POST HARVEST TECHNOLOGY IN ORCHIDS






L.C. De, P. Deb, Geetamani Chhetri
R.P. Medhi and H. Pokhrel

National Research Centre for Orchids
(Indian Council of Agricultural Research)
Pakyong – 737 106,

POST-HARVEST TECHNOLOGY IN ORCHIDS

L.C. De
P. Deb
Geetamani Chhetri
R.P. Medhi
H. Pokhrel

National Research Centre for Orchids
(Indian Council of Agricultural Research)
Pakyong – 737 106,
Sikkim, India

Post-harvest Technology in Orchids

National Research Centre for Orchids
Pakyong-737106, Sikkim

Compiled and Edited by

L.C. De

Published by

L.C. De and R.P. Medhi
National Research Centre for Orchids
Pakyong-737106, Sikkim

Cover Photographs

Front: Glimpses of Post-harvest techniques

Back: Post harvest evaluation of *Vanda* hybrids

Printed
December, 2013

PREFACE

Orchids account for a large share of global floriculture trade and are estimated around 10% of international fresh cut flower trade. They have taken a significant position in cut flower industry due to its attractiveness, diversity in forms, shape and colour, high productivity, right season of bloom, easy in packing, long keeping quality and transportation. Post-harvest life of orchid cut flowers is influenced by pre-harvest factors like varietal or species differences, light intensity, sugar level of flowers, temperature and water loss; harvest factors including time and stage of harvest and post-harvest factors viz. ethylene production, pre-cooling, pulsing, use of preservatives, packaging and storage.

The hybrids of *Dendrobium*, *Vanda* and *Mokara* remain perfect from 7 days to 30 days. The flowers of *Cattleya* and *Phalaenopsis* remain fresh for 1 to 4 weeks whereas *Aranda l*asts for 18 to 28 days. Higher sugar levels of flowers improve longevity of cut flowers. The optimum harvesting stage of commercial orchids is fully open and mature flowers. In *Cymbidium* hybrids harvest at two buds opened stage had maximum vase life (66.8 days). Ethylene is the main factor responsible for early senescence.

The present technical publication *'Post-harvest Technology in Orchids'* covers the wide aspects of post-harvest management starting international scenario of orchid cut flowers, species and hybrids for cut flowers, physiology of cut flowers, pre-harvest, harvest and post-harvest factors, physical and chemical treatments for increasing longevity and grading, packaging,

storage and transport of cut flowers.

I hope that it will be a useful handy reference technical bulletin for amateur and professional orchid growers, small and big orchid farmers, orchid entrepreneurs, florist shops, exporters and students.

(Lakshman Chandra De)

Contents

l.	Introduction	1
2.	Orchids in international cut flower trade	
3.	Species and hybrids for cut flowers	
4.	Physiology of cut flowers	
5.	Pre-harvest factors	
6.	Harvest factors	
7.	Post-harvest factors	
8.	Physical treatments	
9.	Chemical treatments	
10.	Grading in orchids	
11.	Packaging in orchids	
12.	Storage of cut flowers	
13.	Transport	
14.	References	

Introduction

Orchids comprise the largest family of flowering plants with 25,000 to 35000 species belonging to 600-800 genera. They are prized for their incredible diversity in the size, shape and colour and attractiveness of their flowers and high keeping qualities even upto 10 weeks. Most of the orchids have originated from tropical humid forests of Central and South America, India, Sri Lanka, Burma, South China, Thailand, Malayasia, Philippines, New Guinea and Australia. Brazilian Cattleya, Mexican Laelia and Indian Cymbidium Vanda and Dendrobium have played a major role in developing present day beautiful hybrid orchids which numbers more than 200000. In the international trade, among top ten cut flowers, orchids rank the sixth position and among orchids Cymbidium ranks the first position and in floricultural crops it accounts for 3% of the total cut flower production.

In India, orchid comprises 158 genera and 1331 species which grow upto an elevation of 5000m. Indian terrestrials are located in humus rich moist earth under tree shades in North Western India. Western Ghats harbour the small flowered orchids. Epiphytic orchids are common in North eastern India which grow upto an elevation of 2000m from sea level. Indian orchid species having high ornamental values are *Aerides multiflorum, Aerides odoratum, Arundina graminifolia, Arachnis, Bulbophyllum, Calanthe masuca, Coelogyne elata, Coelogyne flavida, C. corymbosa; Cymbidium aloifolium, C. lowianum, C. devonianum, C. hookerianum, C. lancifolium,; Dendrobium aphyllum, D. nobile, D. farmeri, D. chrysanthum, D. densiflorum, D. moschatum, D. fimbriatum, D. jenkinsii;*

Paphiopedilum venustum, P. spicerianum, P. hirsutissimum, P. insigne, Phaius wallichii, Pleione praecox, Renanthera imschootiana, Rhyncostylis retusa, Thunia alba, Vanda cristata, Vanda coerulea and *Vanda coerulescens* (Singh, 1990).

In India, some of native genera like *Cymbidium, Paphiopedilum*, *Vanda, Arachnis* and *Dendrobium* are cultivated on a large scale for cut flower production. The Cymbidium is mainly grown in NEH Region, Sikkim, Darjeeling hills and Arunachal Pradesh. Tropical orchids are cultivated in Kerala and some parts of Tamil Nadu. We should prefer those species which flower during winter and spring months to export flowers to temperate regions from December to May. The orchids have taken a significant position in cut flower industry due to its attractiveness, long shelf life, high productivity, right season of bloom, easy in packing and transportation.

Orchids in international cut flower trade

Orchid accounts for a large share of global floriculture trade both as cut flowers and as potted plants and is estimated around 10% of international fresh cut flower trade. The value of fresh cut orchids and buds trade during 2007-2012 with the average trade value was US $ 483 million. In 2012, there are more than 40 exporting orchid countries and 60 importing orchid countries around the world, and the total size of the global trade is US $ 504 million (Table 1).

Table 1. Value of fresh cut orchids and buds global trade (2007-2012) (Unit : Million US$)

Year	2007	2008	2009	2010	2011	2012
Import	233,734,023	252,647,645	232,568,129	251,445,523	265,702,077	267,196,847
Export	230,470,421	238,702,950	217,781,745	227,389,789	244,996,271	237,543,797
Total	464,204,444	491,350,595	450,349,874	478,835,312	510,698,348	504,740,644

Source: Department of Foreign Trade, Thailand (2013)

The Netherlands is the top most orchid exporting country (39. 67%) followed by Thailand (28.41%), Taiwan (10%), Singapore (10%) and New Zealand (6%), respectively. Importing countries are mainly Japan (30%), UK (12%), Italy (10%), France (7%) and the USA (6%), respectively. The total orchid cut flower trade of the world mostly consists of 85% *Dendrobium* species and 15% *Phalaenopsis* and *Cymbidium* species and Asia is the main source of orchid to enter the world.

Major markets in Asia are occupied by Japan and Singapore. Total imports of orchids by Japan accounted for US$ 57.4 mn in 2008 making it the largest importer of the orchids in the world. The main sources of imports include Thailand, Taiwan, New Zealand and Malayasia together accounting for as much as 96.5% of the total imports of the orchids by Japan in 2008. Imports by Singapore of fresh orchids amounted at US $ 6.5mn in 2007 with Malayasia, Thailand and Taiwan being the main sources of imports for the country. Imports of fresh orchids by Singapore from India was only US$ 1379.3 representing a share of 0.02% of the country's total imports of the product in 2007 (Table 2). This clearly indicates that there is vast scope of increasing India's exports to Singapore particularly considering the proximity of the country and Indias East Policy.

Table 2. Imports of orchids by Singapore (2007)

Country	Value (US$)	Share (%)
Malayasia	5422069.0	83.03
Thailand	520699.7	7.97
Taiwan	307596.2	4.71
Mauritious	149655.2	2.29
Indonesia	117241.4	1.90
Netherlands	8275.9	0.13
New Zealand	2758.6	0.04
India	1379.3	0.02
China	699.7	0.01
Total imports	6530344.8	100.00

Source: International Enterprise Singapore

Species and hybrids for Cut flower

Orchid species like *Cymbidium iridoides, Paphiopedilum fairreanum, Papahiopedilum hirsutissimum, Paphiopedilum insigne, Paphiopedilum spicerianum, Paphiopedilum venustum, Paphiopedilum villosum, Renanthera imschootiana, Vanda coerulea, Vanda stangeana, Vanda tessellata* and *Zygopetalum intermedium* can be directly used as cut flowers.

Among hybrids, *Cymbidium, Dendrobium, Phalaenopsis, Odontoglossum, Oncidium, Cattleya, Paphiopedilum, Vanda, Aeridovanda, Aranda, Mokara, Arachnis, Vascostylis, Renanthera, Rhyncicentrum, Rhyncovanda* etc. are important as cut flowers.

A good quality cut flower of an orchid should have the following characteristics (Sarkar et al., 2009):

- Minimum eight standard blooms per stem
- Flowers must be cleaned, evenly coloured and free from physiological disorders

- Stem must have flowers evenly arranged and around the stem.
- Two third of the stem should be covered with the flowers.
- Flowers must have a firm texture and a luminescent sheen
- Stems must be firm when held up
- The minimum base diameter of the stem should be of 10mm

Important varieties and hybrids under different genera of orchids for cut flower purposes are listed in Table 3 (Bhattacharjee and De, 2005).

Table 3. Important varieties and hybrids under different genera of orchids

Sl No.	Genera	Hybrids/Varieties
1	*Aeridovanda*	'Doctor Poyck', 'Vieng Ping', 'Bensiri', 'Noreen', 'Early Bird', 'Shiv Sidhu', 'New Dawn', 'Harrison Luke Somsri Sunlight'
2	*Aranda*	'City of Singapore', 'Hilda Galistan', 'Urmila Nandey', 'Christine', 'Thailand Sunspot', 'Millenium Dawn', 'Broga Giant', 'Salaya Red', 'Propine White', 'Propin Spot', 'Lueng Cholburi', 'Ishbel Manisaki', 'Baytown', 'Chao Praya Blue', Chao Praya Dot Com', 'Chao Praya Beauty', ' Ethan Pride', 'Taksari Chandrabir'
3	*Arachnis*	'Ishabel', 'Maggie Oei'

4	*Ascocenda*	‘Apinantat Red Berry', 'Pralor Tuyen', 'Pak-Kred', 'Bangkok', 'Surin', 'Karnada', 'Crownfox', 'Sundancer', 'Laksi', 'Red Ruby',Guo Chia Long 'Spotty', 'Fuchs Angel Frost', 'Carol Belk', 'Renuka Angle', 'Joyce Bevins', 'Adisak Blue', 'Renu Gold', 'Tipi Blue Boy', 'Bobs Fortune', 'Rubychai', Shah Rukh Khan', 'Yang Sophia Firuz', 'Abdul Ghani Othman', 'Chunika', 'Fuch's Star'
5	*Cattleya* and allied	‘Lovely Bangkok', 'Admiration', 'Bob Belts', 'General Patton', 'Joyce Hannington', 'Little Angel', 'Margaret Stewart', 'Nillie Roberts', 'Pearl Harbour', 'Primma Donna', 'Queen Sirkhit', 'Diamond Crown', 'Secret Love', Ladda Belle 'Pink Pearl', Maikai, Pastoral, Robert, Prism Palette 'Tricolour Magic', 'Chinese Beauty Orchid Queen', 'Ahmad Seikhi', 'Purple Cascade Fragrant B', 'Hsinging Catherine'
6	*Cymbidium*	‘Levis Duke Bella Vista', 'Madrid Forest King', 'Sparkle Late Green', 'Angelica December Gold', 'Sleeping Nymph', 'Pine Clash Moon Venus', 'Soul Hunt', 'Dr. H. C. Aurora', 'Susan Highes', 'Tia Gaig Suther Land', 'Miss Sanders', 'Amesbury', 'Kenny Wine', 'Red Star', 'Red Princess', 'Show Gir'l , Jungfrau 'Snow Queen', Jungfrau 'Dos Pueblos', Lilian Stewart 'Coronation', Lilian Stewart 'Party Dress', Orkney 'Pink Heather', Ensikhan 'Alpha Orient', 'Winter Beach Sea Green', 'Fire Storm Ruby'
7	*Dendrobium*	‘Emma White', 'Thongchai Gold', 'Julie', 'Erika', 'Sonia-17', 'Sonia-28', 'Kasem White', 'Madam Pompadour', 'Bangkok Blue', 'Ann', 'Gold Twist', 'Candy Stripe Pink', 'Genting Blue', 'Bengal Beauty', 'Sakura Pink', 'Candy Stripe', 'Burana Charming', 'Blue Fairy', 'Channel', 'Nette White', 'Dang Saard'
8	*Mokara*	Walter Oumae 'Seksan', Thailand, Sayan, Walter Oumae 'Royal Sapphire', Susan 'Orange', Walter Oumae 'Calypso' , 'Eng Ling', 'Madame Panne', 'Mak Chin On', 'Bangok Gold', Bibi, 'Chao Praya Gold', 'Chark Kuan Orange', 'Chark Kuan Pink', 'Chark Kuan Rose', 'Chark Kuan Super', 'Dinah Shore', 'Kelvin Red', 'Kelvin Orange', 'Luenberger Gold', 'Margaret Thatche'r, 'Pink Star', 'Sayan', 'Sayang Pink', 'Walter Oumae, 'White, 'Jiti', 'Happy Beauty', 'Salaya Gold'

9	*Odontoglossum*	‘Carroll', 'Ismene', 'Palnina', 'Italian Job', 'Joyce Stewart', 'Pepe Gerald', 'Purple Rain', 'Katherine Jenkins', 'Roy Wittwer', 'Laguna Blanca', 'Precocious', 'Snow Fall', 'Pesky', 'Queen of Mars', 'Stam Point', 'Holiday Yellow', 'Ronald Norman', 'Bridget Ring Lawless', 'John Hanry Hanson', 'Point Pesky'
10	*Oncidium*	‘Aloha Iwanga Dogasima', 'Goldiana', 'Gower Ramsey', 'Golden Shower', 'Sum Lai Who Jungle Queen', 'Taka H & R', 'Sharry Baby Sweet Fragrance AM/AOS', 'Golden Glow', 'Popki Red', 'Irine Gleason Red', 'Vision Brownish Red', 'Catherine Wilson x New Calidonia' 'Brownish Red', 'Robson Orchid Glad'
11	*Paphiopedilum*	'Niveum', 'Concolor', *P. rothschildianum* (3 to 5 flowers), *P. sanderianum* (3 to 5 flowers), 'Prince Edward of York', 'Michel Koopwitz', 'Saint Swithin', 'Mount Toro', 'Sorcerers Apprentice', 'Grande', 'Don Wimber', 'Elizabeth March', 'Hanne Popow', 'Jason Fischer', 'Living Fire'.
12	*Phalaenopsis*	‘Taisuco Crane', 'Taisuco Kochdian', 'Cygnus', 'Yukimai', 'Sogo Musadian', 'White Dream', 'Florida Snow', 'Nobby's Pink Lady', 'Minho Valentine', 'Minho King Beauty', 'New Cinderella', 'Taisuco Firebird', 'Sogo Smith', 'Carol Campbel'l, 'Emil Giles', 'Brother Lawrence', 'Taipei Gold', 'Golden Bells', 'Sogo Managers', 'Brother Passat', 'Strawberry', 'Cassandra', 'Vilind', 'Carmelas Pixie', 'Zuma's Pixie', 'Timothy Christopher', 'Be Tris', 'Quevedo', 'Manchester', 'Detroit'
13	*Renanthera*	‘Brookie Chandler', 'Manila T-Orchids', 'Kilauea', 'Mok Yark-Seng', 'Poipu', 'Tom Thumb', 'Red Leopard', 'Scarlet Belle', 'Chanachae', 'Serdang', 'Brady Crocker', '20th WOC Singapore-2011', 'Bart Motes'
14	*Rhynchovanda*	‘Wilton Hill', 'Jammie Harper', 'Apichart', 'Noo Noi', 'Peter Draper', ' Brighton's Albino', 'Prairie Lady'

15	*Vanda*	'Annette Jones', 'Antonio Real', 'Golamcos Blue Magic', 'Fuch's Charmer', 'Jimmy Millers RF Orchids', 'Keree Delight', 'Memoria Lyle Swanson', 'Motes Indigo x Merrillii', 'Motes Honeybun', 'Motes Primerose', 'Miss Joaquim', 'Motes Indigo Blue', 'VTMA –Red', Pink, White, Vasco, 'Johnny Miller', 'Veerawan', 'Roberts Delight', 'Rasriprai', 'Pat Delight', 'Pakchong Blue', 'Mimi Plammer', 'Manuvade', 'Lumpini Red', 'Kultana Gold x Thongchai Gold, 'Fuchs Delight', 'Charles Goodfellow', 'Pine River', 'Adisak', 'Doctor Anek', 'John Club', 'Bill Sutton', 'Ellen Noa', 'Emily Notley', 'Evening Glow', 'Honomu', 'Honolulu', 'Hilo Blue'
16	*Vascostylis*	'Paragon Joy x Kasems Delight', 'Precious', 'Veeraphool', 'Crown Fox 'Red Yen', 'Aroon Fairy', 'Viboon Velvet'

Physiology of cut flowers

Vase life or longevity of a cut flower is determined on the basis of attributes like diameter and length of florets, opening of flowers, changes in fresh weight, diameter or length of stem or pedicel, senescence pattern, colour of petals, total longevity and foliage burning (De and Bhattacharjee, 2000). In general, cut flowers complete their life cycle in two distinct phases, (i) bud swelling to bud opening and (ii) maturation, senescence and wilting. Flower bud development to swelling involves growth or change in orientation of petals or subtending tissues and may also require abscission of protective structure (Reid and Evans, 1986). When an inflorescence is cut from the plant, a number of physiological processes are affected which include the supply of water, depletion of stored substrates and production of ethylene. The most common symptom of flower senescence is wilting i.e. loss of turgor pressure of the cells due to failure of

water uptake(Eze *et al*., 1986). The failure of water uptake as a result of stem blockage may be due to air blockage, microbial growth or physiological plugging. Otherwise senescence is accompanied by a dramatic increase in the leakage of several molecules such as aminoacids, sugars, inorganic ions, anthocyanins and activity of petal ACC synthetase and disintegration of tonoplast and mitochondria (Bieleski and Reid, 1992). Two major metabolic and biochemical changes occurring in senescing petals are increase in respiration and hydrolysis of cell components. Vase life of cut flowers depends upon the rate of transpiration through open stomata of leaves and solutes present in vase water (Van Doorn, 1997). Experimental evidences show that cuticular transpiration plays an important role in the water loss of orchid flowers. The transpiration rate of tropical orchid flowers ranges from 0.15 to 0.17 mg water $cm^{-2}h^{-1}$ or 0.4 to 1.9 g of water per inflorescence per day depending upon the total floral surface area. Halevy (1986) classified flowers climacteric or non-climacteric based on presence or absence of an increased rate of ethylene production associated with petal senescence. In most vegetative tissues, the overall synthesis of ethylene is the conversion of SAM (S-adenosylmethionine) to ACC (1-aminocyclopropane-1-carboxylic acid). Water loss in orchid flowers is considerably lower than that reported for roses and carnation due to the absence of supporting leaves in orchid sprays. It has been found that carbohydrate levels in mature flowers are lower than the levels in the tight buds. Moreover, the level of carbohydrates in the flower decrease markedly with time after harvest as reflected in the decreasing rate of respiration. This problem can be overcome by the exogenous supply of sucrose.

In orchid flowers, ethylene production is an autocatalytic process and ethylene level of 1 ppm causes premature fading of flowers (Lindner, 1946, Fischer, 1950). The premature fading of petals may be induced by pollination and by removing pollinia (Akamine and Goo, 1981). In *Cymbidium*, fading of flowers due to pollination is characterized by the formation of anthocyanin in both column and lip, swelling of column, stigmatic closure and wilting of sepals and petals. The anthocyanin level begins to decrease with age (Arditti et al., 1971, 1973). Developmental processes associated with post-pollination events include senescence of perianth, pigmentation changes, ovary maturation, ovule differentiation and female gametophyte development (O'Neil, 1997). Flowers of *Dendrobium* 'Pompadour' develop premature petal and sepal senescence following pollination. Pollination induces an ethylene climacteric accompanied by a small respiratory climacteric, epinasty and increased flower and inflorescence fresh weight and water uptake (Ketsa and Rugkong, 1999). The orchid flowers harvested in the tight bud stage had a lower rate of respiration than open flowers. The respiration rates continuously declined during the post harvest period until the flower faded (Sheehan, 1954).

J, A. Teixeira da Silva (2003) reviewed the some aspects of changes and programmed cell death occurred in petal senescence.

Cellular structural changes:

- Membrane rupturing and increase in cytoplasm debris and loss of permeability and fluidity due to oxidation.
- Invagination of tonoplast and endocytosis of

cytoplasmic contents and disappearance of cortical microtubules.

- Reduction in cytoplasm volume, cessation of cytoplasmic streaming and change in proton flux across plasma membrane.
- Degeneration and collapse of organelles and increase in number of peroxisomes.

Biochemical and structural molecular changes:

- Increase in proteinases and nucleases; upregulation of phospholipases, acyl hydrolases and lipoxygenase neutral lipids; sterol/phospholipid ratio; lipid peroxidation; reactive oxygen species; water leakage and cell wall cross linking.
- Decrease in phospholipids, chlorophylls, proteins, thiol groups, nucleic acids and RNA.

Post harvest life of orchid cut flowers is influenced by pre-harvest factor like varietal differences, light intensity, sugar level of flowers, temperature, nutrition and water loss;

harvest factors like time, method and stage of harvest and post-harvest factors including ethylene production, pre-cooling, water quality, pulsing, use of preservatives, bud opening, packaging and storage.

Pre-harvest factors

It is estimated that a third of the post-harvest life of flowers is programmed by pre-harvest handling.

Varietal differences: Varietal differences in cut flowers have

been reported due to variations in water uptake, fresh weight, flower diameter, stem lignification, vase life and senescence behaviour. Among different species, the vase life ranges from *Lycaste* spp. (9 days), *Phaius tankervillaea* (24 days**),** *Zygopetalum intermedium* (18 days), *Aerides multiflorum, A. odoratum, Cymbidium iridioides, Dendrobium nobile* and *Renanthera imschootiana* (28-56 days), *Paphiopedilum hirsutissimum, P. wardianum* (56 days) and *Vanda coerulea, Vanda teres* (28-42 days) (Table 4). Out of nine hybrids of *Cymbidium,* 'PCMV', 'Red Princess', 'White Beauty', 'H.C. Aurora', 'Sun Gold', 'Ensikhan, Florance', 'Valley Legend' and 'Platinum Gold', evaluated at NRCO, Pakyong, Sikkim during 2008-2009, 'Florance' had the highest vase life of 54 days followed by 'White Beauty' (53 days) and lowest in 'Platinum Gold' (22 days) (Fig 1). The present day orchid hybrids of *Dendrobium*, *Vanda* and *Mokara* remain perfect for 7 to 30 days. The flowers of *Cattleya* and *Phalaenopsis* remain fresh for 1 to 4 weeks whereas *Aranda* lasts for 18 to 28 days.

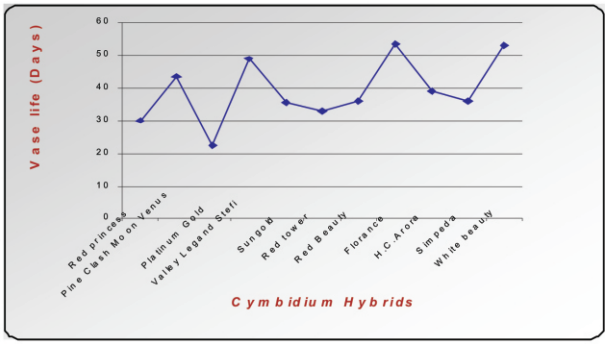

Fig 1 Evaluation of *Cymbidium* hybrids for their vase life

Cymbidium, ‘ Fire Storm Ruby’ for cut flower

Dendrobium, ‘Dang Saard’ for cut flower

Vanda, ‘Roberts Delight Blue’ for cut flower

Oncidium, ‘Sharry Baby Sweet Fragrance’ for cut flower

Blc, ‘Hsinging Catherine’ for cut flower

Phalaenopsis, ‘Strawberry’for cut flower

Table 4: Vase life of orchids due to species and varietal differences

Name of Species/hybrids	**Vase life (days)**
Aerides odoratum, Aerides multiflorum, Cymbidium iridioides, Dendrobium nobile, Renanthera imschootiana	28-56 days
Paphiopedilum hirtussimum, P. wardianum	56 days
Phaius tankervillae	28-42 days
Vanda coerulea, Vanda teres, Zygopetalum intermedium	14-21 days
Cymbidium hybrids	20-55 days
Dendrobium hybrids	14-21 days
Vanda, Mokara hybrids	14-30 days
Cattleya hybrids	10- 20 days
Phalaenopsis hybrids	25-30 days
Aranda	18-28 days

Barendse (1979) reported that there were great differences in cut flowers keeping quality among the 12 Cymbidium cultivars.

Light intensity: Light determines the carbohydrate levels before harvest which in turn influence the keeping quality. Flowers containing relatively higher amounts of carbohydrates especially mobile sugars last longer in the vase. Plants having few leaves, or leatherlike leaves (like most cattleyas and oncidiums), require a high-light environment. If the leaves are soft and limp (like some phalaenopsis and most paphiopedilum), the plants are probably very light-sensitive, and should not be placed in a sunny south-facing window. Most orchids prefer indirect or filtered light and 50% shading.

- **Low light orchids (1200-2000 f.c.):** *Phalaenopsis, Calanthe*
- **Medium light orchids (2000-3000 f.c.):** *Cattleya, Laelia, Brassovola*
- **High light orchids (3000 f. c. or more):** *Cymbidium*, Vandaceous groups.

Temperature: Generally, higher temperature results in higher level of respiration. Cooling is essential to reduce other metabolic changes such as enzymatic activity and to slow the maturation of flowers. Cooling prior to packaging and transport reduces ethylene production and improve longevity. Based on temperature requirements, orchids are classified into three groups:

- **Warm orchids** (*Aerides, Vanda, Rhyncostylis & Dendrobium*): 32.2°C day temperature and 15.5°C night temperature

- **Intermediate orchids** (*Cattleya, Laelia, Oncidium, Miltonia*): 26.6°C day temperature and 12.8°C night temperature
- **Cool orchids** (*Cymbidium, Odontoglossum, Cypripedium*): 24°C day temperature and 10°C night temperature

Humidity: As a thumb rule, orchids require 80-85% humidity for satisfactory growth. Monopodial orchids require higher humidity than sympodial ones. Many sympodial orchids like *Cattleya, Oncidium* and *Dendrobium* form pseudobulbs, which are swollen shoots that store water and nutrients to help the plant survive periods during prolonged drought. Insufficient humidity during summer may lead to shriveling of pseudobulb. Excessive humidity during winter may lead to spotting of flowers usually caused by *Botrytis.* Most orchids prefer water of pH 5.0-6.5. Watering with lower or higher pH or with high levels of dissolved minerals can hamper nutrient uptake. Rain water is the best. Regular watering is essential under high sunlight and high temperature conditions. Sprinkling or misting may be practiced during hot summer. Watering should be reduced in late summer and keep the plants barely moist during winter. Watering the plants with thick leaved orchids having CAM activities such as *Aranda* and *Dendrobium* in the late afternoon prior to harvesting season improved the keeping quality.

Nutrition: Orchids are light feeders and they require nitrogen from beginning to two-third of their life cycle. During rest period, they do not need any fertilizers. During flower initiation and inflorescence development plant are fed with less nitrogen,

more phosphorus and potassium. During the blooming time, a small level of nitrogen and phosphorus and high levels of potassium are maintained. In orchids, foliar feeding is found to be ideal. Frequent application of fertilizers in low concentrations is the best way of feeding orchids. A concentration of 0.2 to 0.3 % of 30:10:10 (N: P: K) at vegetative stage and 10:20:20 (N: P: K) at blooming stage are applied for quality flower production. Sometimes, fresh coconut water, diluted cow urine, leaf manures and fish meal emulsions are also useful as foliar spray.

Harvest factors

Time of Harvest: Flowers should be harvested in mild temperature because high temperature causes rapid respiration rates and excessive water loss. Flowers should be harvested in the early morning or in the evening. In the early morning, flowers remain turgid due to transpiration at night and higher sugar levels. Similarly, flowering stems retain a higher amount of stored carbohydrates if cut in the afternoon and retains more vase life.

Method of Harvest: Sharp tools or secateurs should always be used to detach the stem of flowers from the mother plant. The angle of the cut should be slanting and the stem should not be crushed during harvesting, especially hard wood stems. The spikes should be dipped in a bucket containing water immediately after harvest.

Stage of Harvest: The optimum harvesting stage of the commercial orchids is fully open and mature flowers. The stage of harvest, spike length and number of flowers of some

commercial orchids are given in Table 5.

Table 5**: Stage of harvest, spike length and no of flowers of some commercial orchids**

Orchid hybrid	Commercial stage of harvest	Spike length (cm)	No of Flowers
Aranda	50% bloom	45-60 cm	8-10
Cattleya	24 days before bud open	25-40 cm	1 or more
Cymbidium	75% bloom or two buds open stage	60-90 cm	10-15
Dendrobium	All flowers except top bud	40-60 cm	8-12
Oncidium	80 % bloom	60 cm	Many
Paphiopedilum	3 to 4 days after opening of flowers	25-40 cm	1-5
Phalaenopsis	Fully open flowers	40-60 cm	8-10
Vanda	Fully open flowers	50-75 cm	8-15

Out of three *Cymbidium* hybrids namely 'Pine Clash Moon Venus', 'Valley Legend Stefi', 'Pure Inca Gold' flower spikes harvested at four stages like fully open, 75% open, 50% open and 25% open to standardize the stage of harvesting, vase life was noticed highest in 75 % open stage. Maximum vase life of 59 days was recorded in 'Pine Clash Moon Venus' and followed by 48.83 days in 'Valley Legend Steff' and 53 days in 'Pure Inca Gold'.

Post Harvest Factors

Temperature: Opening of flower buds and rate of senescence accelerate at higher temperatures. At lower temperature, the respiration comes down and the flowers produce a lesser amount of ethylene. Temperature plays an important role for

flowers harvested at the immature stage for full expansion of buds and the flower buds are kept at temperatures as low as 0.5 to 4.0°C in *Cymbidium* and *Paphiopedilum*, 5-7°C in *Dendrobium* and 7-10 °C in *Cattleya*.

Light: Light is essential for long distance transport or prolonged storage of cut flowers. Similarly, high light intensity is essential for opening of tight bud cut flowers. Flowers like carnations can be stored in darkness for a longer period without affecting quality. Florists should maintain a light intensity of 2000-3000 lux for 12-24 hours in their shops for illuminations.

Humidity: Cut flowers should be kept at 90-95% relative humidity for maintaining turgidity. Flowers start showing wilting symptoms when they have lost 10-15% of their fresh weight. The rate of transpiration from leaves is reduced with the increase of high relative humidity.

Water Quality: Water quality is defined as pH and EC value, hardness contents of phytotoxic elements and microorganisms causing vascular occlusions affecting longevity of cut flowers. Saline water decreases the vase life of cut flowers. In case of cut gladiolus, the longevity of flowers decreases when the concentration of salts in the water reaches 700 ppm, whereas for cut roses, chrysanthemum and carnations, 200 ppm is harmful. The increase in concentration of salts over 200 ppm shortens vase life by half a day for each 100g per litre increase in salinity. Basic ions like $Ca^{++,}$ Mg^{++} present in hard water are less harmful to flowers than soft water containing sodium ions. Fluorine is very toxic to most of the cut flowers and causes injury to freesias, gladiolus and gerberas at 1 ppm, and chrysanthemums, roses, poinsettias and snapdragons at 5 ppm. Flowers like lilacs,

cymbidiums and daffodils are resistant to fluorine ions. Vase life increases in tap or well water passed through a de-ionizer. The importance of low pH of the holding solutions is well known for improving vase life. A holding solution of pH 3.0-5.0 is optimum for increasing vase life of cut flowers.

Ethylene: Ethylene plays an important role in the regulation and co-ordination of senescence in climacteric flowers. Production of this hormone is less and stable in floral buds and young flowers. A sharp increase in ethylene evolution is found during flower maturation, opening and senescence. Afterwards, ethylene production decreases and remains static. Basically, ethylene is first produced in the pistil and the evolved ethylene acts on the petals and induces expression of genes for ACC synthase, ACC oxidase and cysteine proteinases, resulting in the auto-catalytic ethylene production from the petals, in-rolling of petals and wilting of flowers (ten Have and Woltering, 1997). The gynoecium has been shown to produce a significant amount of ethylene before its production in the petals possibly induced by the factors like ABA or IAA suggesting its importance in controlling ethylene production in the flower during natural and pollination induced senescence, with emasculation hastening the release of ethylene (Shibuya et al., 2001). A wide range of flowers is affected by ethylene with showing of some typical symptoms such as sleepiness of carnation and kalanchoe petals, fading and in-rolling of the corolla of *Ipomoea*, fading and wilting of sepal tips in orchids and induction of anthocyanin formation in female reproductive parts and abscission of flowers and petals (Arditti, 1994). Orchid flowers are highly sensitive to ethylene. High level of ethylene production is due to herbivore damage, mechanical

injuries and pollination. De-capped and emasculated flowers produce more ethylene than untreated ones. Sometimes, forced unfolding of flower buds in orchids reduces vase life.

Diseases and insect pests: Fungi, bacteria and insects affect the quality of cut flowers by producing higher amounts of ethylene. Microbes accelerate flower senescence by the plugging of xylem vessels with pectin degraded products, by producing ethylene and toxic compounds. Among bacteria genera, *Alcaligenes, Pseudomonas, Enterobacter, Erwinia, Bacillus, Corynaebacteria, Aeromonas, Acetinobacter* and *Flavobacterium* are commonly found in vase water. Some fungal species *Botryris cinerea*, *Fusarium oxysporum*, *Mucor*, *Penicillium* spp, *Rhizopus*, *Aspergillus* spp*, Alternaria alternata* and *Acremonium strictum* are responsible for early senescence of flowers and wilting and decaying of potted plants (De and Bhattacharjee, 2000, 2002).

Treatments for improving longevity of cut orchid flowers

Physical treatments:

- **Pre-cooling:** It is the fast removal of field heat and is an important operation in post harvest handling and transport of cut flowers, wherever flowers are held dry pack. All flowers should be pre-cooled immediately after harvest by placing them in cold storage without packing or in open boxes until they reach the desired temperature (Bhattacharjee, 1997). It varies with the species and cultivars: Cattleya (7-10^{o}C), Cymbidium and Paphiopedilum (0.5 to 4^{o}C), Dendrobium (5-7^{o}C).

Precooling lowers respiration rate and decreases the break down of nutritional and other stored materials in the stems, leaves and petals; delays bud opening and flower senescence. It also prevents rapid water loss and decreases flower sensitivity to ethylene. Several pre-cooling techniques such as room cooling, forced air cooling, hyder-cooling, vacuum cooling and ice bar cooling etc. are available.

- **Vase life of cut flowers as affected by stem cut ends**: The resistance to water flow through stem segments increases predominantly in the lower most one to two centimeter of the cut stems. Re-cutting stems under water improves longevity due to elimination of air from the conducting vessels.

Chemical treatments

Conditioning: Conditioning or hardening is a simple process where flowers are kept standing loosely in a big container so that air can circulate around the stems. The purpose of the treatment is to restore the turgidity of cut flowers with water stress during storage and transport. Conditioning is achieved by treating the flowers with de-mineralized water supplemented with germicides and acidified with citric acid to pH 4.5 to 5.0 but with or without sugar. Hydration is improved when water is de-aerated or acidified or when a wetting agent like Tween 20 at the rate of 0.01 to 0.1 % is added. Flower stems should be placed in warm water or in a preservative solution in plastic jars at a depth of 2-4 cm and held at room temperature or in cold storage for several hours.

Impregnation: Sometimes, the cut ends of the flower stems are impregnated for a short time with chemicals. This treatment protects the blockage of the water vessel in the stem by microbial growth and stem decay. Impregnation of cut bases of flowers with high concentration (1000 ppm-1500 ppm) of silver nitrate, nickel chloride or cobalt chloride for 10-15 minutes improves the longevity of several flowers such as aster, gerbera, gladiolus, carnation, chrysanthemum, phalaenopsis and snapdragon. In *Cymbidium* 'Baltic Glaciers Mint Ice', highest longevity was recorded with $CoCl_2$ (1000ppm) for 15 minutes (46 days) followed by $CoCl_2$ (1500ppm) for 15 minutes (44days) over control (39 days).

Pulsing: The absorption of chemical solutions containing sugars and germicides through the lower cut bases of flower stems is known as pulsing. Pulsing may be used by growers, wholesalers or retail florists in order to enhance the cut flowers subsequent vase life in water. Pulsing is employed with higher concentrations of sugar, mainly sucrose, the percentage of which varies with species and cultivars. Other chemicals used in the pulsing treatments are STS, $AgNO_3$, HQ, MH, AOA, $CaCl_2$, $CoCl_2$, nickel sulphate, aluminium sulphate and benzyladenine. Pulsing is found to be of great value in prolonging life, promoting opening and improving the colour and petal size of petals through osmo-regulation. In *Cymbidium* hybrid 'Red Princess' pulsing with 5% sucrose increases vase life (56 days) followed by sucrose @ 8% (54.78 days). In *Cymbidium*, 'Baltic Glaciers Mint Ice' pulsing of flowers with 5 % sucrose followed by 150 ppm 8-HQS increased the vase life of flowers with pollina (49.33 & 46.33

days) and without pollinia (44.00 & 41.67 days), respectively. In *Aranda*, pulsing with 4mM STS for 10 minutes (Hew et. al, 1987) and in *Dendrobium* hybrid 'Pompadour' with 25ppm $AgNO_3$ + 135 $Na_2S_2O_3$, $5H_20$ for 30 minutes increases vase life of cut flowers (Hew and Yong, 2004). In *Oncidium* 'Goldiana' cut sprays pulsing with $AgNO_3$ for 30 minutes improves vase life (Ong and Lim, 1983). In *Phalaenopsis*, pulsing with 0.5mM STS for 24 hours blocks the deleterious effect of ethylene. In *Dendrobium* cv. 'Sonia' pulsing with 4% sucrose + 400 ppm HQ recorded the highest vase life of 21.33 days. Inflorescences pulsed with 6 % sucrose + 400 ppm HQ recorded the highest sugar content in the flowers (27.64%) (Jomy and Sabina, 2002).

Bud opening: It is a procedure of harvesting flowers at a stage earlier than normally considered as the cutting stage and then opening the buds off the plant. Such types of post harvest handling may be applied by growers or wholesalers. Bud opening of flowers increases longevity of cut flowers by reducing the sensitivity of flowers to extreme temperatures, low humidity and ethylene, saving space during shipment and extending the useful storage life. The sugar concentration used is lower than the concentration of pulsing and the optimum temperature is kept lower. In *Dendrobium* hybrid, 'Thongchai Gold' opened flowers had 29%, half opened flowers had 28.25 % and buds had 16.17% reducing sugars. In *Dendrobium* hybrids, HQS or $AgNO_3$ (50ppm) is effective for opening of tight bud cut flowers. Ketsa et al. (2001) reported that a preservative solution containing 225ppm HQS, 30ppm $AgNO_3$ and 4% glucose increased bud opening and the time to wilting of the open florets of *Dendrobium* Cv. 'Ceasar'. In *Cymbidium*

Cv. 'Ensikhan' 4% sucrose + 100 ppm acetyl salicylic acid or 4% sucrose + 100ppm $Al_2(SO_4)_3$ improved bud opening. In *Cymbidium* hyb. 'PCMV', sugar(4%) + salicylic acid (200 ppm) showed maximum per cent of flower opening (75%) and vase life (45 days) followed by sugar (4%) + $Al_2(SO_4)_3$(100 ppm) (57% & 44 days) and sugar (4%) + 8-HQS (200 ppm) (53.8% & 44 days) over control (bud drop and senescence on 27th days), respectively (Table 6). Highest content of carbohydrate (140mg/g) was estimated at bud stage in fresh condition followed by at bud stage (131mg/g) at senescence in control. Minimum carbohydrate content (60mg/g) was observed with Sugar 4% + 8-HQS (200 ppm) followed by Sugar 4% + Salicylic acid 200 ppm) (64mg/g). In *Dendrobium* hybrid 'Thongchai Gold', per cent of fully opened buds (66%) was recorded maximum with sucrose(4%) + $Ca(NO_3)_2$ (1%) followed by sucrose (4%) + acetyl acetic acid (100 ppm) (60%). Longest vase life (36 days) was found with sucrose (4%) + $Al_2(SO_4)_3$ (100 ppm) followed by sucrose (4%) + acetyl acetic acid (100 ppm) (33 days).

Table 6. **Effect of chemicals on bud opening in Cymbidium hyb. 'Pine Clash Moon Venus'**

Treatment	Days to first floret opening	Diameter of first floret (cm)	Per cent of half opened buds	Per cent of Fully opened buds	Vase life (Days)
Distilled water	---	----	0	0	27
Sugar 4%	20	5.1	5.8	44	37.8
Sugar 4% + $Al_2(SO_4)_3$(100 ppm)	21	5.4	0	57	44
Sugar 4% + 8 -HQS (200 ppm)	18	5.5	30.7	53.8	44
Sugar 4% + Salicylic acid (200 ppm)	21	6.6	0	75	45
Sugar 4% + Ca $(NO_3)_2$ (1%)	25	4.85	2	22.8	37.8
Sugar 4 % + Boric acid 200 ppm + K_2SO_4 (2mM)	20.5	5.5	6.25	25	36.2

Sugar 4 % + Boric acid 200 ppm + K_2SO_4 (2mM)	20.5	5.5	6.25	25	36.2

Preservatives: Preservatives are used in the holding solutions in the form of tablets containing a mixture of chemicals such as sugars, germicides, salts, growth regulators etc. Besides, the chemicals are employed during conditioning, pulsing and for making bud opening solutions to improve flower shape, size and opening and colour of the flowers.

Sugar, biocide, anti-ethylene compounds and hydrated compounds are used for conditioning. The sugar and biocide solutions are effective for opening of bud cut flowers

The vase solution should contain sugars, acidifying agent and a biocide. Citric acids are mainly used for acidifying agent and hydroxy quinoline as biocide. Metallic salts like silver nitrate, cobalt chloride, aluminium sulphate, zinc sulphate, calcium nitrate and nickel chloride have been found for prolonging post-harvest life of various cut flowers. Among several growth regulators used to increase vase life of cut flowers, BA, IAA, NAA, 2,4,5-T, GA3, B9, CCC are common.

New chemicals that have been found promising as floral preservatives are ethylene inhibitors like amino- oxyacetic acid, 1-amino cyclopropane, aminotriazole, aminoethoxy vinyl glycine, alpha aminoisobutyric acid, diazocyclopentadiene and phenidone.

Different chemicals used in holding solution for improving vase life of orchids are listed in Table 7.

Table 7. **Holding solutions for different types of orchids**

Name of orchid	Holding solution	References
Oncidium	8-HQC (100-200 ppm) + 4% sucrose	Lin, 1998
	kinetin (50ppm) + 4% sucrose	Chen et al,, 2001
Cymbidium	8-HQC 200 ppm + sucrose 2%	
	1-MCP (500ppb)	Heyes and Johnston, 1998
	1% Sucrose + STS (1 mM)	Bhattacharjee and De, 2005
Arachnis, Aranda, Aranthera, Cattleya	STS (1mM) + 1% sucrose	Bhattacharjee and De, 2005
Paphiopedilum	8-HQC (200 ppm) +2% sucrose	Bhattacharjee and De, 2005
Vanda	AgNO3 (30 ppm) + 1.5% sucrose	Bhattacharjee and De, 2005
Dendrobium	8-HQC (200 ppm) + sucrose (2%),	Nowak and Vacharotayam (1980)
	0.5 mM AOA + 4% sucrose,	Chandran et al., 2006
	AgNO3 (30 ppm) + 4% sucrose	Ketsa and Boonrote (1990)
	400ppm HQ + 30ppm AgNO3 + 2 % sucrose	Jomy et al., 2000
	200 ppm 8-HQS + 50ppm AgNO3 + 8% sucrose	Ketsa, 1989

Table 8. **Effect of chemicals on post-harvest life of Cym. 'PCMV'**

Treatments	Loss in wt (g)	Longevity of first floret (days)	Vase life (days)	Solution uptake (ml)
Distilled water)	12.6	37.2	44.4	21
$Al_2(SO_4)_3$ (100 ppm)	18.4	45.2	53.4	33
$Al_2(SO_4)_3$ (500 ppm)	21.4	28.4	36.8	21
Ca $(NO_3)_2$ (100 ppm)	16.4	42.0	54.8	27
Ca $(NO_3)_2$ (500 ppm)	29.6	32	35.6	24
8-HQS (100 ppm)	27.4	33.2	45.6	29
8-HQS (200 ppm)	26.8	42.2	49.8	33
BA (25 ppm)	24.0	49.2	48.0	27

In *Cymbidium* 'PCMV', 2% cane sugar had shown maximum depletion of stored carbohydrates, maximum longevity of first floret (54 days), zero per cent of flower dropping, maximum solution uptake (24ml) and highest vase life (61.2 days) followed by 4% cane sugar. 8% cane sugar had least longevity of first floret (27.2 days) and vase life (36.2 days). Longevity of first floret was recorded maximum with BA (25 ppm) (49.2 days) followed by $Al_2(SO_4)_3$ (100 ppm) (45.2 days) (Table 8). Maximum vase life (54.8 days) was found with $Ca(NO_3)_2$ (100 ppm) followed by $Al_2(SO_4)_3$ (100 ppm) (53.4 days). Solution uptake (33 ml) was observed maximum with $Al_2(SO_4)_3$ (100 ppm) and 8-HQS(200 ppm). In *Cymbidium*, 'Baltic Glaciers Mint Ice', 8HQS 150 ppm increased the vase life of flowers with pollinia (48.33 days) followed by 8 HQS 200 ppm (46.80 days). 8 HQS 200 ppm increased the vase life (36.67 days) of flowers without pollinia.

In another experiment, in *Cymbidium* hybrid, 'PCMV', out of six treatment combinations, 2% sucrose + 200 ppm 8-HQS had shown maximum vase life (77.6 days) followed by 2% sucrose + 100 ppm $Al_2(SO_4)_3$ (77.4 days) over control in tap water (65 days).

Grading and packing

Grading in orchids:

Grading is done based on the basis of parameters like appearance, stage of maturity, blemishes or injuries due to diseases, infestations caused by insect pests, colour and size of the bud, straightness, strength as well as length of stem**.** Flowers

are generally grouped into bunches of 5, 10, 12 or 20 stems and loosely tied with rubber bands. Before placing them in the package, individual flower bunches are wrapped with suitable packing materials like cellophane paper, kraft paper, newspaper, tissue paper or corrugated cardboard sheet. For local markets, the bunches are held in buckets containing water or preservative solution. It is advisable that for long distance transport and storage, flower bunches are held in dry cardboard boxes. The minimum length of boxes should be about twice the width and it's width about twice the height. Use of telescope-style boxes made of CFB is ideal.

Table 9 : **Grading of Cymbidium cut flowers**

Cymbidium	Grades	Flower count	Spike length	Other consideration
Cymbidium Standard	AAA	12-15	1.25m	Strong straight stems, uniform length, no marks on flowers.
	AA	8	90 cm	
Cymbidium Miniature	XL	15	65+	Bent crooked spikes but with perfect flowers.
	L	12-14	55-64	
	M	8-11	40-54	
	S	5	30-39	

Table 10. **Grading in Dendrobium Orchids**

Grade	**Spike length**	**No. of opened flowers**
Small (S)	30cm	4-5
Medium (M)	40cm	6-8
Large (L)	45cm	8-10
Extra Large	50cm	>10

Packaging in orchids:

Cut flowers are inserted in plastic vial containing water or water with preservatives or simply wrapped in wet cotton swab and the same is covered with a piece of plastic tape and tied with rubber band to keep in it place. Flower spikes are bunched into bunch of 5 or 10 or so. Bunches or individual spikes are placed inside the box in alternate fashion. Ethylene scrubbers with $KMnO_4$ or Purafil may also be kept in the box. For export purpose, packing of flowers in two piece box is better option. In *Cymbidium*, single flowers backed by a fern leaf are inserted in small flasks containing preservative solution, the flasks are then packed in 3 sided box with a display window. In *Dendrobium* hybrid 'Sonia-17' a low gauge polyfilm of 100 gauge thickness the cotton dipped in 8-HQS (25ppm) covering the base of the spike had maximum vase life and flower quality (Jawaharlal et al., 2006). In *Cymbidium*, Cilindra - a gift of a glass flute containing a flowering mini Cymbidium and Stylish setting- Festive packaging for special occasions like Birthday are common.

Cut flowers are inserted in tube containing water or water with preservatives

Individual spikes are placed inside the box in alternate fashion

Evaluation of keeping quality orchid hybrids with packaging materials

- In foam, longevity of cut spikes of *Aranda* ranges from 27 days (Propine spot) to 40 days (Thailand Sunspot), in *Mokara*, from 13 days (Happy Beauty) to 27 days (Walter Ouame White), in *Oncidium*, 17 days (Taka Yellow), in *Dendrobium*, 9 days (Lervia) to 34 days (Bangkok Blue), in *Vanda*, 9 days (Sansai Blue) to 17 days (Prao Sky Blue) and in *Cattleya*, 10 days (Queen Sirikhit).
- In plastic vials, longevity of cut spikes of *Aranda* ranges from 22 days (Propine Spot) to 34 days (Thailand Sunspot), in *Mokara*, from 26 days (Kultana Gold) to 50 days (Happy Beauty), in *Oncidium*, from 20 days (Sweet Fragrance) to 27 days (Taka Yellow), in *Dendrobium*, from 21 days (Erika) to 58 days (*Emma White*), in Vanda, from 27 days (Pat D) to 60 days (*Prao Sky Blue*) and in Cattleya 14 days (Queen Sirikhit).

Storage of cut flowers

Low temperature treatment during storage or shipment period reduces the entire metabolism in the tissues, slows down the respiration, transpiration and ethylene action and retards the multiplication of bacteria and fungi.

In general, temperate orchids are stored at lower temperature even at 5°C in cold chambers whereas tropical orchids are stored at 7-10° C. A 90-95 % relative humidity is necessary during storage to minimize moisture loss and to prevent wilting.

There are two types of cold storage methods, namely 'Wet storage' and 'Dry storage'. In wet storage, flowers are stored with their bases dipped in water or preservative solution for a short time. Dry storage methods are used for long term storage. In this method, fresh flowers are harvested in the morning, graded and sealed in plastic bags or boxes to prevent the loss of moisture.

In Controlled Atmosphere (CA) storage, cut flowers are kept in gas tight cool chambers equipped with cooling systems at a higher level of CO_2 and lower level of O_2 to reduce the respiration rate and production and action of ethylene. Generally, the concentration of CO_2 should be maintained higher than 4 % and not below 0.4% in CA storage.

Table 11. **Storage of orchid cut flowers**

Name of Orchid	Storage Temperature	Storage period
Oncidium, Phalaenopsis, Odontoglossum, Cattleya	7-10^{o}C	2 weeks
Dendrobium	5-7^{o}C	10-14 days
Cymbidium	1-4^{o}C	14 days
Paphiopedilum	-0.5-3.0^{o}C	20 days
Arachnis, Aranda, Aranthera, Ascocenda, Epidendrum	8-13^{o}C	10-14 days

Transport: Flowers are short lived and perishable in nature and should be delivered to destination as early as possible immediately after harvest. For long distance markets, cut flowers are transported by cargo planes, merchant ships and trucks. Other modes of transportation are head loads, bicycles, two-three wheelers, cars, vans etc. Hence, for long distance transportation, advanced methods of post-harvest handling like

cooling, conditioning, impregnation, pulsing, bud opening and packaging are followed. Short time pulsing of flowers with optimal concentration of sucrose, $AgNO_3$, STS and growth regulators is important for long term truck and sea shipments. Other than tropical flowers, the best method of transport of most of the cut flowers is under refrigeration from the grower to final consumers. In Dendrobium, while transportation a temperature of 15°C is maintained.

References

Akamine, E.K. and Goo, T. (1981). Controlling premature fading in Vanda 'Miss Joaquim flowers with potassium permanganate. Univ. of Howaii, College of Tropical Agric.and Human Resources. Res.Series, No. 007, 8.

Annual Report (2008-2009). NRC for Orchids, Pakyong, Sikkim (India).

Arditti, J. (1994). In : *Orchid Biology-Reviews and Perspectives*. VI. New York, USA, John Willey & Sons.

Arditti, J., Flick, B.H. and Jeffrey, D. (1971). Post-pollination phenomena in orchid flowers-II. induction of symptoms by abscissic acid and its interaction with auxin, gibberellic acid and kinetin, *New Phytol*, **70**: 333-341.

Arditti, J., Hogan, N.M. and Chaelwick, A.V. (1973). Post-pollination flowers in orchid flowers-III, Effects of ethylene. *Amer. J. Bot*., **60**: 883-888.

Barendse, H.V.J. (1979). The keeping quality of early flowering miniature cymbidiums. *Vakblad voor de Bloemisterij*, **34** (12): 36-37.

Bhattacharjee, S.K. (1997). Packaging fresh cut flowers. *Indian Horticulture*, **41** (4):23-27.

Bhattacharjee, S.K. and De, L.C. (2005). *Post-harvest Technology of Flowers and Ornamental Plants.* Pointer Publishers, Jaipur, Rajasthan (India), Pp. 440.

Bielaski, R.K. and Reid, M.S. (1992). Physiological changes accompanying senescence in the ephemeral daylily flower. *Plant Physiol*., **98**: 1041-1049.

Chandran, S., Toh, C.L., Zuliana, R., Yip, Y.K., H. Nair and Boyce, A.N. (2006). Effects of sugars and aminooxyacetic acid on the longevity of pollinated Dendrobium (Heang Beauty) flowers. *J Applied Hort*., **8**(2): 117-120.

Chen, Par, W.S., Liao, Li-Jen, Chen, C.Y. and Huang, K.U. (2001). Kinetin, gibberellic acid and sucrose affect vase life in Oncidium spp. *Acta Bot. Gallica*, **148** (3): 177-181.

Da Silva, J.A.T. (2003). The Cut Flower: Postharvest Considerations. *J. Biol. Sci*., **3**(4): 406-442.

De, L.C. and Bhattacharjee, S.K. (2000). Methods for prolonging vase life of cut flowers-a review. *Orissa Journal of Horticulture*, **28**(1): 73-78.

De, L.C. and Bhattacharjee, S.K. (2002). Vase life of cut rose 'Queen Elizabeth' as affected by aquatic fungi and bacteria. *Indian Rose Annual*, **18**: 86-90.

Evans, R.Y. and Reid, M.S. (1986). Control of petal expansion during diurnal opening of roses. *J. American Soc. Hort. Sci*, **111**: 55-63.

Eze, J.M.O., Mayak, S. Thompson, J.E. and Dumbroff, E.B. (1986).Senescence in cut carnation flowers, temporal and

physiological relationship among water status, ethylene, abscissic acid and membrane permeability. ***Physiol. Plant***., **68**: 323-328.

Fischer (1950). Presence of ethylene gas poses problems in cut-flower storage. *Florists Rev.,* **106**: (3814): 31-32.

Halevy, A. H. (1986). Flower senescence. In: *Processs and Control of Plant senescence*, (Eds).Lesham, Y.Y., Halevy, A.H. and Frenkel, C. Amsterdam, The Netherland: Elsevier.

Hew, C.S. and Yong, J.W.H. (2004). *The Physiology of Tropical Orchids in relation to industry*. World Scientific A1 Books. Co.in, pp370.

Hew, C.S., Wee, K.H. and Lee, F.Y. (1987). Factors affecting the longevity of cut Aranda flowers. *Acta Hort*., **205**: 195-202.

Heyes, J.A. and Johnston, J.W. (1998). 1-methyl cyclopropane extends Cymbidium orchid vase life and prevents damaged pollinia from accelerating senescence. *New Zealand Journal of Crop and Horticultural Sciences*, **26**: 319-324.

J. Hort. Sci., **64** (5): 611-615.

Jawaharlal, M., Dinesh Babu, M. and Indhumathi, K. (2006). Postharvcest packaging techniques for Dendrobium Hybrid Sonia -17. *J. Orn. Hort*. **9** (1): 16-19.

Jomy, T.G. and Sabina, G.T. (2002). Effect of conditioning and pulsing on vase life of Dendrobium Sonia inflorescences. *J. Orn. Hort*., **5**(1): 80-81.

Jomy, T.G., Sabina, G.T. and Nair, S.K. (2000). Effect of holding solutions on vase life of pulsed Dendrobium cv. Sonia inflorescences. *J. Tropical Agric*., **38** (1/2): 41-45.

Ketsa, S. (1989). Vase life characteristics of inflorescences of Dendrobium 'Pompadour'.

Ketsa, S. and Boonrote, A (1990). Holding solutions for maximizing bud opening and vase life of Dendrobium 'Yauppadeewan' flowers. *J. Hort. Sci*., **65**: 41-47.

Ketsa, S. and Rugkong, A. (1999). Senescence of Dendrobium 'Pompadour' flowers following pollination. *J. Hort. Sci. & Biotechnol*., **74**(5): 608-613.

Ketsa, S., Uthairatanakij, A. and Prayurawong, A. (2001). Senescence of diploid and tetraploid cut inflorescences of Dendrobium 'Caesar'. *Scientia Hort*., **91**(1/2): 133-141.

Lin, R.S. (1998). Effect of post-harvest recut, sucrose and 8-hydroxyquinoline sulphate on the quality of cut oncidium flowers. *J. Agric. and Forest*, **47**: 115-123.

Lindner, R.C. (1946). Studies on packaging and storage of Vanda (Joaquim) flowers. *Howaii Agric. Exp. Stat. Progress Notes*, **49**: 1-5.

Nowak, J. and Vacharotayam (1980). Evaluation of different chemical treatments on keeping quality and vase life prolongation of some orchid cultivars. Skierniewice , Poland; Pra.Inst.Sad.J. Kwiac Ser**., B-5**: 57-87.

O'Neil, S.D. (1997). Pollination regulation of flower development. *Ann. Rev. Plant Physiol. & Plant Mol. Biol*., **48**: 547-574.

Ong, H.T. and Lim, L.L. (1983). Use of silver nitrate and citric acid to improve shelf life of Oncidium Golden showers flowers. *Orchid Rev*., **90**: 264-266.

Sarkar, Indrajit, Mandal, T. Naveen Kumar, P., Kumar, Rajiv,

Sanyat Misra, Misra, R.L. and Singh, Kishan Pal (2009). *Temperate orchids*. AICRP on Floriculture, Technical Bulletin No.**28**, IARI, Pusa, New Delhi-12, Pp.77.

Sheehan (1954). Respiration of cut flowers of Cattleya mossiae. *Amer. Orchid Soc. Bull*., **23**: 241-246.

Shibuya, K., Yoshioka, T., Hashiba, T. and Satoh, S. (2000). Role of the gynoecium in natural senescence of carnation (*Dianthus caryophyllus* L.) flowers. *J. Exp. Bot*.,**51**: 2067-2073.

Singh, Foza (1990). Indian orchids. *Indian Horticulture*, **35**(1): 14-15.

Ten Have, A. and Woltering, E.J. (1997). Ethylene biosynthetic genes are differently expressed during carnation (*Dianthus caryophyllus* L.) flower senescence. *Plant Mol. Biol.,* **34**: 89-97.

Van Doorn, W.G. (1997). Water relation of cut flowers. *Hort. Review*, **18**: 1-85.