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Production and postharvest management for *Dendrobium* orchids

The *Dendrobium* genus of orchids mostly comprises of epiphytic and lithophytic type of orchids. This large genus contains~1,800 species which are distributed in diverse habitats of south, east and south-east Asia, including India, China, Japan, Indonesia, Philippines, Australia, Vietnam, New Guinea and many parts of the Pacific islands. It has immense importance as commercial floricultural crop for subtropical India. Roots of these orchids generally creep over the bark of trees (for epiphytes) or rocks (for lithophytes). They rarely insert their roots in soil. As the crop has mostly epiphytic or lithophytic growth habit, it requires some special conditions and nourishment. It can not be grown in pots having soil as potting media. To mimic epiphytic conditions, special potting media, nutritional management, special growing condition, disease and pest management are required. These complete management practices largely differ from agricultural or horticultural crops. In this article, the cultivation requirements of *Dendrobium* orchids have been elaborated.

DENDROBIUMS are popular as potted plant as well as cut flowers. The national and international markets have huge demand for potted and cut flower because of their wide range in flower colour, size, attractive shape, prolonged vase life, year round availability and floriferousness. Among orchids, *Dendrobium* is the most favourite for many countries, including Thailand. Thailand is the worlds number one producer and exporter of this orchid. Commercial cultivation of this orchid is becoming very popular in India especially in South, North West, East and North Eastern India, because its cultivation and business has become very profitable in Indian markets and international markets.

Botanical description

Dendrobium consists of ~1800 species of sympodial epiphytic orchids. The plants under these genera sometimes have swollen or short pseudobulbs with terminal leathery leaves, or have long canes or pseudobulbs covered entirely with leaves. The pseudobulbs may be categorised in four groups, i.e. cane woody, cane clavate fleshy, cane cylindric and bulbous round. The plants may be evergreen or deciduous. In some plants, flowers appear on entire pseudobulbs with small peduncles holding two to three flowers. In some species, flowers appear in groups of two or three closely set erect flowers forming pendent thyrsus. In some groups, single and small flower appear from the axils of leaves. Generally, *Dendrobium* inflorescences are subterminal or terminal with one to few dozens of florets. Florets are extremely diverse in colour, shape and size.

Flowering plant of *Dendrobium nobile*

Importance and uses

Dendrobiums are adored by people as cut flowers, pot plants or hanging baskets. Some species of *Dendrobium* are grown on walls, on tree trunk or branches to beautify and cover them. Some herbal medicines can be prepared from the dried stems of *Dendrobium nobile*. As *Dendrobium* can enhance salivation, it can cure dry coughs, dry mouth and severe thirst. Many other diseases can be cured from the herbal medicines prepared from different species of Dendrobiums, which specifies the importance of these plants in the field of medicine. *Dendrobium* blossoms are the most common spices used in cooking. In Thailand and Europe, these

Dendrobium fimbriatum flower

Dendrobium moschatum flower

flowers are consumed after deep frying with butter. Fried *Dendrobium* canes are also used as food materials.

Few important *Dendrobium* species and hybrids

The name of some important dendrobium species are: *Dendrobium aggregatum* (*lindleyi*), *Dendrobium superbum* (*anosmum), Dendrobium bigibbum, Dendrobium chrysotoxum, Dendrobium densiflorum, Dendrobium fimbriatum, Dendrobium formosum, Dendrobium loddigesii, Dendrobium nobile, Dendrobium pierardii (aphyllum), Dendrobium speciosum, Dendrobium spectabile, Dendrobium thyrsiflorum, Dendrobium crepidatum, Dendrobium denudans, Dendrobium heterocarpum, Dendrobium bensoniae, Dendrobium jenkinsii, Dendrobium devonianum, Dendrobium falconeri, Dendrobium farmer, Dendrobium gibsonii, Dendrobium infundibulum, Dendrobium parishii, Dendrobium primulinum, Dendrobium transparens, Dendrobium williamsonii, Dendrobium ochreatum,* and *Dendrobium moschatum*.

Important hybrids of Dendrobium based on colour are given below.

White: Snow White, Pagoda White, Emma White, White Surprise, Jacquelyn Concert × Walter Oumae, Kasem White, Big White Jumbo, White 5N, Airy White.

Blue: Worawit Blue, Lee Chong Blue, Kiyoshi Izumi, Blue Fairy, Bangkok Blue.

Pink: Chiengmai Pink, Ekapol Panda, Jisus Star, Juree Red, Kiilani Stripe, Long Champ, Penang Sugar, Sakura Pink, Miss Singapore, Madam Pink, Sonia -16, Ear Sakul, Candy Stripe Pink, Sonia-17, Sonia -28, Dr. A. Abraham.

Yellow: Sri-Siam, Swan Lake, Thongchai Gold, Bonchoo Gold.

Green: Kanjana Green, Green Mist, Little Green Apples.

Red: Meike Beauty, Little Lolita, Cleopatra, Fireball.

Interspecific hybrids: Australian Lemon Pepper, Jiali Paradise, Green Elf, Memoria Dipper Nishii, First Star, Mini Snowflake, Scotts Valentine, Dounan Spicy, Black Gold, Winter Frost, Peng Seng, Silver Wings, Aminah Khatum, Bruce Gorden, Green Mist, Sweet Phurichaya, Big Alex, Carly Hera, Pink Glow, Mollys Angel, Go Secret.

Inter-varietal hybrids: Candy Smile, Angel Moon, Million Gold, Liberty Girl, Asian Smile, Happy Holiday, Happy Smile, Popeye, Sunny Bird, Wonder Rabbit, Peach Blossom, Sally Fiesta, Rudkin, Ice Storm, Hawaiian Twinkle, Sea Sky, Singa Beauty, Arthur Reserve, Green Wonder, Open Heart Leaf, Rising Star, Fairy Star, Burbank Candy, Burnt Orange, Justine.

Variety-species hybrid: Blue Rain, Samson Toy, Margaret Thompson, Third Eyes Vision, Rods Eagle, Spider Lily, Sylvester, Paradise Fortune, Sky Mirror, Butterfly Dawn, Island Snow, Australian Idol, Fine Ford, Half Moon Bay, Special Bride, Two Kings, Genting Lipstick, Singa Kagoshima, Jairak Spin.

Cultivation

Potting mixture: The potting media of *Dendrobium* orchid should be well-drained, loose and friable. It should mimic epiphytic condition and supply sufficient air nearly equivalent to the amount that a *Dendrobium* root gets while growing on tree top. At the same time, it should hold sufficient moisture for the plant and hold the plant erect. If it supplies some nutrients to the growing roots, it can be a win-win situation. A potting medium consisting of charcoal or leaf mould, brick pieces and coco chips/ coconut fibre/woodchips in equivalent proportions is ideal for plant growth as well as flowering. Under low humid conditions {30% relative humidity (RH)}, a mixture of tree bark/perlite/sphagnum moss or osmunda are used in plastic pots; under average humidity (35 to 50% RH), a mixture of tree bark and sphagnum moss are used in plastic pots; under high humidity (≥55% RH), bark, stone culture, charcoal or tree fern are used as potting media in clay pots. Among potting mixtures, cocochips + cocopeat + leaf mould + brick pieces (4: 1: 2: 3) is found to perform well. If some potting materials are not available to the growers, locally available stone/brick pieces, wood chips (1-2 inch size), leaf mould (chopped in small pieces) could be used as potting media in 1:1:1 ratio on volume basis. Plastic pots should have a fair number of drainage holes (4 to 8 holes on 3" to 4" pots, 8 to 12 holes on 5" to 6" pots) and the pots should be kept at 2-3 feet high table or other structure so as to provide sufficient aeration.

Potting *Dendrobium* orchids: The roots of the *Dendrobium* should be placed in the pot and accordingly pot size should be just large enough to accommodate the roots. For clay pots, one size larger than the plastic pot should be used; for clay orchid pots, little larger

Flowering plant of *Dendrobium densiflorum*

size should be used. In *Dendrobium,* new growths appear along a rhizome and usually in the opposite direction of old growths. Therefore, the plant should be placed close to one edge of the pot, so that some room may be left on the opposite side of the pot for the new growths. While potting, plant should be held in such a way that the junction of roots and lower leaves flush on the top of the pot. For best results, potting media needs to be well moist (but not dripping wet). Potting should be done in such way, that the leaves should not touch the potting media and the top roots a little exposed. Yellow, shrivelled leaves, diseased part of the leaves should be trimmed. If necessary, the plants should be staked so that it does not wobble. After two or three months, the stakes should be just pulled out without disturbing the plants.

Repotting: As the growth continues, substrate decomposes or roots start rotting or there is no space in pots for new roots, the orchids need repotting. In most orchids, new roots and new growths start growing right after flowering. As soon as new roots start growing (before reaching 1 cm long) repotting should be done. Between the months of February and June repotting can be done. For a few weeks after repotting, it should be nurtured a bit. Their leaves should be sprayed (misted) lightly twice a day for two weeks for healthy plants and up to four weeks for weak and ailing plants. Spraying should be done early in the day and again not later than mid-day. Watering should not be done after 12 noon in winter. Addition of 2 or 3 drops of a rooting solution and Superthrive in the misting water can be beneficial. In absence of rooting solution, a pinch of phosphorus rich fertilizer may be added. For first 3-4 weeks, the repotted plants should be kept in less light than usual. The lower light levels can reduce the repotting stress and let the plants recover faster and better. Plants should be watered lightly (just enough to get the potting material moist, for one week). Enough water should not be applied to run through the drainage holes. After one week, watering thoroughly once a week is recommended. The plants should not be fertilized at least for two weeks of repotting.

Temperature: The cool growing *Dendrobium* orchid group thrives well at temperatures ranging between 10-24°C. The intermediate *Dendrobium* orchid prefers a temperature range of 14-26°C whereas the warm growing *Dendrobium* orchids prefer 16-30°C. The warmer group species like *Dendrobium gouldii*, *D. phalaenopsis*, *D. antennatum, D. biggibum* and *D. discolour* comes to bloom if the night temperature remains above 16°C and the cool growing *Dendrobium* species like *D. lindleyi*, *D. parishii, D. aggregatum*, *D. densiflorum*, *Den. pierardii*, *D. anosmum* and *D. chrysotoxum* grow well with night temperature of 10°C. Low day temperature reduces vegetative growth, causes leaf yellowing and ultimately defoliation and higher day temperatures delay flower bud development. Orchids can survive and grow ±5°C temperature out of the optimum range, but they will perform best under the optimum temperature range.

Light: *Dendrobium* orchids like indirect or shaded light. Although it varies from species to species, depending on their habitat and growth habit, as per thumb rule, 50% shading is prescribed for most commercial *Dendrobiums.* With optimum light, *Dendrobium* plants have plump stems with leathery bright green leaves, when the light is too high the plants show yellowing, stunting and scorching, whereas with less light, plants have succulent, soft and darker green leaves with spiny and thin stems. All types of *Dendrobium* orchids need warm bright but shaded light (2500 to 3000 foot candles). They should get at least ~11 to 13 hours of light throughout the year.

Atmosphere: Good circulation of fresh air is essential for *Dendrobium* orchid production, because continuous light breezes make a good supply of CO_2 for photosynthesis.

Watering: Over-watering as well as under-watering can be equally harmful for potted orchids. In many instances, it has been found that over-watering has damaged orchids instead of under-watering. Excess application of water may lead to root rot and several other diseases. The quality of water is very important for orchid cultivation; rainwater is suitable for watering Dendrobiums. Well water or underground water is acceptable if its content of Total Dissolved Solids (TDS) is below 120 ppm. Hard water (water with mineral contents, TDS above 120 ppm) will create hard deposits on the leaves of plants and may clog the pores on the leaves. If water is hard, it may be beneficial to periodically (once or twice a year) clean the leaves with distilled water or at least with rain water. Most orchids prefer water of *p*H 5.0-6.5, but water of near neutral *p*H can work well. Under high temperature and sunlight frequent watering is essential. Plants grown in small pots dry out quickly as compared those in large pots. Plants grown in earthen pots need more watering as compared to the plants grown in plastic pots. A hanging plant with better aeration requires more frequent watering than a plant in a pot. Fresh potting materials also need more frequent watering.

The potting material should never be soggy but potted plants should be watered regularly to prevent them from becoming bone dry. Generally, watering should be done once a week, but small pots (5" or less) need more frequent watering than large pots (6" or more). Depending on the composition and amount of potting materials it will dry at different rates. Clay pots will evaporate more water than plastic pots when other factors are equal. Clay orchid pots, because of their openings, will dry out faster than regular clay pots. Grower should adjust the watering

Dendrobium nobile in full bloom

habit as the season changes. As per thumb rule method, by inserting finger an inch or two in the potting media one can feel the moisture condition of it, it should be moist and not soggy; if not moist it should be watered to moisten it; and if it is soggy, it should be allowed to dry. Watering should be done only on sunny days. On cloudy, cool or rainy days, watering should be avoided. Watering should be done early in the day and not after 2 PM in summer, after 12 PM in winter and after 1 PM in spring. Normal temperature water or lukewarm water should be used, as a difference of 10 degrees or more between the temperature of the water and the room temperature may cause injuries to the plants. Watering should be done from the top till the water runs freely through the drainage holes. Humidity affects the orchid cultivation prominently; it should be ~50-75%. It may vary from species to species depending on their ecotypes, light, temperature and habit of growth, as per thumb rule, high humidity should be maintained during high temperature. Provisions of forgers or misting units, even humidifiers will ensure adequate humidity. Keeping water bowls or buckets below the orchid benches may improve humidity.

Fertilization: *Dendrobium* orchids are light feeders; they need higher nitrogen (N) and less phosphorus (P) and potassium (K) during the initial two-third of their life before flower initiation. During flower initiation and inflorescence development, plants are fed with less N, more P and K. During blooming time, a low level of N and high levels of P and K are applied. In orchids, foliar application of fertilizer solution is found to produce good plant growth; frequent fertilization in low concentrations is the best way of feeding orchids. More specific fertilizer recommendation is given below.

- For young plants (1st year) NPK fertilizer of 20:10:10 composition @ 0.1% should be applied. For this, 1 g fertilizer having N:P:K composition of 20:10:10 should be dissolved in 1 litre water and sprayed well on the plant as foliar and on potting materials as basal application at an interval of 15 days. Also calcium nitrate @ 0.05%, magnesium sulphate @ 0.1%, iron sulphate @ 50 ppm, boric acid @ 50 ppm, zinc sulphate @ 50 ppm should be applied at 60 days interval. For this, 0.5 g calcium nitrate, 1g magnesium sulphate, 0.25 g iron sulphate, 0.28 g boric acid, and 0.22 g zinc sulphate should be dissolved in one litre water and sprayed well on the plant and potting media at an interval of 60 days.
- For intermediate growth stage (2nd year onwards, in the month of February to May) N:P:K fertilizer of 10:20:20 composition @ 0.2% should be applied; for this 2 g fertilizer having N:P:K composition as 10:20:20 should be dissolved in one litre water, and sprayed well on the plants and potting materials at an interval of 15 days. Also, calcium nitrate @ 0.05%, magnesium sulphate @ 0.1%, iron sulphate 50 ppm, 50 ppm boric acid and 50 ppm zinc sulphate should be applied at 60 days interval. For this, 0.5 g calcium nitrate, 1g magnesium sulphate, 0.25 g iron sulphate, 0.28 g boric acid and 0.22 g zinc sulphate should be dissolved in one litre water and sprayed well on

the plants and potting materials at an interval of 30 days.

- At late growth stages (2nd year onwards in the month of June to September) 20:10:10 NPK should be applied @1 g/litre at an interval of 15 days. Also, calcium nitrate @ 0.05%, magnesium sulphate @ 0.1%, iron sulphate @ 50 ppm , boric acid @ 50 ppm and zinc sulphate @ 50 ppm at 60 days interval should be applied. For this, 0.5 g calcium nitrate, 1 g magnesium sulphate, 0.25 g iron sulphate, 0.28 g boric acid and 0.22 g zinc sulphate should be dissolved in 1 litre water and sprayed on the plants as foliar spray as well as on potting materials as basal application at an interval of 30 days.
- At late growth stages (2nd year onwards in the month of October to January) 20:20:20 NPK should be applied @ 2 g/litre at an interval of 30 days. Or only N free P K fertilizers may be applied before flower initiation; the P and K should be applied @ ≤100 ppm.

Dendrobium hybrid flower

Disease and pest management

Diseases: *Dendrobium* species as well as hybrids under commercial cultivation are infected with fungal diseases that include rot, leaf blight, flecks and floral blight. The sources of inoculum for these diseases are mainly infected potting media or infected plants. The moisture stress during active growing period pre dispose the plants to cane rot and over watering exposes the plants to suffocation and leads to root rot. These root, collar or cane rots are caused by *Fusarium, Phytopthora* or *Sclerotium* fungal species. The leaf blight symptoms incited by *Colletotrichum* with exposure of plants to direct light leads to anthracnose that expands and causes leaf drying and death of the plants. Floral blight incited by Botrytis is a major cause of concern in commercial cut flower production that makes the flowers unviable for marketing through spots and blight symptoms that damages the ambience of the flowers. The disease of bacterial origin includes soft rot and brown rot on leaves and root region. Virus infections in the Dendrobiums are characterized by the necrotic or chlorotic spots, flecks and/or streaks on the leaves. Diseases can be managed by providing adequate air circulation and shade for the plants with optimum moisture level. On the incitation of diseases, alternate spray of non-systemic and systemic fungicides helps in the spread of the diseases. Plants infected with viral disease should be immediately separated from other plants and destroyed.

Pests: The incidence of insect pest causes structural damage to the plant parts, thereby decreasing the potential and vigour of the plants. Boisuduval scale that sucks the plant sap by residing in the leaf sheath region and forms white velvety growth; Yellow aphids that aggregately sucks plant sap causing sooty growth over the leaves and flowers; Shoot borer that resides in the young growing shoot and floral buds thereby causing the death of growing end and damage of the flowers; Thrips mainly prefers young tender leaves causing yellow patches that turns black spots in later stages; Snails that are highly nuisance during monsoon period brings considerable damage by the eating away the root and canes. Yellow beetles, grasshoppers and spiders cause minor damage on the crop. The insect damage can be controlled through adequate insect nets all over the polyhouses and maintenance of proper cultural requirement inside the house. Prophylactic spray with azadirachtin followed by systemic insecticides spray is recommended for the management of the insect pest.

Propagation

Dendrobiums can be easily propagated by division of pseudobulbs and through keikis. Keikis are generally produced along the old canes. Dendrobium orchids are famous for producing keikis. Keiki (pronounced Kay-key) is the Hawaiian word for “babies”. At first, keikis will develop leaves followed by roots. When roots (at least two) are about 1-2 inch in length, the keikis can be removed from the mother plant and planted in another container. Keikis will be identical to the plant they were removed from and are also entitled to be recognized by the same variety name. From healthy, leafless, older canes, 10 to12 cm long cuttings with ≥ three nodes per cuttings, can be used for sowing in moist sphagnum moss for rooting. Commercially, *Dendrobium* orchids are propagated by tissue culture. Either seed or apical or lateral buds are used for tissue culture; which proliferates as protocorm like bodies.

Post-harvest management

Harvest and economics: *Dendrobium* spikes possess vase life of 2 to 3 weeks. Usually, 40-60 cm long floral spikes with 10-15 flowers are harvested at a stage when all flowers are open except for the top bud. Harvested spikes should be placed in a clean water pot instantly, emerging the cut ends ~2 to 3 inches inside water. The spikes are then taken to the packing area. The packing should be cool and shaded. In *Dendrobium*, it has been reported that flowers harvested in early morning generally survive longer as compared to those harvested late. Depending on the grade and quality, the cost of *Dendrobium* spikes may range from ₹10 to 25 or more. In an area of 500 m^2, 3000 plants can be kept. *Dendrobium* growers can sell ~3000 cut spikes and 3000 mother plants by three years after it starts flowering, by which one can earn ~₹5 lakhs from 500 m^2 area. *Dendrobiums* can be propagated through vegetative method and number of mother plants can be increased.

Pre-cooling: After harvesting and before packaging, *Dendrobium* cut flowers must be precooled at 5-7°C for 1 to 2 hours. Precooling decreases breakdown of nutritional and stored materials and lowers the rate of respiration of the leaves, petals and stems and thus delays flower senescence. Besides, it decreases ethylene sensitivity of flowers and reduce water loss from it. Several pre-cooling techniques such as forced air cooling, room cooling, vacuum cooling, hyder-cooling and ice bar cooling, etc. are available.

Pulsing: It prolongs vase life, promotes flower opening and improves the colour and petal size of the flowers through modified osmoregulation. *Dendrobium* hybrids can be pulsed by keeping flowers erect in a solution of 135 ppm $Na_2S_2O_3$. $5H_2O$ (Sodium thiosulfate pentahydrate) + 25 ppm $AgNO_3$ (Silver nitrate) for 30 minutes increases vase life of the cut flowers. *Dendrobium* cv. *Sonia* recorded the highest vase life of 21.33 days after pulsing with 400 ppm HQ+ 4% sucrose.

Bud opening: Bud opening of flowers (when kept in vase) decreases flower sensitivity to extreme temperature, ethylene and low humidity thereby prolongs vase life. Giving sufficient space during shipment allows the buds to open and extends the storage life. Some vase solutions can be useful to help buds to open in vase. In vase solution, the sugar concentration and temperature is kept lower as compared to pulsing. In hybrid *Dendrobium*s $AgNO_3$ or HQS (@ 50 ppm) can be effective for opening cut flower buds. Preservative solution with $AgNO_3$ @ 30 ppm + HQS @ 225 ppm + 4% glucose increases bud opening and decreases senescence time of the opened florets of *Dendrobium* Cv. Ceasar. In *Dendrobium* hybrid Thongchai Gold 36 days vase life (Longest) was found with vase solution containing $Al_2(SO_4)_3$ (Aluminium sulfate) @ 100 ppm + sucrose @ 4% followed by acetyl acetic acid @ 100 ppm + sucrose @ 4% (33 days).

Preservatives: The vase solution should contain sugars, acidifying agent and a biocide. Citric acid and hydroxyquinoline may be used as acidifying agent and biocide respectively. Metallic salts i.e. $AgNO_3$, $CoCl_2$, $Al_2(SO_4)_3$, $ZnSO_4$, $Ca(NO_3)_2$ and $NiCl_2$were found to prolong post-harvest life of *Dendrobium* cut flowers. Combined use of sugar + biocide + hormone (like sucrose @ 2% + 8-HQC @ 100 ppm + BA @ 25 ppm) can remarkably increase the vase life of *Dendrobium* cut flowers.Vase solutions for increasing vase life of *Dendrobium* cut flowers may be any of the following AOA @ 0.5 mM + sucrose @ 4%, 8-HQC @ 200 ppm + sucrose @ 2%, $AgNO_3$ @ 30 ppm + sucrose @ 4%, 8-HQS @ 200 ppm + $AgNO_3$ @ 50 ppm + sucrose @ 8%, HQ @ 400 ppm + $AgNO_3$ @ 30 ppm + sucrose @ 2%, 400 ppm Carbendazim.

Grading: The orchid flowers are graded as per the standards before marketing. Spikes are graded by colour, length, flower size, etc. There are four standard size grades based on spike length and stalk quality.

Grade	Spike length (cm)	Number of opened flowers
Extra-large (XL)	50	>10
Large (L)	45	8-10
Medium (M)	40	6-8
Small (S)	30	4-5

Packaging: Around 5 spikes with same grade are bunched in a pack box. The cut end of each flower stem in the box must be placed in a preservative solution or water containing tube (specialized tube that prevents solution emission from any side). During transportation the water loss from the spikes is supplemented by liquid from the tubes. Wet cotton can also be used to wrap the cut end of the spike. Cotton dipped in preservative solution or water should be wrapped at the cut end of the spikes with the help of a polythene sheet and tied with rubber band or thread. A cushioning material can be kept at back of the tube that can prevent damage during transportation.

These graded flowers are packed in cardboard or hard paper boxes of suitable sizes. The base of the spikes can be fixed with the carton with the help of some adhesive tapes so that the movement of the spikes inside the boxes during transit can be restricted. The box length varies according to the length of the spikes. Sufficient number of holes should be there on the box to provide proper aeration to the flowers.

Storage: *Dendrobium* cut flowers can be stored at 7-10 C with 80-95% RH. *Dendrobium* hybrid Sonia 28 can have vase life of ~19 days (longest) and Sonia 17 may have ~15 days vase life while storing at 10 C. The *Dendrobium* flowers stored below optimum temperature suffer from chilling injury that causes darkening of labellum; sepals and petals may also get affected in extreme cases. The storage environment must be kept ethylene free as orchid cut flowers are quite sensitive to it. Use of ethylene absorbent or scrubber (containing $KMnO_4$) and proper ventilation in the storage area can help to keep the place ethylene free.

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