ICAR-National Research Centre on Orchids
Pakyong-737106, Sikkim

Annual Report

2016 -17

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PREFACE

It gives me immense pleasure to place before you the Annual Report (2016-17) of the ICAR-National Research Centre for Orchids, Pakyong, Sikkim the nodal institute mandated with planning, execution and coordination of all activities concerned with orchid research and development in the country. Since, its establishment in 1996 by the Indian Council of Agricultural Research (ICAR), NRCO has played a pivotal role in the management and sustainable utilization of orchid genetic resources for improvement of technologies. The institute has taken up several initiatives to upscale the research and development activities. Four broad thematic areas were taken up this year *viz.*, Conservation, Genetic Improvement, Production Management and Transfer of Technologies. The major thrust has been laid on orchid conservation through various means *viz.*, ex-situ, in-situ, DNA bank etc. The institute undertook several explorations in different states. Besides, collection and conservation of orchid germplasm filed gene bank and the institute obtained IC number for 112 accessions from NBPGR.

Due to the constant efforts of the scientists, two greater achievements were received by farmers. The prestigious Pandit Deen Dayal Upadhyay Antyodaya Krishi Puruskar 2015 (Zone-VI) was conferred to Smt. Anuradha Chettri, Progressive Orchid Grower from Sikkim on 25/09/2016. Plant Genome Savior Community award for the year 2014-15 was declared to Nonglwai Orchid Conservation Society, West Khasi Hills of Meghalaya where the TSP scheme demonstration site of ICAR-National Research Centre on Orchids submitted in 2015.

The first variety of institute 'Sheetal 1' (Pahiopedilum) lady's slipper orchid was filed with PPVFRA, New Delhi. Four Paphiopedilum breeding lines registered with NBPGR (**IC 617522-617525**). Three Zygopetalum progenies *viz.*, PB-ZI-15-19 Sel-01, PB-ZI-15-43 Sel-02 & PB-ZI-15-28 Sel-03 registered with NBPGR (**IC 617526-617528**). New early flowering 6 progeny lines viz., PBX-12-99/01 (Phalaenopsis), PBX-05-772 and PBX-05-29/95 (Cymbidium) were characterized. New scented species hybrid of Phaius developed is characterized (PBX-11-22).

Progress achieved in identification of liquid organic manure (1:30) for organic cultivation of orchids, where it had shown enhanced bulb size, no of leaves/ bulb, leaf length and number of bulbs/plant in two year old plants and full grown plantlets enhanced bulb size, spike length, rachis length, no. of flowers/spike and flower size. Refining of potting mixtures developed with locally available dry leaf fern and tree barks.

Seventeen scented volatile compounds were identified from studies on *Zygopetalum maculatum* flowers of four different developmental stages and seventeen fragrant orchid species and 01 hybrid were trapped in different columns for chemical analysis at different flowering stages. During the year, five new externally funded projects were granted to the institute.

The institute had organized many trainings, demonstration, farm visit, meeting and awareness programme along with execution of mandatory programmes of Government of India and ICAR. The celebration of Institute Foundation Day met a grad success. The institute actively took part in organizing cleanliness cum awareness drives in the premises and surrounding areas of institute *under Swachh Bharat Abhiyan*. Under the *Mera Gaon, Mera Gaurav* Scheme institute adopted four villages and created awareness regarding the different schemes of Government of India *i.e.*, Har Khet Ko Pani "Prime Minister Krishi Sinchayee Yojana (PMKSY), Pradhan Mantri Fasal Bimal Yojna (PMFBY), Paramparagat Krishi Vikas Yojana (PKVY) for the farmers. Institute has also created awareness among the unemployed youths

of North-East India under the ICAR programme Attracting Rural Youth towards Agriculture (ARYA) by organizing job training.

I consider it a privilege to place on record the encouragement and support given by Dr. T. Mohapatra, Secretary, DARE & Director General, ICAR during this period. We would not have made such achievement without the support and guidance of Dr. N. K Krishna Kumar, Deputy Director General (Horticulture). I am also grateful to Dr. T. Janakiram, ADG (Hort. I) for all the support and advice given to us time to time. I am equally thankful to the Chairman and Members of Quinquennial Review Team and Research Advisory Committee for their suggestions to reorient our research programmes. I am thankful to Chairman of various State Biodiversity Boards for speedy processing our applications and granting us permission to collect the germplasm from their states. I am also thankful to line departments especially the Horticulture and Cash Crops Development, Sikkim for their support. I also place on record my sense of gratitude to all my scientific, technical, administrative and contractual staff for their active involvement and unwavering commitment to the institute.

Place: Pakyong, East Sikkim
Date: 28.05.2017

(D. R. Singh)
Director

Executive Summary

Plant Genome Savior Community award for the year 2014-15 was declared to Nonglwai Orchid Conservation Society, West Khasi Hills, Meghalaya; the TSP scheme demonstration site of ICAR-National Research Centre on Orchids submitted in 2015.

Facilitated the prestigious Pandit Deen Dayal Upadhyay Antyodaya Krishi Puruskar 2015 (Zone-VI) conferred to Smt. Anuradha Chettri, Progressive Orchid Grower from Sikkim on 25/09/2016.

Maintained NAGS collections (> 2,500) and passport data of 112 orchid species collected from different locations around the country were submitted to ICAR-NBPGR and obtained IC numbers. Twenty four Meghalaya collections were registered with NBPGR (**IC 617566-617589**).

Molecular diversity of 10 native species of the genus *Paphiopedilum* and 11 fragrant *Coelogyne* species were performed using ISSR markers. During the year, purified DNA of 196 orchid species were deposited in DNA Bank.

Paphiopedilum variety 'Sheetal 1' filed for PPVFRA registration (REG/2016/1534) and constituted SVRT & CRRC trails.

New early flowering 6 progeny lines viz., PBX-12-99/01 (Phalaenopsis), PBX-05-772 and PBX-05-29/95 (Cymbidium) were characterized.

Four Paphiopedilum breeding lines registered with NBPGR (**IC 617522-617525**). Three Zygopetalum progenies *viz.*, PB-ZI-15-19 Sel-01, PB-ZI-15-43 Sel-02 & PB-ZI-15-28 Sel-03 registered with NBPGR (**IC 617526-617528**).

New scented species hybrid of Phaius developed is characterized (PBX-11-22). Three promising Phalaenopsis breeding lines developed (PBX-12-99) and seventeen Cymbidium breeding lines characterized for selection.

In-vitro sub-culturing was done for crosses *viz.*, PBX-12-154, *Cym. dayanum,* PBX-12-58, & PBS(x)-13-148 & *Zygopetalum intermedium* and plantlet from crosses PBX-12-58 and PBX-12-159 were hardened. Successful strong rooting achieved with IBA & NAA in Zygopetalum.

Seventeen scented volatile compounds were identified from studies on *Zygopetalum maculatum* flowers of four different developmental stages. Seventeen fragrant orchid species and 01 hybrid were trapped in different columns for chemical analysis at different flowering stages.

Potting mixtures with Cocochips + Cocopeat + Brick pieces + green moss (3:1:1:1) and Cocochips + Cocopeat + Brick pieces + dry leaf fern (3:1:1:1) showed maximum vegetative growth for 'Winter Beach See Green' (Cymbidium) and *Zygopetalum intermedium* respectively.

Out of 10 tree barks, the material from Malato (*Macaranga denticulata*) and Payun (*Prunus cerasoides*) had shown promising vegetative growth in terms of leaf length and bulb size in 'WBSG' (Cymbidium).

Weekly spray of liquid organic manure (1:30) had shown enhanced bulb size, no of leaves/ bulb, leaf length and number of bulbs/plant in two year old plants and full grown plantlets

enhanced bulb size, spike length, rachis length, no. of flowers/spike and flower size. of 'WBSG' (Cymbidium).

Seasonal incidence of aphid, *Macrosiphum luteum* was recorded on *Epidendrum radicans* revealed the lowest mean population of 23.83 aphids (mean of thirty plants) during 2nd standard week, January and highest population were recorded in 48th standard week with a mean population of 94.7 aphids respectively.

Application of botanical products from neem *viz.*, azadirachtin (neem oil 0.03% EC) @ 5ml/L and *Allium sativum* gave effective management of biosduval scale insect under polyhouse conditions.

Microbial biopesticides *Verticillium lecanii* and *Beauveria bassiana* @ 2ml/L of water gave effective management of biosduval scale insect under polyhouse conditions. Management of aphids, *Macrosiphum luteum* on *Epidendrum* sp. was effectively managed with *Beauveria bassiana*, neem oil and *Metarhizium anisopliae*.

Sealer and healer product in citrus plants in selected places of Sikkim and Darjeeling District was found effective in control of trunk borer. Orchid shoot borer, *Peridaedala* sp. was found to be parasitized by an Ichneumonid wasp.

Nectar-foraging insects visited in the flowers of orchid species *Paplionanthe vandarum, Vanda pumila* and medicinal orchid *Goodyera procera*. Three partial Cytochrome oxidase-I gene sequences of orchid shoot borer, Peridaedala sp. has been submitted to National Centre for Biotechnology Information, USA.

Rhynchostylis retusa plants were found to be regularly foraged by carpenter bees (*Xylocopa* sp) and euglossine bee or orchid bee. Lesser banded hornet, hoverfly, hawkmoth was recorded as flower visitors in orchid, *Pholidota rubra*.

Six field visits were conducted at demonstration units. Rs. 33,700 generated from sale of planting materials (RFS). Organized 4th Stakeholders meeting (19/04/16) and organized Kisan Mela 2017 (Mar 10-11, 2017).

कार्यकारिणी विवरण/सारांश

वर्ष २०१४-१५ का "वनस्पति जीनोम संरक्षक समुदाय पुरस्कार" नोगलाई आर्किड संरक्षक समुदाय, पश्चिम खासी पहाड़ी, मेघालय के लिए घोषित था। भाकृअनुप- राष्ट्रिय आर्किड अनुसंधान केंद्र ने टी.एस.पी स्कीम प्रतिपादन वर्ष २०१५ मे निवेदित किया था।

श्रीमती अनुराधा छेत्री (सिक्किम राज्य की प्रगतिशील आर्किड किसान) को प्रतिष्ठित "पण्डित दीनदयाल उपाध्याय अंतयोदय कृषि पुरस्कार-२०१५ " से २५/०९/२०१६ को सम्मानित किया गया है।

देश के अलग-अलग स्थानो से संग्रहीत ११२ आर्किड प्रजातियों के एन.ए.जी.एस संग्रह (>२५००) और पासपोर्ट विवरण, भाकृअनुप-एन.बी.पी.जी.आर को जमा करा दिया गया एवम आई.सी संख्या प्राप्त किया गया है।

पफिओपेडिलम प्रजाति के १० देशी प्रजातियों और ११ सुगंधित सीलोगायनी प्रजाति की आणविक विविधता का आकलन आई.आई.एस.आर मार्कर द्वारा किया गया। इसी वर्ष १९६ आर्किड प्रजाति के विशुद्ध डी.एन.ए को डी.एन.ए बैंक मे जमा किया गया।

पफिओपेडिलम के किस्म "शीतल-१" को पी.पी.वी.एफ.आर.ए पंजीकरण (REG/२०१६/१५३४) के लिए आवेदन और एस.वी.आर.टी एवम सी.आर.आर.सी किया गया है।

नयी जल्दी पुष्पित होने वाली ६ प्रोजेनी PBX-१२-९९/०१(फेलेनोप्सिस), PBX-०५-७७२ और PBX-०५-२९/९५ (सिंबीडीयम) को चिन्हित किया गया।

पफिओपेडिलम के ४ प्रजनन किस्मों को एन.बी.पी.जी.आर से पंजीकृत किया गया (**IC** ६१७५२२-६१७५२५) जाईगोपेटलम की ३ प्रजातिया PB-ZI-१५-१९ Sel-०१, PB-ZI-१५-४३ Sel-०२ & PB-ZI-१५-२८ Sel-०३ को एन.बी.पी.जी.आर से पंजीकृत किया गया है(IC ६१७५२६-६१७५२८).

हाइब्रिड फेयस की नयी सुगंधित प्रजातियों (PBX-११-२२)को चिन्हित किया गया है। फेलेनोप्सिस की ३ बेहतरीन प्रजनन किस्मों को विकसित किया गया है और १७ सिंबीडीयम की प्रजनन किस्मों को चयन हेतु चिन्हित किया गया है।

PBX-१२-१५४, सिंबीडीयम डेयनम, PBX-१२-५८, & PBS(x)-१३-१४८ और जाईगोपेटलम इंटरमीडियम ka इन-विट्रो(कृत्रिम परिवेशीय) सब-कल्चर किया गया और क्रॉस से अर्जित

पौधो, PBX-१२-५८ and PBX-१२-१५९ की हार्डेनिंग की गयी। जाईगोपेटलम मे सबसे सफल मजबूत जड़, आई.बी.ए और एन.ए.ए के प्रयोग से पाया गया।

जाईगोपेटलम मेकुलेटम पुष्पों के अध्ययन मे उनके ४ अलग-अलग पुष्पन विकास अवस्था मे १७ सुगंधित उदवायी समासो का पता चला। आर्किड के १७ सुगंधित प्रजातियों और १ हाइब्रिड प्रजाति का अलग-अलग पुष्पन विकास अवस्था मे रासायनिक विश्लेषण किया गया।

पॉट मिश्रण कोकोचिप्स, कोकोपिट, ईट के टुकरे, हरी मोस (३:१:१:१) एवम कोकोचिप्स, कोकोपिट, ईट के टुकरे, हरी फ़र्न की पत्तीयो के उपयोग से "विंटर बीच सी ग्रीन" (सिंबीडीयम) और जाईगोपेटलम इंटरमीडियम मे अधिकतम वनस्पति विकास हुआ।

१० पेड़ की छालो मे से, मलातों का एक तत्व मेकारेंजीया डेंटिकुलाटा और पायून (प्रूनस सिरासोइडस) ने WBSG (सिंबीडीयम) मे पत्तियों की लंबाई और कंद की लंबाई मे बहुत अच्छा विकास दिखाया है।

तरल जैविक खाद(१:३०) के साप्ताहिक छिड़काओ से कंद की उन्नत लंबाई, पत्ती/कंद की संख्या मे वृद्धि, पत्ती के आकार मे वृद्धि, स्पाइक की लंबाई, रेकीस की लंबाई, पुष्प/ स्पाइक संख्या और फूलो का आकार मे उन्नत विकास देखा गया।

"मेक्रोसिफम लुटियम" एफ़िड का एपीड्रेंड्रम रेडिकन्स पर मौसमी संकर्मण लेख्यांकित किया गया। जनवरी माह के दूसरे सप्ताह न्यूनतम औसत एफ़िड कीट संख्या २३.८३ देखा गया(३० पौधो का औसत) मे देखा गया और अधिकतम एफ़िड कीट संख्या ४८ सप्ताह मे लेख्यांकित किया गया जिसमे औसत एफ़िड कीट संख्या ९४.७ देखा गया।

नीम के वनस्पतिक पदार्थो के प्रयोग से उदाहरण क लिए एजडाइरेक्टिन (नीम तेल ०.०३%)@ ५ मी.ली और ऐलियम सेटाइवम से पॉलीहाउस मे बायोस्डुवल स्केल कीट का प्रभावी रोकधाम प्रभंधन हुआ।

सूक्ष्मजीव जैविक कीटनाशक वर्टिसिलियम लेकानाइ और बिउवेरिया बेसियाना @ २ मी.ली/ ली पानी के साथ से पॉलीहाउस मे बायोस्डुवल स्केल कीट का प्रभावी रोकधाम प्रभंधन हुआ। एफ़िड "मेक्रोसिफम लुटियम" का एपीड्रेंड्रम प्रजाति मे संक्रमण को बिउवेरिया बेसियाना, नीम तेल और मेटराइजम ऐनोसिफेलि के प्रयोग से प्रभावी रोकधाम प्रभंधन कर सकते है।

सिक्किम और दार्जिलिंग जिले मे पाये जाने वाले साइट्रस पौधो से निर्मित कुछ उत्पाद " ट्रंक बोरर" के रोकधाम मे प्रभावी पाये गये। आर्किड टहनी बोरर, पेरिडेडाला प्रजाति का से इकनूमोनिड वास्प se parasitized होते देखा गया।

पराग ढूंढते कीट पेप्लिओंथे वेंडेरम, वेंडा पुमेला और औषधीय आर्किड गुदाइरा प्रोसेरा के फूलो के तरफ जाते है। आर्किड टहनी बोरर के ३ आंशिक साइटोक्रोम ऑक्सीडेस-I जीन क्रम, पेरिडेडाला प्रजाति को नेशनल सेंटर फार बायोटेकनोलाजी इनफॉरमेसन, यू.एस.ए मे जमा कर दिया गया है।

रींकोंस्टाइलिस रेटूसा आर्किड को कारपेंटर मक्खी(जिलोकोपा प्रजाति), ईउग्लोसिन मक्खी और आर्किड मक्खी से नियमित तौर पे संक्रमित होते देखा गया है । lesser banded hornet, होवर फ्लाई, हाकमोथ को फोलिडोटा रूबरा आर्किड के फूलो पे संक्रमण करते देखा गया है।

प्रदर्शन इकाईयो के ६ क्षेत्रीय दौरे किए गए। पौधो (RFS) के बिक्री से रु. ३३,७०० अर्जित किए गए। चौथी हितधारक बैठक १९/०४/२०१६ और किसान मेला मार्च १०-११, २०१७ को आयोजित किया गया।

Introduction

The National Research Centre for Orchids was established on 5th October 1996 by the Indian Council of Agricultural Research (ICAR), New Delhi to organize research programme on improvement in productivity, quality and commercialization of orchids. The Sikkim state authorities handed over 22.19 acres of land belonging to Regional Agricultural Centre along with all other assets to ICAR for establishment of the centre. In October 1997, the centre also took over the CPRS, Darjeeling from CPRI and established a campus for research on temperate orchids.

In the initial years of establishment the major focus of research was on collection, characterization evaluation, conservation and utilisation of available germplasm in the country in general and north eastern region in particular. With the changing scenario of floriculture in the country, the centre has modified its approach and thrust areas of research to meet the challenges. Today, the focus is on development of marketable varieties/hybrids, molecular characterization, standardization of agro-techniques, post- harvest management, production of quality planting materials through tissue culture and creation of repository of information related to all aspects of orchids in the country. On the basis of recommendations of QRTs and RACs the research programmes have been modified on the mission oriented research projects on germplasm management, crop improvement, crop production and extension.

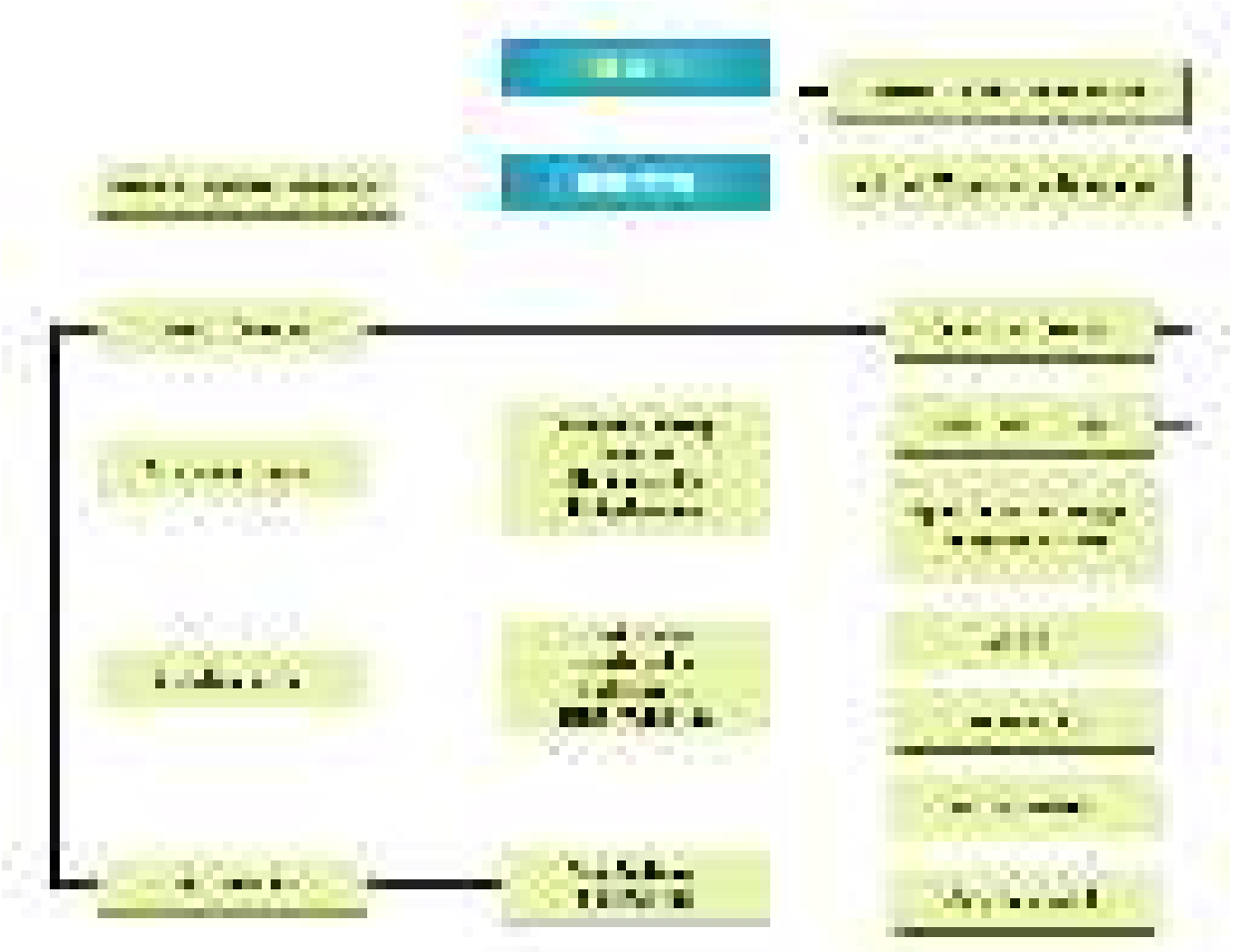
Mandate:

- Applied and strategic research on conservation, improvement and culture of orchids for enhancing productivity and utilization.
- Transfer of technology and capacity building of stakeholders for enhancing and sustaining productivity of orchids.

Vision: To act as a premier centre for research and development activities related to orchid commercialization and sustainable utilization.

Mission: Science and Technology driven development of orchid industry in the country.

ORGANOGRAM



Organogram of ICAR-NRC Orchids

Staff Position (2016-17)
Category Wise

Category	Sanctioned	In position	Vacant
RMP	01	01	00
Scientific	14	09	05
Technical	07	06	01
Administrative	10	06	03*
Skilled Supporting	07	06	01
Total	**39**	**30**	**09**

(*) 01 AAO post abolished w.e.f. 01/03/2016

Budget (2016-17)
Rs. In Lakh

Head	Received	Expenditure Incurred	(%) Expenditure
Plan	**295.93**	**276.37**	**93.39%**
Non Plan	**379.36**	**378.06**	**99.65%**
Total	**675.29**	**654.43**	**96.91%**

Revenue Generation (Rs. In Lakh)

Target for the year 2016-17	Revenue received for the year 2016-17
0.31	**0.11**

Research Achievements

Project: Conservation, Characterization and Sustainable Use of Diversity in Orchids

Documentation & cataloguing of Orchid germplasm:
ICAR-NRCO is conserving nearly 341 species which belongs to 90 genera. Beyond this, institute is having more than 100 hybrids for carry out research work and commercial production. Main campus is conserving tropical and sub-tropical germplasm whereas Darjeeling centre conserving 115 species which include primarily temperate germplasm (Table 1). ICAR-NRCO is one of the NAGS network in the Indian Plant genetic resource information system. During this year, 20 species were added to the species list (Table 3). The most dominating three (03) genera in the list are *Dendrobium*, *Bulbophyllum* & *Coelogyne* etc (Table 2, Fig 1).

Table 1. No. of species with correspond to nature of place

S. No.	Place	Nature of collections	Altitude (MSL)	No. of Sps
1	Pakyong (Sikkim)	Tropical & Sub–tropical collections	1276	311
2	Darjeeling (West Bengal)	Temperate collections	2042	115

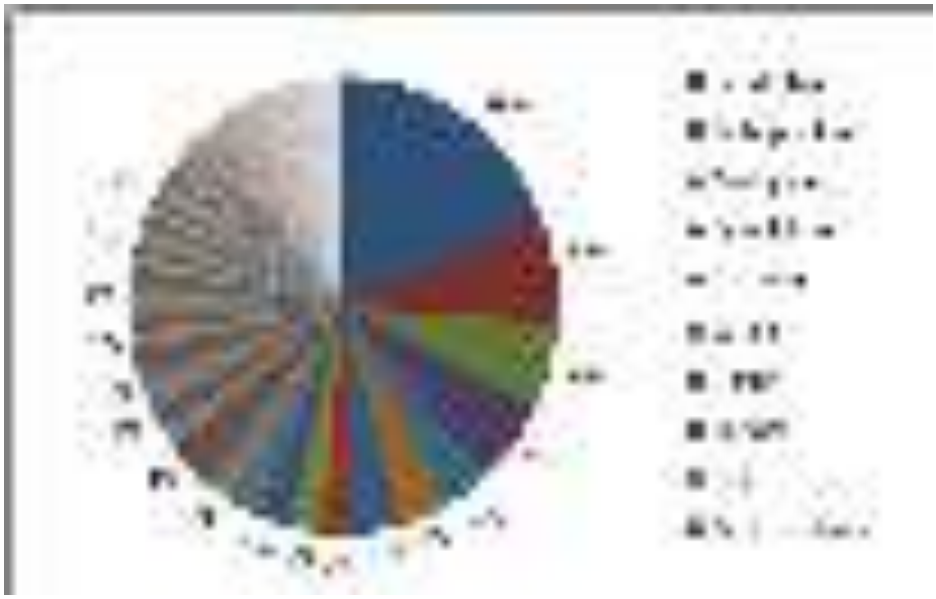


Fig. 1. Pictorial view - Ratio of genera wise at ICAR-NRC on Orchids, Sikkim

Table 2. No. of species in contribution to genera

S. No.	Genus	No. of Species	Percentage (Total no. of species/ Genus)
1	*Dendrobium*	61	19
2	*Bulbophyllum*	25	8
3	*Coelogyne*	20	6
4	*Cymbidium*	20	6
5	*Calanthe*	12	4
6	*Vanda*	12	4
7	*Liparis*	11	3
8	*Aerides*	8	2
9	*Eria*	8	2
10	*Paphiopedilum*	8	2

Table 3. List of some rare collections conserving in ICAR-NRCO (Both Pakyong & Darjeeling)

S. no	Species	IC no.s
1	*Chiloschista parishii* Seidenf.	--
2	*Cymbidium cochleare* Lindl.	--
3	*Dendrobium draconis* Rchb.f.	IC-0614951
4	*Dendrobium nanum* Hook.f.	--
5	*Dendrobium praecinctum* Rchb.f.	IC-0614880
6	*Dendrobium ruckeri* Lindl.	Awaited
7	*Dendrobium transparens* Wall. ex Lindl.	--
8	*Diplomeris hirsuta* (Lindl.) Lindl.	--
9	*Ornithochilus difformis* (Wall. ex Lindl.) Schltr.	--
10	*Paphiopedilum fairrieanum* (Lindl.) Stein	IC-0614906
11	*Paphiopedilum hirsutissimum* (Lindl. ex Hook.) Stein	IC-0614907
12	*Paphiopedilum spicerianum* (Rchb.f.) Pfitzer	--
13	*Paphiopedilum venustum* (Wall. ex Sims) Pfitzer	IC-0614908
14	*Paphiopedilum villosum* (Lindl.) Stein	--
15	*Pleione humilis* (Sm.) D.Don	IC-0617074
16	*Pleione maculata* (Lindl.) Lindl. & Paxton	--
17	*Satyrium nepalense* D.Don	IC-0614913
18	*Zeuxine flava* (Wall. ex Lindl.) Trimen	--
19	*Zeuxine reflexa* King & Pantl.	--
20	*Taeniophyllum retrospiculatum* (King & Pantl.) King & Pantl.	--

		
Chiloschista parishii	*Dendrobium praecinctum*	*Dendrobium ruckeri*
		
Pleione praecox	*Paphiopedilum fairrieanum*	*Taeniophyllum retrospiculatum*
		
Paphiopedilum spicerianum	*Paphiopedilum villosum*	*Dendrobium draconis*
		
Renanthera imschootiana	*Cymbidium cochleare*	*Phalaenopsis mannii*

Fig. 2. Rare orchids conserving in ICAR-NRCO

IC numbers allotment & Passport data submission: Submitted **250 collections** passport data from Karnataka, West Bengal & Sikkim to ICAR-NBPGR and obtained 32 IC numbers

from NBPGR, New Delhi. Passport data of 112 orchid species collected from different locations of the country by Genetics section.

Collected few accessions of species of orchids like *Sunipia bicolor*, *Sunipia cirrhatae*, *Bulbophyllum viridifolium*, *Pleione precox*, *Lusia* sp., *Dendrobium aphyllum* from farmer's field, Omching, West Sikkim District by Agricultural Entomology section (Fig 3).

Sunipia bicolor ***Sunipia cirrhatae*** ***Bulbophyllum viridifolium***

Fig. 3. Germplasm collections from farmer's field, Omching, West Sikkim District

From Horticulture section *Paphiopedilum villosum*, *Paphiopedilum venustum* and *Paphiopedilum hirsutissimum* were collected from Shillong; followed by other species from Sikkim, Uttarakhand, Karnataka and West Bengal. Among them, 26 were sent for IC number to NBPGR. Morphological characterization of 26 species were completed *viz.*, *Aerides multiflorum* (West Bengal)), *Aerides crispa* (Pune), *Aerides odorata* (Uttarakhand), *Acampe pachyglossa* (Odisha), *Bulbophyllum khasyanum* (Meghalaya), *Bulbophyllum nodosum* (Uttarakhand), *Bulbophyllum affine* (Uttarakhand), *Coelogyne Ovalis*,(Uttarakhand), *Dendrobium formosum* (Mizoram), *Dendrobium aphyllum* (Manipur), *Dendrobium aphyllum* (Meghalaya), *Dendrobium amoenum* (Sikkim), *Dendrobium amoenum* (Uttarkhand), *Dendrobium bicameratum* (Uttarakhand), *Eria lasiopetala* (Uttarakhand), *Eria globulifera (Uttarakhand), Eria spicata* (Uttarakhand), *Eria globulifera (Uttarakhand), Liparis petiolata,(Sikkim)*, *Liparis, Malaxis rheedii* (Karnataka), *Ornithochilus difformis* (Sikkim), *Rhynchostylis retusa* (Uttarakhand), *Staurochilus ramosus* (Meghalaya), *Smitinandia micrantha* (Uttarakhand) and *Uncifera obtusifolia* (Sikkim)

Finalized NAGS list:

ICAR-NRCO is a part of NAGS of Indian Plant Genetic Information System. The collections were maintained and conserved in the field genebanks (Fig 4-11). The collections were identified authentically [As per IPNI, Plant list (www.plantlist.org.in) & Check list)] and properly labeled and documented.

Fig. 4. NAGS collections (Sub-tropical)

Fig. 5. Poly house overview

Fig. 6. NAGS collections (Tropical)

Fig. 7. Poly house overview

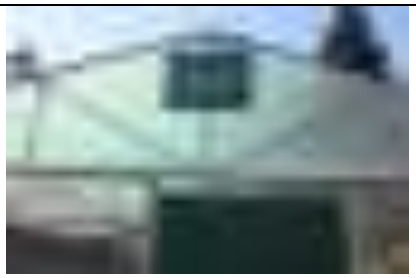


Fig. 8. Meghalaya house

Fig. 9. Assam house

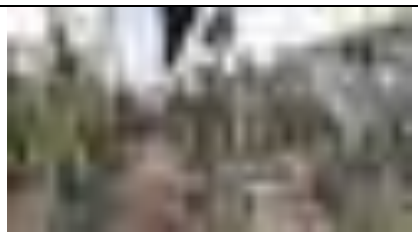


Fig. 10. Conservation house

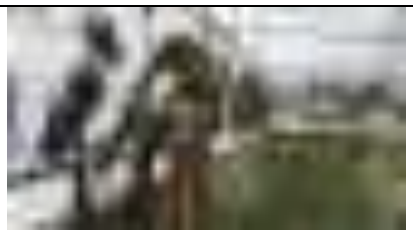
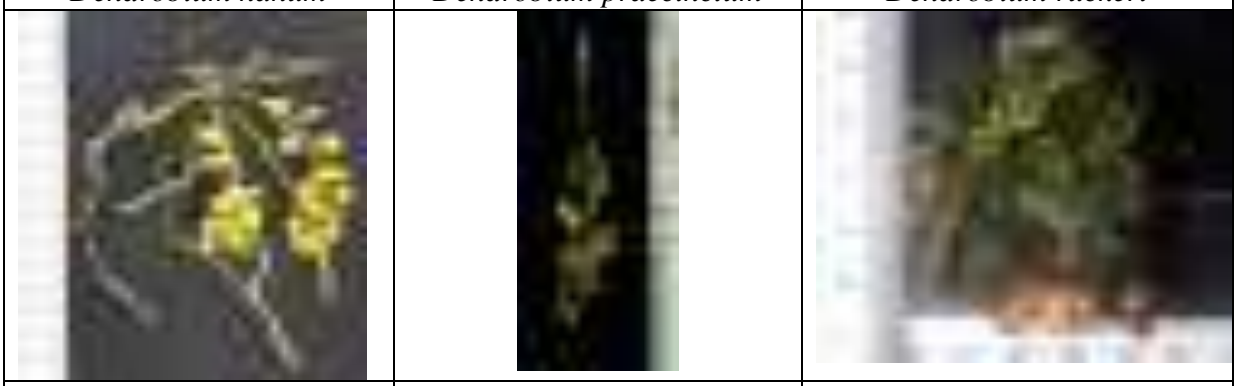


Fig. 11.Vertical conservation

Identified 06 rare collections:

Identified 06 rare collections of orchids namely *Chiloschista parishii* Seidenf., *Cymbidium cochleare* Lindl., *Dendrobium praecinctum* Rchb.f., *Dendrobium nanum* Hook.f., *Dendrobium ruckeri* Lindl.and *Taeniophyllum retrospiculatum* (King & Pantl.) King & Pantl.from existed collections from Genetics sections. These orchid species are conserved in the poly-house by ex-situ method of conservation (Fig 12).

Dendrobium nanum	*Dendrobium praecinctum*	*Dendrobium ruckeri*



Chilostylis parishii	*Cymbidium cochleare*	*Taeniophyllum retrospiculatum*

Fig. 12. Six rare collections identified from existing collections

Photo plates of 70 species: Orchid species were dissected properly and compiled the species photo plates by using digital photography and high resolution scanning. Currently, photo plates of 70 species were completed.

Habitat studies on saprophytic/ mycotrophic orchids *i.e. Galeola* sp., *Lecanorkis sikkimensis,* and *Epipogium roseam* (Fig 13).

***Galeola* sp.:** *Galeola* is a genus of orchids (family Orchidaceae) belonging to the subfamily Vanilloideae. In India, the genus is distributed to Sikkim, West Bengal and Arunachal Pradesh.

Lecanorkis sikkimensis:

This genus was established by Carl Blume during 1856 in his Museum Botanicum Lugduno Batavum. The genus comprises about 15 species. This species is distributed in Sikkim, West Bengal and Bhutan.

Epipogium roseam:

This genus was established by S.G. Gmelin during 1747, in his flora Siberica. The genus comprises about five species. This species is distributed in India, Africa, Asia, Australia, China, Japan, Malaysia, Nepal and Philippines.

Fig. 13. Saprophytic/ mycotrophic orchids in their natural habitat

Morphological Characterization

An unique accession of *Calanthe plantagenea* was selected for its more number of flowers.. Flower number in selected accession varies from 17 to 35 where in common *C. plantagenea* it varied from 6 to 14 (Fig 14). The diameter of inflorescence at the base varied from 4.75 to 7.35 mm. The flowers were selfed for seed setting and viable seeds were obtained. The selection would be multiplied through *in-vitro* seed culture and using meristem culture.

A white coloured bud mutant of *Calanthe puberula* was identified. The flowers were selfed for seed setting. The seeds obtained from selfing were sterile. Hence, it was crossed with the common *C. plantagenea* which was purple in colour and the fertile seeds were obtained. The seeds will be cultured *in vitro* for further multiplication and selection (Fig 15).

A white flowering accession of *Anthogonium gracile* was collected from Sittong (26°55.570'N latitude and 88°19.896'E longitude, elevation 1932 m), Bagora Range, Darjeeling district of West Bengal. The pH level and the moisture content of the substratum

were measured with the help of Soil pH and moisture tester (Takemura Electric Works, Ltd). The vegetation with white colour *A. gracile* was also studied, which is very rare (Fig 16).

Fig 14. ***Calanthe plantagenea***

Fig 15. ***Calanthe puberula***

Fig 16. ***Anthogonium gracile***

Molecular Characterization

Diversity analysis of native orchid species: Analysis of molecular diversity of 10 native species of the genus *Paphiopedilum* was going on using ISSR markers. The work is in progress (Fig 17).

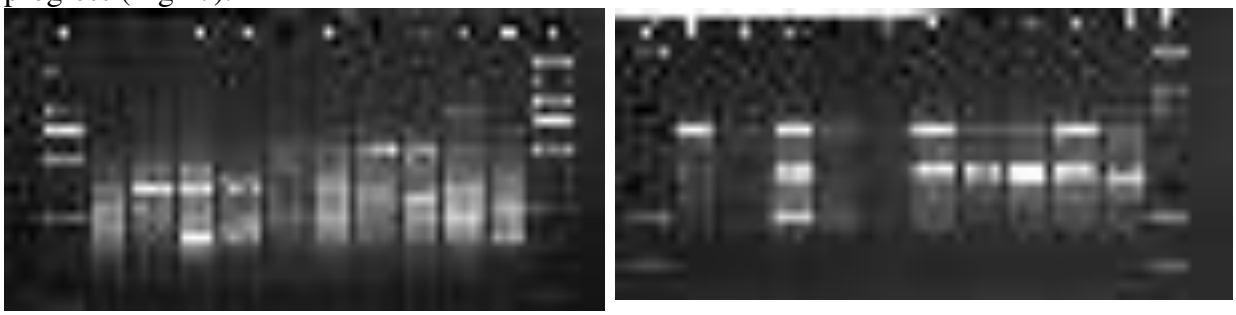


Fig. 17. Banding pattern of 10 *Paphiopedilum* species

DNA Bank: Purified DNA of 196 orchid species were deposited in DNA Bank developed by Genetics section for future research work.

Identification of variants of *Dendrobium nobile*: Two more variants among collections of *Dendrobium nobile* were identified (Fig 18 & 19). In case of variant one variant, the average flower size measures 10-11 cm and others with small size have strong fragrance.

Variant with large flowers

Variant with small flowers having fragrance

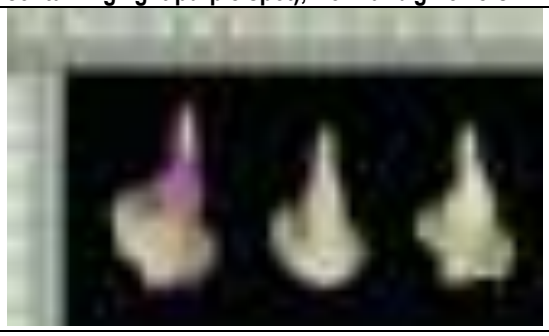
Fig. 18. Variants of *Dendrobium nobile*

Intra-specific variation among collections of Dendrobium *nobile*: On the basis of floral morphological parameters, 5 variants were observed and characterized *Dendrobium nobile*.

Variants in *Dendrobium nobile*

Variants in *D. nobile* (White-albus) , Semi white (lip containing light purple spot), Normal big flowers

Labellum – Dorsal view



Labellum – Ventral view

Fig. 19. Variants in *Dendrobium nobile* Flowers

Identification of nectar-foraging insects attracted to Orchids: Some insects visited the flowers of the orchid species *Paphiolanthe vandaram, Vanda pumila* and medicinal orchid *Goodyera procera* for foraging of nectar. The insects were documented for specific identification and studies of their role as pollinator (Fig 20).

Paplionanthe vandarum	*Vanda pumila*	*Goodyera procera*

Fig. 20. Orchid flowers being visited by nectar foragers

Standardized the *in-vitro* propagation protocol for noble orchid *i.e. Dendrobium nobile* (Fig 21)**.**

Dendrobium nobile	Different stages of seed germination	Seed germination
Emergance of shoot	Shoot elongation and rooting	Hardening of plants

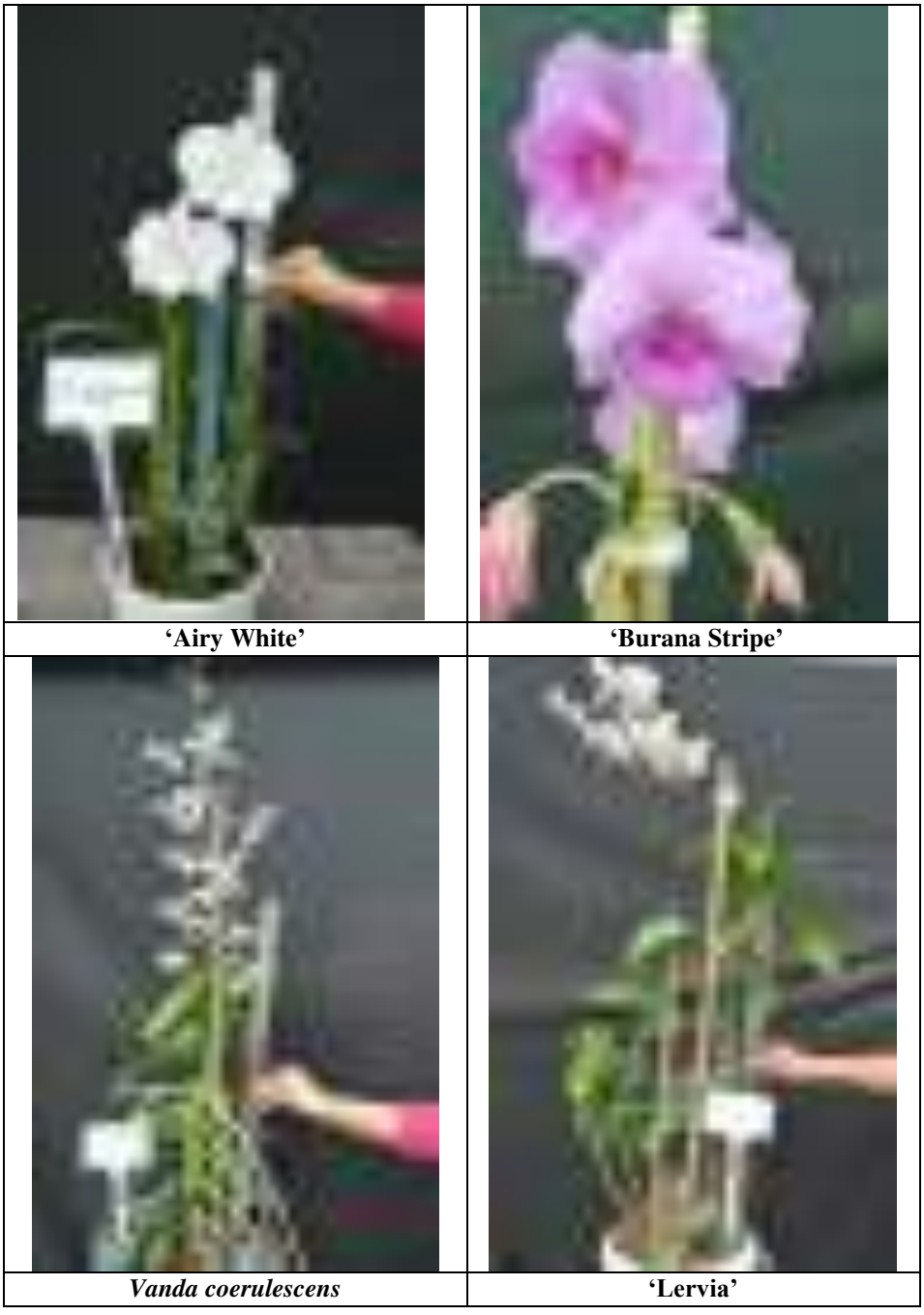
Fig. 21. *In-vitro* propagation of *Dendrobium nobile*.

Project 2: Genetic Improvement of Orchids for Yield, Quality and Resistance to Biotic and Abiotic Stresses

(I) Genetic Enhancement:

The NAGS collections of Orchids are maintained under ex-situ conservation for both sub-tropical and tropical accessions. The concept of vertical conservation is initiated under NAGS using working collections. Documentation and characterization was done for hybrids and parental lines of Dendrobium *viz.*, 'Queen Pink', 'Red Bull', 'V. Nagaraju', 'A. Abraham',

'Burana Stripe' and 'Airy White' (Fig 22). Monitored the flowering pattern of different species, genetic stocks and progeny lines (453 no.). Twenty four accessions received from 'Nonglwai Orchid Conservation Society', Nongstoin from West Khasi Hills (District), Meghalaya received IC numbers from NBPGR (**IC 617566-617589**) that includes *Neogyna gardneriana*, *Cephalantheropsis obcordata*, *Spathoglottis pubescens*, *Eria clavicaulis*, *Coelogyne schultesii*, *Coelogyne fuliginosa*, *Coelogyne fimbriata*, *Rhomboda lanceolata*, *Bulbophyllum griffithii*, *Bulbophyllum leopardinum*, *Eria acervata* and *Gastrochilus calceolaris* etc.



'Airy White' | **'Burana Stripe'**

Vanda coerulescens | **'Lervia'**

Fig. 22. Documentation of NAGS Collections for Hybrids and Species

Monitoring Pest Complexity in Germplasm Collections & breeding populations:

- Different orchid germplasm and hybrids were found to be infested mainly with biosduval scale, thrips, shootborer, aphids and mites.

- Different accessions of *Zygopetalum intermedium, Pholidata rubra, Pholidata articulate, Flickengeria fugax*, *Lusia* sp., *Dendrobium chrysotoxaum*, *Dendrobium moschatum* etc and in Cymbidium progenies *viz.*, HxB, Cym. BxH, PBX-05-772, PBX-10-33, PBX-05-122, PBX-05-34, PBX-11-22, PBX-05-178, AxV, Cym. G, AB x SG *etc* were found to be infested with Biosduval scale (*Diaspis biosduvali*) and the average population of scale in Cymbidium pendulum was 11.3/5cm/plant.
- Two spotted spider mites, *Tetranychus urticae* Koch., were found in different accessions in few plants of *Dendrobium densiflorum, Dendrobium moschatum, Dendrobium fimbriatum*, PBX-05-772, PBX-05-826, PBX-11-155, BxH and NRCO/PlxPw lines. The average population of mite in Cym. PBX-05-772 was 4.4/5cm/plant.
- Orchid shoot borer, *Peridaedala* sp., was found to infest accessions of *Papilionanthe teres*, 'A. Abraham' (Dendrobium), Mokara Hybrids, *Zygopetalum intermedium*, *Vanda coerulea* and *Dendrobium nobile* with mean percent infestation of 1 shoot/plant.
- Aphid, *Macrosiphum luteum* was found in few plants of *Epidendrum* species with average population of 7 aphids/panicle/plant.
- Thrips, *Dichromothrips nakahari* was found to infest flowers of several Dendrobium species like *Dendrobium moschatum, Dendrobium densiflorum* and *Dendrobium fimbriatum.*

(II) New Breeding lines identified and selection

Paphiopedilum hybrid 'Sheetal 1' (IC 614753) filed for Plant Breeder right's with PPVFRA, New Delhi (Ackn No: REG/2016/1534).

Sheetal 1 (IC 614753)/REG/2016/1534

Four more breeding lines identified from progeny lines of NRCO/*Paphiopedilum lawrenceanum* x P. 'Winston Churchill '/20, 27, 39 & 03 received IC registration (**IC 617522-617525**), apart from selections done for Zygopetalum intermedium *viz.*, , & registered with NBPGR (**IC 617526-617528**) (Table 4). Promising genetic stocks under evaluation *viz.*, NRCO/P. venustum/Clone-I, NRCO/P. venustum/Clone-II, 'V. Nagaraju' (Dendrobium), 'Kunga Gyatso' (Aranda) and eight Paphiopedilum breeding lines were characterized. Other six moderately promising NRCO/PlxPw lines flowered viz., 28, 08, 30, 33-34, 23 & 26 were characterized.

Table 4. Breeding lines identified for NBPGR registration

S. no.	*Breeding line*	Genus/Group	*Pedigree*	*IC Number*
1	NRCO(PlxPw)/20/2013	*Paphiopedilum*	*P. lawrenceanum* x *P.* 'Winston Churchill'	IC 617522
2	NRCO(PlxPw)/27/2013	*Paphiopedilum*	*P. lawrenceanum* x *P.* 'Winston Churchill'	IC 617523
3	NRCO(PlxPw)/39/2013	*Paphiopedilum*	*P. lawrenceanum* x *P.* 'Winston Churchill'	IC 617524
4	NRCO(PlxPw)/03/2013	*Paphiopedilum*	*P. lawrenceanum* x *P.* 'Winston Churchill'	IC 617525
5	PB-ZI-15-19 Sel-01	*Zygopetalum*	Selection	IC 617526
6	PB-ZI-15-43 Sel-02	*Zygopetalum*	Selection	IC 617527
7	PB-ZI-15-28 Sel-03	*Zygopetalum*	Selection	IC 617528

Cymbidium progeny lines evaluated during current flowering season:

Fig. 23. NRCO (PBX-05-29/95)

Fig. 24. PBX-05-772/84

1. **PBX-05-29/95**: Very early flowering progeny (2nd Wk, Aug) suitable for potted variety and flowers twice in a year. Spike length – > 58 cm, thin and multiple spikes. The flower size – medium small, 6 cm x 7.5 cm and in dominating yellow-green colour (RHS 153B). Dorsal sepal – 5.7 cm x 1.7 cm with deep purple veins on dorsal side visible. Petals – greyed purple colour (RHS 185A). The potted vase life < 40 days and proposed for IC registration, which has dominating spikes over leaves (Fig 23).

2. **PBX-05-772/84**: Early flowering progeny (2nd Wk, Nov) with medium spike length. Flower colour – dominating yellow brownish (greyed orange group, RHS N167) with fragrance. Dorsal sepal – 5.5 cm x 1.9 cm, concave with veins in deep greyed orange group colour (RHS 175B/A). Petals – 5.7 cm x 1.1 cm in pale yellow colour (RHS 13B) and anterior lobe of lip with distinct red colur spots (RHS 60C/B). Potted vase life > 44 days (Fig 24).

Fig. 25: PBX-05-772/126

Fig.26: PBX-05-772/81

3. **PBX-05-772/126**: Early to mid flowering progeny (3rd WK, Oct) suitable for potted and cut variety. Bulbs more in number and size big (9.7 cm x 5 cm) and compressed on sides with pointed tip. Spike – 59 cm x 0.8 cm, slender with 9 flowers. Flower size – 5.2 cm x 7.5 cm with dominating width and greyed yellow colour (RHS 162B). Dorsal sepal – 4.5 cm x 1.8 cm, incurved/boat shaped with pointed tip. Petals – 4.7 cm x 1.2 cm, 9-10 veins, elongated purple lines from base to tip along lower margin. Lip – 3.4 cm x 1.7 cm, lateral lobes narrow, deep purple maroon shining lines inside from base to tip of lateral lobes, Potted vase life < 37 days and being proposed for IC registration for flower colour (Fig 25).

4. **PBX-05-34/81**: Mid flowering progeny (4th Wk, Nov) suitable for potted variety. Spike – medium size, 43 cm length, slender with 8 flowers with potted vase life > 110 days (Fig 26).

Fig. 27: PBX-05-34/96

Fig. 28: PBX-05-34/84

5. **PBX-05-34/96**: Mid-late flowering progeny (2nd WK, Jan) suitable for cut flower variety. Spike – 63 cm x 0.58 cm, slender with 7 flowers. Flower size – big, modern with size 7.3 cm x 9.8 cm with dominating width and shining yellow colour (RHS 11A). Dorsal sepal – 6.2 cm x 3.7 cm, slightly incurved, pale yellow colour (RHS 162B/C Greyed-Orange group, blunt tip with pointed vein. Petals – 6 cm x 2.8 cm, plae yellow colour (RHS 11A) with tip portion in dark yellow colour (RHS 4B), ovate shaped with blunt tip & pointed and raised vein. Lip – 3.5 cm x 3 cm, dark purple spots in round and elongated spread from base to lateral lobes inside, anterior lobe curvy-open & broad shaped, mid lobe largely fuzzy pubescent. Potted vase life < 75 days and being proposed for IC registration for distinct lip spots & pattern (Fig 27).

6. **PBX-05-34/84**: Mid-late flowering progeny (3rd WK, Jan) suitable for cut flower variety. Spike –73 cm x 0.49 cm, slender with 11 flowers. Flower size – big, modern with size 5 cm x 9.6 cm with dominating width and greyed yellow colour (RHS 162B). Dorsal sepal – 6.4 cm x 3.2 cm, slightly incurved with margin out curved, greyed yellow colour group (RHS 162D) with pointed tip. Petals – 5.8 cm x 2.8 cm, greyed yellow colour (RHS 162D). Lip – 3.8 cm x 2.6 cm, regular greyed purple stripes from base to lateral lobes inside, dark purple spots on anterior lobe and patches on margin of anterior lobes. Potted vase life < 69 days and being proposed for IC registration for distinct lip spots & pattern (Fig 28).

Fig. 29. PBX-05-34/31

Fig.30. PBX-05-34/19

7. **PBX-05-34/31**: Mid-late flowering progeny (4th WK, Jan) suitable for cut flower variety. Spike –72 cm with 11 flowers. Flower – medium size, bulb shape, compact type, mild fragrant, modern with size 4.5 cm x 5.2 cm with dominating greyed yellow colour (RHS 162B). Dorsal sepal – 6 cm x 3.6 cm, greyed yellow colour (RHS 162B) with purple (RHS 186A) strips of small spots inside at base and broad tip. Petals – 6 cm x 2.8 cm, greyed yellow colour (RHS 162B). Lip – 3.7 cm x 2.8 cm, regular greyed purple stripes (RHS 186A) from base to lateral lobes inside, dark purple spots on anterior lobe and wavy margin. Potted vase life < 88 days and being proposed for IC registration for distinct flower shape (Fig 29).

8. **PBX-05-34/19**: Mid-late flowering progeny (1st WK, Jan) suitable for cut flower variety. Spike – 47.5 cm with 9 flowers. Flower – large size, broad, semi-open type, modern with size 7 cm x 7.5 cm with dominating shining greyed pink colour (RHS 56C). Dorsal sepal – 6.2 cm x 3.5 cm, pink red group colour (RHS 56C) with greyed purple colour on mid rib (RHS 186A), margin curved outward and pointed tip. Petals – 5.6 cm x 2.7 cm, pink red group colour (RHS 56C). Lip – 3.5 cm x 2.2 cm, regular greyed purple stripes (RHS 187B) from base to lateral lobes inside, anterior lobe broader and median lobe pointed. Potted vase life < 88 days and being proposed for IC registration for distinct flower colour, size and shape (Fig 30).

Fig. 31. PBX-05-34/13

Fig. 32. PBX-05-34/124

9. **PBX-05-34/13**: Mid flowering progeny (4th WK, Jan) suitable for cut flower variety. Spike – 73 cm length & girth 0.61 cm with 11 flowers. Flower – large size, highly fragrant, broad, semi-compact type, modern with size 8 cm x 10 cm with dominating shining white colour group (RHS N155B), uniform colour for sepals & petals and two directional. Dorsal sepal – 6.5 cm x 3.4 cm, broadly ovate shaped, pointed tip, incurved & saucer shaped with distinct pale red-purple colour on mid vein. Petals – 6.2 cm x 2.8 cm, spreading type, broadly ovate shape and pointed tip. Lip – 4 cm x 2.5 cm, compact type lateral lobes, inside & borders in red-purple colour (RHS 65C/B), elongated stripes (2 mm) from base to lateral lobes inside, anterior lobe broad with pink-purple dark spots (RHS 70A) in dispersal manner and ridges has distinct raised yellow hairs with very small purple spots. Potted vase life < 78 days and being proposed for IC registration for distinct flower characters (Fig 31).

10. **PBX-05-34/124**: Late flowering progeny (1st WK, Feb) suitable for potted variety. Spike – 43.5 cm with 5 flowers. Flower – medium size, bulb shape, compact type, modern with size 6.5 cm x 7 cm with dominating pale yellow colour (RHS 11D) with modern lip. Dorsal sepal – 5.6 cm x 3.7 cm, amber yellow colour (RHS 11D), broader, saucer shaped, but upper portion recurved and pointed at tip. Petals – 5.5 cm x 3 cm, broad & obovate shape, incurved with pointed tip. Lip – 3.5 cm x 2.8 cm size with prominent lateral lobes and anterior lobes, inside lateral lobes partially netted in red-purple colour (RHS 179A) strips from bottom to curves, median lobe lower, anterior lobe broad and narrowed down to pointed tip with having broader broken lines/stripes in red-purple colour. Potted vase life < 78 days and being proposed for further evaluation (Fig 32).

Fig.33. NRCO/ABxSG/02

Fig. 34. NRCO/HxB/14

11. **NRCO/ABxSG/02**: Late flowering progeny (1st WK, Feb) suitable for both cut flower and potted variety. Spike – 69 cm, slender (0.65 cm) with 12 flowers. Flowers – large size, broad, semi-open type, modern with size 5.8 cm x 8.4 cm with dominating width and pale purple colour on sepals. Dorsal sepal – 4.4 cm x 2.5 cm, broad tip, ovate shape. Petals – 4.8 cm x 2.2 cm, ovate shaped and greyed yellow colour and slightly reflexed. Lip – 3 cm x 2.5 cm, greyed yellow colour (RHS 161D) and purple maroon stripes from base to mid portion inside of lateral lobes. Potted vase life < 62 days and being proposed for IC registration for distinct flower colour, size and lip shape (Fig 33).

12. **NRCO/HxB/14**: Late flowering progeny (2nd WK, Mar) suitable for potted variety. Spike – 43 cm, slender (0.46 cm) with 8 flowers. Flowers – medium size, broad, open type with size 5.5 cm x 9.6 cm with dominating width and greyed pink-red group (RHS 179C/D) on yellow background. Dorsal sepal – 6.2 cm x 2.2 cm, incurved, pointed tip and lanceolate shape. Petals – 6.2 cm x 2.1 cm, narrow oblong shape with pointed tip, incurved and bottom margin curved back. Lip – prominent & exotic look, 3 cm x 2 cm size, greyed yellow colour (RHS 13D), anterior lobe dominated by scattered patches in orange-red group colour (RHS N34A) and margin pale red colour (HS 179D). Being proposed for further evaluation and use as genetic stock in breeding programmes (Fig 34).

Fig. 35. NRCO/HxB/20

Fig.36. NRCO/HxB/21

13. **NRCO/HxB/20**: Late flowering progeny (2nd WK, Mar) suitable for potted variety. Spike – 62 cm, slender (0.56 cm) with 15 flowers dominating over leaves. Flowers – medium size, broad, open type with size 6.3 cm x 8.3 cm with dominating width and in green-yellow colour (RHS 1D). Dorsal sepal – 5.2 cm x 2.1 cm, semi-curved, pointed tip and lanceolate shape. Petals – 5.1 cm x 2 cm, narrow oblong shape with pointed tip, incurved and margin slightly curved back. Lip – exposed lip in pale red-crimson colour on white background (RHS 155A), lateral lobes curved outward, open & broad, anterior lobe broad & narrowed down to pointed tip, curvy margin and dominated by scattered grey purple spots (RHS 185A). Has high breeding value for scientific studies and advancement of lines (Fig 35).

14. **NRCO/HxB/21**: Late flowering progeny (3rd WK, Mar) suitable for potted variety. Spike – 52.5 cm, slender (0.56 cm) with 08 flowers dominating over leaves. Flowers – medium size, broad, open type with size 6 cm x 9.5 cm with dominating width in shining yellow colour (RHS 12B/C). Dorsal sepal – 5 cm x 2.4 cm, incurved and blunt tip. Petals – 5.3 cm x 1.8 cm, narrow oblong shape with blunt tip. Lip – 3 cm x 2 cm, medium big size, lateral lobes prominent, articulated downwards, pale orange-red colour stripes (RHS N34A) inside from base to upper margin of lateral lobes and also spots & patches spreading across anterior lobe (Fig 36).

Fig.37. NRCO/BxH/11

Fig.38. NRCO/BxH/12

15. **NRCO/BxH/11**: Late flowering progeny (2nd WK, Feb) suitable for both potted and cut flower variety. Spike – 71 cm x 0.72 cm with 14 flowers dominating over leaves. Flowers – medium size, broad, open type with size 6 cm x 9.7 cm with dominating width and in yellow-green colour (RHS 150B). Dorsal sepal – 5.6 cm x 2.1 cm, incurved, base slightly curved back and tip unequal but narrow pointed. Petals – 5.2 cm x 1.6 cm, upper edge half curved, tip unequal but narrow pointed and uniform colour on upper surface. Lip – 3 cm x 2 cm, medium size & modern type, close to column, anterior lobe pointed downward, red-purple patches (RHS 59A). Being proposed for IC registration for distinct flower colour and marked lip colour (Fig 37).

16. **NRCO/BxH/12**: Late flowering progeny (1st WK, Feb) suitable for both potted variety. Spike – 35 cm x 0.52 cm with 12 flowers. Flowers – big size, broad, open type with yellow colour (RHS 10D) with pale yellow purple colour tinge on sepals and column. Dorsal sepal – 5.7 cm x 1.7 cm, edges curved back and tip unequal & blunt. Petals – 5.2 cm x 1.5 cm, edge curved back and reflexed. Lip – 2.5 x 2.5 cm, lateral lobes prominent & open type, colour dominated by greyed yellow colour (RHS 160B), anterior lobe in orange red colour (RHS N34A), recurved 2-3 times and tip is curved back. Being proposed for registration for distinct genetic stock for negative characters (Fig 38).

Fig.39. NRCO/BxH/35

Fig.40. PBX-11-22

Fig.41. PBX-05-10

17. **NRCO/BxH/35**: Late flowering progeny (4th WK, Feb) suitable for both potted and cut flower variety. Spike – 66 cm x 0.62 cm with 18 flowers dominating over leaves. Flowers – medium size, semi-compact, close to spike, open type with size 7.2 cm x 8 cm and in yellow-green colour (RHS 153C). Dorsal sepal – 5.2 cm x 2.2 cm, semi flat and tip unequal but narrow pointed. Petals – 5.1 cm x 1.7 cm and oblanceolate shape. Lip – 3 cm x 2.3 cm, medium size & modern type, prominent lateral lobes, anterior lobe pointed downward & triangular shape marked by dark red-maroon purple colour (RHS 187B/A). Being proposed to evaluate further to use as genetic stock for more flowers (Fig 39).

18. **PBX-11-22**: A new species hybrid developed from native Phaius species *viz.*, *P. tankervilleae* x *P. flavus*. The novel cross flowered has new colour in yellow-green colour (RHS 144B) with 6-8 flower that flower sequentially from bottom to top (Fig 40).

19. **PBX**-05-10: A cross of 'Fency Free' x 'Tetraploid Oklahama' (Cymbidium) flowered with big flower that subsequently withered (Fig 41).

20. **PBX-12-99**: The new generation Phalaenopsis hybrids with high commercial value generated under evaluation and characterization and so far four promising progenies identified (Fig 42-45).

Fig.42. PBX-12-99 (1)

Fig.43. PBX-12-99 (2)

Fig.44. PBX-12-99 (3)

Fig.45. PBX-12-99 (4)

(III) *In-vitro* progeny cultures of hybridization

Seed culture response of Phalaenopsis cross: Left over small plantlets of cross PBX-12-99 (*P*. 'Brother & Sister' x *P*. 'Rousserole') were attempted for better plantlet with root development in half strength media with banana powder and no sucrose, to decrease the cost of effective hardening. Media (Q1) with ½ Gamborg + Banana (2 g) – Scu - AC given moderately better planets with roots with slow response (Fig. 46).

Fig.46. In-vitro response of PBX-12-99

Seed culture response Cymbidium crosses: The *in-vitro* studies for effective rooting on crosses PBX-11-154 (*C.* 'Free Style No. 3' x *C. tracyanum*) completed and mature plantlets were shifted to hardening. In previous experiments, good shoot development was achieved with less root development. The treatment (T2) with G+AC(2 g)+Suc (2%)+BAP (0.5)+IAA (1 mg) found to be the best treatment with quicker response and more number of roots than others. Root length of 15.75 cm with 8 roots formed with best treatment (Fig 47).

Fig.47. In-vitro response of PBX-11-154 for effective rooting

Field Visits/Demonstration Units: Field visit at Yangang, South Sikkim (19/10/2016), Pedong, Kalimpong (20/10/16), Sombaria, West Sikkim (28/10/2016) & Nongstoin (11/11/16) for conducting breeding trials and assist farmers (Fig. 48-51).

Fig.48. Field Trail/FLD at Sombaria, West Sikkim

Fig.49. Field Trail/FLD at Yangang, South Sikkim

Fig.50. Field Trail/FLD at Pedong, Kalimpong

Fig.51. Field Trail/FLD at Nonglwai, Meghalaya

Multilocation Trials: 'Kunga Gyatso' (*Aranda*) is under AICRP trial at three locations *viz.,* NRCO, ICAR RC NEHR and AAU from 2014 onwards. SVRC and CVRC trial for 'Sheetal 1' (Paphiopedilum) is being constituted.

Project 3: Development and refinement of production and protection technologies for improved productivity, marketing and utilization of orchids

Effect of ionic strength of nutrient solution and medium composition of *Zygopetalum intermedium*

Uniform sizes of plants were planted in 6" size pot in perlite, vermiculite, moss, and Cocopeat media. Plants were applied with ¼, ½ and full strength of Hoagland Solution at monthly interval. There were 12 treatment combinations. The experiment was set to identify the medium and nutrition requirement of Zygopetalum grown under semi hydroponic system. The experimental results revealed that application of full strength of Hoagland Solution in plants grown in moss growing medium increased plant height (53.94 cm), no. of leaves (15.80), length of leaves (40.85 cm) and no. of floret per spike (7.16). Application of ¼ strength of Hoagland Solution improved the spike length of plants grown in moss medium (Table 5).

Table 5. Vegetative and Floral characters of *Zygopetalum intermedium* as influenced by growing media and nutrition

	Plant height(cm)	No. of Leaves	No. of shoots/plant	Leaf length(cm)	Length of spike(cm)	No. of floret/spike
H1M1	45.58	12.73	2.2	38.96	61.02	6.0
H1M2	37.84	14.13	1.33	26.81	48.38	6.33
H1M3	49.47	13.80	1.87	37.69	**66.27**	6.83
H1M4	38.77	12.50	1.33	28.34	43.30	6.16
H2M1	48.14	13.27	1.53	35.50	55.59	6.00
H2M2	47.55	13.13	1.27	32.56	55.04	6.66
H2M3	47.67	**14.67**	1.87	36.16	54.79	6.66
H2M4	37.07	13.20	**3.70**	28.19	47.91	6.50
H3M1	43.11	13.67	1.67	31.54	52.45	6.5
H3M2	44.87	12.47	1.53	32.74	47.28	6.83
H3M3	**53.94**	**15.80**	2.0	**40.85**	52.05	**7.16**
H3M4	35.63	11.80	1.33	25.13	36.89	**7.16**

Effect of different media on growth and flowering of *Dendrobium nobile*

Uniform size plants of *Dendrobium nobile* were planted in 6" diameter pots. Regular dose of macro nutrients (N: P: K) 20:20:20 @ 0.1% foliar spray) was applied to all the treatments at weekly interval. Three rooted cane were planted in each pot with different locally available growing media comprised of Coco chips (Control), Tita pati (*Artemisia vulgaris),* Panisas (*Terminalia myriocarpa),* Utis (*Alnus nepalensis),* Chilauni (*Schima wallichii),* Fern *(Gleichenia gigantea),* Maize cobs, Big Sage: *Lantana camara,* Titapati+Panisas+Utis+Fern, Maize cob+Panisas+Utis+Fern, Maize cob +Utis+Fern+Chilauni, Lantana +Utis+Fern+Chilauni, Maize cob+Chilauni + Lantana+ Titapati, Chilauni+Lantana+Titapati+ Panisas, Lantana+Titapati+Panisas+Utis. Growing of *Dendrobium nobile* in maize cob medium increased plant height (13.32 cm) followed by Cocochips (control) and *Lantana camera* and intermodal length (2.08 cm). Growing media Chilauni+Lantana+Titapati+Panisas improved stem size (6.08 cm) and no. of cane per pot (1.33). Cocochips improved the size of leaves (25.63 cm^2).

Identifying suitable location for cultivation of Cymbidiums

For identifying suitable production locations a evaluation of three cultivar (Levis Duke 'Bella Vista'; Ruby Anniversary 'Pink Surprise' and Margaret Thatcher) was conducted at four locations Gadidhura, 245m alt.; Rohini,648m alt., Lower Sirubari, 966m alt; and St. Mary's Hill 1553m alt.). The varieties cultivated at lower elevations (L1 and L2) showed the early vegetative bud development as compared to plants cultivated at higher elevation (Fig. 52). However, no flowering was observed at lower elevations. The lower elevations can be utilized for plantlet development.

Fig. 52. Growth and development of current year's growth (vegetative bud in three cultivars of Cymbidiums at four locations

Vertical farming

Working models of vertical farming for potted *Phalaenopsis* orchids has been developed in the ICAR-NRC for orchids, from PVC pipes and locally available bamboo. The structures were made in 3 storeys and the pipes/bamboos were arranged at a degree that the slopes allow water to flow from one layer to another. Brick pieces were use as media to anchor the plants. The advantages of these structures are (a) it minimizes the space use: These structures can accommodate more plants than individual pot cultivation for the same space. It would be very beneficial for urban areas where space is limiting factor. (b) Conservation of irrigation water: Three-fourth of the irrigation water used in these vertical farming structures can be recollected and re-use, whereas, in individual pot cultivation, maximum irrigation water is wasted. (c) Increases the aesthetic value of the garden (Fig. 53).

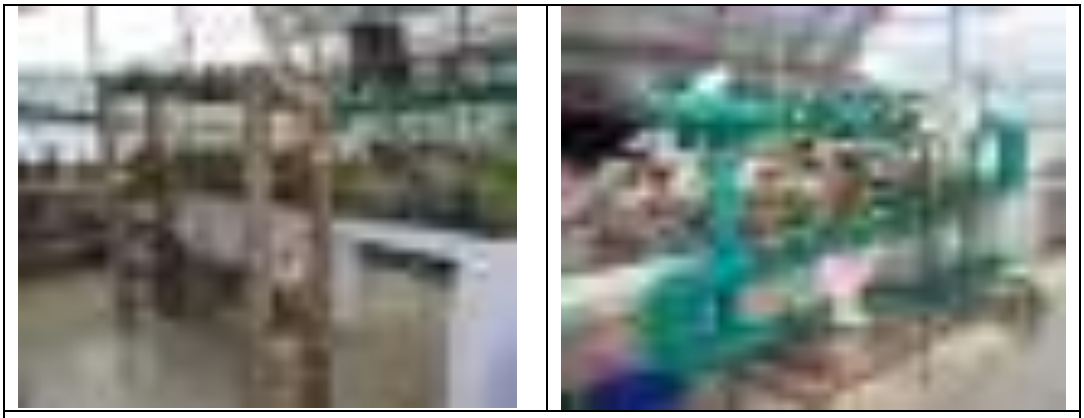


Fig.53. Vertical structure for potted *Phalaenopsis*

Multiplication of *Phalaenopsis* from flower stalks

Phalaenopsis orchids possess neither pseudobulbs nor rhizome, propagation through cuttings is definitely not a feasible option and the rate of keikis production is very low. In general, vegetative propagation in monopodial orchids is done through keikis. Under normal conditions, *Phalaenopsis* flower may bloom for two to three months. After flowering, the

same flower stalk may bloom again from the dormant bud. However, the stalks are generally cut off so as to facilitate the orchid plant to re-establish and to produce larger flower and strong stem within a year. The flower stalks were usually discarded. The discarded flower stalks can be used to produce keikis by treating with plant growth regulators. Healthy flower stalk were selected and 2-3 dormant buds from the base were cut, while the apex portion was discarded. The stalks were then *ex-vivo* cultured in aqueous solution containing 2 g BAP and 0.5 g NAA per litre and incubated in bio-incubator with a temperature set at 27^{o}C Day and 20^{o}C Night. Visible bud growth can be observed within the fortnight and the plantlets were ready to be potted within a year after having inches long 2-3 roots (Fig 54).

Fig.54. Multiplication of *Phalaenopsis* from flower stalks

Approach on *ex-situ* conservation of rare orchid, *Diplomeris hirsute* (Lindl.) Lindl. (Snow Orchid)

Diplomeris hirsuta (Lindl.) Lindl. popularly known as 'snow orchid', which is very curious species for botanists and orchid growers for highly attractive large white flowers. The present species is extremely rare & distributed from north western Himalaya to north eastern Himalayan region in India, Nepal and China. In India, it is reported from Uttarakhand, West Bengal, Sikkim and Arunachal Pradesh. This species is under threat due to habitat destruction by anthropological activities and landslide. It is typically lithophytic and generally found growing near the sides of running water streams on the sandy-rocks with the altitude of 300-1000 meter and requires warm humid climate during the active growing stage. Plants are terrestrial tuberous pubescent herbs and starts sprouting with the onset of rainy season during

the month of June. Flowering will start during the month of July and up to September followed by fruiting and stayed dormant rest of the year.

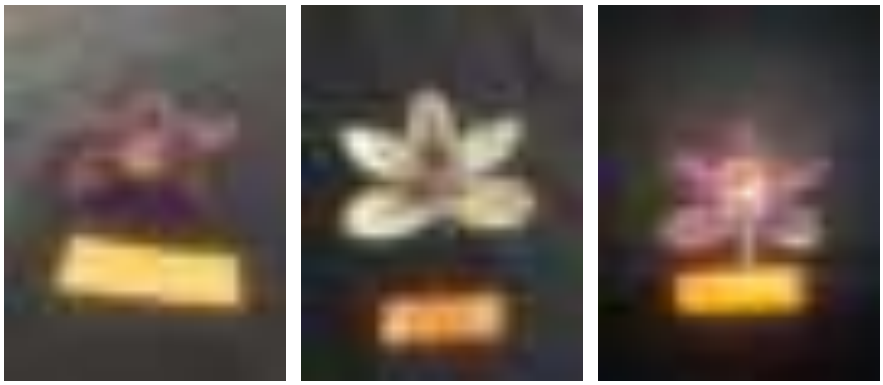
The species was collected from the road side of Kalikhola bridge, Sevoke area, West Bengal State. We took the initiative for ex-situ mode of conservation of *Diplomeris hirsuta* by simulation of its habitat and succeeded the germination and flowering in semi-controlled Green House. It leads to a new step towards the conservation of this species under natural and controlled conditions (Fig. 55).

Fig.55. Population of *Diplomeris hirsuta*(Lindl.) growing in the natural habitat (above). *Diplomeris hirsuta* in full bloom at Green house (below).

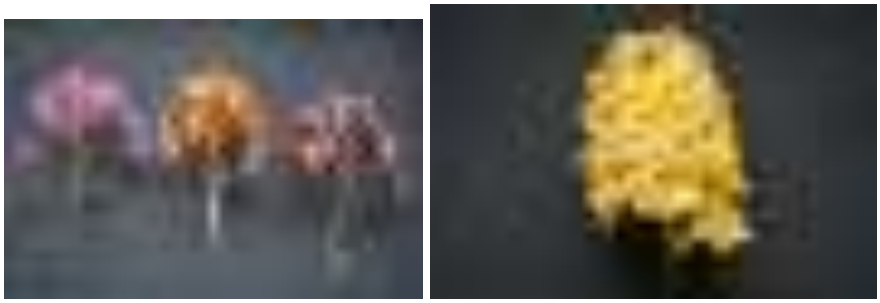
Flower drying in orchids

Embedded drying with borax and silica gel at 45-55^{o}C was found successful Den. Thongchai Gold, Bangkok Blue, *Paphiopedilum*, *Vanda*, *Phalenopsis* 'Detroit', Buenos Aires' Plumerai, Hydrangea, Gladiolus and Lilium.

Embedded drying with borax at 50-60^{o}C was found successful in Phal. 'Nagasaki, 'Manchester', 'Boston', 'Detroit', *Den*. 'Emma White', 'Lervia', 'A. Abraham', 'Triple Pink', *Epidendrum* spp. and *Cym*. 'Valley Teaser', 'N. Cherry', 'Bartha Peterson', and 'Platinum Gold'. (Fig. 56).



Bertha Peterson N. Cherry Valley Teaser



Epidendrum spp. *Den. densiflorum*

Under room condition (25-28^{o}C and 60% RH), perlite, perlite + borax and perlite + silica gel were found successful for drying florets of Phalaenopsis, Cattleya, Dendrobium and Oncidium orchids.

Fig: 56. Floret drying of orchids

Post-harvest management of orchids

- Treatment with 2% glucose + 8-HQS (200 ppm) + citric acid (100 ppm) enhanced post-harvest life of fully open *Zygopetalum intermedium* cut flowers to the extent of 10 days over control 7 days in tape water.

- Treatment with 2% glucose + 8-HQS (200 ppm) + citric acid (100 ppm) and 2% sucrose + 8-HQS (200 ppm) enhanced opening of buds and vase life of *Zygopetalum intermedium* cut flowers to the extent of 86% and 11 days over control 14% and 7 days in tape water, respectively.

- At 19.5^{o}C temperature and 60% RH, in *Den.* 'Emma White', 2% sucrose + ASA (200 ppm) and 2% glucose + ASA (100 ppm) were found as best holding solutions for maximum vase life (80 days) over control (without treatment) (48 days).

- Out of nine advanced breeding lines and two species of *Paphiopedilum* evaluated, highest vase life was recorded in NRCO/PLxPW/28 (79 days), followed by Sheetal-1 (52 days) and lowest in NRCO/PlxPw/39 (15 days).

Technology for utilization of unmarketable spikes of Cymbidium orchids

Effect of sucrose concentration in pulsing solution on vase life of Cymbidium florets

Individual florets of Cymbidium hybrids have potential flower market. In thee florets display, vase-life of more than 20 days is observed with proper post harvest management. Pulsing is a pre-shipment given to cut flowers to load them with carbon source, mainly simple sugars, to prolong their vase life. To determine the most effective concentration of sucrose for pulsing of single Cymbidium florets, an experiment was conducted on the variety 'Levis Duke Bella Vista'. Four different concentrations of sucrose (0%, 2%, 4% and 6%) were tested. The florets were harvested in the morning and kept in plain water under shade for 2 hours. Then they were pulsed for 18 hours in the treatment solutions. Afterwards vase life was observed in plain filtered water. The results indicate that pulsing with 2% sucrose solution was best for treating the single florets compared to the control and higher concentrations. The florets pulsed in 0% sucrose wilting signs within 18 days of harvest while florets treated with 4 and 6% sucrose showed reddening of lips within 19 days of harvest. Florets treated with 2% sucrose displayed a vase life of 26 days.

Fig.57. Flowers of 'Levis Duke Bella Vista' at 26 days after harvest (pulsed with 0, 2, 4 and 6% sucrose and held in distilled water)

Harvesting stage effect vase life of Cymbidium* 'Levis Duke Bella Vista' *florets

To determine the optimum stage of harvest of individual florets the present investigation was conducted with Cymbidium cultivar 'Levis Duke Bella Vista'. The florets were harvested at 0, 2, 4, 6, 8 and 10 days after full opening and the vase–life was recorded in distilled water. Quantitative parameters like changes in floret weight, water uptake and water loss through transpiration was monitored at regular intervals till 40 days after harvest. Qualitative changes like changes in lip and column colour, spots and blemishes on petals were also recorded. The results indicated that harvesting at 2 to 4 days after full opening is best for prolonging the vase life of the florets (Fig. 57).

Quantifying macro nutrient requirement of Cymbidium hybrids for optimal growth and flowering

Effect of different macronutrients on growth and flowering of Cymbidium was studied at NRCO Darjeeling Campus. Effect of Nitrogen application rate on growth and flowering of Cymbidium: Treatments comprise of five nitrogen application rate (0, 50, 100, 200, 400 ppm)

which are provided by media drenching at fortnightly interval. Effect of Phosphorus application rate on growth and flowering of Cymbidium: Treatments of the experiment comprises of five graded doses of Phosphorus (0, 25, 50, 75, 100 ppm) applied at weekly interval as media drench. Effect of Potassium application rate on growth and flowering of Cymbidium: Experiment comprises of five different doses of Potassium (0, 25, 50, 100, 200 ppm) as treatments and three replications. Effect of Nitrogen source on growth and flowering of Cymbidium was separately designed to compare two forms of nitrogen i.e. ammonium and nitrate singly (NH_4/ $NO_3$100 ppm) or in combination (NH_4:NO_3: 25:75, 50:50, 75:25 ppm) on the growth and flowering performance of Cymbidiums. Effect of Calcium application rate on growth and flowering of Cymbidium, where treatments comprise of five Calcium application rate (0, 25, 50, 100, 200 ppm).

Insect Pest Management in Orchids

Monitoring of insect and non-insect pest on orchids

Regular monitoring of orchid germplasm and hybrids maintained at the Institute under polyhouse conditions have been done at weekly intervals for natural pest infestation. The following observations have been recorded.

- Infestation of "two-spotted" spider mite, *Tetranychus urticae* was found only on few species and hybrids of orchids in very negligible populations throughout the year. Cym. 'Levis Duke Bella Vista', Cym. 'Pine Clash Moon Venus', Cym. 'Winter Beach Sea Green' was infested with mites. Four out of 8 plants of Cym. 'Levis Duke Bella Vista' was found to be infested with mean population of 3 mites/ leave.
- Different species of scales were found to infest several orchids out of which Biosduval scale (*Diaspis biosduvali*) and cymbidium scale (*Lepidosaphes pinnaeformis*) were the most common.
- Thrips, *Dichromothrips nakahari* was found to infest the flowers of Dendrobium species like *Dendrobium nobile, D. densiflorum, D. aggregatum, D. fimbriatum, D. moschatum* and *Dendrobium wardianum*. Thrips incidence was also found in *Coelogyne* species where the average population was 5.2 thrips/ plant.
- There was severe incidence of aphid, *Macrosiphum luteum* on orchids in the current year. The aphids were found to infest Epidendrum and *Dendrobium nobile* in very high populations.
- Shoot borer, *Peridaedala* sp. was reported to damage on many species of orchids i.e. *Dendrobium nobile, D. fimbriatum, D. aphyllum, D. chrysanthum, D. moschatum*, *D. densiflorum, D. chrysotoxum* and hybrids like Thongchai Gold, Emma White, Madam Pink, A. Abraham, Bangkok Blue, *Arundina bamboosifolia, Epidendrum* sp., *Acampe rigida*.

Studies on seasonal incidence of aphid, *Macrosiphum luteum* on orchid, *Epidendrum radicans*

Seasonal incidence of aphid, *Macrosiphum luteum* was studied on orchid, *Epidendrum radicans* under polyhouse conditions. The lowest mean population 23.83 aphids (mean of thirty plants) was recorded during 2nd Standard week in January and highest population was recorded in 48 Standard week with a mean population of 94.7 aphids, respectively.

Microbial biopesticides *Verticillium lecanii* and *Beauveria bassiana* @ 2ml/L of water gave effective management of biosduval scale insect under polyhouse conditions.

An experiment was conducted to evaluate the relative efficacy of microbial products against Biosduval scale on Cymbidium 'Winter Beach Sea Green' under polyhouse conditions. Eight treatments *viz.*, *Beauveria bassiana* @ 2ml/L of water, *Metarhizium anisopliae* @ 2ml/L of water, *Verticillium lecanii* @ 2gm/L , *Lantana camara* extract (10%), *Schima wallichi* extract (10%), *Ageratum conizoides* extract (10%), Neem leaf extract (10%) and control was applied at 15 days interval. The highest percent reduction was obtained in *Beauveria bassiana* and *Verticillium lecanii* with mean population reduction of 73.67 % and 75.45 % (pooled mean of two sprays) 14 days after spraying, respectively.

Botanical products from neem viz. azadirachtin (neem oil 0.03% EC) @ 5ml/L and microbial biopesticides, *Beauveria bassiana* and *Metarhizium anisopliae* @ 2ml/L of water gave effective management of aphids, *Macrosiphum luteum* on *Epidendrum* sp. under polyhouse conditions

An experiment was conducted to evaluate the relative efficacy of botanicals and microbial biopesticides against aphid, *Macrosiphum luteum* on orchid, *Epidendrum radicans*. Seven treatments, *B. bassiana*@ 2ml/L of water, *Metarhizium anisopliae*@ 2ml/L of water, Neem oil 0.03% EC 5ml/lit, Neem leaf extract (10%), Cow urine (10%), Fipronil @ 1ml/L and control was applied at 15 days interval. The highest percent reduction was obtained in plants treated with *Beauveria bassiana, neem oil* and *Metarhizium anisopliae* with mean population reduction of 80.22%, 73.94% and 66.23% (pooled mean of two sprays) after 14 days of spraying respectively.

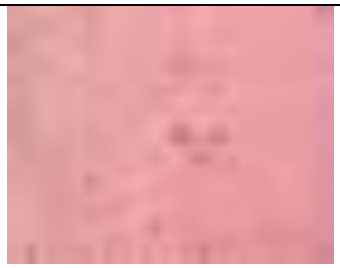
Microbial biopesticides, *Metarhizium anisopliae* and *Verticillium lecanii* @ 2 ml/L of water was found effective in reducing the populations of thrips, *Dichromothrips nakahari* on Cymbidium 'Levis Duke Bella Vista'

Different biopesticides and botanicals were evaluated for the management of thrips, Dichromothrips nakahari under polyhouse conditions. Nine treatments viz., Beauveria bassiana @ 2ml/l water, *Metarhizium anisopliae* @ 2ml/l water, *Verticillium lecanii* @ 2gm/l water, *Clerodendrum viscosum* extract (10%), *Artimesia* sp, neem oil 0.03% @ 5ml/L, *Ageratum conizoides* extract (10%), *Lantana camara* extract (10%) and control (water treatment) was applied at 15 days interval. Highest mean reduction in thrips population was observed in plants treated with *Metarhizium anisopliae* @ 2ml/L and *Verticillium lecanii* @ 2ml/L with mean number of 6.20 and 5.37 thrips/plant after 14 days of treatment, respectively.

Testing of media for mass multiplication of fungal entomopathogens

Fungal entomopathogens, *Beauveria bassiana* and *Metarhizium anisopliae* were mass multiplied on different host media like wheat, millet, maize, rice bran and husk, saw dust with and without adding agar. Highest spore concentration of *Beauveria bassiana* was found in wheat media with and without adding agar with a spore concentration of 2.31 X 10^7 and 2.35 X 10^7 spores/ml 15 days after inoculation respectively. Highest spore concentration of *Metarhizium anisopliae* was found in maize media with and without adding agar with a spore concentration of 2.31 X 10^7 and 2.35 X 10^7 spores/ml 15 days after inoculation respectively. There was no sporulation in millet and saw dust media 15 days after inoculation (Fig. 58-60).

Fig.58. *B. bassiana and M. anisopliae* on wheat and maize extract



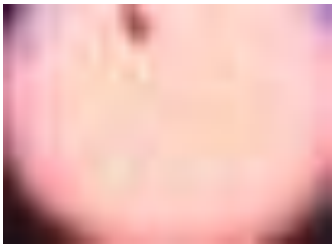


Fig.59. Hyphae, fruiting bodies and spores of *Beauveria bassiana*

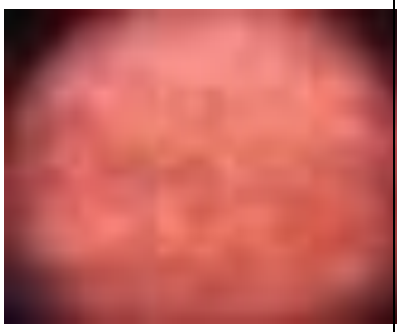


Fig.60. Spores of *M. anisopliae* under microscope

Project 4: Strengthening farmers and stakeholders through adoption of technologies

Survey on Orchid growers

- Altogether 79 orchid growers from Mirik, Pokhriabong and Kurseong of Darjeeling District responded in regards to Cymbidium cultivation
- The major problem was encountered by the Cymbidium growers is availability of land as the major share of land is Tea Planters. About 90% land owned by Tea Planters
- Majority growers' faced the non-availability of quality planting material (85%) at reasonable price
- Other problems are ranked as Finance (75%), Govt. support (71%), Marketing (62%), Agricultural inputs (54%) and Transportation (43%)

Prepared the webpage as **Orchid Farm School** for Orchid growers of East Sikkim and initiated the work for preparation of **Mobile Application** on commercial orchids (Fig 61).

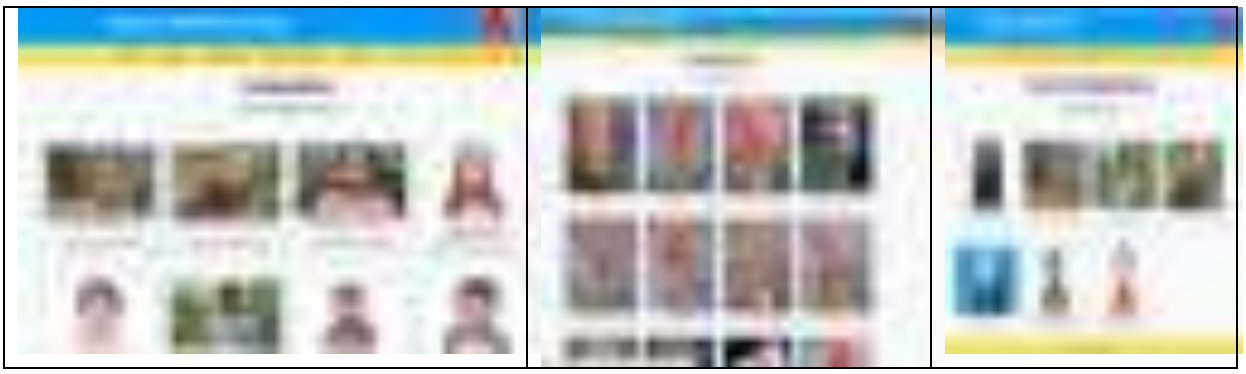


Fig.61. website view of Orchid Farm School

External Funded Projects

Project 1: DUS Testing on Orchids: Preparation for Plant Varieties Protection and DUS Testing through ICAR-SAU System

- 40 hybrids of Cymbidium, 20 hybrids of *Vanda*, 14 hybrids of *Dendrobium*, 10 hybrids of *Oncidium*, 9 hybrids of *Cattleya* and 10 hybrids of *Phalaenopsis* maintained and multiplied under DUS project on Orchids.
- In *Paphiopedilum*, DUS Test Guidelines with 77 morphological descriptors have been developed and notified for registration.
- In *Mokara* (*Arachnis* x *Ascocentrum* x *Vanda*), DUS Test guide lines developed.

Grouping characters in Mokara

- Plant: width (cm)
- Inflorescence: number of flowers
- Flower: length (cm)
- Flower: width (cm)
- Dorsal sepal: main colour
- Lateral sepal: main colour
- Petal: main colour
- Lip: apical lobe: main colour
- Lip: colour of throat

Project 2: Project: Assessment of chemical and genetic divergence of some fragrant orchids of north-east India for sustainable improvement of community livelihood (DBT-TWIN in collaboration with IIT, Kharagpur, West Bengal)

Molecular diversity analysis of 11 fragrant *Coelogyne* species

Molecular diversity analysis of 11 fragrant *Coelogyne* species was done using 19 ISSR primers (Fig. 62). The results showed high polymorphism among the species. The UPGMA dendrogram and Principal coordinate analysis (PCoA) revealed a clear differentiation among the species of different groups. As the genetic diversity and inter species relationships of native *Coelogyne* species of India is not well known which limiting the efficiency of the

breeding programme for development of commercial hybrids, this investigation will help the breeder to prepare hybridization programme for developing fragrant *Coelogyne* commercial hybrid.

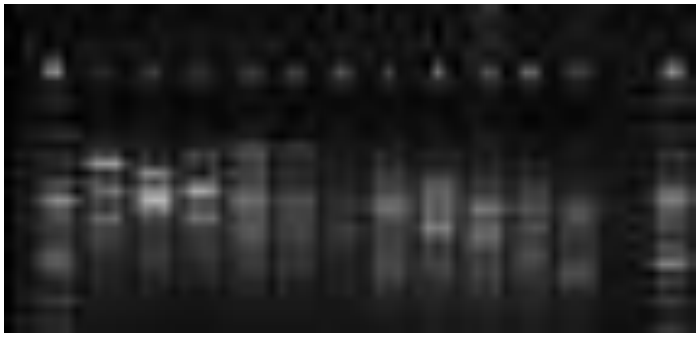
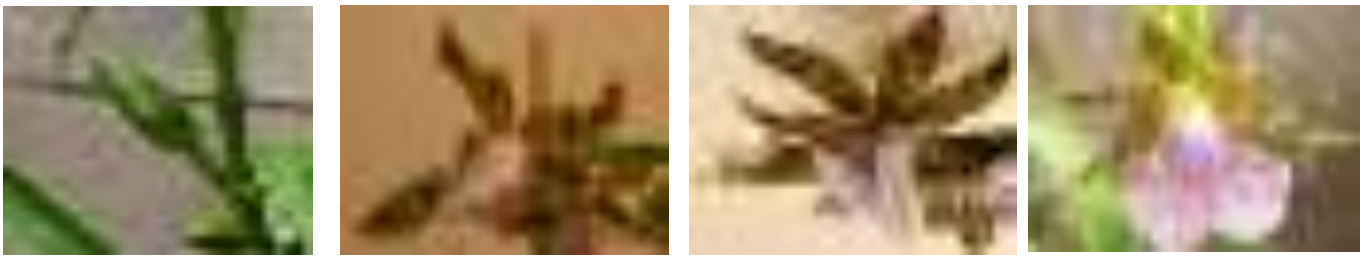


Fig.62. Agarose gel photographs of the PCR products amplified by ISSR primers

Comprehensive study of headspace scent volatiles emitted from *Zygopetalum maculatum* flowers using different adsorbent materials

Zygopetalum maculatum has significant importance in commercial cultivation for long-lasting and fragrant flower spike. Composition of floral scent emitted by *Zygopetalum maculatum* investigated which represent numerous very interesting classes of floral components. Because of the great market value for this orchid as cut-flower, it is necessary to elucidate the scent volatiles profile of this orchid species to develop an understanding on the fundamentals of floral scent volatiles biosynthesis in this particular orchid, on the basis of which a new variety with an improved scent quality is able to develop. Future target is also fix to find the correlation in the anthocyanin pigmentations and volatiles through molecular approaches. Seventeen scented volatile compounds emitted from *Zygopetalum maculatum* flowers of four different developmental stages recorded (Fig. 63 & 64).

Fig.63. GC-MS chromatogram of *Zygopetalum maculatum* flower scent volatiles. The peaks numbered from 1 to 15 are benzaldehyde, β-myrcene, *trans*-α-ocimene, 2-phenylethanal, *o*-diethylbenzene, *p*-diethylbenzene, cymene, benzylacetate, methylsalicylate, 2-phenylethylacetate, eugenol, cinnamylacetate, (E,E)-α-farnesene



S1 **S2** **S3** **S4**

Fig.64. *Zygopetalum maculatum* in different developmental stages. S1 (stage1) budding stage; S2 (Stage 2) early opening stage, S3 (Stage 3) half opening stage, S4 (Stage 4) full opening stage

Volatiles emission in fragrant flowers
Trapping columns with different adsorbents

Different types of porous polymer and carbon based adsorbents - packed inside narrow glass tubing (8 cm length, 8 mm internal diameter) used to trapping volatile emission of 17 fragrant orchid species and 01 hybrid at different flowering stages (Fig. 65).

Analysis was completed in nine fragrant *Dendrobium* species. Among them, eight compounds were identified in *Dendrobium aphyllum,* 10 compounds were identified in *Dendrobium aduncum* and *Dendrobium crepidatum var. asamica, six compounds* in *Dendrobium draconis*, *Dendrobium moschatum*, *Dendrobium wardianum* and *Dendrobium williamsonii,* 04 in *Dendrobium formosum* and 12 in *Dendrobium primulinum.*

Fig. 65. Trapping of volatiles emission in fragrant flowers

Identification of nectar-foraging insects attracted to fragrant orchids
Some insects visited the flowers of the fragrant orchid species *Coelogyne cristata, Coelogyne flaccida, Coelogyne nitida, Dendrobium aphyllum*, *Dendrobium moschatum*, *Dendrobium primulinum* and *Dendrobium wardianum* for foraging of nectar. The insects were documented for specific identification and studies of their role as pollinator (Fig. 66).

Fig.66. Nectar-foraging insects attracted to fragrant orchids

Project 3: National Mission for Himalayan Studies (NMHS)

Sub-project B (HRA2): Long-term Ecological / Environmental Monitoring of Orchids & Assessment of Threats to Biodiversity and Extent of IKP Documentation & Strengthened Under NMHS

The studies were conducted on *Diplomeris hirsuta* population located near Coronation Bridge, on NH 31 A. The habitat ecology, population structure, morpholgy, anatomy and breeding system were studied. The population structure revealed that there are high number of young recuits in the population. During high rainfall plants slips from the lime stone (substrate). The stomatal density ranged from 20 to 98 mm^2 whereas the stomata index ranged from 0.19 to 0.71. The stomatal apparatus size was found to be 99.16-228.17 x 99.16-228.17µm. The pore size of the stomata was recorded as 28.76-57.53 x 11.64-23.40 µm. The length of the guard cell size 55.87-90.53 x 12.44-22.17 µm. We also observed clustering of stomata which could be indication of alteration of habitat conditions. The studies have shown that in degraded habitats plant show the tendency of clustering of stomata. The leaves of the *Diplomeris* posses trichome. The length and width of the trichomes varied from 157.96 to 365.89 and 99.16 to 228.17 mm respectively (Fig. 67).

Fig.67. Photograph showing stomata (a) and clustering of stomata (b), trichomes

The transverse sections of the roots revealed presence of pelotons in cortical regions of the root (Fig. 68). No infection of mycorrhizal fungi were observed in tubers. The mycorrhizal fungi enter into the plants through the root hairs.

Fig.68. Transverse sections of the roots

The preliminary results from the studies on breeding system showed that seeds in *Diplomeris hirsuta* set without pollination (Apomixis). However no seeds were found in capsule of treatments conducted for autogamy and xenogamy. Some of plants were washed away during heavy rains. We observed the pollens get attached with sepals and petals of flowers probably due to wind and alternation of moist and dry weather (Fig. 69).

Fig. 69. Apomixis in *Diplomeris hirsuta*

Sub-project (H-JRF1): To carry out survey, GIS mapping of collected orchid populations of Indian Himalaya

The objective of the study is to map the exquisite orchid diversity of Sikkim Himalaya in terms of its species density, area density, Species density area wise. Arc GIS 10.3 has been used to prepare species wise mapping of the area. Geodatabase of point feature to locate the species of Orchid has been prepared. Geographic projection system and Datum WGS 1984 has been taken into account for the preparation of the location map.12 species of orchids has been located named as follows

1. *Acampe ochracea*
2. *Acampe papillosa*
3. *Acampe rigda*
4. *Acanthephippium striatum*
5. *Acanthephippium sylhetense*
6. *Acriopsis lilifolia*
7. *Aerides odoratum*
8. *Aerides multiflorum*
9. *Agrostophyllum brevipes*
10. *Agrostophyllum callosum*
11. *Agrostophyllum myrianthum*
12. *Agrostophyllum planicaule*

Sub-project (H-JRF2): **Orchid biodiversity database of Sikkim and Darjeeling Himalayas**

- Collect the data of the Orchids of Sikkim Himalaya by using the secondary sources. (Distribution, Status, Flowering Time, and Altitude)
- Prepared the end user page for the Database.
- Prepared the database by using MySQL, which includes the 10 parameters as filters.
- Upload the data for 190 species in the database (Fig. 70).

Fig.70. Website view of orchid database

Sub-project (H-JRF5): Chemical profiling of medicinally important orchids, *in-vitro* multiplication and re-introduction of selected rare orchid species of Sikkim Himalayas In their Natural Habit

Preliminary assay for the presence of plants metabolites in three species *i.e.*, *Dendrobium nobile*, *Dendrobium densiflorum* and *Vanda tessellate*.

Dendrobium nobile

- Leaf, stem and root extract of *Dendrobium nobile* was found positive for Reducing sugars, Flavanoids, Glycosides and Alkaloids, whereas for tanins root and stem extract was found positive and leaf extract found negative for tanins.
- Leaf, stem and root extract of *Dendrobium nobile* was found negative for saponins.

Dendrobium densiflorum

- Leaf, stem and root extract of *Dendrobium densiflorum* was found positive for Reducing Sugar, Glycosides, Steroids and Phytosterols, whereas for flavonoids stem and root extract was found positive, while leaf extract was found negative.
- Leaf, stem and root extract of *Dendrobium densiflorum* was found negative for Saponins and Alkaloids.
- Condensed Tanins was found in leaf extract and for leaf and stem extract was found as negative.

Vanda tessellate

- Leaf, stem and root extract of *Vanda tessellate* was found positive for Reducing Sugar, Glycosides, Steroids and Phytosterols, whereas stem and root extract was found positive for Tanins and leaf extract was found negative.
- Leaf, stem and root extract of *Vanda tessellate* was found negative for Flavanoids and Saponins, while root extract was found negative for Alkaloids.

Project 4: Breeding of Selected Orchids for Cut Flower and Pot Plants: *Strengthening the weakest link between orchid research and industry* (ICAR-Extramural Grant)

Crosses at plantlets Stage

(1) *Cym* Cronulla 'The Khan' x *Cym* Cronulla 'The Khan'; (2) *Cym* Baltic Glacier Mint Ice x *Cym* Red Star; (3) *Cym* Floripink x *Cym* Valley Vampire; (3) *Cym* Freestyle No.6 x *Cym* Freestyle No.6; (4) *C. eburneum x C. devonianum*; (5) *C. lowianum x C. eburneum*; (6) C. *lowianum* x C. *devonianum*; (7) *Cymbidium erythraeum x Cymbidium ensifolium*; (8) *Cym* Baltic Glacier x *Cymbidium lowianum* (MRK); (9) *Cym* Valley Zenith x *Cym* Lovely Bunny; (10) *C. erythraeum x C. tracyanum*; (11) *Cymbidium erythraeum* x *Cymbidium tracyanum* (12) *Cym* Valley Vampire x *Cym* Floripink; (13) *C. erythraeum x C. elegans* ; (14) *Cym* Baltic Glacier x *Cym* Khan Flame (15) *Coelogyne elata* x *Coelogyne ocultata* (16) *Paphiopedilum insigne* x *Paphiopedilum villosum*.

Cymbidium Crosses at protocorm stage

(1) *Cymbdium hookerianum* x *Cymbidium irridioides* (2) *Cym* Baltic Glacier x *Cym* Khan Flame (3) *Cym* Pine Clash 'Moon Venus' x *Cymbidium tracyanum* (brown) (4) *Cym* Red Star x *Cym* Red Star (5) *Cymbidium lowianum* (MRK) x *Cymbidium devonianum* (6) *Cym* Morning Moon Great Tiger x *Cym* Valley Vampire (7) *Cym* Baltic Galcier x *Cym* Valley Vampire (8) *Cym* Baltic Galcier x *Cym* Cronulla (10) *Cym* Valley Vampire x *Cym* F. J. Hansbury; (11) *Cym* Showgirl Coocksbridge x *Cym* Morning Moon Great Tiger (12) *Cym* Showgirl Coocksbridge x *Cym* Cronulla 'The Khan' (13) *Cym* Pineclash 'Moon Venus' x *Cym* Red Star (14) *Cym* Ammesburry x *Cym* Morning Moon Great Tiger (16) *Phaius flavus* x *Phaius tankervilleae*

Crosses at seed stage

(1) *C. eburneum* x *C. hookerianum* (2) *Paphiopedilum fairrieanum* x *Paphiopedilum spicerianum* (3) *Paphiopedilum spicerianum* x *Paphiopedilum insigne* (4) *Paphiopedilum fairrieanum* x *Paphiopedilum villosum* (5) *Paphiopedilum insigne* x *Paphiopedilum fairrieanum* (6) *Paphiopedilum fairrieanum* x *Paphiopedilum insigne* (7) *Paphiopedilum hirutissimum* x *Paphiopedilum villosum* (8) *Paphiopedilum venustum* x *Paphiopedilum villosum* (9) *Paphiopedilum villosum* x *Paphiopedilum venustum* (10) *Paphiopedilum hirutissimum* x *Paphiopedilum venustum* (11) *Paphiopedilum hirutissimum x Paphiopedilum fairrieanum* (12) *Paphiopedilum hirutissimum* x *Paphiopedilum spicerianum* (13) *Paphiopedilum spicerianum* x *Paphiopedilum fairrieanum (*14) *Pleione maculata* x *Pleione praecox*.

Project 5: Consortia Research Platform on Borers in Network Mode

Demonstration on sealer-cum-healer against citrus trunk borer in citrus trees (Sikkim/Darjeeling Mandarin)

Demonstration trials on the use of sealer-cum-healer, a product developed at IIHR, Bengaluru was done in Kalimpong and at Omching village, West Sikkim and Upper Kabrey and Kateng villages in South districts of Sikkim on citrus trees. Sealer cum healer powder was made into a slurry form and applied to the trunks of the tree. Wherever fresh frass was seen, the hole was covered with a sealer cum healer paste. Total 60 plants were treated in selected places of Sikkim and Darjeeling District. After treatment, no infestations were seen on the treated surface. However, trunk borer was found to infest tree branches in few treated plants. The holes were found to vary from 15 cm to 135 cm in distance away from the treated surface. Hence, it can be concluded that since no infestation was found on the treated surface, painting

of the entire plants can be done in severe trunk borer infested areas to protect the citrus plants and reduce the infestation of the citrus trunk borer (Table 6).

Table 6. Efficacy of sealer-cum-healer against citrus trunk borer in citrus trees

Villages	No. of trees treated	No. of trees infested after treatment	If holes present in treated surface	No. of holes present on the infested trees after treatment (Avg.)	Distance of infestation from treated surface (in cm)
Upper Kabrey, South Sikkim	10	3	0	1.3	23, 31, 79, 81
Kateng, South Sikkim	10	3	0	1.3	26, 41, 52, 79
Omching, West Sikkim	15	4	0	1	49, 63, 78, 93
Kalimpong, West Bengal	25	10	0	10	15, 52, 65, 82, 92, 97, 104, 109, 121, 135,

Parasitization of shoot borer, *Peridaedala* sp. by an Ichneumonid wasp (a new report)
The larvae of shoot borer, Peridaedala sp. was found to be parasitized be an ichneumonid wasp. The pupa is off white to cream in colour measuring about 4-5 mm in length. Adults are black in colour with long antennae and measured about 10 mm in length. The female wasps equipped with a long ovipositor. This is the first report of this biocontrol agent on orchid shoot borer (Fig. 71).

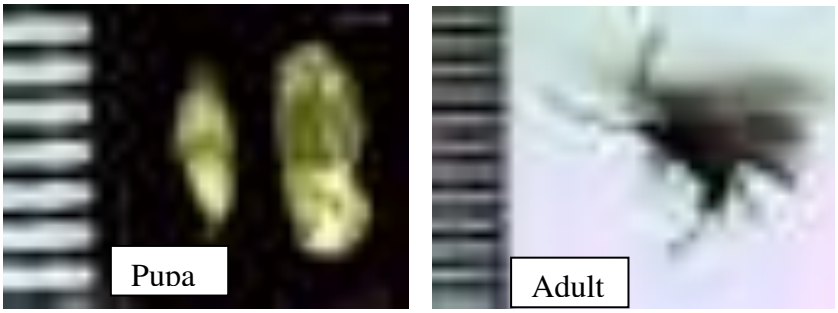


Fig.71. Ichneumonid wasp pupa and adult

Molecular characterisation of orchid shoot borer, *Peridaedala* sp.: Orchid shoot borer was characterised at the molecular level. Three partial Cytochrome oxidase Gene sequences of orchid shoot borer, Peridaedala sp., were submitted to National Centre for Biotechnology Information, USA. The Accession numbers are as follows:

i. Peridaedala_sp_GB80_329415 Peridaedala KY628008
ii. Peridaedala_sp_Samp19_1265 Peridaedala KY628009
iii. Peridaedala_sp_Samp22_1268 Peridaedala KY628010

Project 6: Studies on Pollinators of orchids under Ex-situ Conservation

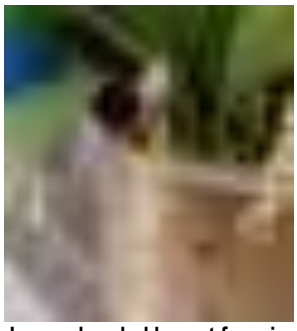
- *Rhynchostylis retusa* plants were found to be regularly foraged by carpenter bees (*Xylocopa* sp) and euglossine bee or orchid bee. Mass of pollinaria was seen attached on the forehead of *Xylocopa* and thorax of Euglossine bee. These carpenter bees and Euglossine/orchid bees played active role in the pollination of this particular orchid.

- Syrphid flies were found to be frequent visitors of *Coelogyne elata*.
- Lesser banded hornet, hoverfly, hawkmoth was recorded as flower visitors in orchid, *Pholidota rubra*. Pollen load was present on lesser banded hornet.
- Honeybees were seen to regularly foraged the orchid, *Pholidota articulata*.
- Wasp, blue bot flies, solitary bees, hover fly was found to be regular visitors of orchid, *Arundina graminifolia* under *in-situ* conditions.
- Observation was also carried out in *Anthogonia* sp. plants under in-situ conservation, however no pollinator was observed except for few insect visitors (Fig. 72).

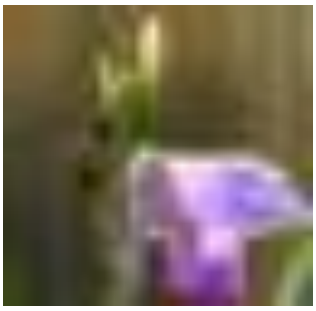
Xylocopa sp. foraging flowers of *Rhynchostylis retusa*

Xylocopa sp. with pollen load

Euglossine or orchid bee with pollen load



Lesser banded hornet foraging the flowers of *Pholidota rubra*



Wasp in *Arundina graminifolia*

Wasp visiting flowers of *Pholidota articulata*

Fig.72. Flower visitors and pollinators in orchids

Studies on pollinators in *Coelogyne ocultata*

The pollination and reproductive biology of cool growing *Coelogyne ocultata* was studied. It is pollinated by an insect (sent for identification). The insect is active during the day especially sunny weather. During these conditions the flowers emit the scent. These insects are attracted towards the flowers (Fig. 73). The pollination mechanism and reproductive behavior was documented for this species.

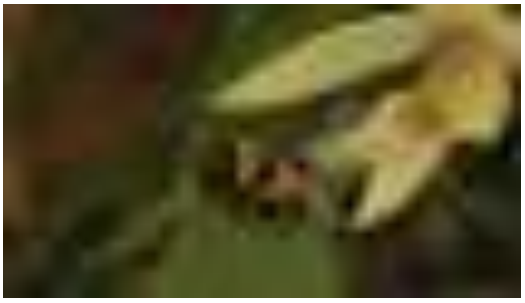


Fig.73. Pollinator with Pollinia in head region

***Cymbidium lowianum* type plants**

The segregating progenies of a cross Cym Sleeping Nymph (4n) and *Cymbidium lowianum* (2n) produced some plants morphologically similar to *Cymbidium lowianum.* These plants were found to be pollinated by bumble bees (specimens sent for identification). Floral and insect morphology in relation pollination was studied, apart from pollination mechanism and reproductive behavior studied (Fig.74).

Fig.74. Bumble bee with pollen load in thorax region

Rain Assisted Pollination in *Coelogyne longipes*

Coelogyne longipes is a cool growing species. It flowers during rainy season. Studies conducted how rains assist in pollination of this species and reproductive mechanism and breeding system of species. This may be the first report on rain assisted pollination of orchids from India (Fig. 75).

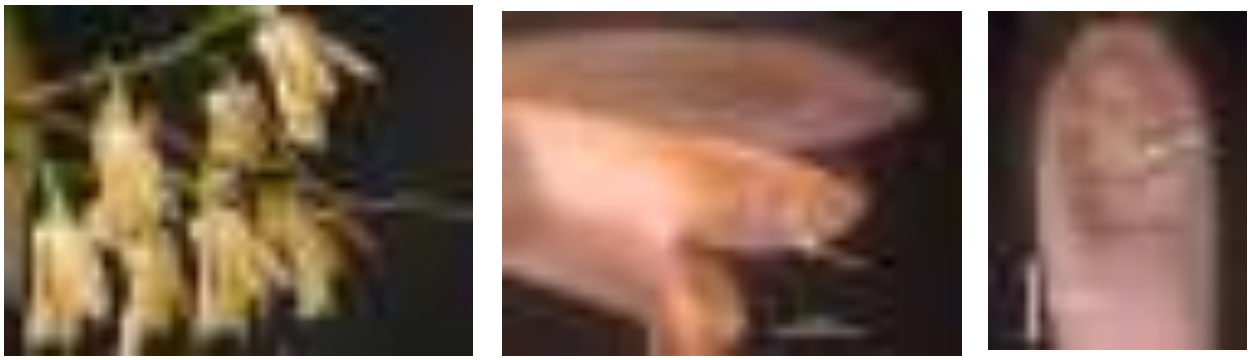


Fig.75. (a) Flowers of *Coelogyne longipes* **(b)Pollinia in stigma**

Cymbidium erythraeum

C. erythraeum is an early flowering *Cymbidium*. It flowers during September and October. The pollination mechanism, breeding system was studied in this species. The species is lightly scented. The pollinators visit the flowers when there is sufficient sunlight. The pollinator was collected and identified as *Bombus haemorrhoidalis* Smith (male) while the female of this species pollinates *Pleione praecox* (Fig. 76).

Fig.76. Pollination in *Cymbidium erythreum* Lindl.

Cymbidium tracyanum

Cymbidium tracyanum an early flowering scented *Cymbidium* species not native to India. This species flowers during the month of September and October. We studied pollination mechanism and pollination behaviour of bumble bee (scientific identity needs to be established). The mechanism is similar to other pollinators of large flowered Cymbidium like *Cymbidium lowianum*. This pollinator visits to the flower when there is sufficient light. Species releases aroma when light intensity is high (Fig. 77).

Fig.77. Pollination in *Cymbidium tracyanum* Lindl.

***Coelogyne nitida* Lindl.**

Coelogyne nitida a sweet smelling *Coelogyne* species found in higher hills usually 1500 m and above altitude. This species flowers during April- May in Darjeeling Hills. Studies were conducted on pollination, breeding system and pollination mechanism. This species is self incompatible and it is pollinated by *Apis cerena* Fabricious. Some pollinators get entrapped in the flowers may be due to high variability of flower size (Fig. 78).

Fig.78. Pollination in *Coelogyne nitida* Lindl.

Pleione praecox

Pleione praecox a sweet smelling orchid naturally grow on rocks and trees in higher hills, which flowers during September and October. It has flowering synchrony with *Cymbidium erythraeum*. It is pollinated by female *Bombus haemorrhoidalis* Smith and studied pollination mechanism and experiment with regard to breeding system are under study (Fig. 79).

Fig.79. Pollination in *Coelogyne nitida* Lindl.

Project 7: Inventorization of gamma radiation irradiation technology for Orchid varietal improvement (BRNS-BARC Project)

The base material (*Dendrobium* and *Zygopetalum intermedium)* handling and basic training in tissue culture were completed. Selfing of selected orchid species (*Vanda coerulea, Dendrobium and Zygopetalum intermedium)* were initiated for seed development related to mutation work. Tissue culture work for developing check material development is as follow:

Root development with IBA in *Zygopetalum intermedium* {PBS(X)-13-148)}: Sub culture of plantlets in Nitsch media supplemented with IBA (3 mg/l), NAA (0.5 mg/l), activated charcoal (2 g/l) and sucrose (2%) showed strong and well-developed roots (6 nos.), measuring approx. 5-6 cm (length) and 1.5 mm (width). The shoot length and leaf growth was minimal, hence sub-culture proposed for shoot growth promotion with BAP (Fig. 80-81).

Fig.80. Sub-cultured plants {PBS(X)-13-148)

Fig.81. Root development in {PBS(X)-13-148)

Shoot growth promotion with BAP: Subculture of plantlets in Nitsch media supplemented with BAP (2mg/l), NAA (0.5 mg/l), activated charcoal (2 g/l) and sucrose (2%) showed multiple shoot growth (max. 3 no.) in a single plantlet with approx.. 1 cm height and 3–4 leaves for PBS(x)-13-148. The observation suggested new treatment in same media with lower concentration of BAP. Hence, three different treatments (T1, T2, and T3) were set up, wherein T1 with absence of BAP, T2 with 0.5 mg/l BAP and T3 with 1mg/l BAP. Observation made after 20 days showed multiple shoots in all the three treatments with no further improvement in shoot growth. Some of the plantlets send to hardening for trial failed to grow and subsequently died.

***In-vitro* callus induction of *'Emma White'* (*Dendrobium*)**

Healthy and good number of plbs were developed earlier were sub-cultured using Gamborg (G), BAP (1mg/l), NAA (0.25mg/l) and activated charcoal (1.5g/l) to increase the growth of small plantlets. *In-vitro* hardening (HI) of well grown plantlets was conducted using ½ G, 4% sucrose and combination of BAP (2mg/l) and IBA (1mg/l) in a semi liquid media (agar 6.5g/l). The left over callus sub-cultured into callus induction treatment (CALD) showed good but slow response. In case of HI, shoots turned yellow and later brown, suggesting that higher concentration of BAP may have negative effect on shoot development. The treatment was modified later with absence of any growth regulators. The response noted was very slow for both shoots and roots development. Finally, effective hardening of well-developed plantlets, using IBA (0.5 mg) and NAA (0.25 mg) combination gave plantlets with normal roots and new side shoots (2 to 3 per plant).

Other tissue culture work accomplished within two months of training period:

- Sub culture/ treatments of PBX-12-119 (*Dendrobium*); PBX-12-159 *(Vanda)*; PBX-12-99 *(Phalaenopsis)*; PBX-12-58 (*Dendrobium*); PBX-11-154*(Cymbidium)*.
- Seed culture (germination expt. phase I) initiated for PBX-15-127; PBX-15-129; PBX-15-287 *(Zygopetalum intermedium)*; PBS(X)-16-64 (*Thunia sps.)*; PBS(X)-16-65 *(Cymbidium ensifolium)*

Chromosomal work initiated with root tip samples of *Zygopetalum intermedium, Vanda, Phalaenopsis*, using Leica DM2500 microscope, following standard protocol developed by Sllindo and kamemoto (1963). So far, the results were promising with minute structures of chromosomes under 40X The next work aims at visualizing clear and distinct structure of chromosome under 100X (Fig. 82-83).

Fig.82. *Vanda* sp.

Fig.83. *Zygopetalum intermedium*

Project 8: Tribal Sub-Plan Scheme

- Off campus training on Orchids & Demonstration on Orchid Cultivation was conducted at Marlelangso, Karbi Anglong, Assam during July 19-20, 2016 (Fig. 85).
- Training-cum-Awareness Programme on Orchids at Diphu, Karbi Anglong, Assam on Nov 9-10, 2016 (Fig. 86).
- TSP field visit at Nonglwai Orchid Conservation Society, Nonglwai, Nongstoin, West Khasi Hills, Meghalaya on 11/11/2016 (Fig. 87).
- Off campus training on Orchids & Demonstration on Orchid Cultivation was conducted at Hee-Gyathang, North Sikkim on 29/11/2016 (Fig. 88).
- Training-cum-Awareness Programme on Orchids at Nongstoin, West Khasi Hills, Meghalaya on Jan 14-15, 2017 (Fig. 89 & 90).
- Exposure visit-cum-Input supply at ICAR-NRCO, Pakyong for TSP farmers from Hee-Gyathang, North Sikkim on 18/02/2017 (Fig. 91).
- Kisan Mela 2017 at IACR-NRC on Orchids, Pakyong on Mar 10-11, 2017, where TSP farmers from Sikkim, Assam & Meghalaya participated (Fig. 92).
- Received prestigious 'Plant Genome Savior Community' (PGSC) award for 2014-15 was conferred to Nonglwai Orchid Conservation Society from West Khasi Hills, Meghalaya on 19th April, 2017 at Mohihari, Bihar which was under Tribal Sub-Plan Scheme (Fig. 84).

Fig.84. Plant Genome Savior Community Award (2014-15) for Nonglwai Orchid Conservation Society, Meghalaya

Fig.85. Off Campus TSP Training, Maelelangso (20/07/2016)

Fig.86. Awareness Programme, Diphu (09/11/16)

Fig.87. Field Visit at NOCS, Meghalaya (11/11/2016)

Fig.88. Off Campus TSP Training, Hee-Gyathang (29/11/2016)

Fig 89. Training-cum-Awareness Programme on Orchids, Nongstoin (Jan 14-15, 2017)

Fig.90. Demonstration (15/01/17)

Fig.91. Exposure Visit-cum-Input Supply for North Sikkim (18/02/2017)

Fig.92. Kisan Mela 2017, Pakyong (Mar 10-11, 2017)

Project 9: Revolving Fund Scheme

- Rs. 33,700/- generated from sale of planting material distributed to TSP schemes.

Project 10: Ad-hoc Project (AICRPF)

Effect of micronutrients on growth, development and flowering of *Dendrobium nobile*

Uniform size plants of *Dendrobium nobile* were planted in 6" diameter pots containing a media comprised of Coconut husk chips + brick pieces + leaf mold at 1:1:1 ratio. Regular dose of macro nutrients (N: P: K) 20:20:20 @0.1% foliar spray) was applied to all the treatments at weekly interval. The micronutrient treatments were applied as foliar spray at 15 days interval. The treatment consists of Zn, Mn and Fe@0.05 and 0.1ppm; Bo, Mo and Cu @ 0.01 and 0.05 ppm and control. It was recorded maximum plant height (45.80cm), leaves no. (30.53) and intermodal length (4.07cm) at Bo 0.05 ppm. Application of Zn 0.1 ppm increased no. of stem (6.13), whereas Cu0.05ppm influenced stem diameter (12.19cm). Mo 0.05ppm influenced the size of leaves (39.16cm^2) (Table 7).

Table 7. Influence of micronutrients on vegetative growth of *Dendrobium nobile*

	Plant Height (cm)	Steam Girth(cm)	Leaf Area (cm^2)	No. of leaves	No. of stem	Internodal length (cm)
T1	28.99	8.34	29.32	23.27	5.4	3.13
T2	28.83	10.21	30.28	17.40	**6.13**	2.97
T3	33.01	9.56	32.25	24.07	4.87	2.95
T4	31.59	10.11	28.41	27.80	5.13	3.10
T5	**45.80**	7.79	13.70	**30.53**	5.87	**4.07**
T6	35.00	9.44	29.08	20.40	4.93	3.22
T7	33.60	8.98	32.77	26.07	4.27	3.55
T8	35.49	10.15	32.31	29.20	5.40	3.37
T9	41.65	9.12	36.16	28.73	5.27	3.65
T10	39.72	10.21	***39.16***	23.27	4.20	3.37
T11	37.64	11.59	33.79	26.00	5.53	3.97
T12	37.87	**12.19**	37.28	22.93	5.13	3.67
T13	28.17	6.42	33.36	14.47	3.47	2.71

Technology Transfer

❖ Conducted the following training programs:

S. no	Date & duration	Topic and Venue	No. of Beneficiaries		
			Female	Male	Total
1.	May 17-25, 2016 (9 days)	Exposer Visit cum Internship of trainees of CIH, Nagaland; Pakyong	4	11	15
2	06.01.2017	Advances in Commercial Cultivation of Orchids; Mirik, Darjeeling	42	62	104
3	08.01.2017	Agro techniques and Value addition for maximization of income through orchid cultivation; Pokhriabong, Darjeeling	08	49	57
4	10.01.2017	Pre & Post Harvest Management and Value Addition in Orchids , Kurseong, Darjeeling	13	67	80
5	Feb 6-7, 2017	Commercial Cultivation of Cultivation; Mongpoo, Darjeeling	16	20	36

❖ **IV Stakeholders Meeting on Orchids**: Organized 4rd farmers Scientist interface meet on 19th April, 2016. Honourable Governor of Sikkim, Shri. Shriniwas Patil inaugurated the '4th Stakeholder Interaction Meeting on Orchids' on his maiden visist to ICAR-National Research Centre for Orchids, Pakyong, Sikkim. Prof. K. V. Peter, Ex Vice-Chancellor of Kerala Agricultural University and Ex-Director (IISR) and Dr. Brahma Singh, Padma Shri Awardee, Ex-Director (DRDO-Life Sciences) also graced the occasion. Nearly 150 participants from state and central organizations and progressive orchid growers from Sikkim, Meghalaya, Assam, Arunachal Pradesh and West Bengal took part in the meet (Fig. 93 & 94).

Fig.93. Award handed over by the Hon"ble Governor

Fig.94. Delegates on the Stake holder meet

❖ **Field Day**: Field Day was organized on 27th September, 2016 at adopted village with a view to acquaint the growers with modern technologies used for the orchid cultivation. Emphasis had been given on **"think globally, act locally".** Further, orchid growers also been suggested to link eco-tourism with orchid cultivation and Orchid School for dissemination of know-how. Altogether, 30 orchid growers were participated in the programme (Fig. 95).

Fig. 95. Field Day Celebration

- **Agriculture Education Day**: Indian Council of Agricultural Research initiated to observe Agricultural Education Day on 3rd December, 2016 emphasizing on awareness among youth and farming society on holistic development of Agriculture and its education (Fig. 96). In this regards, ICAR-NRC for Orchids, Pakyong, celebrated this day by arranging debate and Essay writing on current scenario of Indian Agriculture. The Scientists of NRCO also had interactions with farmers at kartok and stressing on the importance of scientific knowledge in crop production, organic cultivation, conservation of agriculture diversity and proper post-harvest handling.

Fig.96. Agriculture Education Day

- **World Soil Health Day:** The programme organised at Namchepong on 5th Dec.2016 and 18 farmers participated in the program (Fig. 97).

Fig.97. World Soil Health Day celebration

- **Agriculture Productivity Week:** The program organized at the institute from 12th-18th February, 2017 and 30 office staff attended (Fig. 98).

Fig. 98. Celebration of Agriculture Productivity Week

- **Kisan Mela 2017**: 4th Kisan Mela of this institute was held on March 10-11, 2017 with a theme "Horticulture - A promising Enterprise in Hills". Shri. Hemant Adhikary, MLA (Rhenock) inaugurated the programme. Prof. T.B. Subba, Vice-Chancellor, Sikkim University and Prof. Premjit Singh, Vice-Chancellor, Central Agricultural University were acted as Guest of Honour. Shri. Jitendra Chauhan, Scientific Advisor, Ministry of Agriculture, GOI, enriched the programme as Special Guest. In this two days programme, around 1008 people assembled which includes enthusiastic farmers, students of local schools, colleges and university, teachers, entrepreneurs, agricultural scientists, Central and State Govt. organizations NGOs, SHGs. There were 52 stalls arranged for the exhibitors to show cash their activities (Fig. 99).

Fig. 99. Kisan Mela 2017

Training-cum awareness program: One Day Training-cum Awareness program on PPV & FRA was organized at the institute on 11th March, 2017 with 100 participants. The following matters were discussed in the aforesaid program:

1. Awareness on Protection of Farmers varieties
2. Farmers rights
3. Plant breeding rights
4. DUS guidelines of orchids and other commercial crops
5. New variety registration procedures etc.

Training under PDDUUKSY-1: 5 days ICAR Sponsored Training Under Pt. Deen Dayal Upadhyay Unnat Krishi Siksha Yojana organized at Sikkim Kalyan Asram, Ranipool from 24th-28th March, 2017.

ICAR Sponsored Training Under Pt. Deen Dayal Upadhya Unnat Krishi Siksha Yojna **w**as Organised by ICAR NRC for Orchids, Pakyong Sikkim at Sikkim Kalyan Ashram, Ranipool from 24/03/2017 to 28/03/2017 (Fig. 100).

The 1st day (24/03/2017) Program was initiated with inauguration program with 65 participants including 35 farmers. Inauguration Program was started with ICAR song followed by lighting of lamp by Dr. H. P. Singh (Ex. DDG Horticulture) Chief Guest and Saraswati Bandana by the children's of Kalyan Ashram followed by welcome address and introductory remarks by Dr. D.R. Singh, Director, ICAR-NRCO, remarks by Shri Ram Pada Paira, i/c Kalyan Asram, Shri L.D. Subba, Vice-President, Kalyan Asram, Shri C.P. Giri, VHP and address by Dr. H.P. Singh, Ex-DDG (Hort.) & Chief Guest. Afterthat, three practical Sessions by farmers on Farmers inventory, Farmer's Practice and farmers list of challenges on organic/ natural farming.

Lighting of Lamp by Dr. H. P. Singh, Ex-DDG (Hort.), Chief Guest

Lighting of Lamp Chief Guest and other Dignitaries

Honoring to Dr. H. P. Singh, (Ex. DDG Horticulture) Chief Guest by Dr.D. R. Singh, Director, ICAR – NRCO, Pakyong

Welcome Speech by Dr. D. R. Singh, Director, ICAR – NRC for Orchids, Pakyong

Releasing of Souvenir

Interaction with farmers by Dr. H. P. Singh

Conclusion of 1ST Day program with National Anthem

Group photography with the participants along with the Guest and Dignitaries

Fig. 100. Inaugral programme on training under PDDUUKSY-1 at Kalyan Ashram, Ranipool

The 2nd day (25/03/2017) program was completed by six lectures based on the following topics:

1. Principles of nutrient management through processes of nature, Zebu Cattle (Nitrate formation by lightning, plant waste recycling), Principles of nutrients management by role of micro organisms, Mulching and Green manuring by **Dr. A. B Sherpa CAE & PHT Ranipool.**

2. GAU KRISHI ADHIRAKSHINI SIDANTH (Zebu cattle based conservational agriculture), including focus on its breed conservation; understanding the issue of A1 – A2 milk with production methods of other Panchgavya products including proper method of cow urine collection and treatments of cattle diseases by **Dr. S.N. Yadav, CAE & PHT, Ranipool.**

3. Gauchar Bhoomi Samrakshan (Cattle Grazing Common Property Resource Conservation) for providing innovation in feeding solutions for cattle of villages by **Shri. Norbu Tamang, Retd. ACF, Sikkim Kalyan Ashram, Ranipool.**

4. Understanding the role and importance of earthworm (endogenous – belonging to the village ecosystem), Production of enriched compost and vermi-composting, Production

of bio-control agents- (Neemastra, Brahmastra, Agnestra, Dasparni ark etc.) **by Dr. R.Ch. Sangma, ICAR NRCO Pakyong.**

5. Sampling and testing of Soil for base line data of the field and for monitoring by **Dr. Ch. Birendrajit, CAE & PHT, Ranipool.**

6. Protected Cultivation Options by **Dr. L.C. De, ICAR, and NRCO Pakyong.**

The 3rd day (26/03/2017) program was completed by five lectures based on the following topics:

1. Zero Budget Agriculture by **Dr. Satyanaryan, Siliguri.**

2. Water management through planning of optimized mix of crops and Advanced method of water management such as drip, sprinkler, micro-sprinkler. Other Water conservation techniques (emphasizing Per Drop, More Crop) – farm pond, check dam, bunding, land shaping for slope management; Raised – bed mulching and laser leveling; Irrigation scheduling and water budgeting, by **Dr. G.T. Patle, CAE & PHT, Ranipool.**

3. Water Quality Management by **Dr. A.K. Vasisht, CAE & PHT, Ranipool.**

4. Emphasis on alternative source of Energy shall be clarified as judicious mix of solar, wind, bio gas and bullock – power, could be done, in different ways, at different location, **By Dr. M.S. Seveda, CAE & PHT, Ranipool.**

5. Success Stories (Case studies & Videos), Important Varieties of flower Crop and their package of practice – Rose, Gladiolus, Chrysanthemum, Marigold, Rajnigandha, China Aster, Orchid, Anthurium, Gerbera, by **Dr. Raj Kumar, Scientist (Floriculture) ICAR-NRCO, Pakyong.**

The 4th day program was completed start by two lectures and two practicals based on the following topics:

1. Identification of appropriate and locale specific variety of crops, vegetables, horticulture; focus on production of its seeds and provisioning of quality planting materials useful for the area, by **Dr. S. Manivannan (Sikkim University), Gangtok.**

2. Organic /ZB natural farming-based integrated farming system (Crops, fruits, vegetables, flowers, fish, poultry, duck rearing) by **Dr. L.C. De, Pr. Scientist, ICAR – NRCO Pakyong.**

3. Practical on Farm Tools demonstration at CAE & PHT, Ranipool. By **Dr. S.N. Yadav, CAE & PHT, Ranipool.**

4. Farm visit (Practical Survey for farmers) at ICAR NRCO, Pakyong. Attended by **Dr. Raj Kumar, Scientist (Floriculture) ICAR – NRCO Pakyong.**

The 5th day program was completed by four lectures based on the following topics:

1. Post – Harvest management, processing, value addition, storage, marketing with development of entrepreneurship through mentorship and guidance in the selection of

enterprise, its launch with branding, By **Dr. S. Manivannan (Sikkim University) Gangtok.**

2. Group mobilization for community action- SHG, FPO/FPC, Farmers' Club and promotion of methods such as custom hiring, by **Shri Karma Bhutia, Sajong-Rumtek, Sikkim.**

3. Latest Marketing Tools – Digital and Internet – based cashless system of transactions, By **Dr. Raj Kumar, Scientist (Floriculture) ICAR- NRCO, Pakyong.**

4. Raising finance and knowledge of Government Schemes and initiatives such as Unnat Bharat Abhiyan, which offer turn-key models of establishing organizational structure for Cluster of Villages in selected villages around the village of Nodal Officer (innovative farmers, who is conducting the training), By **Dr. D.R. Singh, Director, ICAR-NRCO, Pakyong.**

Lecture by Dr. D.R. Singh, Director, ICAR-NRCO

Group photographs of Farmers Participants

Fig.101. Concluding Day of the training programme under PDDUUKSY-1

The program was concluded with distribution of certificates to the Farmers Participants, followed by advisory remarks by Dr. D.R. Singh, Director, ICAR-NRCO, Pakyong and ended with Vote of Thanks by Dr. L.C. De, Chairman (PDDUUKSY-1), ICAR-NRCO (Fig. 101).

Demonstrations

- Established one demonstration unit at Demaji, Assam (Fig 102).

Fig.102. Demonstration at Demaji, Assam

Trainings at ICAR-NRCO Darjeeling campus


Fig.103. Training on 'advances in commercial cultivation of orchids at Mirik, Darjeeling on 6th January, 2017


Fig.104. Training on 'agrotechniues & value addition for maximizing income through orchid cultivation' at Pokhriabong, Darjeeling on 8th January, 2017


Fig.105. Training on 'pre & post harvest management and value addition in orchids' at Kurseong, Darjeeling on 10 th January, 2017

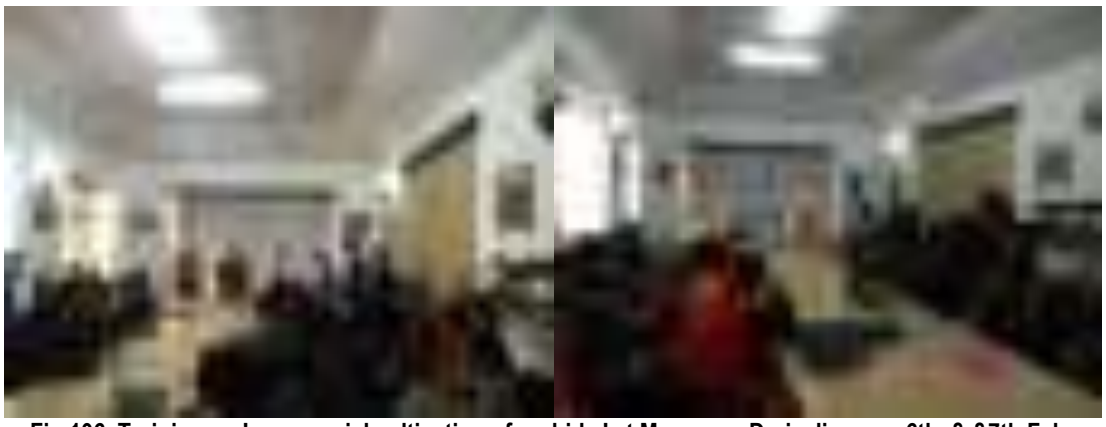


Fig.106. Training on 'commercial cultivation of orchids ' at Mangpoo, Darjeeling on 6th & &7th February, 2017

Krishi Mela: The Centre participated in Krishi Mela, Organised by Gorkhaland Territorial Administration from 2oth to 26th January, 2017 at Jamuney, Darjeeling, West Bengal (Fig. 107).

Fig. 107. Participated in Krishi Mela at at Jamuney, Darjeeling, West Bengal

Technology Week and Workshops:
The Centre organized technology week from Jan 5-10, 2017. During week-long celebration the technology developed by the institute was displayed and workshops on different topics were held at three different orchid growing areas Mirik, Pokhriabog and Kurseong (Fig. 108-110). Through these workshops problems orchid growing areas of Darjeeling were assessed.

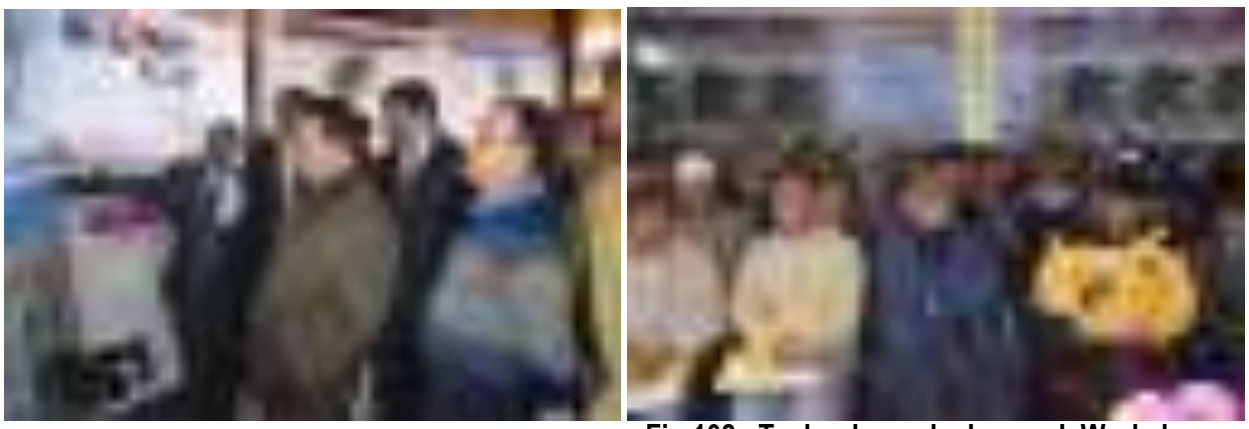


Fig.108. Technology dsplay and Workshop on 'Commerical orchid cultivation: challenges and opportunities at Mirik, Darjeeling on 5th January, 2017

Fig.109.Technology dsplay and Workshop on 'maximizing profit in orchid cultivation' at Pokhriabong, Darjeeling (07/01/17)

Fig.110. Technology display and Workshop on 'orchid cultivation in darjeeling: Strength, weaknesses and opportunities at Kurseong, Darjeeling (09/01/2017)

Inauguration of office cum laboratory building and workshop: Office cum laboratory building of the campus was inaugurated by Hon'ble Union Minister of State for Agriculture & Farmers Welfare and Panchayatiraj Sri Purushottam Bhai Rupala on 5th March, 2017. On 6th March he inaugurated the workshop on '*orchid ke anusandhan evam vikash men krishkon ki sahbhagita'*. In this workshop various issues related to research and development of orchids were discussed. The farmers also apprise the Hon'ble Minister about the problems faced by them in expanding orchid cultivation in the region (Fig 111 & 112).

Fig.111. Inauguration of the office cum laboratory building


Fig.112. Workshop on *'orchid ke anusandhan evam vikash men krishkon ki sahbhagita'*

Demonstrations: 6 demonstration units on Cymbidium cultivation in different altitudes of Darjeeling were initiated and it will be continued. The demonstration places are Dilaram (1800 m), 2. Kurseong (1600m), Shirubari (1400 m), Rohini tea estate (1100 m), Proper Rohini (800 m) and Garidhura (350 m).

Central Government Schemes

Mera Gaon Mera Gaurav

Adopted Villages: Raigaon, Namcheypong and Kartok in East Sikkim

Different activities were taken in adopted villages and in nearby areas of this Institute to acquaint the people of village about modern agricultural practice (Table 8). An innovative initiative "Mera Gaon Mera Gaurav" has been launched this year to promote the direct interface of scientists with the farmers to hasten the lab to land process in adopted villages of Raigaon, Kartok and Upper Namchepong. Since inception of programme, farmer were briefed about adoption of modern agricultural technologies, clean and good agricultural practices like vermicomposting, soil health, water harvesting, awareness about climate change etc.

Table 8. Events under Mera Gaon Mera Gaurav

Events	Total activities	No. of Beneficiaries
Visit to village	47	430
Gosthis/ Meetings conducted	14	213
Mobile based Advisory	177	141
Linkages created with other Departments/ Organizations	6	119
Literature Support Provided	159	89
Total no. of beneficiaries		992

Swachh Bharat Abhiyan

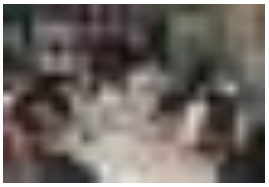
Staff of NRC for Orchids met 36 times and provided 2072 hours

Major activities - Awareness of cleanliness, digitisation of office records, painting cleaning and beautification of surrounding areas, vermicomposting, composting of biodegradable waste management, use of water for horticulture application and display of posters and banners at different location (Fig. 113).

- Awareness programme on Conservation of Orchid biodiversity along with Swatch Bharat Pakwada by the fellows of NMHS at Yakten village (East Sikkim) on 19-10-16.

Swachh Bharat Abhiyan at Kartok School

Cleaning of Water resources and arrangement of drinking water



Painting Competation on Swach Bharat Abhiyan

NRCO Team at Pakyong PHC

Fig. 113. Different activities under under Swachh Bharat Abhiyan

ARYA and Student READY Programme

ICAR-National Research Center for Orchids, Pakyong, Sikkim organized the one day programme on ARYA (Attracting and Retaining Youth in Agriculture) and student READY (Rural Entrepreneurship Awareness Development Yojna) on 11th March, 2017. In this programme more than 300 students from four schools *i.e.* St. Xavier School, Dikling Senior Secondary School, Jawahar Navodaya Vidhyalaya, Pushpanjali School and Students from Sikkim University, CAU-College of Agricultural Engineering & Post Harvest Technology were participated in the programme. Thirty women entrepreneurs from 03 self-help groups of Pakyong area also participated in the programme and they learn about the various products prepared from dry flowers (Fig. 114).

Fig.114. ARYA and Student READY Programme

Other Institute Activities

Independence Day Celebration

Independence day was celebrated on 15th Aug, 2016 at the campus. Te flag hoisting was done by the Director, followed by staff meeting by welfare committee.

20th Foundation Day Celebration

20th Foundation Day Celebrations

Orchid Centre, Pakyong celebrated its foundation day celebrations to mark completion of 20 years. Padma Shree awardee Dr. K. L. chadha, President, Horticultural Society of India was the Chief Guest of the function. Dr. T. Janakiram, ADG (HS), ICAR; Prof. P. K. Srivastava, Dean, CAE & PHT; Dr. S. K. Chakrabarti, Director, ICAR-CPRI, Shimla and Shri. T. P. Bhutia, Addl. Director (Hort.), Govt of Sikkim were guest of honors during inaugural session. Dr. Singh in his inaugural welcome address, highlighted the significant achievements of the institute and awards received during the year. On this occasion, institute released a Paphiopedilum variety 'Sheetal 1' developed at institute. The newly developed website of institute and Orchid farm school with online portal were launched by chief guest on this occasion. Orchid conservation pledge was taken by farmers, along with Dr. Singh. Ten orchid conservation farmers and nine orchid growers were awarded with mementos and certificates for their dedicated efforts. Best employees of the institute in category were awarded. Dr. K. L. Chaddha presented foundation day lecture on 'Climate Change & Climate Smart Horticulture' for the benefit of farmers, scholars and scientists.

Vigilance Week

Dr. D. Barman, Vigilance Officer

The vigilance week was organized from 31st Oct – 5th Nov, 2016 at institute. Dr. D. Barman, Principal Scientist (Hort.) & Vigilance Officer briefed about the relevance of vigilance week for awareness to the employees.

Hindi Fortnight at ICAR-NRCO, Pakyong

The ICAR- National Research Centre of Orchids, Pakyong is celebrating Hindi fortnight programme from 14/09/2016 to 28/09/2016. The programme was inaugurated on 14/09/2016 on the occasion of Hindi Diwas.

Sh. Vandan Saxena, DIG, SSB was present as the Chief Guest during the Programme. Sh. Alok Kumar Sriwastava, Executive Engineer, CPWD, Gangtok & Secretary, Town Official Language Implementation Committee, Gangtok and Hindi Teacher Mrs. Uma Sharma, from Puspanjali School, Pakyong also attended the programme.

The Chief Guest highlighted the importance of Hindi as official language and emphasized Hindi as effective medium for communication at national level. Member Secretary TOLIC -

Sh. A.K Sriwastava also elaborated how to successfully implement Hindi as official language.

On this occasion Director ICAR-NRCO conveyed the message of Honourable Home Minister, Govt of India, Honourable Agriculture & Farmer Welfare Minister, Govt. Of India and Director General ICAR.

Self composed poem recitation and extempore competitions were also organized, program ended with vote of thanks from Sh. Raj Kumar, Scientist and Chairman, Hindi Committee.

Training and Capacity Building

(A) Physical targets and achievements in training

S. No.	Category	Total No. of Employees	No. of trainings planned for 2016-17 as per ATP	No. of employees undergone training during April' 16-Mar' 17	% realization of trainings planned during 2016-17
1	2	3	4	5	5/4x100=6
1	Scientist	10	3	8*	266.67
2	Technical	5	2	0	0
3	Administrative & Finance	6	3	3	100
4	SSS	6	1	5	500
Total		27	9	16*	177.77

(B) Financial targets and achievements (All employees)

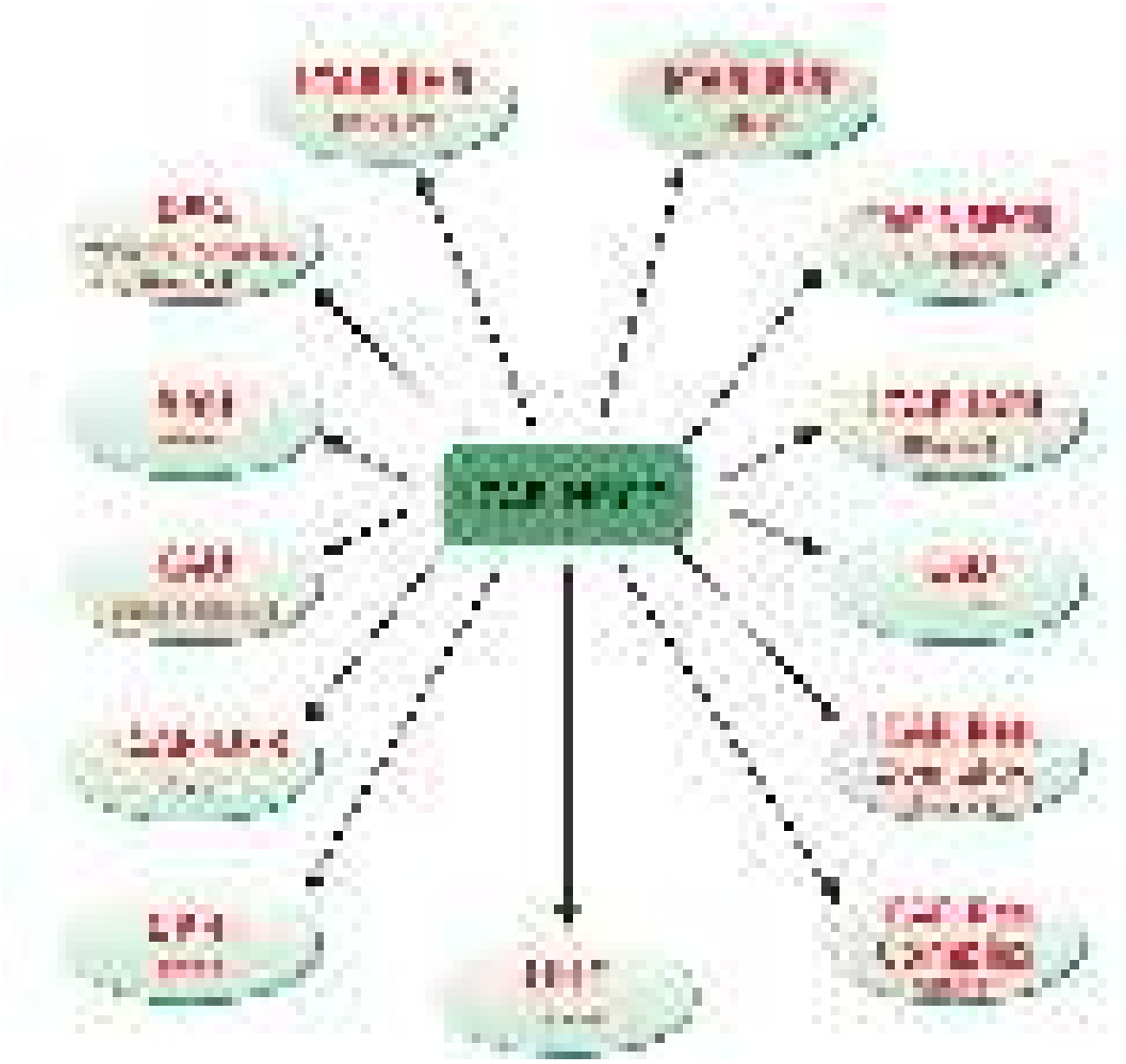
Actual Expenditure with effect from 01/04/2016 - 31/03/2017 for HRD			% Utilization of allotted budget
Plan	Non-plan	Total	
(Lakh Rs.)	(Lakh Rs.)	(Lakh Rs.)	2016-17
5.01	Nil	5.01	102.00

(C) Training programmes attended by staff

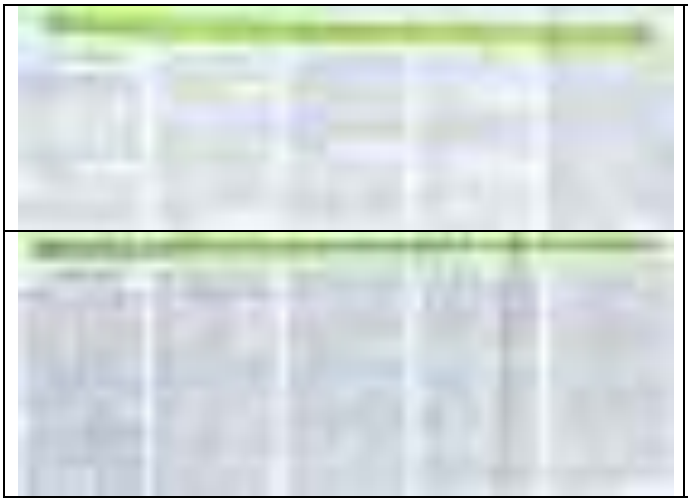
		programme attended
Dr. D. R. Singh	Director	Conf. on perspective..Agri, Mumbai
Dr. L. C. De	Principal Scientist (Hort.)	Conf. on perspective..Agri, Mumbai
Dr. D. Barman	Principal Scientist (Hort.)	Nat. Con. On Flori., Nagaland
Mr. R. Kumar	Scientist (Floriculture)	Nat. Con. On Flori., Nagaland
Dr. Rampal	Principal Scientist (Hort.)	Technology Week, Darjeeling
Dr. A. M. Khan	Scientist (Floriculture)	Technology Week, Darjeeling
Dr. N. Sailo	Scientist (Plant Physiology)	Nat. Con. On Flori., Nagaland
Mr. P. R. Kishore	Scientist	Hindi Training
Mr. R. K. Das	AF & AO	Hindi Training
Mrs. Diki Bhutia	UDC	FMS/MIS Training, Pakyong
Mr. P. T. Bhutia	LDC	FMS/MIS Training, Pakyong
Mr. T. S. Balmiki	SSS	Basic in computer application, Pakyong
Mr. Dawa Bhutia	SSS	Basic in computer application, Pakyong
Mr. Arjun Gurung	SSS	Basic in computer application, Pakyong
Mr. Tularam Dulal	SSS	Basic in computer application, Pakyong
Mrs. Robinkala Subba	SSS	Basic in computer application, Pakyong

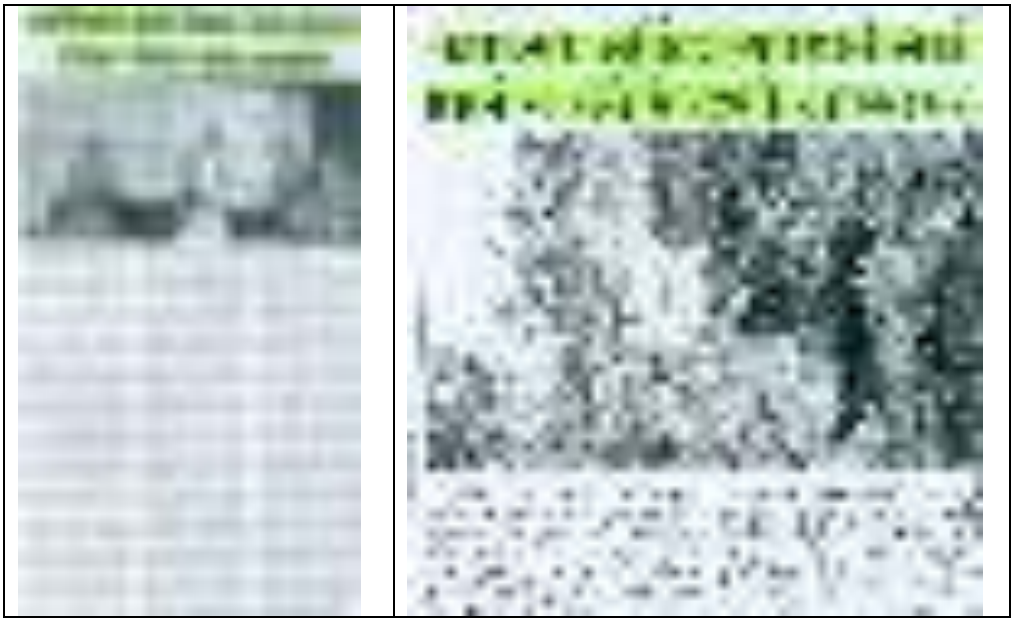
Linkages and Collaboration

The centre has linkages with several universities, research institute and developmental agencies for collaborative research and developmental activities in orchids and other mandate floriculture crops.

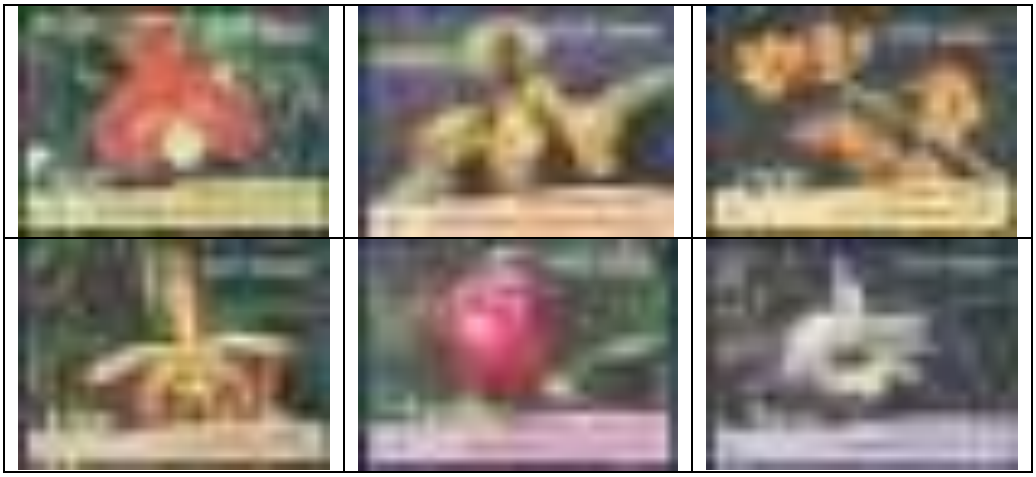


NRCO in Media





Stamps: Stamps released by postal department in India (2016)



(Courtesy: https://www.epostoffice.gov.in/eProducts_info.aspx; https://stampsofindia.com/lists/2016stamps.html)

Publications

Research Papers

1. D. Barman, S. K. Nayak (**2016**) Effect of Substrate, Nutrition and Growth Regulator on Productivity and Mineral Composition of Leaf and Pseudobulb of Cymbidium Hybrid "Baltic Glacier Mint Ice". *Journal of Plant Nutrition,* DOI: 10.108.

2. L. C. De, R. Devadas, D. R. Singh, S. Thapa, W. Rai (**2016**) Performance of some Vanda hybrids at Sikkim Himalaya. *International Journal of Current Research,* 8 (5), 30276-30281.

3. L. C De, W. Rai, S. Thapa, D. R. Singh (**2016**) Input Management in Organic Floriculture- an Overview. *International Journal of Humanities, Arts, Medicine and Sciences* (BEST: IJHAMS), Vol. 4, Issue 5, May 2016, 47- 56.

4. L. C. De, A. N. Rao, P. K. Rajeevan, S. R. Dhiman, R. Prakash **(2016)** Development of DUS Test Guidelines of High Value Orchids. *The Journal for Horticulture*. Photon 104 (2016): 149-160.

5. L. C. De, D. R. Singh **(2016)** Floriculture Industries, Opportunities and Challenges in Indian Hills. *International Journal of Horticulture*, 6 (13): 1-9.

6. L. C. De, R. Kumar, N. Sailo, D. R. Singh **(2016)** Evaluation of some Oncidium hybrids at Sikkim Himalaya. *International Journal of Research in Applied, Natural and Social Sciences*, 4(7): 1-8.

7. L. C. De, D. R. Singh, D. Barman **(2016)** Valuable Terrestrial orchids-an overview. *International Journal of Research in Applied, Natural and Social Sciences*, 4 (9): 55-64.

8. S. Gupta, V. Bhatia, G. Kumawat, D. Thakur, G. Singh, R. Tripathi, G. Satpute, R. Devadas, S. M. Husain, S. Chand (**2017**) Genetic Analyses for Deciphering the Status and Role of Photoperiodic and Maturity Genes in major Indian Soybean Cultivars. *Journal of Genetics*, 96 (DOI 10.1007/s12041-016-0730-2).

9. R. Devadas, S. L. Pattanayak, D. R. Singh (**2016**) Studies on cross compatibility in Dendrobium species and hybrids. *Indian Journal of Genetics and Plant Breeding*, 76(3): 344-355.

10. R. Devadas; S. L. Pattanayak, M. Adhikari, D. R. Singh (**2016**) Morphological description of selected breeding line of Paphiopedilum: NRCO - *P. lawrenceanum* x P. 'Winston Churchill'/2013/29 (IC-0614750). *Indian Journal of Hill Farming*, 30(1): 125-128.

11. L. C. De, D. R. Singh, D. Barman **(2016)** Evaluation of Some Phalaenopsis hybrids at Sikkim Himalaya. *International Journal of Agricultural Science and Research,* 6(5): 189-196.

12. L. C. De, D. R. Singh, R. Kumar, P. Pathak **(2016)** Description, Production Technology and Uses of Some Medicinal Orchids. *The Journal of Orchid Society of India*, 30: 97-101.

Books/ Book Chapters

L. C. De and D.R. Singh (**2016**) '*Year Round Production of Orchids*', Pp.104, Published by Pointer Publisher, Jaipur, Rajasthan (ISBN: 978-81-7132-839-0).

L. C. De, A. N. Rao, D. R. Singh (**2016**) Endangered Orchids and their Conservation in North East India. Bioprospecting of Indigenous Bio-resources of North-East India. Purkayastha, Jubilee (Eds.), Springer Publications, pp. 61-75.

D. R. Singh, Ram Pal (**2016**) Floriculture in North Eastern States of India. In: Doubling Farmers Income through Horticulture, K L Chaddha, S K Singh, D. Kalia, W S Dhillon, T K Behra, and Jaya Prakash (Eds) pp 921-928. The Horticulture Society of India, Daya Publishing House, New Delhi.

D. R. Singh, P. R. Kishore, R. Kumar, A. Singh, Deepak Rai (**2017**) Orchid Preparations. Souvenir – Kisan Mela 2017 (Eds.). ICAR-NRC on Orchids, Pakyong-737106, Sikkim.

R. Devadas, A. L. Meitei (**2017**) Plant variety protection in Orchids. Souvenir – Kisan Mela 2017 (Eds.). ICAR-NRC on Orchids, Pakyong-737106, Sikkim.

S. Chakrabarti, D. R. Singh, T. Janakiram (**2017**) Indigenous Knowledge Practices in Orchids.

Technical Bulletins/ Reports

A. M. Khan, Ram Pal and D. R. Singh **(2016)** Unique uses of Single Cymbidium Flowers, (Tech. Bull. No. 39), NRC for Orchids, Sikkim, pp39.

L. C. De, L.C., Raj Kumar, R. Devdas, D. Barman, R.P. Medhi, J. Gogoi, B. Hakmoasha, S. Bhattacharjee, D. Rai and T. C. Bhutia (**2015**) Purbattar Tatha Himalayo Rajya Ke Liye Bagbani Mission Ki Saphalata Ki Gatha. ICAR-NRC for Orchids, Pakyong, Sikkim, pp49.

L. C. De, R. Kumar (**2016**) Mini Mission–I ki Anusandhan Bisheshataye evam Upalabdhiya. ICAR-NRC for Orchids, Pakyong, Sikkim, pp. 132.

R. Devadas, N. Meetei, M. Chakraborti (**2016**) Voices of Stakeholders – IV. *Proceedings of 4th Stakeholders meeting, April 19th, 2016* at ICAR-NRC on Orchids, Pakyong-737106, Sikkim.

R. Devadas, A. L. Meitei (**2017**) Souvenir – Kisan Mela 2017 (Eds.). ICAR-NRC on Orchids, Pakyong-737106, Sikkim.

R. Kumar, D. R. Singh, D. Barman, L.C. De, Rampal, N. Sailo, Rumki Sangma and A.M. Khan. Dendrobium Aur Phalaenopsis Ka Bybsaik Utpadan, Technical Bullertin No.50.

R. Kumar, L.C. De, Rampal (**2015**) Anusandhan Upalabdhiya (2014-15), ICAR-NRC for Orchids, Pakyong, Sikkim, pp.17.

R. Kumar, L.C. De, M. Chakraborti, Rampal (**2016**) Anusandhan Upalabdhiya (2015-16), ICAR-NRC for Orchids, Pakyong, Sikkim, Pp.28.

R. Pal, M. Dayamma, A. M. Khan, D. R. Singh **(2016)** A techno-guide for propagation *Lilium* (Tech. Bull. No. 49), NRC for Orchids, Sikkim, pp 32.

D. Barman, N. Sailo, R. Kumar, Rampal and Rumki Sangma (**2017**). Organic Cultivation of Cymbidium. Pp 1-44.

Folders

D. Barman 2017. Organic Production Technology of Alstroemeria.

D. Barman 2017. Organic Production Technology of Carnation.

D. Barman 2017. Organic Production Technology of Gerbera.

R. Ch. Sangma, R. Kumar, N. Sailo, R. K. Singh, G. Pradhan, D. R. Singh. Aphids on Orchids.

R. Ch. Sangma, N. Sailo, R. Kumar, R. K. Singh, D. R. Singh 2016. Two-spotted Spider Mites on Orchids.

R. Ch. Sangma, Raj Kumar, N. Sailo, R.K.Singh, G. Pradhan and D.R.Singh. Aphids on Orchids.

रूमकी संगमा, राकेश कुमार सिंह, अंकिता सिंह एवं डी. आर. सिंह. २०१७. आर्किड्स को माहूँ (Aphids) कीटों से नुकसान.

रूमकी संगमा, राकेश कुमार सिंह, अंकिता सिंह एवं डी. आर. सिंह. २०१७. आर्किड्स का मुख्य नाशीजीव बरुथी.

रूमकी संगमा, राकेश कुमार सिंह, अंकिता सिंह एवं डी. आर. सिंह. २०१७. आर्किड्स के नाशी पर्णजीवी कीट.

रूमकी संगमा, राकेश कुमार सिंह, दीपक राई एवं डी. आर. सिंह. २०१७. सुनगाभा माथी लाईकिरा (Aphids) को असर.

रूमकी संगमा,राकेश कुमार सिंह,दीपक राई एवं डी. आर. सिंह. २०१७. सुनगाभामा लाग्ने द्वि छिटका माईट (Mites) किरा.

रूमकी संगमा,राकेश कुमार सिंह, दीपक राई एवं डी. आर. सिंह. २०१७. सुनगाभामा लाग्ने थ्रिप्स (Thrips) किरा.

Popular Articles

Chakrabarti, S. (**2016**) *Spathoglottis* - a beautiful garden orchids. *Rastriya Krishi*, June 2016.

Papers Presented in Seminar/ Symposia

D. Barman**,** R. Kumar and N. Pathak (**2016**) Organic cultivation of Cymbidium Orchid in Sikkim. In: Platinum Jubilee of HIS, "Shaping future of Indian Horticulture", 7th Horticulture Congress held at IARI, N. Delhi on Nov 15-18, 2016.

D. Barman, D. R. Singh (2017) Hydroponic system in Orchids. In: *National Conference on advances in Indian Floriculture with focus on North East and Hill region*. CIH, Dimapur, Nagaland on Jan 13 – 15, 2017 **(Lead lecture**).

L. C. De, S. Thapa, W. Rai, D. R. Singh (**2016**) Drying Techniques in Orchids. 7th Indian Horticultural Congress on Doubling Farmers Income through Horticulture, Nov 15-18, 2016 at IARI, Pusa, New Delhi-110012.

R. Devadas (2016) 'Plant Variety Protection in Orchids – Indian Perspective'. *Winter School on Abiotic and Heavy Metal Stress Management in crop through Physiological, Phytoremediation and Proximate sensing Approaches*" (Sept 2–22, 2016) by Department of Plant Physiology, Assam Agril. University, Jorhat, Assam on 21/09/2016 (**Invited Lecture**).

S. Chakrabarti (**2016**) Molecular Diversity analysis of some fragrant *Dendrobium* orchids using ISSR markers. 1st International Agro Biodiversity Conference, New Delhi (accepted).

Participation in Conferences, Meetings, Trainings, Workshops, Symposia, Seminar etc. in India & Abroad

National Conference on Advances in Indian Floriculture with focus of North-East and Hill Region, CIH, Dimapur, Nagaland on Jan 13-15, 2017 (Dr. L. C. De, Dr. D. Barman, Dr. N. Sailo & Mr. R. Kumar).

Awards/ Rewards/ Recognition/ Bodies acquired during the year

Dr. L. C. De

- Awarded *Fellow*, CHAI, 2016
- Awarded *Fellow*, ISOH, 2017
- Member, Board of Studies, Department of Horticulture, Sikkim University
- As External Examiner for Practical Examination for UG, M.Sc. and Ph. D Students, Sikkim University, Gangtok
- As External Examiner for Question Setting on Landscaping and Ornamental Gardening (FLA-504), CAU, Imphal
- As Chairman, COBACAS best thesis award evaluation & Technical Session 2 (Ecosystem Management and Livelihood Improvement) in National Conference On Bioresources Management for Sustenance of Ecosystem and Livelihood, UBKV, Pundibari, Cooch Behar.
- As Reviewer of British Biotechnology Journal, Journal of Biological Diversity (Indonesia), Indian Journal of Horticulture, Journal of Experimental Agriculture International and British Journal of Applied Science & Technology.

Distinguished Visitors

Hon'ble Governor of Sikkim

Padma Shree Awardee Dr. Brahma Singh

Prof. K. V. Peter, Ex-Vice Chancellor, KAU

Dr. Basu, Ex-Director, NRC on Groundnut

Prof. N. P. Singh, Director, ICAR-CARI, Goa

Dr. Abhijit Mitra, Director, ICAR-NRC on Mithun

Dr. P. Rethinam, Ex-Director, ICAR-IIOPR

Principal Secretary (Agril.), Maharashtra (03/10/16)

Dr. Abhijit Mitra, Director, ICAR-NRC on Mithun, Nagaland

Shri. Hemendra Adhikari, MLA (Rhenock)

Prof. T. B. Subba, Vice-Chancellor, SU

Prof. K. Premjit Singh, Vice-Chancellor, CAU

Peer Recognitions

Director

- Member, Indian Council of Food and Agriculture (ICFA) Board of Working Group on Horticulture
- Chief Editor, Orchids Newsletter, NRCO, Pakyong
- Expert Member, ASRB, New Delhi
- Authored a book in "Indigenous Knowledge and Practices in Orchids (IKP)"
- Received Dr. R. S. Paroda Award (29th May, 2016) by CHAI, New Delhi
- Keynote address during International Conference on "Emerging Trends in Science, Technology, Agriculture & Management – 2016" and National Workshop on Soft Computing Modeling-Food Processing, Pharmaceutical Science and Export Management held at CAEPHT, CAU, Ranipool on 21st April, 2016.
- Chairman, Farmers' Scientists interactive meeting during Pandit Deen Dayal Upadhyaya Antyodya Krishi Puruskar 2015 held on 25.09.2016 at the auditorium of College of Agricultural Engineering & Post Harvest Technology, CAU, Ranipool, Sikkim.
- Chairman, Technical session on Technology led Organic Horticulture and safe food in Platinum jubilee of Horticulture Society of India-An International Meet-Indian Horticulture Congress 2016 with a theme doubling Framers income through horticulture held on 15-18 November, 2016 at IARI, New Delhi.
- Delivered key note address on Floriculture in North Eastern states of India: Prospects and Challenges in National conference on Advances in Indian Floriculture with focus on North East & Hill regions held on **13-15 January, 2017** at CIH, Nagaland.
- Chairman, Technical session on Production and protection technologies in floriculture in National conference on Advances in Indian Floriculture with focus on North East & Hill regions held on 13-15 January, 2017 at CIH, Nagaland.
- Chairman, Reviewed all the projects of Floriculture at ICAR-IIHR Bengaluru on 30 & 31 January, 2017
- **Co-Chairman,** Technical Session during KVK Zonal Annual Workshop held on 22nd April, 2017 at ChintanBhawan, Gangtok.
- **Co-Chairman,** Technical Session on "National Workshop on Quality Production and Handling of Banana Export and Domestic Market" held on 29th May, 2017 at Jalgaon, Maharastra.
- **Co-Chairman,** Technical Session on "Biodiversity and Crop Improvement" during NONI SEARCH, 2016 Eleventh National Symposium on "Noni and medicinal plants for health and livelihood security"on 03.12.2016 at ICAR-IISR, Lucknow

Participation in important Meeting, Symposium and Workshop

- Attended International Conference on "Emerging Trends in Science, Technology, Agriculture & Management – 2016" and National Workshop on Soft Computing Modeling-Food Processing, Pharmaceutical Science and Export Management held at CAEPHT, CAU, Ranipool on 21st April, 2016.

- Attended Inaugural programme of KVK Zonal Annual Workshop held on 22nd April, 2017 at Gangtok.

- *Attended* interactive meeting of the Finance Officers of ICAR institutes East zone with DG, ICAR on 13th May, 2016 at ICAR RC for NEH Region, Barapani, Shillong.

- Attended **Global Conference on Perspective of Future Challenges and options in Agriculture** at Jain Hills, JISL, Jalgaon, Maharastra held during 28th to 31st May, 2016.

- Attended meeting with Honorable Union Minister for Agriculture and Farmers Welfare with Programme Coordinators of KVKs and HODs of ICAR Institutes located in North East India at NRC (P), Guwahati under the chairmanship of the **Secretary DARE & DG, ICAR** on June 17th, 2016.

- Attended **23rd meeting of ICAR Regional Committee**, Zone-II held during June 24-25, 2016 at ICAR-National Academy of Agricultural Research Management (NAARM), Rajendra Nagar, Hyderabad.

- Attended **Midterm Review of the 22nd ICAR Regional Committee Meeting, Zone-III** held on 19.07.2016 at ICAR Research Complex for NEH Region, Umiam, Barapani, Meghalaya.

- Attended Awareness Program of NHB Schemes as Guset of Honour at JantaBhawan, Gangtok, on 24.08.2016.

- Attended Meeting organized by Additional Secretary, ICAR with AAO,s and AFAO,s of ICAR institute of the East Zone at NBSS&LUP, Kolkata on 31.08.2016.

- Attended the 3rd Himalayan Lecture at G.B. Pant Institute on the occasion of Annual Day as **Guest of Honour** on 10.09.2016 at Gangtok.

- Attended a meeting with DDG (HS), ICAR, KAB-II, New Delhi for discussion on various office issues during 22-23 September, 2016.

- Attended Award ceremony of PanditDeenDayalUpadhyayaAntyodyaKrishi Puruskar 2015 as **Guest of Honour** on 25.09.2016 at the auditorium of College of Agricultural Engineering & Post Harvest Technology, CAU, Ranipool, Sikkim.

- Attended an occasion of marking birth anniversary of Mahatma Gandhi on 02.10.2016 as **Guest of Honour** at Junior High School, Raigaon, Pakyong.

- Attended Model Training Course on Employment Opportunity on 17.10.2016 at College of Agricultural Engineering & Post Harvest Technology, CAU, Ranipool, Sikkim as **Chief Guest.**

- Attended Workshop on "Horticulture Development for sub Himalayn Terai Region" held on Oct 20-21, 2016 at ICAR-CPCRI Research Centre, Mohitnagar, Jalpaiguri as **Guest of Honor**.
- Attended Brainstorming Session for Engineering Interventions for Horticultural Crops held during Oct 24-25, 2016 at ICAR-CIAE, Bhopal as **Guest of Honor.**
- Attended the 1st International Agro biodiversity Congress held from November 6-9, 2016 at NASC Complex, Pusa, New Delhi.
- Attended Raj Bhasa Sammelan and Award Ceremony of Hindi at Chintan Bhawan, Gangtok on 12th November, 2016.
- Attended the 7th Indian Horticulture Congress held from 15-18, November, 2016 at ICAR-IARI, Pusa, New Delhi.
- Attended meeting/presentations of all ICAR Directors of Horticulture Division related to Germplasm issue held on 19th November, 2016 at ICAR-NBPGR, New Delhi.
- Attended National Conference on Advances in Indian Floriculture with focus on North East & Hill Region held from Jan 13-15, 2017 at Central Institute of Horticulture, Dimapur, Nagaland.
- Attended CAS interview of Sr. Scientist as an Expert on 02.02.2017 at ASRB, New Delhi.
- Attended Annual Conference of Directors of ICAR Institutes and Vice Chancellors on 14-15 February, 2017 at NASC, Pusa, New Delhi.
- Attended National Seminar on 'Understanding Himalayan Phytodiversity in a Changing Climate' organized by BSI, Gangtok on 09.03.2017 at Chintan Bhawan, Gangtok.

Personalia

Director:

Dr. D. R. Singh

Scientific Staff

Principal Scientist

Dr. D. Barman, Principal Scientist (Horticulture)
Dr. L. C. De, Principal Scientist (Horticulture)
Dr. Syamali Chakrabarti, Principal Scientist (Genetics)
Dr. Ram Pal, Principal Scientist (Horticulture)

Senior Scientist
Dr. Ramgopal Devadas, Senior Scientist (Plant Breeding)

Scientist
Dr. M. Chakraborti, Scientist (Plant Breeding)
Dr. N. Sailo, Scientist (Plant Physiology)
Dr. Arpita Mandal Khan, Scientist (Floriculture & Land Scaping)
Ms. Rumki Heloise CH. Sangma, Scientist (Agril. Entomology)
Sh. Raj Kumar, Scientist (Floriculture & Landscaping)
Sh. Ravi Kishore Pamarthi (Economic Botany & Plant Genetic Resources)

Technical Staff
Ms. Tshering Chomu Butia, Technical Assistant (Horticulture Assistant)
Sh. Ajay Bushal, Sr. Technician (Farm)
Sh. Manoj Adhikari, Sr. Technician (Farm)
Ms. Meena Kumari Chettri, Sr. Technician

Workshop Staff
Shri. Ram Chandra Gurung, Sr. Technical Assistant
Shri. Deepak Khattri, Sr. Technician

Administrative Staff
Sh. Parimal Ghosh, Administrative Officer
Sh. Rajat Das, Assistant Finance and Account's Officer
Sh. Arvind Chauhaan, Assistant
Mrs. Diki Bhutia, Sr. Clerk
Sh. Phigu Tshering Bhutia, Jr. Clerk
Mrs. Sangeeta Lepcha, Jr. Clerk

Personal Assistant to Director
Mrs. W. Stella Sasa

Skilled Support Staff
Sh. Dawa Bhutia
Sh. Tularam Dulal
Sh. Trilok Singh Balmiki
Sh. Arjun Gurung
Mrs. Rabin Kala Subba
Sh. Rabin Raj Subba

Appointments:

Sh. Parimal Ghosh, Administrative Officer joined on promotion (03/11/2016).

Promotions:

Technical
Sh. Manoj Adhikari, Technician (Field/ Farm) promoted as Senior Technician (Field/ Farm) w.e.f., 06/07/2014 (cleared through DPC on 09/06/2016).

Ms. Meena Kumari Chettri, Technician (Lab) promoted as Senior Technician (Lab) w.e.f., 06/09/2015 (cleared through DPC held on 09/06/2015).

Transfers:
Dr. M. Chakraborti, Scientist (Plant Breeding) transferred to ICAR-NRRI, Cuttack on 09/06/2016.

Dr. D. Barman, Principal Scientist (Horticulture) transferred to ICAR-IARI, New Delhi on 31/03/2017.

Resignation:
Dr. A. M. Khan, Scientist (Floriculture & Land Scaping) resigned w.e.f. 31/03/2017 to join at UBKV, Cooch Behar.

Institute Committees:

QRT Committee		
Name	**Designation**	**Assignment**
Dr. K. R. Dhiman	Former VC, YSPUH&F, Soaln, H.P.	Chairman
Dr. A. N. Rao	Director, Centre for Gene Conservation for Eastern Himalaya, Hengbung, Manipur	Member
Dr. S. Ramani	Ex - Project Cordinator, UAS, Bangalore, Karnataka	Member
Dr. Promila Pathak	Professor of Botany, Orchid laboratory, Punjab University	Member
Dr. P. C. Panda	Regional Plant Genetic Resource Centre, Bhubaneswar	Member
Dr. D. R. Singh	Director, ICAR-NRC for Orchids	Member
Dr. Ram Pal	Sr. Scientist (Hort.), ICAR - NRC for Orchids, Darjeeling Campus	Member Secretary

RAC, Committee		
Name	**Designation**	**Assignment**
Dr. V. A. Parthasarathy	Former Director, IISR, Kozhikode, Kerala	Chairman
Dr. T. Janakiram	ADG (HS-I), ICAR, New Delhi	Member
Dr. A. N. Rao	Director, Centre for Gene Conservation for Eastern Himalaya, Hengbung, Manipur	Member
Sh. S. Z. Lucksom	Director (R&D), Orchidologist & Former Director, Himalayan Zoological Park, Gangtok	Member
Dr. V. V. Belvadi	Prof & Head, Department of Entomolgy, UAS, GKVK, Bangalore	Member
Dr. Bikash Mandal	Principal Scientist, Division of Plant Pathology, IARI, New Delhi	Member
Dr. D. R. Singh	Director, ICAR-NRC for Orchids	Member
Sh. Izmir Tikhak	Changlang District, Arunachal Pradesh	Member
Sh. Pempa Sherpa	Kartok, Pakyong, Sikkim	Member
Dr. Ram Pal	Principal Scientist (Hort.), ICAR - NRC for Orchids, Darjeeling Campus	Member Secretary

ISO 9008:2008 Certification Committee		
Name	**Designation**	**Assignment**
Dr. L. C. De	Pr. Scientist, Horticulture	Chairman
Dr. S. Chakrabarti,	Pr. Scientist (Genetics)	Member
Dr. R. Devadas,	Senior Scientist (Plant Breeding)	Member
Dr. N. Sailo,	In-charge AAO	Member
Sh. R. Kumar	Scientist (Floriculture)	Member
Mrs. R. Sangma	Scientist (Agril. Entomology)	Member
Sh. A. Chauhaan	Assistant	Member
Mrs. D. Bhutia	UDC	Member
Sh. M. Adhikari	Technical (Field)	Member

Official Language Committee		
Name	**Designation**	**Assignment**
Dr. D. R. Singh	Director, ICAR-NRC for Orchids	Chairman
Dr. Ram Pal	Sr. Scientist (Hort.)	Member
Dr. R. Devadas	Senior Scientist (Plant Breeding)	Member
Dr. N. Sailo	Scientist (Plant Physiology)	Member
Sh. R. Kumar	Scientist (Floriculture)	Member
Mrs. R. Sangma	Scientist (Agril. Entomology)	Member
Sh. A. Chauhaan	Assistant	Member
Mrs. D. Bhutia	UDC	Member
Sh. M. Adhikari	Technical (Field)	Member

PME Cell		
Name	**Designation**	**Assignment**
Dr. D. R. Singh	Director, ICAR-NRC for Orchids	Chairman
Dr. D. Barman	Pr. Scientist (Horticulture)	Member
Dr. L. C. De	Pr. Scientist (Horticulture)	Member
Dr. S. Chakrabarti	Pr. Scientist (Genetics)	Member
Dr. Ram Pal	Pr. Scientist (Horticulture)	Member
Dr. R. Devadas	Senior Scientist (Plant Breeding)	Member
Dr. N. Sailo	Scientist Plant Physiology	Member