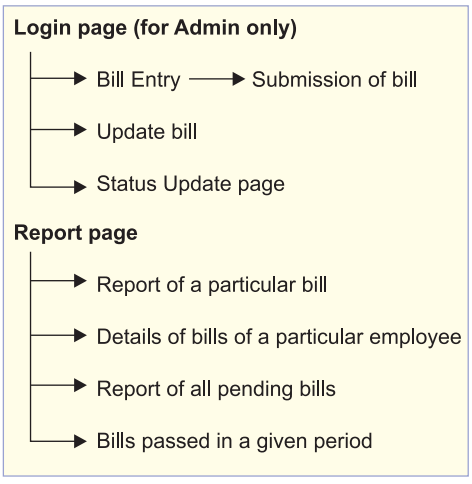
Bill Tracking Information System

This programme has been an attempt to monitor route of all types of submitted bills. Every related Admin personnel is given an authentic User ID and a password, which is changed in the first log-in for security reasons.

Each Admin person enters his ID and password, and opens the system. The option **Bill Entry** is the first stage in the submission of the bill. Each bill submitted to the Directorate is manually entered at the initial point with details such as Employee No., Type of Bill, Amount; and a unique ID is given at the initial stage to each and every bill. Then the option **Submission of Bill** is used to submit it to the concerned Admin person.



The Admin person, who first physically receives the bill, has to clear it in his section. Then log on to his page and send the bill to the next person to whom he is supposed to send the bill. Thus, the database will hold the Admin person's Employee number, who has the bill pending with him at any point of time.

The Admin employee who gets the bill physically has to select the option **Update your Bills** after clearing at his end. The bill number, the name of the person to whom it is sent are selected. The page is submitted along with the remarks, if any.

This way it is routed to 2-3 levels, and the bill is passed to the Audit section. Finally, it is the Administrative Officer who updates the status of the bill when payment has been made/ the bill is adjusted.

Finally when the bill is passed from the Audit section, the option **Status Update** is selected and status is updated to "Passed/Rejected" as the case may be.

The report generation has the following options:

- The first option **Report page of a particular bill** gives the detailed report of a particular bill such as, when it was submitted, its detailed route, and its status is also displayed.
- The second option **Bill tracking of a particular employee** displays all bills, their statuses, amounts and the details of the route of the bill of a particular employee.
- The third option **Report of all pending bills** displays all pending bills in the Directorate and details of their routes.
- The fourth option **Report of bills passed in a period** displays all bills passed during a particular period along with the date of submission and the date when passed.

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WAY FORWARD

INDIAN Agriculture to a large extent depends on the weather and climatic conditions. In early 1988, a National Centre for Medium Range Weather Forecasting (NCMRWF) was established by the Government of India to develop suitable numerical weather-prediction models to issue weather forecasts, and to inform and guide farmers in advance to undertake farming activities.

In India, smallholders' farms constitute 84.97% of the operational holdings, and cover 44.31% of the total operational area. Benchmark data from experimental marginal and small households indicate that individual households spend as much as 42% and 35% of their earnings, respectively, for meeting household food requirements. Crops and livestock constitute the predominant land-use system of these farms. Vertical expansion of the IFS system by integrating appropriate farming system components requiring less space and time is a novel feature for ensuring periodic returns to farmers. A quick survey to characterize existing farming systems across the country indicates existence of 19 predominant farming systems—a majority of them (85%) have crop + livestock as the important components. Crop-dominant systems are common in Andhra Pradesh, Bihar, Chhattisgarh, Goa, Haryana, Jammu and Kashmir, Jharkhand, Kerala, Karnataka, Madhya Pradesh, North-East, Maharashtra, Odisha, Punjab, Tamil Nadu, Uttar Pradesh and Uttarakhand, while livestock-dominant systems are in Rajasthan and parts of Gujarat. West Bengal, parts of Odisha and Asom have fisheries as a major component of farming systems. Jammu and Kashmir, Himachal Pradesh, Maharashtra, parts of Uttar Pradesh and Sikkim have potential for horticulture (fruit)-based systems, while plantation dominant systems exist in Andaman and Nicobar Islands and Kerala. On-farm research in crop diversification and sustainable production indicates that complementary cropping systems with technological interventions can increase profitability by 2 to 3 folds. Low-cost interventions in livestock sector can enhance income of farmers by 3 to 4 folds. Besides, crops and livestock, integration of other need-based small and micro enterprises such as on-farm agro-processing and value-addition, apiary, mushroom, biogas, seedling production of high-value crops, protected horticulture, boundary plantations and kitchen gardening can provide additional returns to farmers. On-farm farming system modules evaluated in various NARP zones through the AICRP on the Integrated Farming Systems gave 6.8-fold increase in net returns (over variable cost of interventions) in improved farming systems with value of household consumption (produced within farm) increasing by 51.4%. The per day profit of marginal and small households can be increased by 69.2% through improved varieties, balanced nutrient application, integrated pest management, good quality and round-the-year fodder supply, area-and-species specific mineral mixture supplementation in feeds, cleaning /grading of farm produce and kitchen-gardening in farming systems' perspective. Efforts have been made to develop IFS models and allied farming system packages for fetching monthly net income of ₹25,000/ha in irrigated and ₹10,000/ha in rainfed systems for marginal and small farmers.

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

Although the IFS models are promising, scientific underpinning of such mixed commodity systems needs to be evaluated further. Attempts needs to be made for *(i)* Systematic characterization of existing farming systems in different agroclimatic regions, *(ii)* Identification of farm constraints, *(iii)* Collective, compatible and convenient farm interventions, *(iv)* Convergence of resources for making a self-reliant farm, *(v)* Auditing of input-output, *(vi)* Impact assessment of interventions on employment generation, productivity enhancement, sustainability of natural resources, and *(vi)* Large-scale demonstration of farming systems in a participatory mode. The challenge before us is to transform cropping systems into farming systems mode to improve living standards of small and marginal households.

Cluster-based demonstrations of the successful IFS models through farmers' participatory approach involving tribal dominant areas/villages will pave a way for their large-scale adoption. Need of the hour in the country is to develop self-sustainable farming systems across different agroclimates to meet long-term goals of reducing poverty, unemployment and malnutrition while improving food and nutritional security at the household level.

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