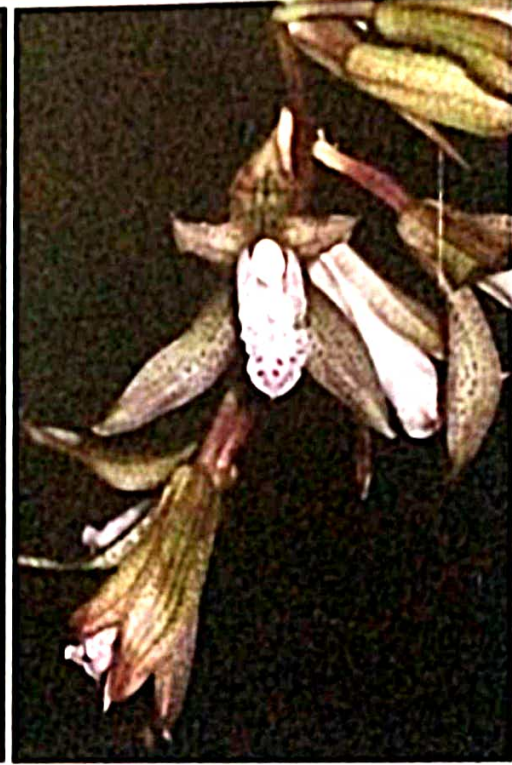


# Research Highlights 2017-18 & 2018-2019



ICAR-National Research Centre for Orchids  
Pakyong-737106, Sikkim, India



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**Research Highlights**

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**Published by:**

Dr D. R. Singh, Director, National Research Centre for Orchids,  
Pakyong-737 106, Sikkim, India

**Printed:**

May 2019

## Foreword

The year 2017-18 and 2018-19 witnessed many accomplishments in research and extension activities of the Centre. The collection and conservation of orchids remain one of the core areas of the Centre. Thirteen species of orchids and 46 hybrids of *Cymbidium* orchids were added to the collection. Seventy species of orchids, several F1 progenies of *Vanda*, *Cymbidium* and *Phalaenopsis* were characterised. A natural hybrid between *Coelogyne nitida* and *Coelogyne corymbosa* was collected confirmed molecular characterization. Similarly, natural hybrid between *Coelogyne flaccida* and *Coelogyne cristata* was also confirmed through molecular characterization. The new cultivation techniques viz. aeroponics, hydroponics, and vertical farming etc were tested in orchid cultivation. Scientists have developed and validated the methods for producing true to type planting material through apomixis. The production and postharvest management technologies were refined to maximise the production and reduce the postharvest losses. Organic solution for feeding of *Cymbidium* and *Zygopetalum* plants were worked out. Studies were conducted for mass multiplication of *Dendrobium* hybrids and *Cymbidium whiteae*, an endemic and threatened orchid of Sikkim. The institute has working on several externally funded projects to enhance the research output. One such project funded by Ministry of Environment and Climate Change, Govt. of India under National Mission for Himalayan Studies, under this project geo-reference database on Indian orchids is being compiled, therapeutic orchids are being validated by chemical profiling, the ecological monitoring of endangered orchids has also being carried out. Many crosses were made for development of commercial hybrids of *Cymbidium* and other orchids. Interspecific crosses of *Calanthe* and *Paphiopedilum* were also made during the period of under report. A BARC supported project on 'Inventorization of gamma radiation irradiation technology for Orchid varietal improvement have also been started for using gamma radiation irradiation in orchid breeding.' Gamma radiated 'Emma White' *in-vitro* plantlets were analyzed using High Throughput analysis. 120 plantlets of 'Emma White' were taken for hardening.

During 2017-18 & 2018-19 twenty-three training programmes were organised that benefitted 227 students, 153 farmers and 160 officers on various aspects of horticultural crops. The Centre also organised training under Pt. Deen Dayal Upadhyaya Unnat Krishi Siksha Yojna on natural farming or cow based farming. Under TSP, capacity building training on Orchids' was conducted at Ukhrul, Manipur jointly by ICAR-NRC on Orchids, Sikkim and Krishi Vigyan Kendra, Ukhrul. Several exposure visits of orchid farmers were organised under tribal sub-plan. Five FLD's on cultivation of *Paphiopedilum* was conducted at Kalimpong, West Bengal; Yangang, South Sikkim; Sombaria, West Sikkim; Hee-Gyathang, North Sikkim & Karthok, East Sikkim. ICAR-NRC for Orchids in collaboration with Government of Sikkim, Central Institute of Horticulture, Nagaland, North East Council, NABARD, Gangtok and Indian Society of Ornamental Horticulture (ISOH), New Delhi organized National Conference on **Floriculture for Rural and Urban Prosperity in the Scenario of Climate Change**. More than 200 Young researchers, academicians, policy makers, entrepreneurs and faculties from across the research institutes and educational organizations of North East India and the other parts of the country participated.

Thus a great emphasis was laid on demonstration and training and extension related activities. All this success came from the active support, contribution and dedicated staff of

## **On-going Research Projects**

### **A. Institute Funded Projects**

**Project 1:** Conservation Characterization and Sustainable Use of Diversity in Orchids.

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

**Project 3:** Development and Refinement of Production and Protection Technologies for Improved Productivity, Marketing and Utilization of Orchids.

**Project 4:** Improvement of Knowledge and Skill of Stakeholders for Improving Production of Orchids

### **B. Externally Funded Project**

1. Preparation for Plant Variety Protection and Conducting Test for Distinctness, Uniformity and Stability for Orchids (*Funded by PPV&FR Authority, Ministry of Agriculture and Farmers Welfare, Govt. of India*).
2. Orchid biodiversity database of Sikkim and Darjeeling Himalayas. National Mission for Himalayan Studies (NMHS)
3. Inventorization of gamma radiation irradiation technology for Orchid varietal improvement

### **A. Institute Funded Projects:**

#### **Project 1: Conservation Characterization and Sustainable Use of Diversity in Orchids.**

351 species belonging to 90 genera were collected and conserved in the conservatory of ICAR-NRC for Orchids. These included 13 new species added to the collection during 2017-18 and 2018-19. The institute has also conserved 100 cultivars of Dendrobium, Cymbidium, Vanda, Cattleya etc.

Forty-six cultivars of Cymbidium were collected and conserved at Darjeeling Campus of NRC for Orchids. Seven accessions of native orchids, *Paphiopedilum fairrienum* (live plant), *Pleione praecox* (live plant), *Cymbidium iridioides* (Capsule), *Cymbidium eburneum* (Capsule), *Cremastra appendiculata* (live plants) and *Cymbidium munronianum* (live plant) were collected and conserved.

Morphological characterization of 70 species was completed during the period of under report. This includes characterisation of *Dendrobium ruckerii* and *Cymbidium whiteae*, two threatened species of orchids of Sikkim Himalaya.

For easy identification of orchid species digital herbarium were prepared for 70 species of orchids.

Molecular characterization of a collection of *Coelogyne nitida* revealed that it natural hybrid between *Coelogyne nitida* and *Coelogyne corymbosa*. Both these species are co-flowering species and found in Darjeeling district of West Bengal.

Molecular characterization of another collection of *Coelogyne cristata* revealed that it is natural hybrid between *Coelogyne flaccida* and *Coelogyne cristata*. Both these species are sympatric and occur in Darjeeling district of West Bengal.

In order to develop rapid and mass in vitro propagation of an orchid, *Cymbidium whiteae* through in vitro culture of thin cross-sections (TCSs) derived from young protocorms. TCS were cultured on MS medium supplemented with different concentrations of N6-benzyl adenine (BA), kinetin (Kn), Zeatin and 6-Benzyleaminopurine (BAP). The optimal growth regulators combination for maximal PLB development was 2  $\mu$  Mole BA or 2  $\mu$  Mole BAP.

Breeding systems for two species of *Calanthe*, *C. puberula*, *C. trulliformis* and *Epigonium amplum* were determined. None of the species in this study produced fruits through apomixis or autogamy, thereby indicating a complete dependency on pollen and pollinators. No significant differences were observed in other treatments.

WPM medium supplemented with 500 mg/l activated charcoal helps in seed germination of *Calanthe*

## **Project -II: Genetic Improvement of Orchids for Yield, Quality and Resistance to Biotic and Abiotic Stresses**

Late flowering progenies of *Cymbidium* population (16 no.) viz., PBX-05-884, PBX-05-46/03, BxH/02, HxB/12, HxB/20, HxB/21, HxB/22, HxB/31, BxH/12, BxH/14, BxH/18, BxH/20, BxH/35, BxH/37 in addition to 3 mid-late progenies were characterised.

Characterized heat tolerant late progenies of *Cymbidium* (02 no.) viz., **PBX-05-56** and **PBX-05-57** derived from cross *C. lowianum* x *C. tigrinum*. 1<sup>st</sup> novel *Cymbidium* combination of breeding line, PBX-05-490/04 (*Cymbidium gammieanum* x *Cymbidium dayanum*) was documented (June). Four other 1<sup>st</sup> blooming *Cymbidium* progeny population recorded viz., PBX-11-150 ('Margaret Thatcher' x *Cymbidium tracyanum*), PBX-11-144 (PCMV' x *Cymbidium tracyanum*), PBX-11-155 ('Free Style No. 3' x *Cymbidium tracyanum*), PBX-05-21 (*Cymbidium tracyanum* x 'Fency Free').

Early flowering elite Phalaenopsis lines viz., **PBX-12-99/02 & PBX-12-99/03** were characterized for 2<sup>nd</sup> year and 09 other early flowering progenies of Phalaenopsis viz., PBX-12-99/01, 07, 09, 14, 05, 06, 10, 12, 15 & 16 evaluated. 03 mid flowering Phalaenopsis progenies viz., PBX-12-99/2, PBX-12-99/3 and PBX-12-99/15 characterized.

Novel reciprocal cross of Phaius primary hybrid (**PBX-11-25/01**) characterized and crossability and incompatibility studies on Phaius summarized.

New promising Vanda progeny line **PBX-12-169/03** characterized, apart from consecutive flowering of promising line **PBX-12-169/01, PBX-12-169/02** and MLS (D). Data collected on field trial on Aranda hybrid at Mohitnagar and repotted (Aug).

21 early Cymbidium progenies characterized (PBX-05-29/95, PBX-05-771/05; PBX-05-772/94; NRCO/3x6/04, PBX-05-772/136; PBX-05-772/127; PBX-05-772/171; PBX-05-772/153; PBX-05-772/84; PBX-05-772/379; PBX-05-772/409; PBX-05-772/189; PBX-05-772/47; PBX-05-772/454; PBX-05-772/158, PBX-11-150/66, PBX-11-150/67, PBX-11-144/25, PBX-11-155/02; PBX-11-155/06; PBX-11-155/03)

9 mid-early Cymbidium progenies characterized (PBX-05-772/107, PBX-11-155/01; PBX-11-155/04; PBX-11-155/05, PBX-11-150/03, PBX-05-751/07, PBX-11-150/04, PBX-05-21/27 , PBX-11-144/14)

14 mid Cymbidium progenies characterized (PBX-05-10/16, PBX-05-10/13, PBX-05-34/83, PBX-05-34/09, PBX-05-34/19, PBX-05-34/90, PBX-05-34/96, PBX-05-34/25, PBX-05-34/29, PBX-05-34/84/K, PBX-05-34/97, PBX-11-144/24, PBX-11-144/18 and PBX-11-144/15), apart from 2 mid-late Cymbidium progenies characterized viz., BxH/33 and BxH/12.

NRCO/Paphiopedilum progenies evaluated viz., *P. venustum* clones 1, 2; PlxPw/05, PlxPw/08, PlxPw/30, PlxPw/33, PlxPw/28, PlxPw/23, PlxPw/26, PlxPw/38, IC 614753, IC 61450, IC 614751, IC 614752, IC 617522, IC 614523 and IC 614524.

RMLT trial data on 'Sheetal 1' collected at six locations. *P. venustum* (Nonglwai collection), Happy Beauty (Mokara) characterized for morphological characters. Mid-late flowering Zygopetalum progenies characterized. Offseason crosses were attempted between Zygopetalum and Cattleya (TC) plants.

Dendrobium crossed progenies (PBX-12-58) semi-hardened and re-potted. Seed culture of PBSx-18-43 (Aranda) was done and induction of new 17 crosses.

Effective protocol on 'Emma White' for rooting was developed. Progenies of PBX-12-119 (ZI) and PBX-12-99 (Phalaenopsis) were semi-hardened.

**Planting material:** Approx. 620 *in-vitro* Zygopetalum plants were given to Plant Physiology for controlled hardening (May). Approx. 300 no. certified material of Zygopetalum (PBSx-17-01) plants were semi-hardened (Aug). 800 *in-vitro* Zygopetalum plantlets of unknown origin were semi-hardened for establishment (Sept). 131 culture bottles of Zygopetalum was shifted for semi-hardening (Jan). IC registered breeding lines were multiplied. Generated Rs.

15,000/- revenue from sale of certified planting material (300 no.) to TSP project (Revenue generation).

### **Breeding of Selected Orchids for Cut Flower and Pot Plants: Strengthening the weakest link between orchid research and industry**

Four interspecific crosses of *Calanthe*: *C. chloroleuca* x *C. plantaginea*, *C. plantaginea* x *C. brevicornu*, *C. brevicornu* x *C. plantaginea* and *C. chloroleuca* x *C. Yuksomnensis* and three of *Paphiopedilum*: *P. venustum* x *P. Villosum*, *P. villosum* x *P. Hirsutissimum* and *P. spicerianum* x *P. fairrieanum* were raised.

Twenty-seven intervarietal and interspecific crosses of *Cymbidium* were cultured and at various stage of development.

### **Project-III: Development and refinement of production and protection technologies for improved productivity, marketing and utilization of orchids**

In *Cymbidium* and *Zygopetalum*, a potting mixture of Cocochips + cocopeat + brick pieces + cowdung (3:1:1:1) was found best for enhancing number of leaves, number of bulbs and bulb size in young plants although in *Cymbidium* Early flowering (3 years after planting) was also was recorded with Cocochips + cocopeat + brick pieces + tree barks with a single spike having spike length (36.7 cm), flower size 10.1cm and 4 no. of florets/spike.

Spraying with liquid manure made from equivalent ratio of *Artemisia vulgaris* + *Dryopteris sikkimensis* + cowdung in higher dilution (1:30) improved vegetative growth of young plants and increased spike length, rachis length, number of flowers per spike, flower longevity and chlorophyll content (93mg/100g) in leaves in bearing plants of *Cymbidium* orchids.

In hydroponic culture of *Zygopetalum*, application of half strength of Hoagland Solution in plants grown in moss growing medium increased plant height no. of leaves, length of leaves and no. of shoots/plant whereas application of half strength of Hoagland Solution improved the spike length and spike longevity of plants grown in perlite medium.

In *Dendrobium nobile*, longest internode (3.66cm), maximum number of spikes (3.16) and number of flowers/spike (16.75) with Mo @0.05 ppm spray. Increased flower size (8.21 cm x 6.67 cm) and pedicel length (5.72 cm) was found with B @0.05 ppm spray.

Orchid based farming system was developed is to utilize maximum space and to generate an additional income for orchid growers. Orchid comes to flowering in 3-4 years which is quite a long time. Moreover, the area below the orchid bench remains unutilized, which can be utilized to cultivate vegetables or any other ornamental planting materials to get an additional income in this farming system. In this system, a total of 21 beds of 1m<sup>2</sup> size was made wherein vegetables were grown season-wise in each bed. The maximum income of Rs. 110/- was obtained from bed no 18 in which mustard leaf-coriander was grown (mustard leaf was harvested thrice) followed by pea only (Bed no 20).

Orchid species used directly as cut flowers like *Renanthera imschootiana* had vase life of 24 days, *Vanda tessellata* 16 days and *Vanda stangeana* 10 days and *Paphiopedilum* 45 days.



In Dendrobium, 50 % opened stage was found as best harvesting stage, 4% Sucrose + 100 ppm Salicylic acid as best bud opening solution and 2% sucrose + 200 ppm ASA as best holding solution for increased vase life of cut flowers.

In Cymbidium, standard types with spike length more than 75cm had vase life from 55-60 days whereas miniature types with spike length 30-60 cm had vase life 30-34 days. Two bud open stage or 70% bloom stage was recorded as optimal stage for harvesting spikes whereas fully open stage for Cymbidium florets for increased vase life. About 5% sucrose for 8 hours as best pulsing treatment, Sucrose 4% + Salicylic acid 200 ppm as bud opening chemicals and 2% sucrose + 200 ppm 8-HQS was found as best vase solution for enhancing vase life of Cymbidium cut flowers. Cellophane paper had maximum longevity as packaging material for both Cymbidium florets and spikes.

Embedded drying with borax and silica gel at 50°C -60 °C in oven or Perlite, Perlite + borax and Perlite + Silica gel under room condition (24-25°C and 75-79% RH) was found excellent for drying of spikes and florets in orchid species and hybrids.

### **Project-IV: Improvement of knowledge and skill of stakeholders for improving production of orchids**

In 2017-18, 14 nos. and 2018-19, 9 no.s of training imparted to 227 students, 153 farmers and 160 officers on various aspects of horticultural crops.

ICAR Sponsored Training Under Pt. Deen Dayal Upadhyaya Unnat Krishi Siksha Yojna on natural farming or cow based farming was organised by ICAR NRC for Orchids, Pakyong Sikkim at Sikkim Kalyan Ashram, Ranipool from 13/03/2018 to 17/03/2018 with 30 farmers of different districts of Sikkim.

Under TSP, Capacity building training on Orchids' was conducted at Ukhrul, Manipur jointly by ICAR-NRC on Orchids, Sikkim and Krishi Vigyan Kendra, Ukhrul on 18/07/17. An Exposure Visit of 30 farmers from Sombaria, West Sikkim for Orchid Cultivation was organized at this institute on 28<sup>th</sup> March, 2019.

Five FLD's on cultivation of Paphiopedilum was conducted at Kalimpong, West Bengal; Yangang, South Sikkim; Sombaria, West Sikkim; Hee-Gyathang, North Sikkim & Karthok, East Sikkim.

Under HRD program, two scientific staff, three administrative staff and 5 technical staff of this institute were deployed for various training programs.

ICAR-NRC for Orchids in collaboration with Government of Sikkim, Central Institute of Horticulture, Nagaland, North East Council, NABARD, Gangtok and Indian Society of Ornamental Horticulture (ISOH), New Delhi organized National Conference on **Floriculture for Rural and Urban Prosperity in the Scenario of Climate Change**. The National Event was held at CAE & PHT (CAU), Ranipool, Sikkim on 16<sup>th</sup> to 18<sup>th</sup> February, 2018 where More than 200 Young researchers, academicians, policy makers, entrepreneurs and faculties from across the research institutes and educational organizations of North East India and the other parts of the country participated.

A Workshop on "Biodiversity and Sustainable Agriculture for Doubling Farmers Income in Sikkim" was organized on 25 Feb 2019 at ICAR-NRCO with Various centre Govt. Organisations viz., ICAR- NRCO, NOFRI, Sikkim University, CAEPHT, IBSD, GB Pant Institute, AYUSH, IIFSR etc.

Exhibition on "Biodiversity Utilization for Ecotourism as an Enterprise" dated 25-26 Feb 2019 which was organized at ICAR-NRCO. There were 18 stalls displayed by the farmers, KVK and other govt. institutions. Around 306 species of orchids flower were displayed. Among all 5 farmers were adjudged best and awarded.

Under Mera Gaon Mera Gaurav program, 143 agricultural and other related activities conducted in three adopted villages of East Sikkim in 2017-18 and during 2018-19, a new village, Khop of South Sikkim was adopted for organic farming.

Under Swachh Bharat Abhiyan, Sapath Taking Ceremony, shramdan diwas, Sewa diwas, essay, rhymes, poems, and painting competition and organic compost management, sanitation and water quality was organized on the eve of Swachhta Hi Sewa (15<sup>th</sup> Sept., 2017 to 2<sup>nd</sup> October, 2017, 15.09.18 to 02.10.18) and Swachhta Pakhawada (16-31<sup>st</sup> May, 2017 and 16.12.18 to 31.12.18) in office premises and public places.

Important days like Republic Day on 26<sup>th</sup> January, Independence Day on 15<sup>th</sup> August, Foundation Day on 5<sup>th</sup> October, Kisan Diwas on 23<sup>rd</sup> Dec, Agricultural Education Day on 3<sup>rd</sup> Dec., World Soil Day on 5<sup>th</sup> December, Agricultural Productivity week (16<sup>th</sup>-18<sup>th</sup> February), International Women Day, 8<sup>th</sup> March, Hindi Pakhawada (14-27<sup>th</sup> Sept) and Vigilance Awareness week (30<sup>th</sup> Oct-2<sup>nd</sup> November) were celebrated.

### **Tribal Sub-Plan Scheme:**

Off-Campus Training and Demonstration Programme on Orchid Cultivation under TSP Project was conducted at Hee-Gyathang, Dzongu, North Sikkim.

One Day Exposure Visit of Farmers (30) from Dzongu, North Sikkim to ICAR-National Research Centre for Orchids, Pakyong was organised.

One day training programme on orchid cultivation was organised at Rumbuk, Sombaria, West Sikkim. Forty farmers participated in the said training programme.

One day exposure visit of farmers from Sombaria, West Sikkim was organized at ICAR-NRC for Orchids, Pakyong under Tribal Sub-Plan project.

## **B. Externally Funded projects:**

### **1. Preparation for Plant Variety Protection and Conducting Test for Distinctness, Uniformity and Stability for Orchids :**

Database of 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 guidelines developed with 61 morphological descriptors.

### **2. Himalayan Research Fellowship scheme under National Mission for Himalayan States ( Funded by Ministry of Environment, Forests and Climate Change)**

Distribution and conservation status of an endemic and threatened orchid of Sikkim *Cymbidium whiteae* King & Pantl. was studied. It was observed that *C. whiteae* grows in undisturbed areas of Dzongu. Tracking the whole area revealed that there are 17 locations of its occurrence in Dzongu. Total population of mature plants does not exceed 48.

The list of RET species of orchids in Sikkim was prepared using primary and secondary data sources. 95 species of orchids fall under this group.

GC-MS analysis of Methanol extract of native *Dendrobium nobile* revealed the presence of 16 compounds. Out of these, 6 compounds possess many biological properties. Longifolene possess antifungal, antibacterial and antioxidant properties, 1-Heptatriacotanol has anti-hypercholesterolemic and anti-microbial effect. Whereas Z,Z-6,28-Heptatriactontadien-2-One possesses the vasodilatory effect and most importantly Dendroban-12-One has antiviral activity against influenza A viruses, anticancer (Lungs cancer treatment), analgesic, antipyretic action and hyperglycemia.

Designed and developed a new web-enabled home page for orchids and floral resource database of Eastern Sikkim Himalayas which provide complete information about orchid species of Sikkim Himalayas. Web-enabled database provides information of 250 orchids species and 100 RET species.

### **3. Inventorization of gamma radiation irradiation technology for Orchid varietal improvement**

Hardening gamma radiated 'Emma White' *in-vitro* plants developed and few samples were analyzed for High Throughput analysis. Approx. 120 *in-vitro* plants of 'Emma White' were sent for semi-hardening and developed putative mutant plants developed from 10 Gy and 20 Gy gamma levels. Sub-culturing of PBSx-17-01 (RGA) & developed plantlet with roots for putative mutant *Zygopetalum*. Inducted *V. coerulea* seed culture (PBS-16-51, PBS-16-61, PBS-16-62) with gamma irradiation and Bamboo orchid at globule stage were gamma radiated. Sub-cultured *in-vitro* material of *Zygopetalum* irradiated. Repotted *Dendrobium* mutant plants (10, 20, 40 Gy; 50 nos.) and leaf sampling and semi-hardened *Zygopetalum* mutant plantlets (10 Gy; 26 nos.).

### **4. Life cycle cryobiotechnology of orchids for bioresources conservation and sustainable development**

The study was undertaken to optimize pollen age, develop procedure for determination of *A. graminifolia* pollen viability, and to define the conditions for short term pollen storage for cross-pollination and hybridization. The study showed that pollen collected on third day of anthesis had highest germination and pollen tube length. The optimum sucrose concentration for germination of *A. graminifolia* pollen was 6 per cent. The pollens of *A. graminifolia* are desiccation tolerant and recorded the highest germination percentage and longest pollen tube length when the pollens were rehydrated at 90 per cent RH for two days. Dehydrated pollens could be stored in viable condition for 15 days at room

temperature but storing pollens at low temperature ( $4^{\circ}\text{C}$  or  $-80^{\circ}\text{C}$ ) enhances longevity. Storing pollens at  $-80^{\circ}\text{C}$  was found better than  $4^{\circ}\text{C}$ .

We investigated the pollen germination and pollen tube growth of 23 species belonging to Dendrobieae (5), Arethuseae (3), Vandaeae (3), Epidendroieae (3), Collabieae (1), Malaxideae (1), Podochileae (2), Cymbidieae (4) and Cymbidium hybrid on Brewbacker and Kwack's, 1963 medium. The pollens were excised from the fresh flowers with the help of toothpicks and cultured on freshly prepared media in Petri plates and incubated at  $22^{\circ}\text{C}$ . The germination and pollen tube length was assessed after 24 h of cultured. One way ANOVA was used for data analysis with Statistical software and the means were separated by Duncan's Multiple Test Range at 95 % Confidence Interval. The germination per cent and pollen tube growth varied from 31.55-89.62 per cent and 38.04-240.17  $\mu\text{m}$ , respectively. The lowest germination per cent was recorded in *Dendrobium longicornu* Lindl. (31.55%) whereas it was the highest in *Epidendrum xanthinum* Lindl. (89.62). The lengthiest pollen tube length was observed in *Calanthe masuca* D. Don (240.17  $\mu\text{m}$ ) but the shortest was in *Phalaenopsis deliciosum* Rchb. f. (38.04  $\mu\text{m}$ ). No correlation with germination percentage or pollen tube growth was found among the tribes.



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