Volume 20 No. 4 ISO 9001:2008 Organization ISSN 2394-3289 October-December 2014

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

Agrisearch with a human touch

भाकृअनुप
ICAR

ICAR NEWS

A SCIENCE AND TECHNOLOGY NEWSLETTER

RESEARCH UPDATE

PROMISING TECHNOLOGIES

Cultivation of *Volvariella bombycina*, a temperate mushroom species

Volvariella volvacea, commonly known as paddy-straw mushroom, is a tropical mushroom, and is mainly cultivated outdoors under the shade of trees at a temperature of 28 to 35°C in the coastal states of the country. This is the fastest growing edible mushroom, and mushroom-growers can take eight crops in eight months from March to October. During the rest of the four months (November-February), the growers have to grow either oyster mushroom or they are idle despite the availability of a very good market for straw mushroom. Short shelf-life of the straw mushroom also restricts its adoption and marketing to far-reaching places.

Three distinguishing features of silver silk-straw mushroom, *V. bombycina,* to those of *V. volvacea* (growth and fruiting at lower temperature, superior shelf-life of fruit-bodies on storage at refrigerated conditions and slow opening of mature fruit-bodies) have made it a better choice at least during four months (November to February) in the traditionally straw-mushroom-growing regions of the country.

Considering round-the-year demand of straw mushroom in conventionally paddy-straw-mushroom-growing areas, a technology has been developed for cultivation of *V. bombycina*;

Volvariella bombycina fruit-bodies growing on composted substrate

Fully-grown fruit-bodies of *Volvariella bombycina*

Indian Council of Agricultural Research
Krishi Bhavan, New Delhi 110 001, India
www.icar.org.in

which can be cultivated under low temperature from November to February. *V. bombycina* is known for its bioactive secondary metabolites (ergosta-4, 6, 8(14), 22-tetraene-3-one, ergosterol peroxide, indole-3-carboxaldehyde, indazole and isodeoxyhelicobasidin in culture broth), and its fruit-bodies have antioxidative, antitumor, hypocholesterolemic and antibacterial properties.

Cultivation technology: *V. bombycina* spawn (seed) can be prepared on wheat-grains or chopped paddy-straw. Inoculated spawn substrate is incubated at >30° C, and it takes 10 days for the preparation of ready-to-mix spawn. The incubation temperature for spawn run is 28-30°C, and mycelial colonization of the substrate takes 10 days. After complete mycelial colonization, temperature of the cropping room is brought down to 23-25°C, while relative humidity and CO_2 are maintained at 80-85% and 800-1,200 ppm, respectively. Under such conditions, mushroom pinhead formation is initiated in the next 2-3 days; and they will develop into full-size fruit-bodies in the next 3-4 days. The first harvest of mushroom fruit- bodies is taken after 16-18 days of spawn-mixing. The first flush stays for 4-5 days and gives about 60% yield of the total fruit- bodies. The next flush follows first flush with a gap of 3-4 days, and it continues for 4-5 days. The total cropping cycle from spawn mixing to crop termination is nearly 30 days. The second flush gives remaining yield of fruit-bodies. The average fruit-body weight varies from 40 to 60 g.

Fresh fruit-bodies

Fruit-bodies after storage for 7 days

Quality of fresh and seven days old stored fruit-bodies of *V. bombycina* at refrigerated temperature

Three cultivation trials were conducted during 2012, 2013 and 2014, using beds prepared from three types of composted substrates — cotton-ginning mill waste, paddy -straw and 1:1 (w/w) combination of cotton-ginning mill waste and paddy-straw. The composted substrate prepared from cotton- ginning mill waste + paddy- straw gave the highest yield of fruit-bodies in the shortest time. The beds prepared with 15-18 kg substrate/bed gave highest fruit-body yield compared to beds prepared with other quantities of composted substrates. Fruit-body yield of 20 kg/100 kg dry substrate can be obtained from this mushroom. The fruit-body weight varied from 40 to 60 g in different treatments, which indicate that 16 to 20 fruit-bodies will make a kg of fresh mushroom.

Shelf-life and nutritional attributes: The shelf-life of fruit-bodies was tested by placing freshly harvested unopened fruit-bodies of average weight (60 g/ fruit-body) under refrigerated (4 ± 2 °C) and ambient temperature (20 ± 4 °C) for seven days. The fruit-bodies were kept in transparent plastic trays (5-6 fruit-bodies/tray) with two holes of 5-mm dia. each on the top lid. The changes in fruit-body weight (%), visual quality (colour, texture and odour) and nutritional attributes were recorded for the next seven days of storage. The changes in the nutritional attributes — ash, fat, protein,

For nutritional status of the fruit-bodies of *V. volvacea* and *V. bombycina,* fifteen to twenty fruit-bodies were randomly drawn from the representative strains and were analyzed.

Nutritional composition of fruit-bodies of *V. volvacea* and *V. bombycina*

Parameter	Fruit-bodies composition (dry wt basis)		Difference with respect to *V. volvacea* (± %)
	V. bombycina	*V. volvacea* (brown strain)	
Dry matter (%)	8.13	10.10	–24.23
Ash (%)	9.37	9.01	+3.99
Fat (%)	2.05	0.97	+111.34
Carbohydrate (%)	46.07	42.30	+8.91
Protein (F=6.25) (%)	34.38	38.10	–10.82
Crude fibre (%)	13.51	4.40	+207.04
Vitamin D (IU/g)	106.995	462.04	–331.83
Calcium (mg/100 g)	25.61	39.74	–55.17
Potassium (%)	4.12	4.16	–0.97
Sodium (mg/kg)	—	345.34	—
Iron (mg/kg)	72.5	72.51	0.00
Copper (mg/kg)	50.2	42.55	+17.98
Zinc (mg/kg)	119.95	94.28	+27.28
Magnesium (%)	0.12	0.11	+9.09
Selenium (mg/kg)	—	ND (MDL 1.0 mg/kg)	—

ND-not detected, MDL-method detection limit, — Not done

carbohydrates, crude fibre and vitamin D — were assayed only at 0 day and after 7 days of storage under refrigerated conditions, following standard protocol at the Punjab Biotechnology Incubator, Mohali (Punjab).

The rate of loss in weight of fruit-bodies stored under refrigeration was less than 1.00% per day, while it was 11.23 to 14.43% per day in fruit-bodies stored under ambient conditions. Keeping-quality of fruit-bodies stored in refrigeration was almost at a par with fresh fruit-bodies even after 7 days of storage. The fruit-bodies stored under ambient conditions were acceptable up to one day of storage. There were changes in nutritional composition (± 4.17 to 6.95 % of the total values in fresh mushrooms) of the fruit-bodies kept under refrigeration for seven days. The significant change was in vitamin D content, which increased to 76.64 % after storage for 7 days in refrigeration.

O.P. Ahlawat and **Manjit Singh**
Directorate of Mushroom Research
Chambaghat, Solan
(Himachal Pradesh) 173 213
*e-mail:*directordmr@gmail.com

Eco-friendly wastewater treatment and reuse

With the rapid expansion of cities and domestic water supply, quantity of gray/wastewater is increasing proportionately. As per the recent estimates, about 70-80% of the total water supplied for domestic use is generated as wastewater. The per capita wastewater generation by the Class I cities and Class II towns, representing 72% of the urban population in India, has been estimated at around 98 lpcd (litres per capita per day) while that from the National Capital TerritoryDelhi alone (discharging 3,663 MLD of wastewaters) is over 220 lpcd. As per the CPCB estimates, the total wastewater generation from Class I cities (498) and Class II (410) towns in the country is around 40 BLD (Billion Litres a Day). And the installed sewage treatment capacity is just 30%. It is projected that by 2050, about 132 BLD of wastewaters (with a potential to meet 4.5% of the total irrigation water demand) would be generated. Overall analysis of water resources indicates that in the coming years, there will be a twin -edged problem of reduced freshwater availability and increased wastewater generation to be dealt with.

In India, though the wastewater treatment capacity in the country has increased by about 2.5 times since 1978-79, yet 10% of the sewage generated is treated effectively, while the rest finds its way into natural ecosystems, and is responsible for large-scale pollution of rivers and ground- waters. One of the major problems with wastewater treatment methods is that the conventional wastewater treatment processes are expensive and require complex operations and maintenance. Besides, the sludge removal, treatment and handling have been observed to be the most neglected areas in the operation of sewage treatment plants in the country.

In view of these limitations, in recent years, an innovative eco-friendly wastewater treatment facility has been evolved in Delhi campus of the IARI. The newly created facility utilizes emergent wetland plant (*Typha latifolia*), local medium, and native microorganisms, present in the natural wastewaters, for treating 2.2 Million Litres per Day (MLD) of sewage water, sourced from the Krishi Kunj colony. The eco-friendly sewage treatment plant (e-STP) has 3-treatment cells (of 80 metre by 40 metre dimension each), and is capable of irrigating 132 ha of the IARI farmlands. The facility is spread over 1.42 hectares and ensures gravity flow of wastewater from the sewage wells to treatment water cells of the system. Each treatment cell is stratified with a thick layer of medium of varying sizes/ grades, onto which *Typha latifolia* – a hyper-accumulating emergent wetland

vegetation — is planted. This wetland plant has the ability to transfer oxygen from its leaves, down through its stem, and rhizomes, and out *via* its root system into the rhizosphere (root system). As a result of this action, a very high population of the native microorganisms tends to build naturally in its root-zone, where most of the organic and inorganic (i.e. nutrient and metal) transformations take place. The flow of wastewater in each treatment cell is regulated to ensure its sub-surface flow, thereby leading to no direct contact or ponding of wastewater over the medium. Thus, with wastewater moving very slowly and carefully through root-mass of the wetland plants and its interaction with native microorganisms and planting medium, various nutrients and heavy metals in the wastewater get transformed, sequestered and removed from the treatment zone, thereby remediating wastewater. The treated water is collected in an 80 metre by 40 metre by 1.5 metre holding tank, from where it is finally pumped, through a riser, into the irrigation network of the Indian Agricultural Research Institute farm.

Treatment efficiency: Long-term monitoring of the treatment capacity over last 1.5 years has revealed e-STP exceptional performance especially with respect to Turbidity (99%), BOD (87%), Nitrate (95%), Phosphate (90%), Lead (81%), Iron (99%) and also other pollutants such as Nickel (59%), Zinc (58%) and Sulphate (48%) — normally present in moderate concentrations in local sewage waters. A comparison of the so treated wastewaters with the local groundwater samples from MB-1A (near NRL), SPU and the STP sites further showed that these treated waters were associated with either better or same EC, *p*H, turbidity, nitrate, sulphate, phosphate and metal concentrations than groundwaters of the surrounding areas (viz. SPU, MB1A and New area).

Benefits: The facility thus created a good annual local surface water source of about 660 million litres, and there was no need of purchasing contaminated surface waters from Bhuli-Bhatiyaari drain to meet irrigation water demand of the IARI farmlands; thus saving annually about ₹ 18.5 lakh, besides bridging an annual gap (of 520 ML) between irrigation water demand vs supply of IARI farmlands. Additionally, the planted biomass in each treatment cell of the fully operational wastewater treatment system can be harvested, once every two months, to yield 12 tonnes of dry biomass per annum per cell that can either be transformed to particle boards (3,000 sq. metres per annum per cell; market price ₹200-250/ sq. metre) or sold to particle board manufacturers (@ ₹2,000 per tonne as dry matter) – an integrated **Cash from Trash** business model associated with a maximum income of about ₹18 lakh per annum from second year onwards.

A comparison of the so created eco-friendly wastewater treatment system with the conventional wastewater treatment system further showed that the proposed technology is associated with just 1% energy requirement; zero-chemical application; zero-sludge generation; 50-65% reduced treatment cost; no skilled manpower requirement, and an integrated business model, thereby making it self-sustainable.

On long-term scale, a conjunctive use of the so created good quality surface water source along with the existing groundwater source, is expected to not only build water-levels in the receding groundwater aquifers of the IARI and reduce total energy required for pumping groundwaters but would also help improve soil quality and agricultural productivity of the IARI farmlands.

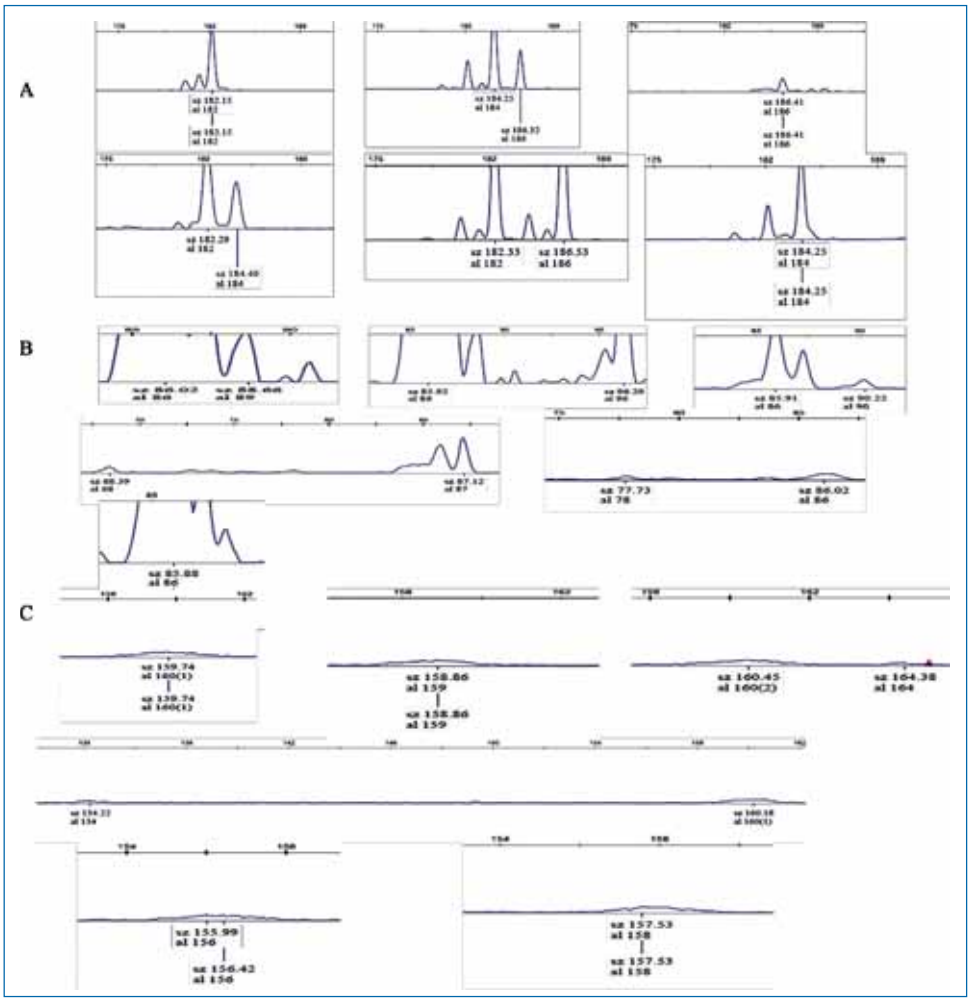
Ravinder Kaur and **H.S. Gupta**
Indian Agricultural Research Institute
New Delhi 110 012
e-mail: rk132.iari@gmail.com

Y-specific microsatellite loci-based screening for quality bull-semen

Bovine Y- chromosome polymorphisms described earlier were used in the analysis of the domesticated bovine breeds showing new perspectives in the paternal origin and also in the development of a breed. But not much information was available on the role of polymorphic Y-specific microsatellite markers on the bull-semen quality parameters. An alternative tool for diagnosis of good and poor quality bull-semen, using allelic variation pattern of the Y-specific microsatellite markers (INRA 126, INRA 189 and BM 861), has been developed. Three Y-specific microsatellite loci of Frieswal bull (HF × Sahiwal) were characterized. For amplification of each Y-specific microsatellite locus from the genomic DNA, primer sequence data were obtained from the scientific literature and gene bank also was consulted. At the 5' end of each forward primer, 6' FAM (Golbia, Bioserver, Pvt. Ltd, India) was added. The polymerase chain reaction (PCR) was carried out in a total volume of 25 µl solution containing 50 ng/µl of template DNA, 1X buffer (Tris-HCl 100 mmol/litre, *p*H 8.3; KCl 500 mmol/litre), 0.25 µmol/

litre primers, 2.0 mmol/litre $MgCl_2$, 0.25 mmol/litre dNTPs, and 0.5U Taq DNA polymerase (Sigma-aldrich, USA). The polymerase chain reaction (PCR) protocol was 94°C for 5 min, followed by 35 cycles of 94°C for 30 s, annealing at 55-58°C for 30 s and 72°C for 30 s, and a final extension at 72°C for 8 min. The PCR products were separated on 1.0% agarose gel (Sigma-aldrich, USA) including 0.5 µg/ml of ethidium bromide, photographed under Gel Documentation system (Alpha imager® EP).

Amplified PCR products were gel purified and sent for genotyping from outsourcing (Science genome Pvt. Ltd, India). Associations of alleles and semen-quality traits including volume, sperm concentration, number of sperms/ejaculate, motility and PTM were analyzed by SPSS (Statistical Package for Social Sciences) for Window version



Different genotypic patterns of Y-specific microsatellite markers in Frieswal bull – **(A)** INRA 126: 182/182, 184/186, 186/186, 182/184, 182/186,184/184. **(B)** INRA 189: 86/89, 86/96, 68/87, 82/86, 86/90, 78/86, 86/86. **(C)** BM 861: 160/160, 159/159, 160/164, 134/160, 156/156, 158/158

Association of microsatellite loci with semen quality traits

Markers	Alleles	Volume (ml)	Concentration (M/ml)	No. of sperms/ejaculate	Motility (%)	PTM (%)
INRA126	182 (n=60)	$4.53 \pm 0.329_a$	$748.51 \pm 102.64_c$	$3397.09 \pm 56.51_{f*}$	45.93±9.26	34.35±7.8
	186 (n=32)	$3.31 \pm 0.523_b$	$1046.21 \pm 102.25_d$	$3262.264 \pm 92.10_{f*}$	40.11±5.42	22.76±6.25
	184 (n=25)	$4.46 \pm 0.371_a$	$875.28 \pm 75.32_e$	$3885.43 \pm 110.31_{g*}$	41.24±3.17	26.884±3.24
INRA189	86 (n=92)	$3.94 \pm 0.264_a$	$988.15.51 \pm 102.64_c$	3606.08 ± 76.81	33.46±7.28	24.65±8.9
	89 (n=18)	$4.68 \pm 0.7643_b$	$894.12 \pm 75.32_d$	3970.023 ± 88.64	45.32±4.22	28.29±6.67
	96 (n=31)	$4.36 \pm 0.423_b$	$900.57.12 \pm 110.75_d$	3749.62±92.94	40.90±8.65	23.345±9.29
BM 861	160(n=80)	4.13 ± 0.126	748.51± 97.98	3169.19 ± 54.56	42.54±7.88	38.95±7.6
	164(n=6)	4.028 ± 0.67	965.43 ± 111.23	4017.34±87.89	41.09±8.75	32.92±5.9

(*Note:* Different subscript letters indicate significant difference)

11.0.1 SPSS Inc. USA computer software programmes, which included fixed effect of the age and origin of the bull. The allelic variations of the loci targeted for association studies with certain bull-semen quality parameters revealed that polymorphic loci of INRA 126 bulls with 182 and 184 alleles had significantly higher semen volume as compared to 186 alleles, however, 186 alleles showed significantly higher concentration per ml of semen compared to 182 and 184.

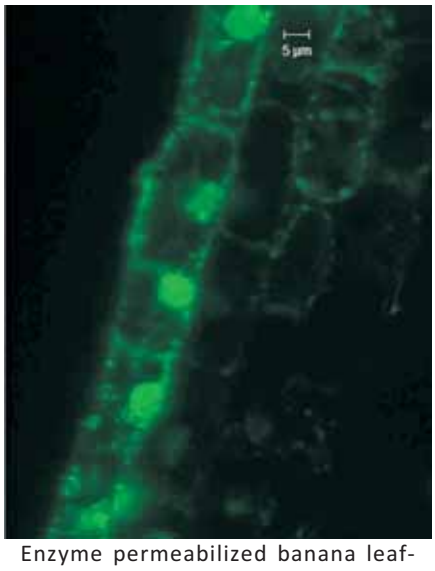
The present study has revealed that the Y-specific microsatellite alleles may be useful as biomarkers for differentiating bulls with good and poor quality semen.

Rajib Deb, Sushil Kumar, Umesh Singh, Shrikant Tyagi, D.K. Mandal and **A.K. Mathur**
ICAR-Central Institute for Research on Cattle
Grass farm Road
Meerut (Uttar Pradesh) 250 001
e-mail: usinghas@gmail.com

Cytobacts: Ubiquitous intracellular colonizing endophytic bacteria

The term endophyte is used for microorganisms that colonize plants internally without any apparent adverse effects on the host; often they are present in a fewer number, primarily colonizing intercellular regions of the roots.

Investigations on the source of tissue-culture contaminants in different horticultural species, where shoot-tip is generally employed as an explant material, indicated ubiquitous presence of bacterial endophytes in various plant parts; largely in non-cultivable ones.



Enzyme permeabilized banana leaf-sheath tissue showing abundant green fluorescing cytoplasmic bacteria 'Cytobacts' with SYTO-9 staining

Staining of tissue sections of different banana cultivars with the Live-dead bacterial staining-kit containing SYTO-9 coupled with confocal laser scanning microscopy (CLSM) showed abundant bacterial colonization along the cell boundary. Further studies adopting bright field microscopy on the fresh tissue sections as well as cell, callus and protoplast preparations after proper cell permeabilization treatments showed abundant live intracellular bacteria also. This is the first-time observation that plants harbour abundant endophytic bacteria inside healthy cells as living entities.

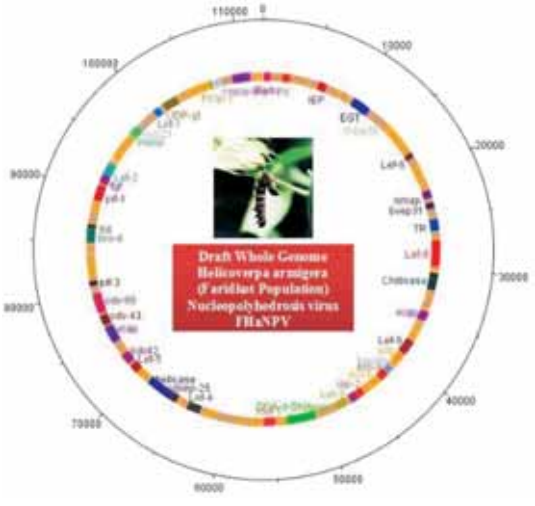
There are two niches of intracellular colonization — cytoplasmic dwellers and inhabitants in perispace between cell wall and plasma membrane. The terms 'Cytobacts' and 'Peribacts', respectively, have been coined to describe organisms in the above-mentioned niches. The observations have considerable implications in basic plant biology and agricultural applications. It also endorses the need for strengthening investigations on the host-endophyte associations and interactions to understand functions or the role played by diverse organisms and future prospects of their exploitation in agri/horticulture.

Indian Institute of Horticultural Research
Hessaraghatta Lake P.O., Bengaluru (Karnataka) 560 089
e-mail: iihrdirector@gmail.com

First draft of whole genome sequence of *Helicoverpa armigera* nucleopolyhedrosis virus

Nucleopolyhedrosis virus (NPV) in India is one of the most potent biocontrol agents for controlling *Helicoverpa armigera,* particularly on pulses, vegetable, etc. The first draft of whole genome of *H. armigera* NPV has been sequenced.

Complete size of the whole genome of the nucleopolyhedrosis virus has been estimated to be 113,631bp long; it is circular in nature having a total of 143 protein coding genes (PCGs), 6 repeat regions, most of the genes comprising A+T-rich region; 67 identified named proteins. The gene arrangement and orientations of the assembled



DNA plotter for gene arrangement in *Helicoverpa armigera* nucleopolyhedrovirus of most virulent strain, whole genome (113,631bp).

NPV whole genome have been found to be identical to the reported single capsid NPV genome from China.

Out of 67 named protein coding genes, 42 were submitted, and out of 76 hypothetical proteins, 44 were submitted to GenBank, constituting 143 ORFs.

S. K. Jalali[1], T.M. Shivalingaswamy[1], A. Verghese[1], Rakshit Ojha[1] and Raj Bhatnagar[2]
[1]National Bureau of Agriculturally Important Insects
Bengaluru (Karnataka) 560 024
[2]International Centre of Genetic Engineering and Biotechnology, New Delhi

Litchi-looper affects litchi production

Litchi-looper has lately acquired a status of the major pest to litchi-crop from a minor one due to climate change. This pest attacks litchi-plant throughout the year; maximum in September-October.

a. Newly emerged larvae defoliating new flush, b. Pupae on leaves, c. Adult

The looper (*Perixera illepidaria)* attacks on tender leaves and defoliates new shoots. In severe cases, it defoliates newly emerged flush, resulting in poor panicle formation and fruit-set.

Litchi-looper incidence from August onwards at a weekly interval

Fortnight	Std week (SW)	Mean number of loopers/30-cm shoot
August I	32	3.00
	33	2.67
August II	34	4.67
	35	4. 67
September I	36	5.33
	37	6.00
September II	38	7.33
	39	8.67
October I	40	9.33
	41	9.67
	42	12.67
October II	43	13.33
	44	9.33
November I	45	8.67
	46	7.00
November II	47	1.33
	48	0.33
December I	49	0.33
	50	0.00
December I	51	0.67
	52	0.67
January I	1	0.00
	2	0.33
	3	0.33
January II	4	0.00
	5	0.33
February I	6	1.00
	7	1.67
February II	8	2.00
	9	2.67
March I	10	3.33
	11	3.67
March II	12	4.33
	13	4.00

It completes life-cycle in around 25 days. Female lays eggs on the underside of the leaves and eggs are hatched within 4-5 days. Larval and pupal stages complete in 8-9 and 5-7 days, respectively; and in a year, 5-6 generations are completed. Being lepidopteran and being succulent at the larval stage, it can be managed by any contact insecticide, and 100% mortality can be achieved with a single spray. Proper surveillance is required to know the most vulnerable stage of the pest.

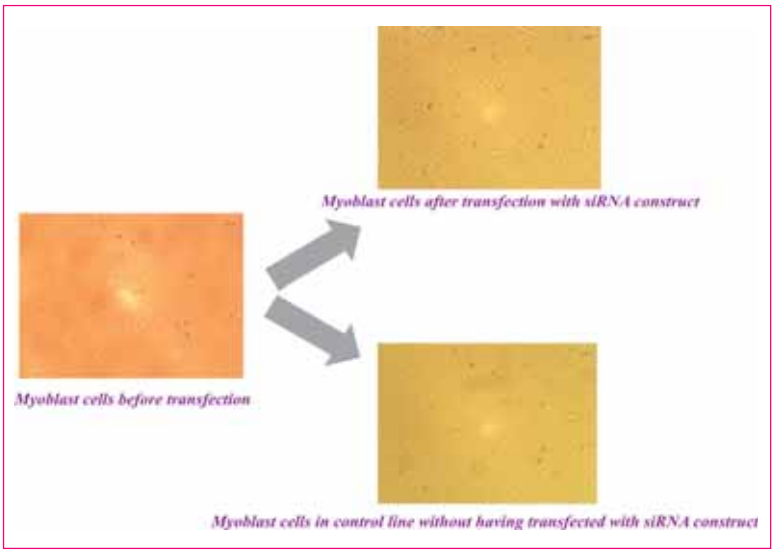
Kuldeep Srivastava, R.K. Patel, Vinod Kumar and **Vishal Nath**
ICAR-NRC on Litchi, Muzaffarpur (Bihar) 842 002
e-mail: vishalnath66@rediffmail.com

Improvement in meat production with RNAi in poultry

Indian Poultry Industry has emerged as one of the fast-growing sectors among various livestock enterprises as is evident from its transformation from traditional backyard rearing to organized commercial farming over the last four decades; placing India at 3rd position in egg production (65.48 billion eggs) and at 5th in poultry meat production (3.6 million tonnes). Still average per capita availability in India is merely 2.3 kg of poultry-meat against the recommended level of 11 kg meat per annum. There is a huge gap between meat production and its requirement. Several approaches including breeding, nutrition and management were employed to increase production potential of poultry, but consequently the steady progress still reached to a plateau.

The advancement of Molecular Biology and Biotechnology has paved a way to enhance production performance of animals by limiting the functions of the negative regulatory factors, which control performance

traits. RNA interference (RNAi) has been one of the very powerful techniques to limit negative functions by causing destruction of specific mRNA with small interfering RNA molecules. Myostatin, and activin receptors play a pivotal role in causing negative growth in animals, which can be minimized by RNAi technology.



An *in vitro* experiment on effect of siRNA for myostatin gene on multiplication of myoblast cells in chicken

Myostatin and activin receptor 2A genes in chicken myoblast cells have been cloned, characterized and expressed *in vitro*. And myoblast cell-lines were developed from chicken-embryo, and were used for expression study. Several siRNA molecules have been designed, synthesized and cloned in vectors for transient transfection; and suitable clones of siRNA have been developed for stable transfection *in vitro* in cell-line.

Different siRNA molecules were transfected *in vitro* to compare efficiencies of these molecules for knock-down effect of myostatin gene in muscle cell-line. The molecules knocked down expression of myostatin up to 69% without any adverse effect on the expression of interferon molecules in the cell-line. They can also be used *in vivo* during embryonic stage to knock down effects of myostatin gene so that muscle cells can grow rapidly and higher quantity of muscle mass can be produced in chicken.

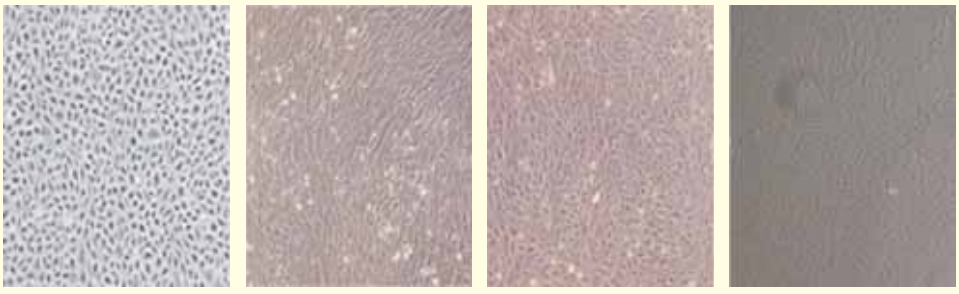
T.K. Bhattacharya and **R.N. Chatterjee**
Directorate of Poultry Research, Rajendranagar
Hyderabad (Telangana) 500 030
e-mail: bhattacharyatk@gmail.com

National Repository established of Fish Cell Lines

A National Repository of Fish Cell Line (NRFC) has been established. It aims to collect, deposit and distribute fish cell lines to researchers across the country. At present, 50 fish cell lines are being cryopreserved and maintained, which were deposited by the research groups working on fish cell lines. The lines were authenticated and characterized using cytogenetic and molecular markers. A website containing information

Fish cell lines available in the NRFC

Sl No.	Fish species	Organ	Submitted by
1.	*Catla catla*	Thymus (epithelial, macrophage), Lymphocytes	NBFGR, Lucknow
2.	*Channa punctatus*	Gill	
3.	*Cyprinus carpio*	Fin	
4.	*Danio rerio*	Muscle	
5.	*Horabragus brachysoma*	Fin	
6.	*Cyprinus carpio* (Koi carp)	Fin	
7.	*Labeo rohita*	Fin	
8.	*Pristolepis fasciata*	Fin	
9.	*Puntius chelynoides*	Fin	
10.	*Puntius denisonii*	Fin	
11.	*Schizothorax richardsonii*	Fin	
12.	*Tor tor*	Fin	
13.	*Wallago attu*	Fin, Gill, Muscle	
14.	*Amphiprion sebae*	Brain, Caudal Fin, Spleen	FCRI, Tamil Nadu
15.	*Etroplus suratensis*	Brain, Eye, Gill, Kidney	
16.	*Channa striatus*	Eye, Gill, Kidney	
17.	*Lates calcarifer*	Kidney, Spleen	CAHC,
18.	*Epinephelus coioides*	Eye, Kidney	Thiruvallavar University
19.	*Catla catla*	Eye, Heart, Brain, Gill	
20.	*Clarias batrachus*	Fin	
21.	*Labeo rohita*	Gill	
22.	*Dascyllus trimaculatus*	Caudal peduncle (Ex), Fin, Caudal peduncle (Tr)	CMFRI, Kochi
23.	*Rachycentron canadum*	Heart	
24.	*Epinephelus malabaricus*	Heart, Gill 1, Gill 2, Spleen	
25.	*Pomacentrus caeruleus*	Caudal peduncle, Fin, Liver	
26.	*Epinephelus merra*	Spleen	



(a) (b) (c) (d)

Photomicrographs of cell lines (a) CCF, NRFC 004, (b) WAF, NRFC 005, (c) TTCF, NRFC 003, and (d) LRG, NRFC 023

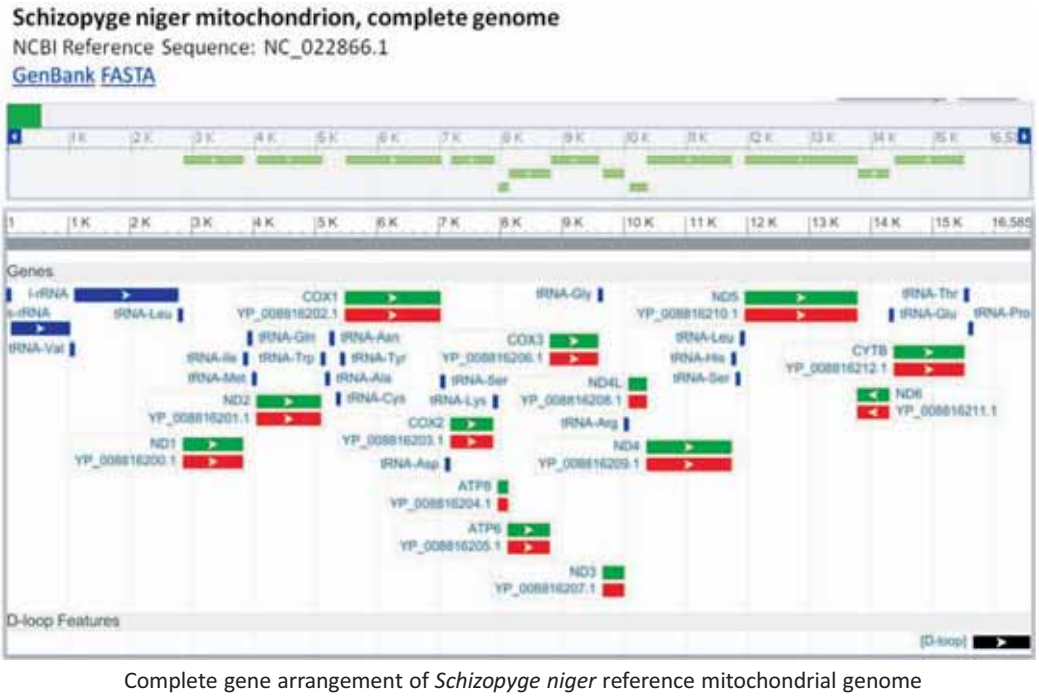
regarding the NRFC has been launched to facilitate deposition and distribution of lines to research community.

National Bureau of Fish
Genetic Resources
Canal Ring Road,
Near Telibagh
Uttar Pradesh (Lucknow) 226 002
e-mail: director@nbfgr.res.in

Sequenced complete mitochondrial genomes of snowtrout species

Total mitochondrial DNA of *Schizothorax labiatus, S. progastus* and *S. plagiostomus* has been sequenced. The genome of these fish species is of about 16 kb, and comprises 13 protein coding genes, 22 tRNA genes, 2 rRNA genes and 1 non-coding d-loop region.

All the sequences have been submitted to the NCBI Genbank. Complete mitochondrial genome sequences of 6 *Schizothorax* species was mapped; and out of which sequence of *Schizopyge niger* (Accession no. NC_022866.1) has been validated by the NCBI, and included in the Refseq database.



Complete gene arrangement of *Schizopyge niger* reference mitochondrial genome

Complete genome details of different *Schizopyge* species

Species	Genome size (bp)	Accession number	Protein coding genes	tRNA	rRNA	A + T content	G + C content
Schizothorax labiatus	16,582	KF739398	13	22	2	55.3%	44.7%
S. progastus	16,575	KF739399	13	22	2	55.2%	44.8%
S. plagiostomus	16,576	KF928796	13	22	2	55.8%	44.2%

ICAR NEWS wishes its readers and contributors

Happy New Year

2015

Directorate of Coldwater Fisheries Research
Anusandhan Bhavan
Industrial Area
Bhimtal (Uttarakhand) 263 136
e-mail: director@dcfr.res.in

Chakhao (delicious) rice landraces of Manipur

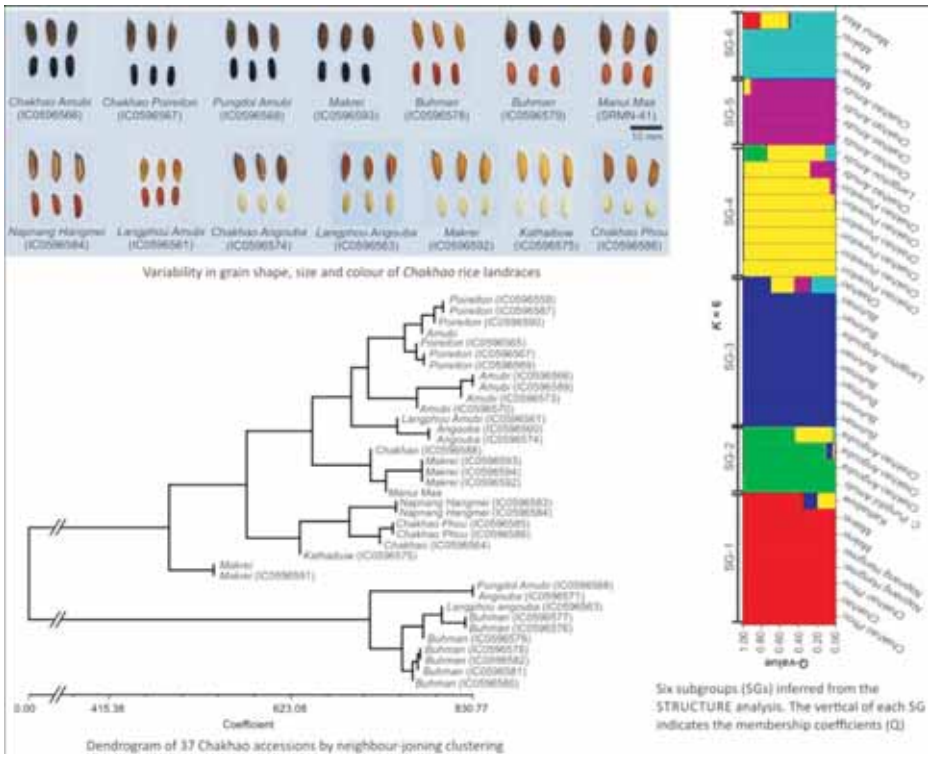
Landraces of aromatic and quality rice of Manipur are locally called as *Chakhao*. In Manipuri language, *Chakhao* literally means delicious rice (*Chak* = rice and *ahoba* or *hao* = delicious). Farmers of Manipur describe different types of *Chakhao,* based on the grain characteristics (*Amubi* = black; *Angouba* = white), and they grow different types of *Chakhao* landraces within a short range of altitude. These landraces are very special for Manipur people, as they use them in festivals and social ceremonies to prepare dishes — *Ethe Tan* (a local *puri* made from black *Chakhao* rice flour in Chandel district), *Buhman Sang* (a local delicacy made from *Buhman* landrace in Churachandpur district) and *Utong Chak* (a special dish prepared in bamboo sticks in Chandel district).

In November 2011, an exploration was undertaken, and a total of 40 aromatic rice cultivars were collected from eight districts of Manipur. Among them, 37 were *Chakhao* rice such as *Chakhao Poireiton*, *Chakhao Amubi* and *Chakhao Angouba* (as recognized by farmers), along with others, *Buhman*, *Makrei*, *Chakhao Phou* and *Napnang Hangmei*.

Analysis of genetic diversity and structure of 37 *Chakhao* landraces based on genotyping with 47 microsatellite markers revealed high gene diversity (0.673) within the populations; with values ranging from 0.303 (*Poireiton*) to 0.471 (mixed *Chakhao*). *Chakhao* accessions could be divided into six sub-groups based on the genetic structure analysis. The population structure derived from the STRUCTURE analysis largely correlated with farmers'

***Chakhao* rice accessions from Manipur**

Sl No.	Accession no. (IC)	Vernacular name	Place of collection	Kernel length class	Kernel shape	Aroma
1	0596559	*Chakhao Poireiton*	Imphal West	long	Medium	High
2	0596560	*Chakhao Angouba*	Imphal West	Short	Bold	High
3	-	*Chakhao Amubi*	Imphal West	Medium	Medium	High
4	0596561	*Langphou Angouba*	Imphal West	Medium	Medium	Low
5	0596563	*Langphou Angouba*	Imphal West	long	Medium	Low
6	0596564	*Chakhao*	Senapati	Short	Bold	Medium
7	0596565	*Chakhao Poireiton*	Thoubal	Medium	Medium	High
8	0596566	*Chakhao Amubi*	Thoubal	Medium	Medium	High
9	0596567	*Chakhao Poireiton*	Thoubal	long	Slender	High
10	0596568	*Chakhao Pungdol Amubi*	Thoubal	long	Slender	High
11	0596569	*Chakhao Poireiton*	Thoubal	long	Slender	High
12	0596570	*Chakhao Amubi*	Thoubal	Medium	Medium	High
13	0596571	*Chakhao Angouba*	Thoubal	long	Medium	Medium
14	0596573	*Chakhao Amubi*	Chandel	Medium	Medium	High
15	0596574	*Chakhao Angouba*	Chandel	long	Slender	High
16	0596575	*Kathaibuw*	Chandel	long	Medium	Low
17	0596576	*Buhman (Angouba)*	Churachandpur	long	Medium	Medium
18	0596577	*Buhman*	Churachandpur	long	Medium	High
19	0596578	*Buhman*	Churachandpur	long	Slender	Medium
20	0596579	*Buhman*	Churachandpur	long	Medium	High
21	0596580	*Buhman*	Churachandpur	long	Medium	Low
22	0596581	*Buhman/ Idaw*	Churachandpur	Extra long	Slender	Medium
23	0596582	*Buhman*	Churachandpur	long	Medium	High
24	0596583	*Napnang hangmei*	Tamenglong	long	Medium	Medium
25	0596584	*Napnang hangmei*	Tamenglong	long	Slender	Medium
26	0596585	*Chakhao Phou*	Tamenglong	long	Medium	High
27	0596586	*Chakhao Phou*	Tamenglong	Medium	Bold	Medium
28	0596587	*Chakhao Poireiton*	Bishnupur	long	Medium	High
29	0596588	*Chakhao*	Bishnupur	Medium	Slender	High
30	0596589	*Chakhao Amubi*	Bishnupur	Medium	Slender	High
31	0596590	*Chakhao Poiriton*	Bishnupur	Medium	Medium	High
32	-	*Makrei (Chakhao)*	Ukhrul	long	Medium	High
33	0596591	*Makrei*	Ukhrul	Medium	Medium	Medium
34	0596592	*Makrei*	Ukhrul	long	Medium	Medium
35	0596593	*Makrei*	Ukhrul	Medium	Medium	Medium
36	0596594	*Makrei*	Ukhrul	Medium	Medium	Medium
37	-	*Manui maa*	Ukhrul	long	Medium	Medium



Variability and genetic diversity analysis of 37 Chakhao rice landraces

classification of *Chakhao* landraces; it demonstrated that traditional farmers of Manipur have been efficiently preserving several types of aromatic rice varieties within a small geographical region. *Chakhao* cultivars with black kernels have a high potential for export as they are preferred by many South-East and East Asian countries because of their attractive colour, stickiness and aroma. Domestic demand for black *Chakhao* rice is also high; consumers pay a higher market price for quality rice landraces as they are rich in nutritive and medicinal value.

Somnath Roy, A.K. Misra, Amrita Banerjee[1], S.S. Roy[2] and A. Pattanayak[1]
National Bureau of Plant Genetic Resources, Regional Station Umiam (Meghalaya) 793 103
[1]ICAR Research Complex for NEH Region, Umiam (Meghalaya) 793 103
[2]ICAR Research Complex for NEH Region, Manipur Centre, Imphal, (Manipur) 795 004
e-mail: sroypbr@gmail.com

Phul-Tarul: a potential tuber-crop of Darjeeling and Sikkim

Canna indica, belonging to family Cannaceae, is an herbaceous perennial minor tuber-crop, domesticated in the Andean region. Forms cultivated for tuber value in South and Southeast Asia are often referred to as *C. edulis* or *C. discolor*. Although best known for being used in the development of ornamental *Canna* cultivars, *Canna indica* has been reported to be cultivated as a tuber-crop in India; earlier reports did not mention places of cultivation, seemingly this report is the first mentioning about its cultivation places.

During exploration in Darjeeling and Sikkim in October 2012, *Canna indica* cultivation, occasionally by *Sherpa* and *Lepcha* tribes, for edible tubers was noticed in areas between 1,200 and 2,200 m high – Sangsay Busty, Algarah, Paiyong, Pudung, Dungra, Baluwakhani, Pedong, Lava and Tukdah – in Darjeeling district of West Bengal; and Tarku, Tanak and Temi areas in South Sikkim district of Sikkim. This is also consumed by *Bhutia* tribe in similar localities and in the other districts of Sikkim. Its plants are grown in small plots around homes. Locally known as *phul-tarul* (*phul*- flower; *tarul*-common term for tuber-bearing edible yams), the plants are 1.5-2.3 m tall, with upright leafy shoots, yielding a cluster of about 10-15 suckers and highly branched rhizomes (usually called tubers) of 2.5-3 -cm diameter. The leaves are broad, 30 cm × 12.5 cm, entire; upper ones are often reddish-brown with thick mid-rib. Flowers are bisexual, petals are red to yellow-orange, 5- cm long with 3-petal like staminodia.

Phul-tarul cultivation in Sangsay Busty village in Darjeeling

Two different forms are found in cultivation — one with the reddish-brown leaves, brownish-purple stems and

Variability in leaf and floral characters of *Canna indica*

orange-red flowers is the most common and preferred one due to its bigger tubers and their better cooking quality and the other is with green-leaves and orange-yellow or orange flowers. Often a field is observed with a mixture of more than one form.

Small terminal portions of the fresh tubers with 2-3 eye buds (weighing 100-250 g) are planted at 15-cm soil depth at a spacing of about 75cm × 75 cm (75 cm × 60 cm is for green-leaf form) in raised beds during March-May. Sprouting starts 25-30 days after planting and one manual weeding is done. Sometimes earthing-up is also carried out. Plants grow faster in rainy season and start blooming thereafter, extending till October. With the onset of winter (November-December), shoots start senescing, and the crop is ready for harvest. Single clump of purple-leaf form weighs 2-3 kg, and of green-leaf form weighs 1-2 kg. Villagers usually keep intact tubers in the soil to be stored, and harvest them whenever required.

Small young tubers are cooked and used like boiled potato; they have a rather mucilaginous consistency with mild sweet taste. During lean season, the plant is frequently used as a supplementary food to staple cereals. Apart from use as a food item, boiled tubers are fed to pigs, goats and cows. Fodder value of shoots and medicinal uses of tubers, leaves, flowers and seeds have also been reported. This has been reported as an important species for farmers' livelihood in adjoining eastern Nepal. Considering availability during lean period, minimal care needed in its cultivation and low incidence of pest and diseases, it can be a good alternative to other tuber crops in high altitude areas.

K. Pradheep, P.K. Singh[1] and Boniface Lepcha[2]
National Bureau of Plant Genetic Resources,
New Delhi 110 012
[1]Indian Institute of Vegetable Research, Seed Production Centre, Kushinagar (Uttar Pradesh) 274 406
[2] Krishi Vigyan Kendra, Ranipool, East Sikkim (Sikkim)
e-mail: kpradheep@nbpgr.ernet.in

Bitterless *Aloe vera* can be a nutraceutical vegetable

Aloe vera is a well- known medicinal plant of antiquity, grown in arid regions. Because of its varied uses to cure many ailments, it is nicknamed as a 'mini pharmacy'.

A. vera, more popular in the southern part of India as '*Kattarvazha*', is a succulent plant of family Xanthorrhoeaceae, and has an Afro-Madagascar-Arab Peninsular origin. In Ayurveda and folk medicine, its aerial parts are extensively used for preparing medicated hair oils, wound- healing oils, skin -care oils and also in preparation of medicines *'Kumarikalpa'* and '*Kumariasava'.* It is widely believed to be a general tonic for curing gynecological disorders, circulatory diseases, digestive problems, skin ailments, and so on. The commonly cultivated varieties of '*Kattarvazha'* are very bitter and have been used restrictively as per the recommendations of an ayurvedic physician.

However, an accession of *A. vera* collected from the Narmada river basin in Dhar district of Madhya Pradesh, maintained in the field genebank at Jodhpur (Rajasthan) and Thrissur (Kerala), has been found non -bitter and directly consumable as fresh vegetable or salad. Named *'Kumari pathram'* and assigned national accession number IC 333202, this has been highly adapted to high humid tropical climate, prevailing in Kerala, and can be

Aloe vera sample plot

Harvested leaf ready for processing

Method of slicing for culinary use

Chopped gel cubes ready-to-eat/serve

promoted as a nutraceutical vegetable. Besides containing in traces bitter alkaloid 'aloein', it has more than 12 vitamins, including vitamin C, 20 plus minerals, many essential amino acids and over 200 polysaccharides. The antioxidant properties of the chemical ingredients make it an ideal choice as a nutraceutical health food.

Dietary Use

The succulent young leaves after being detached from the mother-plant may be washed and wiped. After removing spiny margins, it can be sliced to small pieces of desired size and used in salads, fresh juice and pickles or cooked into curries or sweets, with or without outer skin. Translucent gelatinous mesophyll tissue retains shape and colour even after cooking, making it an attractive item on the dining table. Peeling of skin and extracting out intact gel is very easy.

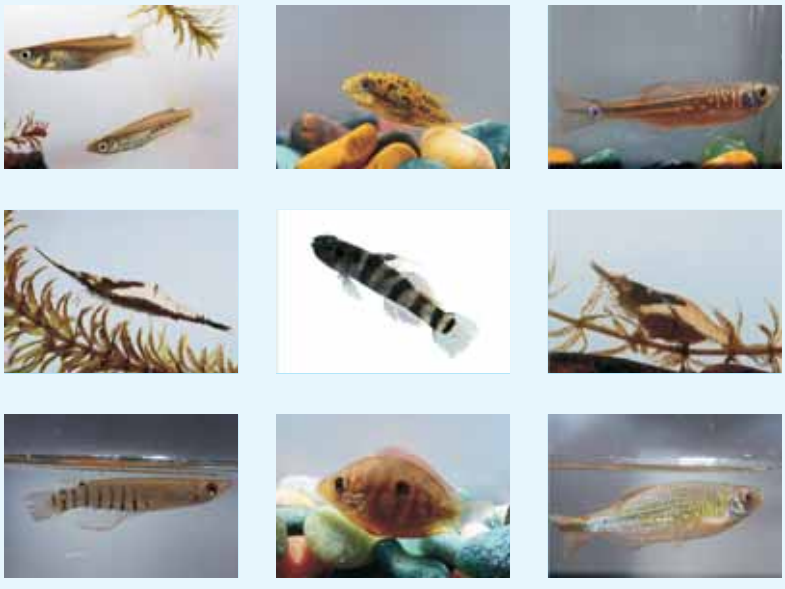
Cultivation: Rooted suckers collected from the base of the mother-plants are used for planting. A 9-12 months old well-maintained plant produces over 12-20 suckers. Land should be tilled and leveled and should have adequate water drainage. Pits of 15 square cm may be dug out 90 cm apart, and be filled with 2-kg well-rotten farmyard manure. Rooted suckers may be planted during pre-monsoon showers or any time during the year subject to provision for life-saving irrigation. Periodic earthing-up of basins enhances tillering, growth and yield of leaves. Leaves can be harvested, while leaving a few heart leaves and basal leaves on the plant.

The farmers may have additional income by growing this accession of *A. vera* (IC 333202) as a sole crop or as a mixed crop with legume crops.

N.K. Dwivedi, K. Joseph John, Asokan Nair and **Indiradevi**
National Bureau of Plant Genetic Resources
Regional Station, KAU Post, Thrissur (Kerala) 680 656

Freshwater fish diversity in Goa

Of the states in Peninsular India with rivers originating in the Western Ghats, Goa remains the least explored for fish biodiversity. The previous attempts date back to seventies, recording 35 fish species from the rivers of Goa.



As part of the efforts to catalogue freshwater fish diversity in the Western Ghats, Kochi Unit of the NBFGR and ICAR Research Complex for Goa conducted intensive appraisal of fish diversity in Goa in freshwater habitats during 2013 to 2014. Nine locations covering two major river systems, Mandovi and Zuari, were sampled intensively using cast- net, drag-net, trap-net and scoop -net. Up to March 2014, a total of 40 species of freshwater fishes and 7 species of crustaceans could be caught. The final round of sampling was conducted between 15 and 19 September 2014, where, in addition to the previous locations, the lower reaches of Zuari and Mandovi basin up to the estuarine zone as well as the Chapora River, which originates in Maharashtra and enters the Arabian Sea in Goa, were also included. This yielded 15 additional fish species along with 6 species of crustaceans, totalling 55 fish species and 13 crustaceans.

This is the first intensive effort of this century for cataloguing freshwater rivers of Goa for fish biodiversity. The major species observed during survey are *Pethia setnai*, *Haludaria pradhani*, *Rasbora dandia*, *Aspidoparia morar*, *Devario malabaricus*, *D. aequipinnatus*, *Garra mullaya*, *Aplocheilus lineatus*, *Dawkinsia filamentosa*, *Mystus malabaricus*, *Schistura altipedunculatus*, *Carinotetraodon travancoricus*, *Channa gachua*, *Puntius mahecola*, *Puntius vittatus*, *Systomus sarana subnasutus*, *X. cancila*, *Aplocheilus kirchmayeri* and *Pseudosphromenus cupanus*. Crustaceans noticed during the survey are: *Macrobrachium canarae*, *M. malcolmsonii*, *M. cf. gracilirostre*, *Caridina cf. babaulti*, *C. cf. gracilirostris*, *C. cf. hodgarti* and *Parathelphusa* sp.

V. S. Basheer[1], Rahul G. Kumar[1], R. Charan[1], R. Shanis[1], K. Shyam[1], G.B. Sreekanth and **Manju Lekshmi N.[2]**
[1]NBFGR, Kochi (Kerala) 682 018
[2]ICAR RC for Goa, Old Goa (Goa) 403 402

ICAR-Central Institute for Arid Horticulture, Bikaner

To harness optimum productivity with strengths and weakness of the arid ecosystem

To conduct mission-oriented research to improve horticultural crops and for developing horticulture-based cropping systems under the arid environment and to act as a repository of information related to arid horticulture, the National Research Centre for Arid Horticulture (NRCAH) was established at Bikaner, and became functional in April 1993. Considering peculiar agroclimate of the region, large number of horticultural crops and a wide range of disciplines involved, for developing appropriate technologies for horticultural sustenance to be holistic could not be achieved under the limited mandate of the NRCAH. In view of this, the Working Group on Agricultural Research and Education that formulated IX Five-Year Plan of the ICAR/DARE, Ministry of Agriculture, proposed up-gradation of the NRCAH to a level of an Institute. Thus, on the recommendation of a High Power Committee and with the concurrence of the Planning Commission, Govt of India, the NRC was upgraded on 27 September 2000 to an Institute named, Central Institute for Arid Horticulture, so as to broaden its mandate for inclusion of research on a holistic basis; incorporating work on potentially economic crops of the arid region, and to consolidate research in the region, the Central Horticultural Experiment Station, Godhra (earlier functioning under the administrative control of the IIHR, Bengaluru) was also merged with the CIAH on 1 October 2000. The Central Institute for Arid Horticulture can be browsed at http://www.ciah.ernet.in, http://www.ciah.ernet.in.

The Rajbhasha unit of the Institute was awarded for excellent work in Hindi by Local Rajbhasha Committee in 2007-08, 2009-10 and 2011-12. The Hindi magazine (Maru Bagwani) published by the CIAH was awarded with the prestigious Ganesh Shanker Vidyarthi award in 2008.

MANDATE

1. To undertake basic and strategic studies for developing technologies to enhance productivity and utilization of arid horticultural crops.
2. To act as a national gene bank of arid horticultural crops.
3. To develop multiple horticulture- based sustainable cropping systems under the arid environment.
4. To act as a national repository of scientific information related to arid horticulture.
5. To coordinate network research with state agricultural universities and line departments, and to act as a centre for human resource development in arid horticulture.
6. To provide consultancy in research and development of arid horticulture.

INFRASTRUCTURE

The Institute has well-developed laboratories, farms and central facilities for research work. The headquarters of the Institute is situated on Bikaner-Sriganganagar highway. The CIAH has one centre—Central Horticulture Experiment Station at Vejalpur, Godhra, situated at Godhra-Vadodra highway. The Krishi Vigyan Kendra (KVK), established at Godhra in 2005, is also under the administrative control of CIAH, Bikaner.

Farmers visit to KVK, Vejalpur, Godhra

Since its inception, the KVK is helping farmers and farmwomen of Panchmahal area to ensure nutrition and income security of the inhabitants.

The Institute has Division of Crop Improvement and Division of Crop Production with laboratories on fruit production, vegetable production, germplasm conservation, fruit breeding, vegetable breeding, biotechnology, soil- and- plant nutrition, soil -and -water conservation, stress physiology, plant pathology, entomology and post-harvest technology. The laboratories are equipped with HPLC, Gas chromatography, Atomic absorption spectrophotometer, UV-VIS-spectrophotometer, Fluorescence microscope, Gel electrophoresis unit with Gel Doc system, Infra-red gas analyzer, Lypholizer, Automatic nitrogen analyzer, Cryo-microtome, Flash evaporator, Bioreactor, etc.

Library: It has a collection of 2,200 books, and subscribes to 5 foreign and 13 Indian journals. It is also connected with Internet.

Museum: It gives the glimpse of the arid ecosystem through charts, photographs and live-specimens.

Varieties released by the CIAH

Sl No.	Crop	Variety released
1.	*Ber*	i) Goma Kirti ii) Thar Sevika iii) Thar Bhubhraj
2.	*Aonla*	Goma Aishwarya
3.	Watermelon (Mateera)	i) AHW 19 ii) AHW 65 iii) Thar Manak
4.	Bottlegourd	Thar Samridhi
5.	*Khejri*	Thar Shobha
6.	*Kachri*	i) AHK 119 ii) AHK 200
7.	Snapmelon	i) AHS 10 ii) AHS 82
8.	*Kakri* (*Kakdi*)	i) AHC 2 ii) AHC 13
9.	Clusterbean	Goma Manjari
10.	*Bael*	Goma Yashi
11.	*Jamun*	Goma Priyanka
12.	Pomegranate	Goma Khatta
13.	Tamarind	Goma Prateek
14.	Clusterbean	Thar Bhadavi
15.	Sword bean	Thar Mahi
16.	Indian bean	i) Thar Kartiki ii) Thar Maghi
17.	Chironji	Thar Priya

Fruit crop varieties

SIGNIFICANT ACHIEVEMENTS

Crop Improvement

- Under the National Field Repository, a total of 715 germplasm accessions of different fruit crops and 488 of vegetable crops have been collected and conserved. At Godhra, 434 germplasm accessions of fruit crops and 136 of vegetable crops are being maintained.
- Among 318 *ber* (*Ziziphus mauritiana*) genotypes, Gola, Seb, Umran, Kaithali and Banarasi Karaka are performing well under the hot arid climate.
- Out of 154 genotypes of pomegranate (*Punica granatum*), Jalore Seedless (32 kg/tree), Ganesh (30 kg/tree), G 137 (29 kg/tree), P 23 (27 kg/tree) and P 26 (24 kg/tree) are promising for yield and quality.
- *Aonla* (*Emblica officinalis*) NA 7 is a prolific bearer (51 kg/tree), followed by Chakaiya (34 kg/tree) & NA 6 (28 kg/tree).

Vegetable crop varieties

- *Bael* (*Aegle marmelos*) NB 5 and NB 9 have performed well under irrigated hot arid ecosystem. A five-year old budded plant of NB 5 yielded about 40 fruits/ tree while NB 9 yielded about 29 fruits/ tree.

Crop Production

- Propagation techniques have been standardized for *aonla, bael, ber, chironji, jamun, ker, khejri, lasora,* pomegranate and tamarind.
- For better establishment and growth of pomegranate orchards in sandy soils, a pit of 60 cm^3 filled with equal proportion of top soil, manure and pond-silt has been recommended.
- Allelopathic effects: It has been demonstrated that aqueous extract of *ber* leaves adversely affect growth of understorey mustard.
- For vegetables under environmentally stressed area, agro-techniques developed or improved for maximizing higher returns per unit area are related to site selection, field micro-climate management, seed treatment, method and time of sowing, maintenance of plant population, soil-water conservation, irrigation systems and scheduling, foliar feeding and crop-protection measures.
- Single lateral line (12-16 mm size) at 1.5-2.0 m distance with on-line drippers (4 litre/hr) at 50 cm distance was found most suitable for production of Kachari, snapmelon and watermelon (mateera).

Linkages and Collaborations

At the national level, the Institute collaborates with the NRC on Plant Biotechnology, NPBGR, New Delhi; Department of Horticulture, Govt of Rajasthan; Maharana Pratap University of Agriculture and Technology, Udaipur; SK Rajasthan Agriculture University, Bikaner; NGOs (Gaushala Santhan, Khadi Gramodyog, Bikaner, Urnul setu, Bikaner, Pasari Social and Rural Development Research Foundation, Jhunjhunu); and KVKs situated at Bikaner, Sardarshahr, etc. At the international level, the CIAH collaborates with Hebrew University of Jerusalem, Israel; Government of Egypt; Govt of UAE, etc.

Plant Protection

- CIAH-111, CIAH-196 and CIAH-311 of *Pseudomonas fluorescens* and CIAH-151, CIAH-240 of *Trichoderma* from soil and plant samples of arid horticultural ecosystem were mass multiplied for formulations.
- *Cercospora* leaf-spot in pomegranate was managed by 3 fortnightly sprays of Topsin-M (0.1%), Captaf (0.2%) or Dithane M-45 (0.2%). Fruit-rot of *aonla* was controlled by 2–3 sprays of Dithane M-45 (0.2%) or Kavach (0.2%).
- Two applications of either Fenvalerate (0.005%) or Dimethoate (0.05%) at 21 days interval, commencing from the second fortnight of September, followed by two applications of NSKE (5.0%) at 10 days interval proved effective against fruit-fly and fruit-borer infestation in *ber*.
- Coat protein gene primer was designed for leaf-curl disease of chilli. This gene has been cloned and sequenced. The length of this gene is 747bp. The sequence has been submitted to the National Centre for Biotechnology Information.
- Management schedules for the important pests of *ber*, hairy caterpillar, leafminer, fruit- fly and fruit-borer, have been worked out. In addition, season-wise damage intensity of *ber* butterfly, leaf webber, stone weevil and grey weevil have been worked out.

Crop Diversification

- Crop combinations, *Aonla-Ber*-Brinjal-Mothbean-Fenugreek, *Aonla*-Bael-Karonda-Mothbean-Gram, *Aonla-Khejri-Suaeda*-Mothbean-Mustard and *Aonla*-Drumstick- Senna-Mothbean-Cumin, have been found sustainable and remunerative.
- In *ber* maximum B. C. ratio of 1:4.54 was achieved with a closer spacing of 5 m × 5 m.

Integrated Nutrient and Water Management

- In pomegranate, vermin-compost and inorganic fertilizers (in 50:50) gave good response in terms of plant vigour, leaf nutrient content and fruit yield.
- In pomegranate and *ber*, alternate-day irrigation through drip at 0.75 CPE with 75% recommended dose of nitrogen was promising for plant vigour, fruit yield and leaf-nutrient content. By drip fertigation, there was a saving of 25% in fertilizers and more than 25% of irrigation water with maximum water-use efficiency as compared to pipe irrigation.
- In kinnow fruit crop, 50% N, 80% P and 30% K of recommended dose (N: 1250g, P: 500g and K: 750g per plant per year) should be given from February to July, and remaining 50% N, 20% P and 70% K should be given during August to November with solid soluble fertilizers through drip fertigation for higher yield and better quality fruits.
- A double-ring method was devised and applied for water management in *aonla* plants. This saved 50-60 % of water. Use of different mulches (maize straw, paddy straw, rice husk, grasses, subbabool loppings and black polythene) showed that application of organic and synthetic mulches increased soil moisture.

Biotechnology

- Micropropagation protocols have been developed for *ker* (*Capparis decidua), lasoda (Cordia myxa),* mulberry *(Morus alba*), citrus *(Citrus limon*) *and* vegetable- type cactus pear (*Opuntia ficus indica) and Aloe vera*.
- PCR-based diagnostic probe to detect begomovirus infection in chilli has been developed. RAPD based marker, OPA 16, has been identified to detect inter-specific hybrids between *Citrullus lanatus* and *C. colocynthis*.

Post-harvest Technology

Value-added products

Crop	Products
Ber	Candy, Ready–to-serve (RTS)
Pomegranate	RTS, Anardana
Aonla	Murabba, Chavanprash, Mouth freshner, Squash, Candy,
Date-palm	Chhuhara, Biscuits, date RTS, pickle, vegetable
Khejri	Biscuits, Sangri
Kachri	Powder
Bael	Powder, RTS

Vegetable crop varieties

Trainings Impact on the Inhabitants

The Institute conducted about 40 on-campus/off-campus trainings. The major impacts observed on farmers and farmwomen attitude are as follows:

Attitude	Impact
Change in cognitive behaviour	Directly/ indirectly increased > 60% knowledge, awareness, and interest of > 10,000 farmers about modern/improved technologies of arid horticultural crop production
Adoption of improved technologies and economic gain	• More than 7-10% area increased under improved varieties of arid vegetables • More than 70% farmers are very eager to produce crop of improved varieties of *kachri* (AHK 119) and snapmelon (AHS 82) at commercial scale • The farmers who adopted improved technologies (improved varieties and their agro-techniques) of arid horticultural crop production, their income increased more than 50% • The farmers (10-15%) have started to produce the seeds of improved varieties of *kachri* (AHK 119) and snaplmelon (AHS 82) to earn money by selling the same to fellow farmers
Social changes	• Increased horti-based commodity interest groups in social system • Increased cosmopolitism and scientific orientation of farmers • Increasing flow of farmers from laggardism to innovatism, etc.

FUTURE THRUST AREAS

Genetic Resource Management: There is a need to collect, characterize and evaluate natural biodiversity available in this region for developing a strong gene bank on which the country can depend for future needs.

Improving Production and Productivity of Arid Crops: Appropriate technological interventions are required for increasing production and productivity.

Exploitation of Biotechnology: Use of molecular markers for gene tagging, transfer of genes from wild taxa, development of transgenes resistant to biotic and abiotic stresses, and micropropagation are potential areas for future.

Basic and Strategic Research: Since arid ecosystem has its unique problems, basic aspects of biotic and abiotic stress tolerance mechanisms, and seed and plant vigour canopy architecture, need to be investigated.

Hi-Tech Crop Production: Hi-tech nursery-raising for production of healthy seedlings. Protected cultivation of high-value crops for off-season production.

Water and Nutrient Management: Efficient use of water and nutrients through drip/sprinkler irrigation and fertigation and use of organic/degradable biomass for mulching will help conserve water. Promotion of precision farming for maximizing input-use efficiency to get higher produce are some interventions to be addressed in future.

Organic Farming: Standardization of norms for certification of organic products, and deciding the certification agency must be addressed immediately.

Plant Protection: Integrated management strategies are required for management of major pests and diseases in arid and semi-arid horticultural crops.

Human Resource Development: For achieving higher productivity, trained manpower in various facets of horticulture production system and post-harvest management is required.

Post-Harvest Management: Efforts are required to minimize post-harvest losses by developing appropriate technologies. Dehydration of produce can also be undertaken.

S.K. Sharma
ICAR-Central Institute for Arid Horticulture
Bikaner (Rajasthan) 334 006; *e-mail:* ciah@nic.in

Community-based water storage structures in the Central Plateau Hill region of Rajasthan

At Kota (Udaipur district , Rajasthan), community-based water-storage structures (15 in number) were surveyed for their type, status and institutional management arrangements to develop suitable strategies for effective management.

All the ponds were of embankment type and were managed by *Gram Panchayats*, excepting Sukher ka naka and Chalwa, which were managed by recently constituted water-user association (WUA) and *Jal Sangam Samittee*. Catchment area of these ponds ranged from 2 to 15 km^2 while their potential command area varied from 50 to 300 ha. Observed irrigated area under these ponds was reduced by 50% of the potential area (20 to 260 ha) owing to heavy siltation up to 2 metres.

All ponds, except Gopalpura, are utilized mainly for irrigation and for animal drinking. Gopalpura pond was additionally used for fisheries also. Wheat was the main crop irrigated with pond-water. In the time of scarcity of water during *kharif*, maize-crop was also irrigated. The water distribution mechanism in all the ponds was same. *Gram Panchayat* forms a water distribution committee every year prior to *rabi* season which looks after cleaning and repair of distribution channels to stop leakages, decision on time for releasing water and to resolve any conflicts arising in the process of water-use. Lack of people participation and lack of funds led to poor water-use efficiency and maintenance of these structures. The water-use charges fixed by the *Gram Panchayat*/WUA varied from pond to pond and ranged between ₹67 and 368 per ha.

It was found that all except Chalwa and Bharodi have sufficient capacity to fulfill the requirement of the dependent households if filled fully at least once in a year. The demand of water under different ponds varied from 36,000 to 780,000 m^3 per annum for crop production; and it ranged between 20,271 and 83,431 m^3 per annum for livestock. There is a need to sensitize farming community for organizing water-user groups and associations for management, operation, maintenance, and cost-recovery of water besides removal of nutrient enriched silt from the tank bed in participatory mode to restore storage capacity of these structures.

Central Soil and Water Conservation Research and Training Institute
218, Kaulagarh Road
Dehradun (Uttarakhand) 248 195
*e-mail:*director@cswcrtiddn.org

Vegetative filter strips for preventing soil and nutrient losses from the fields

Vegetative filter strips in crop fields

Effectiveness of vegetative filters strips (VFS) with *Eulaliopsis binata* and *Dicanthium annulatum* (both grasses) in crop fields and waterways in different widths with various runoff rates was evaluated at the Research Farm, Vasad. Data revealed that in crop fields, vegetative filter strips reduced runoff, soil and nutrient losses up to 40%, 65%, 70%, respectively. These strips increased crop yield up to 20%. From the experimental data it was also revealed that the vegetative filter of *Dicanthium annulatum* in the waterways reduced soil loss up to 80%.

It is recommended that the vegetative filters strips, combining *Eulaliopsis binata* and *Dicanthium annulatum,* can be planted at 45-m spacing with 1-2 m width in the fields and in water ways; 50% of grass coverage can be maintained to prevent runoff, soil and nutrient losses from crop fields and for ultimately reducing sedimentation in water-bodies.

Runoff flow in vegetative waterways with varying grass filter coverage

Central Soil and Water Conservation Research and Training Institute
218, Kaulagarh Road
Dehradun (Uttarakhand) 248 195
*e-mail:*director@cswcrtiddn.org

Reclamation of shallow ravines for agriculture at Kota

A technological package evaluated at Kota for restoring shallow ravines for cultivation is as follows.

Construction of diversion bunds: The marginal bunds of 2.0 to 2.5 m^2 cross section (height 0.9-1.0 m; top width 0.75 -1.0 m; bottom width 3.5-4.0 m; and side slope 1: 1.5) with 0.1 to 0.2% grade are constructed at a distance from the gully heads equal to double the depth of gullies to arrest uninterrupted high velocity flow of surplus runoff water from the arable lands into the adjoining gully heads and in turn to check extension of gullies into the arable lands. These bunds are reinforced by planting grasses.

Construction of spillways: Spillways are constructed for safe disposal of excess runoff from the adjoining arable lands through marginal bunds to gully beds. Depending upon the fall of gully and runoff contributing area at that point, a loose boulder reinforced with vegetative measures or masonry spillways are constructed.

Earthen check-dams: Earthen check-dams are constructed in the gully beds at the regular intervals with horizontal spacing ranging from 20 to 60 m depending on the bed slope of gully and height of dam between two earthen check-dams. Dimensions of the check-dams are 1.25 - 1.75 m height; 1.5 - 2.0 m top width; 5.25 - 7.25 m bottom width; with 1: 1.5 side slope. Minor levelling of the irregular side slopes of the gully is carried out to convert gully bed land into terrace for agriculture. A pipe or small masonry spill is provided at one end of the dam to discharge surplus runoff. The up and down slopes of the earthen dam are stabilized by developing vegetative cover.

These check-dams hold considerable amount of soil to facilitate establishment of vegetation and are also known as soil savers. They facilitate raising of economically useful crops in gullied lands and lead to better survival and growth of the planted vegetation.

Central Soil and Water Conservation Research and Training Institute
218, Kaulagarh Road, Dehradun (Uttarakhand) 248 195
e-mail: director@cswcrtiddn.org

Two-stage hard-wood cutting protocol for pomegranate

Propagation of pomegranate through hard-wood cutting has been very common but recently developed improved protocol for hard-wood cutting ensures greater success, to the tune of 75-80%, and also results in production of healthy planting material. The protocol involves various pre-treatments of hard-wood with antibiotics/ bacteriostatic compounds, fungicides and hot-water for sufficient period of time to ensure freedom from most of the pathogens. Rooting of the cuttings starts 20-25 days after planting, and sufficient root biomass develops at the time of transfer of cuttings to nursery-bags, which contain mixture of pre-sterilized sand, soil and FYM

Sprouted cuttings

Shoots of 60-75- cm length

1. Cut apparently healthy shoots (60-75- cm long of 6-12 mm diameter) from orchard/ mother block
2. Cutting should be done before the initiation of the active growth of shoots (before the onset of monsoon) /from shoots of the rest period / pruned wood of the rest period and from water shoots for faster root initiation and higher cutting success
3. Avoid lateral shoots, which usually flower and fruit heavily; use mostly upright growing branches
4. Cover shoots in moistened gunny bags to be brought to polyhouse/ shade-net

Cutting long shoots to ideal length of 15-20 cm

5. While taking cuttings, top thinner portions should be avoided
6. Cuttings should be of 15-20 cm length and 6-12 mm diameter
7. Polarity of cutting should be taken care of by giving a slant- cut at the top and flat-cut at the bottom
8. Secateurs should be sharp enough to give clean cuts

Solution containing 0.05% Bactronol-100 and 0.2% Carbendazim

9. **Treatment A**

   Submerge cuttings in a solution of 0.05% Bactronol-100® (0.5 g/ litre) and Carbendazim 0.2% (2 g/ litre) for 10-15 minutes (5 min. treatment of cuttings with hot-water and at 52-53° C temperature takes care of most of pathogens)

Solution containing 2,000 ppm IBA

10. **Treatment B**

    Dissolve 2 g IBA (Indole-Butyric-Acid) by adding a few drops of 1N NaOH solution and then making the total volume to a litre by adding warm water (55-60° C). Dip at least the basal half of the cuttings in the IBA solution for 3-5 minutes

Coco-peat tank

11. Plant cuttings by inserting basal half into the medium in a slightly tilted position in a nursery-tank containing coco-peat to the depth of 20-cm and place at the bottom stone pebbles/sand for proper drainage

12. High relative humidity (85-90 %) in the protected structure ensures higher success rate in the establishment of cuttings

Transfer well rooted cuttings to nursery bags having planting mixture

13. After 45 days, shift rooted cuttings to polythene bags containing pre-sterilized mixture of sand, soil and FYM (potting mixture can be solarized or treated with 5% formaldehyde a.i. 37-41 %; extreme care should be taken while handling formaldehyde by covering nose with mask, hand with gloves and eyes with goggles. The mixture should be kept covered with polythene for a week after treatment for effective sterilization and used 5-6 days after uncovering) and place plant beneficial microbes/ bio-hardening agents (plant beneficial microbes) in the root zone of the plants

Root biomass in 120 days old biohardened cuttings

14. Arbuscular mycorrhizal fungi (*Glomus* spp.), *Aspergillus niger* strain 27, *Pseudomonas* and *Bacillus* based microbial formulations can be placed near the root zone of the cuttings

15. 90-120 days old rooted saplings can be used for field planting after keeping them outside the protected structure in a shade for a week

along with bio-hardening agents like arbuscular mycorrhizal fungi. As the rooted cuttings are transferred to nursery bags for better development of roots before planting in the field, the protocol is given the name as **two-stage hard-wood cutting protocol for pomegranate.**

Advantages of Hard-wood Cutting

- This is less labour-intensive and is farmer-friendly.
- The propagation can be round-the-year under the protected structure provided the hard wood taken for cutting should have sufficient reserve material, like the pruned wood of the rest period.
- Produced healthy bio-hardened planting material through chemical treatments and plant-beneficial microbes.
- Pruned wood can be effectively utilized for producing planting material, which otherwise would have gone waste.
- Planting material can be produced, and simultaneously commercial yield can be taken up.

For expanding their pomegranate plantation, pomegranate-growers have not to depend on nurserymen and other planting- material suppliers. They can make sufficient number of elite planting materials from high- performing pomegranate plants by utilizing pruned woods, which otherwise are thrown away. This would also protect entry of infected planting material in the healthy pomegranate orchards. On the basis of calculations for propagation of 5,000 cuttings with 60 % cutting success, cost: benefit ratio worked out approximately 1:4.

N.V. Singh, Ram Chandra and **R.K. Pal**
National Research Centre on Pomegranate
Solapur (Maharashtra) 413 255
e-mail: nripendras72@gmail.com

Sorghum and chickpea energy utilization under poor rainfall conditions in semi-arid tropics

Production data of rainfed sorghum and chickpea for 10 years were investigated. The total input energy required for cultivation of sorghum and chickpea in rainfed vertisols was 5,714 and 7,303 MJ per ha, respectively. During deficient rainfall years, around 49 and 63% decline in output energy was observed in sorghum and chickpea production. Energy efficiency scores were 3.15 and 3.54 for sorghum and chickpea under normal rainfalls, but declined to 1.75 and 1.45 under deficient rainfalls. On the basis of the B:C ratio and energy efficiency, chickpea has been found more promising in the semi-arid Vertisols, although additional fodder availability from sorghum straw cannot be ignored. Higher dry matter efficiency of 0.702 was observed in medium-duration cultivars, and water-use efficiency was higher in short-duration cultivars, followed by medium-duration cultivars, which are found more suitable for semi-arid tropics (SAT) region in *rabi* (winter) season on residual soil moisture in Vertisols.

Central Soil and Water Conservation Research and Training Institute
218, Kaulagarh Road
Dehradun (Uttarakhand) 248 195
*e-mail:*director@cswcrtiddn.org

Bidhan Jhargram 2 – a new cashewnut variety for West Bengal

A selection was made from the cashew-seedling population of H-2/15. This selection was released in January 2014 as Bidhan Jhargram 2 during the AICRP on Cashew Workshop at the BCKVV, Kalyani (West Bengal).

Bidhan Jhargram 2 is an upright tree with compact canopy. It has large bottle- green leaves, intense flowering (12.8 inflorescence/m^2), and its inflorescence is compact, of medium length and is of pyramid shape. It is cluster-bearing in habit, and yielded consistently with an average yield of more than 8 kg/tree at a spacing of 6 m × 6 m. The yield at 7th harvest was 13.5 kg/tree. Its production potential has been found three times more (2.5 q/ha) than the national average productivity (0.772 q/ha). This variety, so far, is not found affected by Tea Mosquito Bug (TMB). It is a mid-season flowering variety with 3-4 fruits with golden yellow apples / panicle. The mean apple weight is about 63 g with a juice content of 68.9%. Its nuts are bold with average weight of 9.2 g, kernel weight of 2.85 g and shelling percentage 32% with W 180 kernel count; making it suitable for export. The variety is recommended for red and laterite soil zone of the East Coast of West Bengal. It has been found superior to popular varieties of the region, BPP 8 and Jhargram 1.

Bidhan Jhargram 2 and other common varieties

Characters	BPP 8	Jhargram 1	Bidhan Jhargram 2
Branching habit	Intensive	Intensive	Intensive
Canopy type	Compact	Medium compact	Upright and compact
Apple colour	Bright yellow	Yellow	Golden yellow
Nut weight	8.2 g	5.0 g	9.28 g
Nuts/panicle	4.0	10.0	3.0
Yield/tree	12.5 kg	8.5 kg	13.50 kg
Yield /ha at 6m x 6m spacing	22.24 q	19.46 q	25.02 q
Shelling percentage	29.0 %	30.0%	31.0%
Kernel weight	1.89 g	1.5 g	2.87 g
Kernel grade	W 210	W 320	W180

Profuse flowering branches

Hanging ripe cashew apple with nut

Harvested raw cashewnuts

Longitudinal section of nut showing kernel inside

Mini Poduva[1] and **P.L. Saroj**[2]
AICRP on Cashew, Regional Research Station, BCKVV Jhargram, Distt-Paschim Medinipur (West Bengal).
[2] AICRP on Cashew, DCR, Puttur (Karnataka)

Popularization of sea-cage farming

Sea-cage farming technology for marine food fishes has been perfected, and its viability has been demonstrated to stakeholders.

Asian seabass (*Lates calcarifer*) farming

Association of Kovalam Progressive Fishermen (AKPF), Kancheepuram District, Tamil Nadu, farmed *Lates calcarifer* in 5 m × 3 m GI cages under the Participatory Programme. Cage was moored in the open-sea, about 1 km from Kovalam shore at 8-m water depth and was stocked with 1,500 Asian seabass fingerlings of mean size 60 g on 3rd June 2014, and were fed with tilapia.

About 600 kg of seabass with a survival rate of 80% were harvested on 16 September 2014. The fish grew faster and attained an average size of 0.5 kg (0.44 - 1.1 kg) in 100 days. The harvest was sold alive to Chennai- based Recreational Sports Fishing Agency at ₹400/ kg, and a total revenue generated was ₹240,000.

Cobia (*Rachycentron canadum)* farming

Cobia Fisherman Welfare Association took sea-cage farming of cobia. About 6,400 cobia fingerlings were stocked in ten 6m × 3.5m cages during middle of November 2013 and were fed with trash fishes. A total of 9 tonnes of fish was harvested on 8 May 2014. They grew to 48 to 62 cm length and 1.0 to 2.3 kg weight in 6 months. The harvest was sold at farm-gate price of ₹270/kg.

A similar farming trial was undertaken by another self-help group of Marakayarpattinam, near Mandapam, Tamil Nadu, in four cages. A total yield of 625 kg fish was harvested from one cage after 135 day, and the harvest was sold at ₹290/kg.

A. Gopalakrishnan
Central Marine Fisheries Research Institute
P.B. No. 1603
Ernakulam North P.O.
Kochi (Kerala) 682 018
e-mail: agopalkochi@gmail.com

Published by Dr Rameshwar Singh, Project Director, Directorate of Knowledge Management in Agriculture, Indian Council of Agricultural Research, New Delhi 110 012. *Phone:* 011-25842787; *Fax:* 011-25843285; *e-mail:* pddkma@icar.org.in. Lasertypeset by M/s Print-O-World, Shadipur, New Delhi 110 008, and printed in India at M/s Royal Offset Printers, A-89/1, Naraina Industrial Area, Phase I, New Delhi 110 028.

Conceptualization and Editing : **Shashi A. Verma** ***Design & Production :*** **Dr V.K. Bharti and Punit Bhasin**

WAY FORWARD

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

In addressing the socio-economic scenario of the Indian agriculture, livestock sector plays an important role in providing nutritional food security and employment. This sector besides being the source for milk and meat, provides draft power, hide, fibre and manure, and contributes to about 22% in agricultural GDP and 3.93% in the total GDP of the country, and 29% to rural employment. India has 529.7 million livestock and is the world's largest producer of milk with 127.9 million tonnes per year with 5% annual growth (Annual Report 2012-13, DADF); registering per capita availability of 290 g milk per day as against the world's average of 289.31 g.

Major challenge in livestock is diseases and pests that have impact on the productivity, and some of their diseases are zoonotic in nature. Protection of human health from zoonotic diseases entails prevention, control and eradication of animal diseases by using cost-effective and easily available rapid, precise and user-friendly diagnostics and efficacious vaccines with long duration of immunity. The ICAR institutions and agricultural and veterinary universities have put in best of the efforts to move forward in this direction. The Indian Veterinary Research Institute (IVRI) was the pioneer in the world that produced first veterinary biologic (anti-rinderpest serum), way back in 1899, which was supplied to Middle East and other Asian countries through silk route. The anti-rinderpest serum alone or in conjunction with rinderpest virus (serum-virus simultaneous method) was used for controlling rinderpest disease.

Recent advancements in cell culture and hybridoma technology, and later in recombinant DNA technology also have led to the development of quick and highly specific New Generation Diagnostic reagents and assays. The enzyme-linked immunosorbent assays (ELISAs), utilizing polyclonal/mono-specific or monoclonal antibodies, purified microbial antigens, or expressed recombinant protein antigens, have been developed for many disease pathogens. Besides developing serological tests for diagnosis of different animal and poultry diseases, the IVRI has played a vital role in developing new generation nucleic- acid- based diagnostic tests like polymerase chain reaction (PCR), RT-PCR, real-time PCR and nucleic acid hybridization tests for early and specific diagnosis of animal diseases and characterization of different pathogens. Nucleic acid-based tests have been developed for quick and specific diagnosis of classical swine fever, bovine viral diarrhoea, bluetongue, brucella, campylobactor, rabies, canine infectious hepatitis and canine laryngotracheitis.

The R&D in veterinary biologics has led to the eradication of rinderpest, African horse sickness, contagious caprine pleuropneumonia from the country, and elimination of dourine and control of diseases of poultry (Newcastle disease, infectious bursal disease, avian influenza, infectious bronchitis), cattle and buffalo (FMD, HS, BQ, anthrax), sheep and goats (PPR, sheeppox, goatpox, enterotoxaemia) and pigs (classical swine fever).

Development of new generation vaccines for important animal pathogens, deletion-mutant *Brucella, Salmonella* deletion mutant BHV-1 marker vaccine, Virus-like particles (VLPs) and reverse genetics-based Newcastle disease vaccines has yielded good results. Thermostability of biologicals is one of the major issues, and this is being addressed by using heavy water (D_2O).

Point-of-the-care diagnostics in human medicine have been the latest hallmark in the diagnostic service. On the similar lines, many tests have been developed for the veterinary use. Latex Agglutination Tests (LATs), using whole or recombinant antigens, are in use for diagnosis of brucellosis, trypanosomosis and leptospirosis.

With striking results and impacts in the areas of diagnostics and vaccines for animal health, the ICAR is further gearing up in developing new and suitable vaccines and effective delivery systems, and along with sustained release of vaccine antigens is being contemplated, to address various animal-health problems.

(S. Ayyappan)
e-mail: dg.icar@nic.in