Technical Bulletin No. - 49

A Technoguide for Propagation of *Lilium*

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Foreword

Lilies have emerged as one of the most important cut flower crop of the country. These are commercially cultivated in the Uttarakhand, Himachal Pradesh, Sikkim and hilly regions of Tamil Nadu and West Bengal. The cultivation of *Lilium* offer higher return per unit area as compared to many other flower crops. Apart from producing cut flower, hilly regions of the country are also suitable for producing planting materials of lilies. At present, the bulk of our demand is met through the imports. There are many constraints associated with the import of the bulbs. These include availability of requisite cultivars in time, delay in consignment, risk of introducing pathogens etc. Hence, it was felt necessary to standardize the *Lilium* propagation technology suitable for local conditions. The present technical bulletin is outcome of research conducted by Dr. Ram Pal who has been working on various aspects of micropropagation and conservation of orchids including propgation of *Lilium*.

It gives me immense pleasure to bring out this bulletin on "A Technoguide for Propagation of *Lilium*" where an innovative *in vivo* propagation technique has been described in a comprehensive manner. I am sure that the bulletin would be useful to lily growers, extension personnel, students and researchers in understanding and propagating *Lilium* through various techniques.

D. R. Singh
Director

Preface

The genus *Lilium* (family Liliaceae) is an important bulbous ornamental crop grown all over the world for cut flower, pot plant and plants for landscaping. This genus consists of about 100 species distributed in Europe, Asia, North and South America. Of them, eighty seven have been utilised for developing several hundreds of cultivars. Some lilies are propagated by seeds but most varieties under cultivation are propagated through bulb scales. Recently, the focus has been shifted to produce the bulbs using tissue culture technology.

In the recent years, the cultivation of lilies has spread in hilly regions of the country. These regions hold good promise not only for production of cut flowers but also for production of planting material. As per an estimate, nearly four million bulbs are imported every year which is likely to increase in near future. Lilies are easy to propagate. They are propagated through seeds, bulbils, stem bulblets, bulb-scales, stems and leaf cuttings as well. Propagating lilies *in vitro* has numerous advantages but requires huge initial investment and skill. The two methods, bulb-scales and stem bulblets are chiefly used in commercial propagation of lilies. This bulletin 'A Technoguide for Propagation of *Lilium*" describes the morphology of *Lilium* plant with emphasis on bulb which is chief source of multiplication. Further, it details various methods of propagation and package of practices for growing of bulblets to obtain commercial size bulbs.

In producing this bulletin I have received valuable advice and encouragement from Dr. D. R. Singh, Director, ICAR-National Research Centre for Orchids, Pakyong, Sikkim and Dr. V. A. Parthasaraty, Ex-Director, IISR,Caulicut and Chairman of Research Advisory Committee (RAC) of the Institute. The same are gratefully acknowledged.

Month, September, Year, 2016

Ram Pal

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Introduction

Lilium is a promising ornamental flower bulb crop of the country. It is a high value flower crop and needs high capital investment on construction of greenhouse and import of flower bulbs. Lilies are productive as well as profitable as they offer highest income per unit area compared to other flower crops grown in the country. In India, nearly four million bulbs are planted every year for cut flower production. Most of them are imported from flower bulb producing countries of the world. *Lilium* is becoming popular in various part of the world. The *Lilium* bulb production area in Netherlands has increased from 100 ha in 1962 to 3699 ha in 2008.

The flower of lily symbolizes beauty, grace, innocence, hope and life. These flowers are increasingly becoming popular in Indian flower market owing to their variety of colors, fragrance and long shelf life up to one week. Several Indian states like Uttarakhand, Himachal Pradesh, Maharashtra, Tamil Nadu, Karnataka, Sikkim and West Bengal have started growing them on commercial scale. The hilly regions of these states offer congenial climate for production of cut flowers as well as planting materials that is bulbs. Presently, the bulbs are produced in a limited quantity and a bulk of requirement is met through the import from other countries. These imported bulbs are often pre-cooled and need to be planted immediately after arrival. These are cultivated for cut flowers, pot plants, landscaping and propagation of planting material.

2

The *Lilium* Plant

2.1 Roots

Lilium cultivars produce two types of roots. These are the basal or contractile root and stem root. The basal roots arise from the basal plate whereas stem roots arise from the stem, just above the bulb. The basal roots pull down the bulb in the soil where the environment conditions are more congenial for the growth of the plant. The contraction occurs because of formation of wrinkles on epidermal layer of the roots. In mature bulbs, daughter buds also produce contractile roots between the scales or even through the axis. Stem roots absorb moisture and nutrients more efficiently than the basal roots and provide mechanical support to flowering stem.

2.2 Stem

The stem is initiated in the center of the daughter bulb or bulblet. It remains dormant after senescence of the mother axis and during the period of chilling. In some cultivars it may emerge with the growth of mother bulb. In mature bulblets (one or two years after) stem produces one or two flowers.

2.3 Leaves

Leaves produced at the apex of the scales of immature bulbs or bulblets are known as scale leaves or radical leaves. The mature bulbs or bolting bulblets produce foliar leaves on main axis. Scale leaves are produced before the growth of

main axis. The bulblets produce three kinds of leaves, radical leaves, foliar leaves or both. The large bulblets bolt and produce scale leaves (Epigeous type plant, ETP), smaller size bulblets produce radicle leaves (Hypogeous type plant, HTP) and intermediate size bulblets produce both types of leaves (Hypo-epigeous type plant, HETP). The mature bulb does not produce radical leaves rather they produce auxiliary leaves at the base. Auxiliary leaves are fleshy and become membranous. On emergence of axis above the ground they become photosynthetic when exposed to light.

2.4 Flowers

In lilies, flower formation occurs after emergence of stem. The flower buds remain enclosed by apical leaves. Flowers are solitary, in raceme or in umbel. The flower consists of two whorls of three teplas. The tepals attach to the receptacle and alternate with neighbour whorl. The flowers are large, showy and vary in color and size with the species.

2.5 Fruits and Seeds

The capsules of *Lilium* are trilocular. Each locule contains two rows of ovules arranged in axil. Seeds are circular with fleshy endosperm where the embryo resides.

3

Lilium Bulb Morpholgy

The bulb of *Lilium* is non-tunicate but is enveloped by modified leaves known as scales. These scales work as storage organ of the bulb. The bulb is composed of scales, a basal plate, a growing point and roots arising out of basal plate. Based on anatomical position, the scales are divided in two groups *i.e.* outer and inner scales. The outer scales are previous year's inner scale while the inner scales form during the current year. The inner scales are formed from a new active growing point near the old flowering stem. All the scales attach to the basal plate which is a compressed modified stem (Fig. 1). The scales constitute bulk of the bulb and act as a reservoir of food mainly carbohydrates. The scales are also chief source of commercial multiplication. The growing point located on the top of the basal plate and surrounded by the new scales, forms the leaves after harvesting and storage. On planting in the greenhouse, growing point continues to form leaves until flower buds form. Every year, in the axis of inner scale, a lateral bud converts in to growing point during flowering time in the field. This growing point first forms the inner scales which enlarge the bulb size and then it forms leaves and flower buds. Thus the cycle is repeated when shoot eventually flowers.

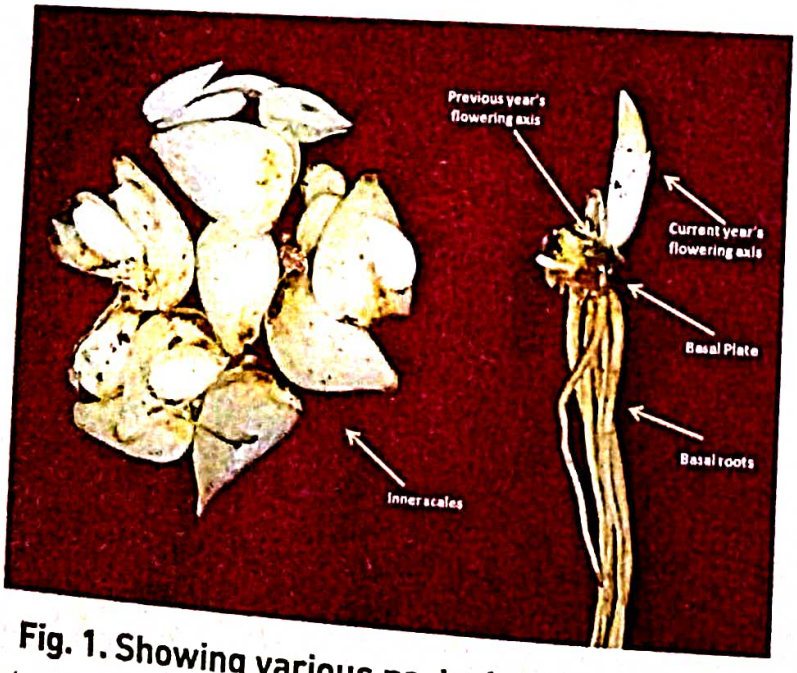

Fig. 1. Showing various parts Asiatic liliy bulb (before planting) after removal of outer scales

4

Lilium Bulb Physiology

The bulbs of *Lilium* are generally harvested after withering of aerial parts. At this stage the terminal bud of the new bulb remains active. The researches have shown that accumulation of starch, ABA level, nitrogen, phosphorous and potash in the bulbs reach half of its maxima at the withering stage. However, fresh and dry weight reaches to its maxima following complete withering. Before planting in field, the bulbs are subjected to low temperature treatment where starch of the bulb is broken down into simpler soluble carbohydrates (sucrose, mannose, fructose). The duration and temperature of low temperature treatment varies with species, variety, bulb size, growing conditions etc. Various studies have revealed change in levels of hormone during low temperature treatment. The researchers have found that endogenous level of ABA decreases with the increasing duration of storage. There are some contrasting reports suggesting no change in ABA content occurs during the low temperature treatment.

Increase in free amino acids particularly, Argenine has been noticed in bulbs subjected to low temperature treatment. Overall, the low temperature increases soluble carbohydrate, phenol, decreases endogenous level of ABA and increases the level of GA_3 which coincides with development of shoot bud. For proper growth and development and release of dormancy, the bulbs should be stored at low temperature for a longer duration.

5

Maintaining Mother Stock

The bulbs selected for propagation should be healthy, true-to- type and free from diseases and pests, especially viral diseases. A minimum isolation distance between mother plant blocks should be followed to maintain purity and check spread of viral diseases. The mother stock should be re-tested at least once a year. The standard sanitation procedure should be followed to clean growing environment. Hands, tools etc. should be disinfected before dealing with a plant. A special precaution is taken once the material is moved from one place to other. All the partners in *Lilium* bulb production chain should implement serious sanitation and strict production procedure for growing of virus free bulbs.

6

Propagation of *Lilium*

6.1 Seed Propagation

Commercially, *Lilium* is multiplied through bulb scales or tissue culture. However, germination of seeds is essential for breeders for creating new variety. The bulbs obtained through the seeds are genetically variable not true-to-type as needed for commercial crop production. Seeds should be harvested just before splitting of seedpods. The seed propagation is desirable for the species having short juvenile phase. The healthy seeds should be separated from the chaffed ones. The seeds should be planted in planting trays or flat beds in fine soil containing FYM, leaf-mold. The propagation through seeds usually needs 5-6 years to get commercial size bulbs.

6.2 Vegetative propagation

6.2.1 Division

The bulbs under the soil starts enlarging because of transfer of food gathered during growing stage to the developing bulb. During this process, some bulbs divide into two parts having common basal plate. These divisions are called as offsets. The offsets have it's own growing point. They grow together as long as not separated from each other. If these bulbs are left longer to split and divide they will eventually lose vigor. The offsets can gently be taken apart using hands or by sharp sterilized knife. The rate of division varies with the genotypes. In general

Asiatic lilies divide faster than oriental ones. We have found that division in *Lilium longiflorum* can be increased by overnight dipping of bulbs in solution containing Etherel @ 500-1500 mg (a.i.) per liter. The rate of splitting increases up to 4.5 times (Fig. 2).

Fig. 2. Showing role of Etherel in promoting branching bulbing of *Lilium longiflorum*

6.2.2 Stem Bulbils

Bulbils are aerial bulblets produced in the axils of leaves. They are usually dark purple to brown and 1-2 cm long. The capacity to produce bulbils varies with

Fig. 3. Photograph showing stem detached bulbils (left) and bulbils attached with flowering axis (right)

the species. *Lilium tigrinum, L. bulbiferum, L sulphureum* and *L. sargentae* are easy to form bulbils. The production of bulbil can be encouraged by disbudding. The bulbils are harvested after flowering is over. They may have dormancy and planted in late summer.

6.2.3 Stem Bulblets

The stem bulblets are formed on the stem above the bulb and beneath the soil. The number and size of bulblets depends upon species, variety and health and vigor of the plant. These bulblets are usually larger than scale propagated bulblets. The stem bulb production can be encouraged by deep planting of bulbs, removing leaves at basal end and earthing up and applying plant growth regulators. The experiment conducted at the campus shows that application of IBA and earthing up increases the stem bulb production in Asiatic Liliy cultivar Nove Cento (Fig. 4). Overnight soaking of bulbs in Etherel (500 mg/l) suppressed the flowering and increased the stem bulb production in oriental lily (Fig. 5).

Fig. 4. Photograph showing stem bulbs on cultivar Nove Cento, control (page 9) enhanced bulblet production by application plant hormone (top)

Fig. 5. Photograph showing increased bulblet production by deep planting of bulbs (page 10, bottom right), bulb dip in of Etherel 500 ppm (page 10 left) and Effect of Etherel on bulblet production in Asiatic lily cultivar Brunello (top)

6.2.4 Leaf Cuttings

Leaves can also be employed for the production of bulblets. The leaf cutting are taken along with small heal of the stem. Small bulblets arise from the parenchymatous cells of the leaves. Usually, leaves are taken from the flowering shoots and placed in suitable cutting mixture like vermiculite, sawdust etc. Placing leaves in solution containing 25 mg/l BAP (Benzylaminopurine) enhances bulblet production from the leaves (Fig. 6)

6.2.5 Stem Cuttings

The flowering axis can also be used for propagation of lilies. After flowering, the flowering axis is cut into 6-in pieces, leaves are removed carefully. The cut stems are soaked in a solution containg 25-50 mg/l BAP for 12 hours. Then they are air dried and planted in moist sawdust or peat. The cuttings produce small

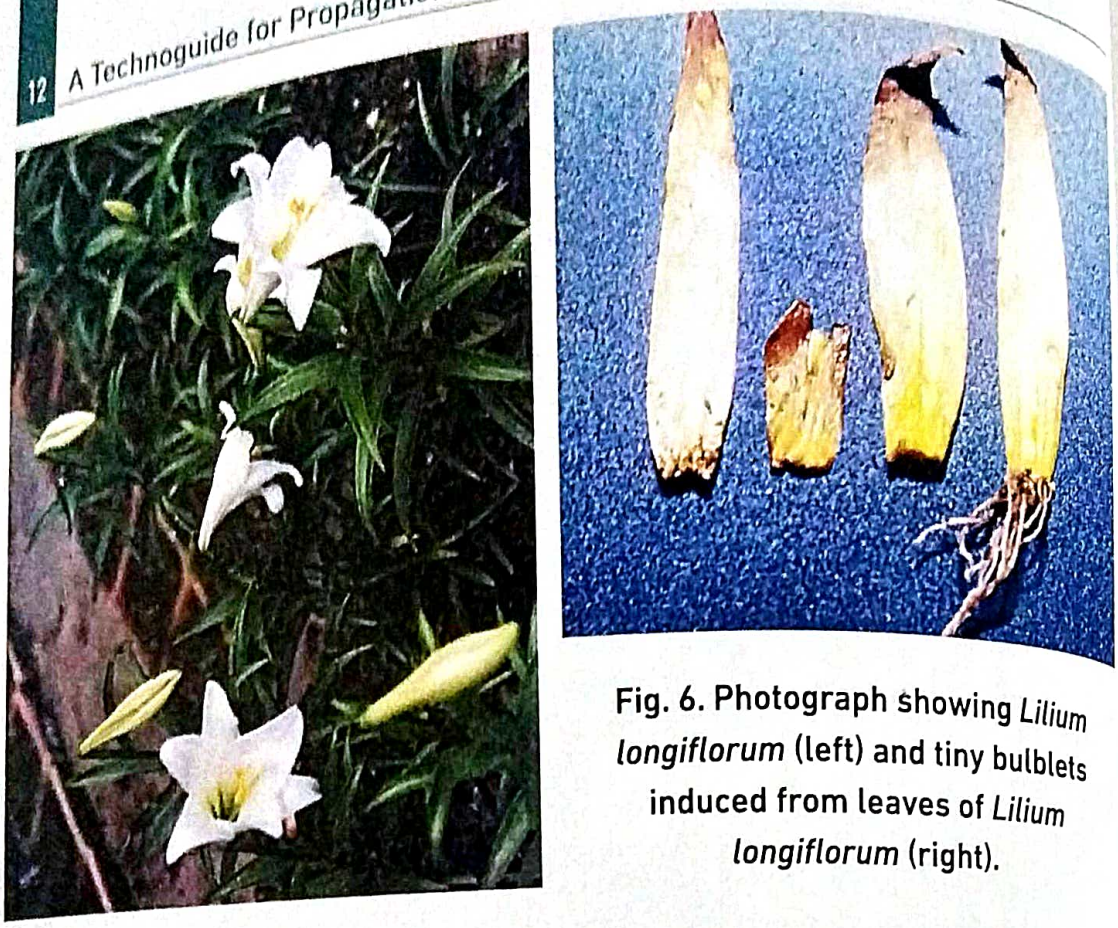

Fig. 6. Photograph showing *Lilium longiflorum* (left) and tiny bulblets induced from leaves of *Lilium longiflorum* (right).

bulblets from the nodes (Fig. 7). These bulblets are small and would take longer time to produce commercial size bulbs.

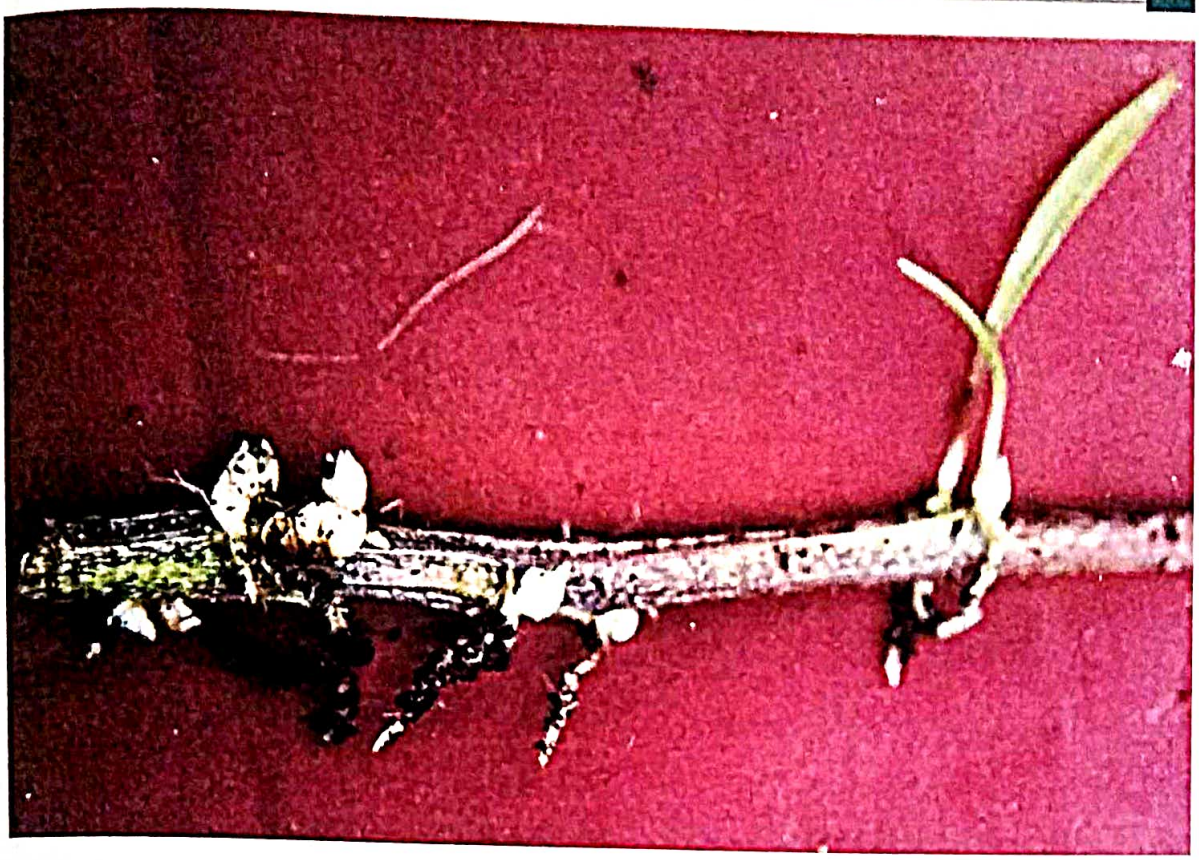

Fig. 7. Photograph showing bulblet produced from stem cuttings of Nove Cento (page12, bottom) and Brunello (top)

6.2.6 Bulb Scales

Propagation through bulb scales is the commercial method of propagation of lilies. The bulbs of lily are composed of many scales attached to the reduced stem (basal plate). When the scales are detached from the bulb and planted in suitable medium they produce bulblets. Planting of bulblets outdoor for two to three seasons produce commercial size bulbs. The steps involved in propagation of lilies through bulb scales are described below:

6.2.6.1 Removal of bulb scales

The clean, healthy, disease free bulbs are selected from the mother stock for removal of scales. The scales are detached very carefully in such a way that they retain tissues from the basal plate. The scales broken halfway fail to produce bulblets. The scales may be removed at any time of the year, however, just before planting or after flowering is the best time. The detached scales should washed in running water and soaked in fungicide (Bavistin 1.5 g/l) for 30 minutes. The scales are air dried in a shady place to get away with adhered water.

6.2.6.2 Potting media

Several potting media has been suggested for planting of bulb scales. These include vermiculite, peat, sawdust, cocopeat, combination of peat and perlite etc. We have found that sawdust of *Crytomeria japonica* is the best medium for planting of scales. It holds optimum moisture (50-60%) and provides sufficient porosity to develop the bulblets. The potting compost should be sterilised before planting of the scales.

In order to increase the size of the bulblet during scale propagation of *Lilium*, the potting mixture was enriched with N:P:K (10:10:10) and N:P:K (10:25:25) @ 5, 10, 20 g /l. The outer bulb scales of four cultivars namely Siberia, Voltage, Farfalla and Cocordia were planted and incubated for 13 weeks. The enrichment of potting mixture with fertilizer had no significant effect on bulblet number, bulblet weight and biomass/scale. It appears that bulblet weight, number and biomass are determined by the reserved food in the scales and roots formed on the bulblets play no role in absorption of nutrient from the medium.

6.2.6.3 Increasing regeneration ability

The reproductive ability of *Lilium* cultivars varies with genotype, position of scales on mother plant, temperature during incubation etc. The reproductive ability can be increased by treating scales with plant hormones like NAA and IBA. The concentration of plant growth hormone varies with cultivar. We have found that wounding of bulb scales increase the bulblet production. For this, the adaxial (inner) surface of bulb scales of *Lilium longiflorum* was wounded by different methods *viz.* streaking, pricking and slitting. The wounding of bulb scales increased number of bulblets per scale irrespective method of wounding. Out of various methods of wounding tested, the slitting of bulb scales at basal portion was found most effective for increasing number of bulblets per scale and producing the bulblets of uniform size. The mean number of bulblets in this method was increased to 3.79 per scale as compared to 1.93 in control (Fig. 8).

From the above wounding experiment it was found that basal cut was the best means to increase the bulblets during scaling. Hence, the base of the scale was cut at various lengths (2,4,6,& 8 mm) and width (2, 4,6 & 8 mm). The cuts 2x4 mm produced highest (8.95) bulblet/scale follwed by 2x2mm (7.53), 4x4 (7.41) and 2x6 and 2x8 mm7.06. The least number of bulblets (2.90) were obtained from 8x8 mm cut . It was concluded that slitting of scale base at 2x4, 4x4 or 4x2 mm is useful for increasing the bulblets/ scale (Fig. 9). The slitting at base is also helpful in developing uniform size bulblets as hydrolysed carbohydrates were equally distributed to the developing bulblets.

Fig. 8. Photograph showing effects of wounding , A-Control; B-Cut at all sides; C-Slitting at base; D-Longitudinal streaking (middle); E-Pricking at base; F-Pricking at all places; G-Transversal streaking; H-Longitudinal streaking

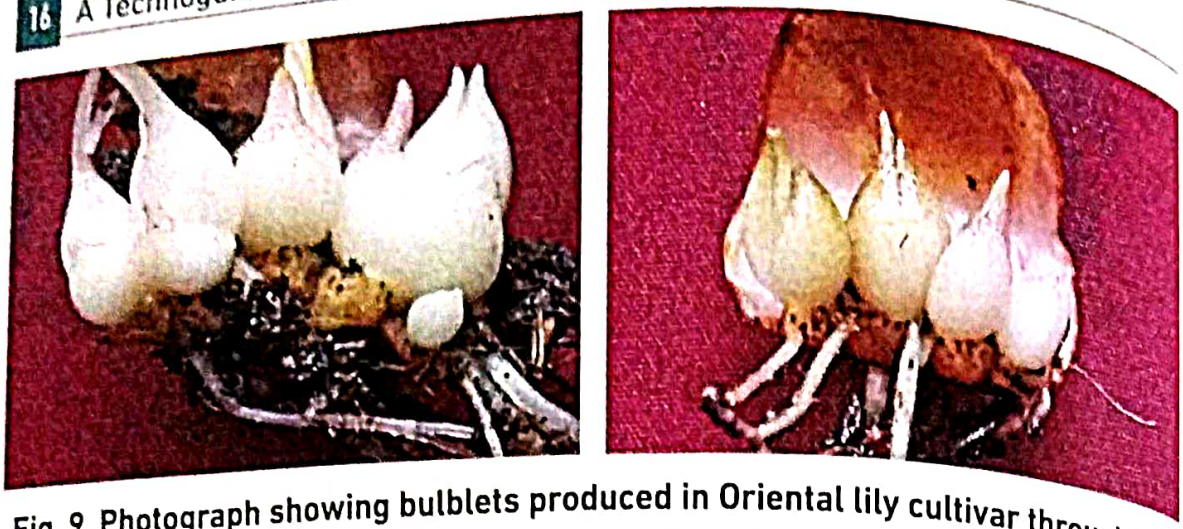

Fig. 9. Photograph showing bulblets produced in Oriental lily cultivar through 4x4 cm cuts on the basal portion of the scale

6.2.6.4 Planting scales

The bulb scales can be planted in the trays or in plastic crates lined with polyethylene sheets. The sterilised potting mixture is moistened (50-60%) and spread in a layer at the bottom. The scales are inserted half-way into potting mix and slightly pressed to keep them in their position. Hereafter, they are covered with moist potting mix. If these are to be planted in big perforated trays several layers of bulb scales can be placed one after the other (Fig. 10). The top of the tray is covered with the plastic and placed in cool place (18-21°C) for 11-14 weeks.

Fig. 10. Photograph showing planting of scales in plastic crate, placing of scales on sawdust (left) top layer of scales placed in the crate (right)

6.2.6.5 Harvesting

The bulblets are formed at the basal end of the scales. The bulblets at this stage have roots which might be interwoven. Separate the bullets carefully with roots intact. Removing roots adversely affect the growth of the bulblets. These are washed in running water, air dried and followed by dipping in fungicide (Captan 1.5 g/l), air drying, packing and storing.

6.2.7 Tissue Culture

Tissue culture technology brought a revolution to plant propagation industry. It is used to produce a large quantity of disease free planting material in a short span. The technology is also useful in production of virus-free plants. For production of virus-free plants, the mother stock is screened with ELISA (enzyme-linked immunosorbent assay) for common lily viruses. On detection, these are eliminated using meristem culture technique. Several chemical compounds have been tested for production of virus-free plants *in vitro*. The two chemical compounds, ribavirin and dithiouracil have been found promising to eradicate viruses from lilies. The tiny explant is grown on culture media supplemented with of these chemicals. The presence or absence of viruses is tested in the multiplying stock. The stock tested negative is multiplied further in large-scale and those carrying viruses are discarded. In lilies, bulb scales are the chief source of explants however, nodes, flower buds, leaves, embryos can also be employed. The bulb scales are washed in running water. They are then sterilized in sodium hypochlorite (5%) for 15-30 minutes, washed. The portion of scale, closer to basal plate, is cut into 5mm size and placed on medium aseptically. The culture bottles are incubated in dark at 21 ^{0}C. The bulblets are produced within few weeks of culture (Fig. 11).

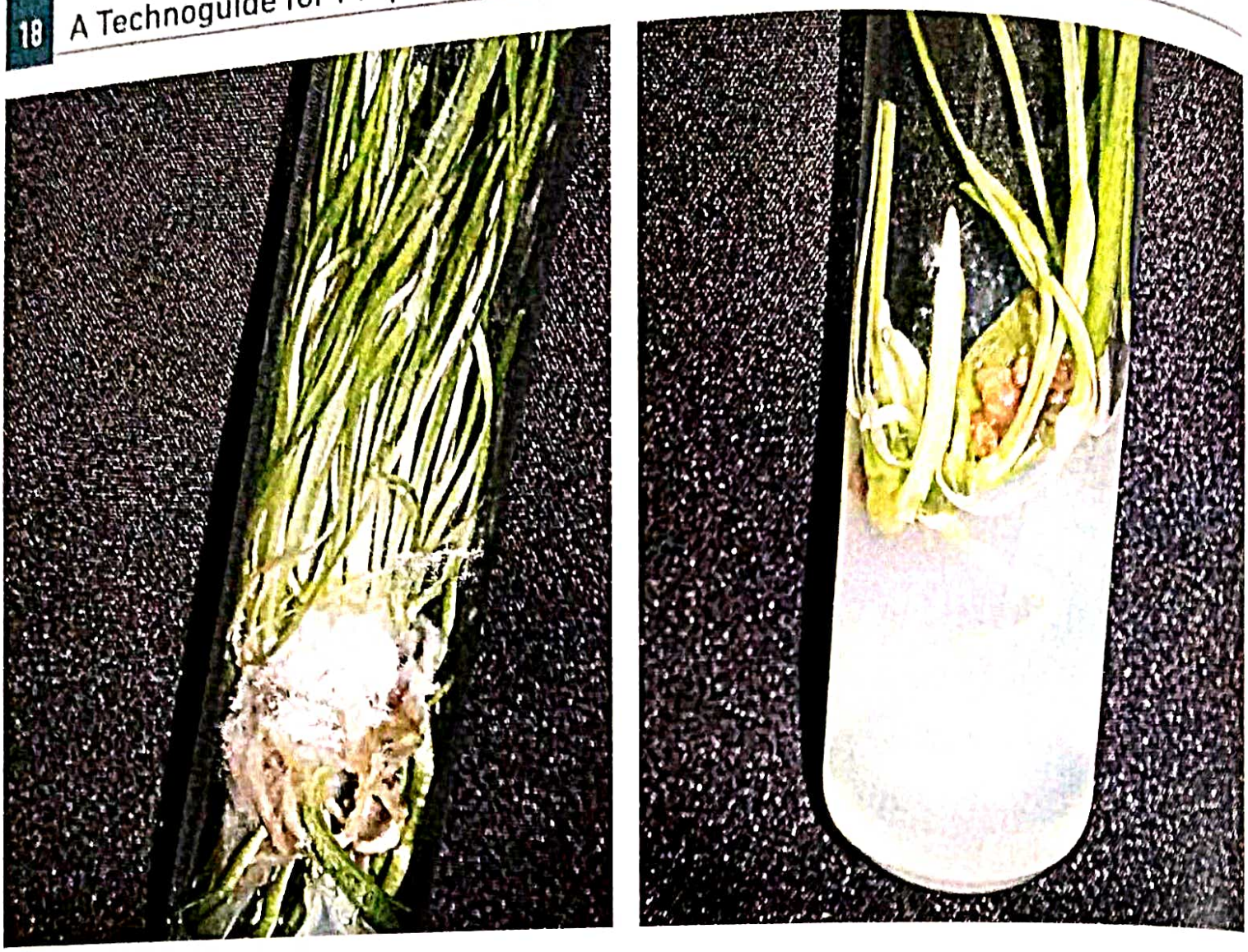

Fig. 11. Photograph showing plantlets raised from a portion of scale of two varieties of *Lilium*

7

Grading of Bulbs and Bulblets

Bulbs of lily are graded based on circumference. These are generally graded as 2-4, 4-6, 6-8, 8-10, 10-12 or >12 cm. The grading is done through the mechanical graders. For small-scale, the graders can be made from plastic or wooden trays (Fig. 12) and can be used for grading bulbs or bulblets. The bulbs having circumference greater than 10 cm are considered as commercial bulbs. Grading of bulblets also helps in uniform planting, breaking of dormancy and taking care during cultivation. The smaller bulblets have less chilling requirement, require close planting and more care during outdoor cultivation.

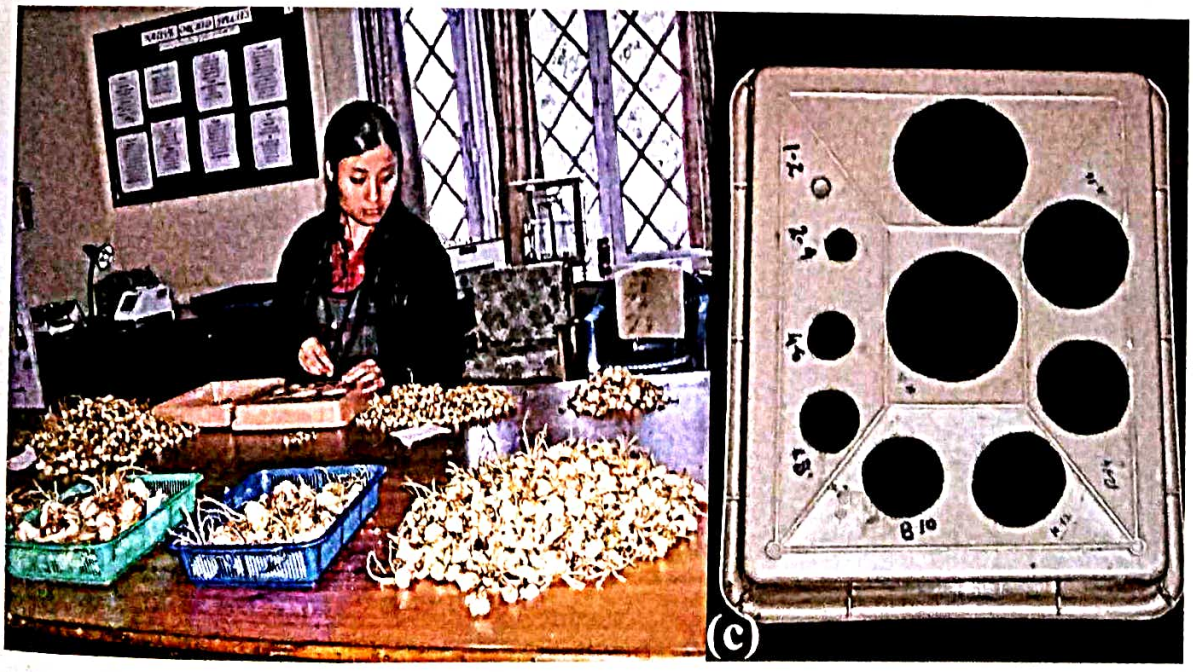

Fig. 12. Photograph showing grading of bulbs (left) using NRCO-Lily Grader (right)

8

Packing and Storage of Bulbs

After harvesting, the bulbs are washed, graded, packed and stored at -2 °C. Various medium has been suggested and used in packing of bulbs. These include sawdust, peat moss, argex granules etc. Peat moss is the common medium for packing of lily bulbs. We use moist sawdust of *Crypomeria japonica* (40-50 % moisture content) for packing of bulbs. The tray is lined with the plastic sheet and a layer of moist saw dust (approx 5 cm) is spread at the bottom. The lily bulbs are placed with nose up position (Fig. 13). The gaps are further filled with moist sawdust and in second layer the bulbs are placed with nose down position. It is repeated till the tray is filled. The tray is sealed with plastic and stored in cool place.

Fig. 13. Packaging of bulbs in plastic crate lined with polyethlene sheet.

9

Growing of Bulblets

9.1 Planting

Lilies are best suited in sandy loam soils. Asiatic lilies prefer soil pH in between 6 - 7 while Oriental hybrids like a little acidic soil (pH 5.5 – 6.5). The basal roots of bulblets penetrate up to a depth of 10 – 15 cm so dig the land up to a depth of 20-25 cm and remove stones / boulders to give the soil a fine tilth. Add well-decomposed cow dung manure/ leaf mould @ 1 cubic meter per 100-square meter. The excess salt concentrations have inhibitory effect on water absorption through the roots. In any case salt and chlorine concentration should not be more than 1.5 mS and 1.5 m mol/l. Excess salts may be removed by flooding the soil before planting. The bulblets should be planted on raised beds, approximately 1 meter width and having 45 cm paths between the two beds. The paths would facilitate the weeding operations and draining of excess water. The soil should be moist at the time of planting. The bulbs should be planted 5-7.5 cm deep to have at least 2 to 3 cm soil on top of bulb. These could be planted at 5x5cm or 7.5 x 7.5 cm distance. The places receiving excess sunlight may be covered with shade nets (Fig. 14).

9.2 Aftercare

9.2.1 Watering and Feeding

The soil should be kept constantly moist as the stem roots are formed in the top layer of soil. Too much water supply may affect oxygen supply, which is detrimental to developing roots. Watering should preferably be carried out in the

Fig. 14. Photograph showing bulblets growing under low height tunnels covered with 50% shade nets.

morning hours so that leaves can dry during the day. Lilies do not require feeding during first three weeks but after that they need to be fed properly to obtain good and healthy bulbs. The feeding can be carried out by dissolving NPK 10:20:20 or 10:25:25 @ 1g/l at weekly interval.

10

Disease and Pest Management

10.1 Disease Management

10.1.1 Blue mould

This disease is caused by *Penicillium* sp. and transmitted during storage when the fungus penetrates the bulb tissues through the wounds. Lily bulbs have high sugar content and bruising or mechanical injury can accelerate the growth of *Penicillium* mould on the wounds. During storage, diseased areas are covered with a white and later on with a fluffy, bluish green fungus visible on the scales (Fig. 15). The disease gradually increases during storage even when the temperature is very low (-2°C). The infection can eventually penetrate the basal plate making them unfit for cultivation. In some cases, the infected bulbs can continue to grow as long as the basal plate doesn't get affected. The infection is not transmitted to the stem and rarely affects the aerial part of the plant. Bulbs should be stored at the lowest recommended temperature and desiccation of the bulbs should be avoided.

10.1.2 Basal rot

Bulb and scale rot and *Fusarium* stem rot disease are caused by both *Fusarium oxysporum* and *Cylindrocarpon destructans*. These fungi infect the underground parts where wounds occur as a result of splitting of bulbs or stem roots parasite infestation. Plants having bulb and scale rot will be retarded in growth. The

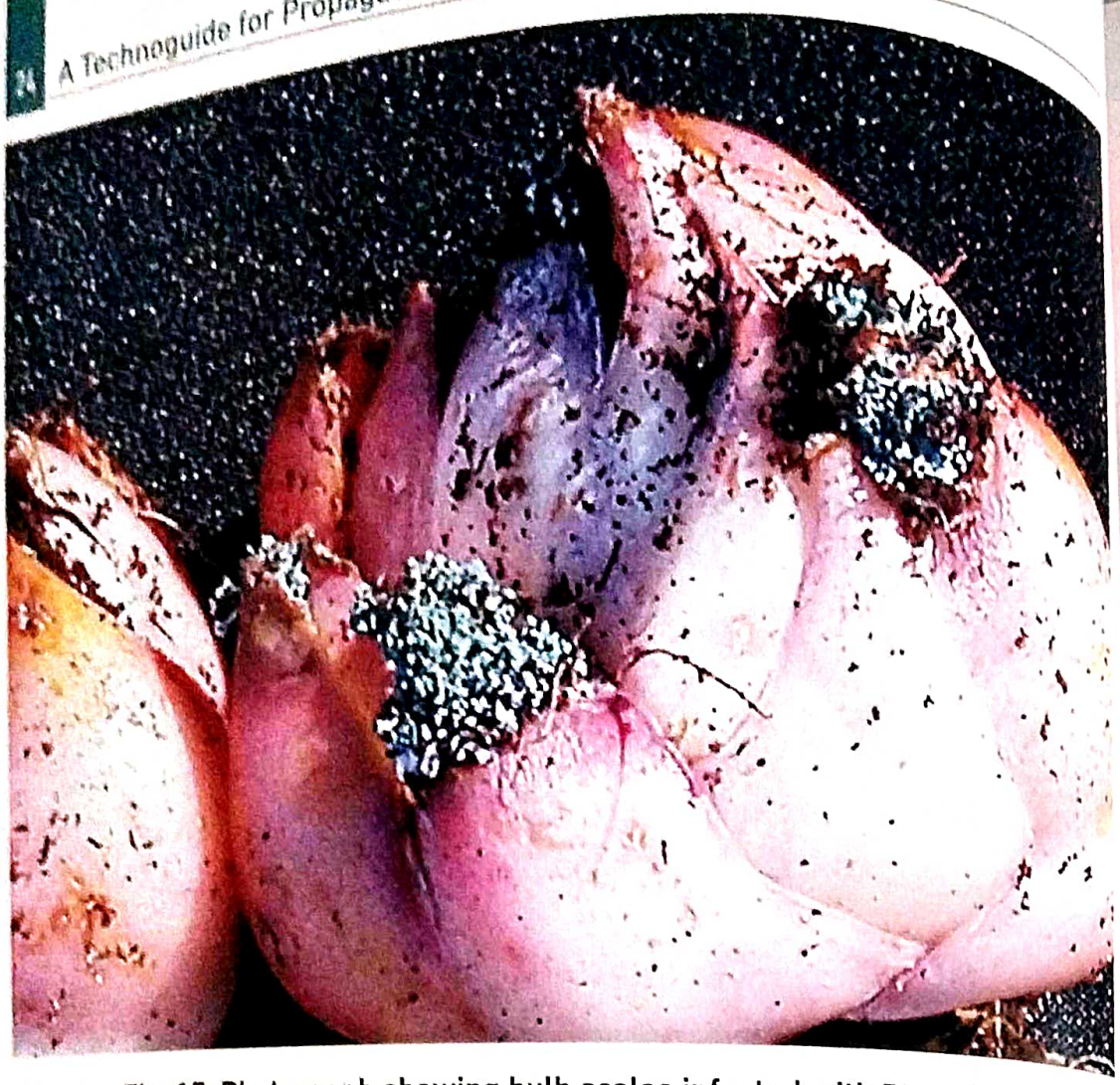

Fig. 15. Photograph showing bulb scales infected with Blue Mold

foliage will be pale green in colour. Brown spots appear on the top and sides of the bulb scales or at the junction of the bulb scales with the basal plate. Bulb rot is developed when the basal plate and the scales are infected at the base (Fig. 16). In case of *Fusarium* stem rot disease, the visual symptoms include premature yellowing of leaves, which turn brown and drop off. Orange to dark brown spots appear on the underground part of the stem, which later become enlarged and spread to the internal part of the stem. This eventually leads to rotting of the plant tissue and ultimately death of the plant.

10.1.3 Botrytis

Botrytis is a fungal disease caused by *Botrytis elliptica* under excessive moisture and warm weather. The first visual symptoms are circular or oval and yellowish to dark brown spots having a diameter of 1-2 mm on the leaves. In moist conditions, they can quickly develop into larger, round or oval, sharply defined

Fig. 16. Bulbs of Asiatic lily showing symptoms of with Basal Rot disease

spots visible on both sides of the leaf. In severe cases, the whole leaf and stem can become infected resulting in death and decay of whole plant. The infection can start in the middle of the leaf blade but also at the edge causing a deformed growth. Stems are also affected at times and the leaves are shed from the site of infection. Flower buds, when infected, rot completely or show deformed growth. During the initial stages of infection, raised areas appear on the outer petals. Opened flowers are particularly susceptible to infection that is characterized by the appearance of grey, watery, round spots known as 'fire' spots. In moist conditions, spores develop and are spread by the wind and rain to the neighbouring plants. Spores do not germinate on the dry plant and therefore do not get infected. This disease can be controlled by spraying 2% Bordeaux mixture. Spraying with suitable fungicides *viz.* captan, thiram and dithiocarbamate during moist conditions when an infection is suspected and also before flowering helps in preventing the disease.

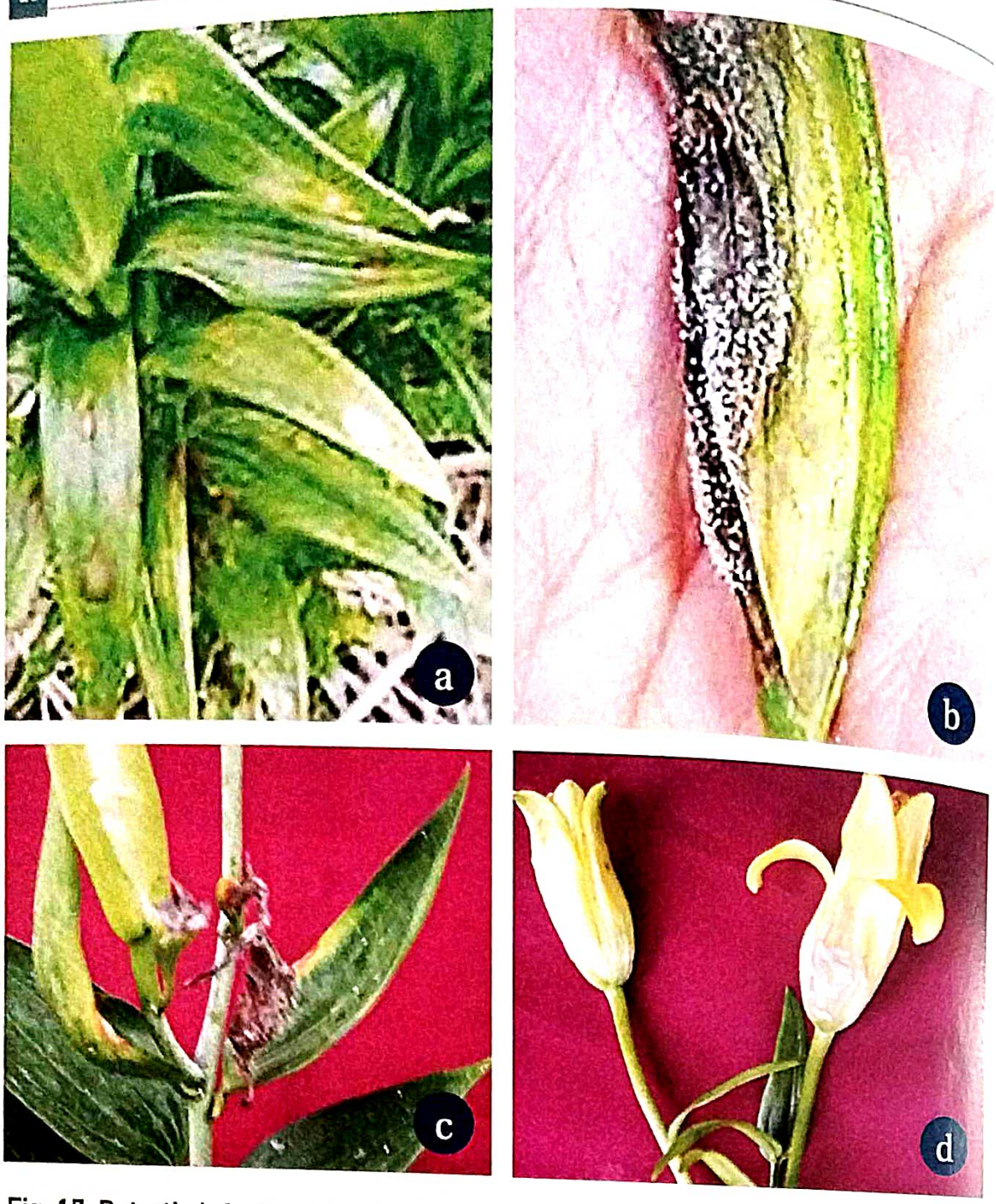

Fig. 17. Botrytis infection symptom on (a) leaves of Asiatic lily (b) spores on leaves (c) leaves of Oriental lily, and ((d) flowers of Asiatic lily

10.1.4 Foot rot

Foot rot is caused by the fungus *Phytophthora* sp. which attacks portion of the stem just below the surface of the soil. The disease is prevalent in soils after the cultivation of tomatoes and gerbera and can survive in moist soils for a number of years. Soils having high moisture and temperatures above 20°C are suitable for disease incidence. Infected parts become shunken and plants wither and die but

the bulbs are usually not damaged. Plants show retarded growth or wilt suddenly. The stem base is infected with soft rot and is dark green to dark brown in colour, spreading upwards. The leaves become yellow and start to discolour at the base of the stem. A similar soft rot infection often occurs in the part of the stem above the ground causing the stem to topple or bend. The soil should be sterilized and pretreated with suitable fungicides before planting.

10.1.5 Root rot

This disease is associated with poor drainage and lack of soil aeration. Cultivation in heavy clay soils retard the aeration and store excess water which is unfavourable for the growth of the bulbs. Lilies should be grown in light textured soil which are less water retentive and dry away quickly. Lily roots require plenty of oxygen for their proper growth.

10.1.6 Viral diseases

Lily symptomless virus (LSV), Cucumber mosaic virus (CMV), Lily mottle virus (LMoV), Lily virus X (LVX), Arabis Mosaic virus (ArMV), Tobacco ring spot virus Narcissus mosaic virus, Strawberry latent ring spot virus (SLRSV), Tobacco ratlle virus (TRV) are some of the viruses reported to affect *Lilium*. Symptoms of viral infection include foliar mosaic (bright to faint yellow mottling and streaking), rings (dark or yellow), abnormal flower size, colour breaking, stunting of random plants and distorted leaves (Fig. 18).

10.2 Pest Management

10.2.1 Aphids

Aphids are serious pest of lilies. They suck sap from young shoots and flower buds. They transmit viral diseases by feeding on diseased plant and then moving onto healthy plant. They excrete large quantities of sugar rich honey dew on which sooty mould fungus may grow. Lady bugs are useful agents for controlling for aphids and can be brought and released in the field.

Fig. 18. Photograph showing mosaic symptoms on leaves (top left), mottling of leaves (top right), and colour breaking of flower (bottom right)

Fig. 19. Photograph showing aphid infestation on leaves (left) flower buds (right)

10.2.2 Slugs

Slugs cause damage by feeding on new shoots. The population of slugs can be reduced by placing beer in shallow containers close to lily plants. Shallow inter culture operation controls the snails by exposing the eggs which are eaten by birds or die due to frost injury. Controlling weeds also reduces its population in the field.

10.2.3 Thrips

Thrips (*Liothrips vaneeckei* and *Taeniothrips simplex*) scar the lily foliage as they feed on the underlying cells by piercing them with their mouth parts and sucking out the sap. This causes deformation of flowers, leaves and shoots. As the infected leaves expand they often exhibit silvery streaking and flecking. Thrips often deposit tiny greenish black fecal specks on leaves as they feed. Plants grown from infested bulbs are stunted in appearance.

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Technology Dessemination

For disseminating the technology of *Lilium* bulb production 120 farmers were trained. These farmers learned (i) what are various methods of propagating lilies (ii) how and when to remove the bulb scales (iii) how to plant them (iv) how to take care of regenerated bulblets and bringing up to a commercial stage (vi) pest and disease attack on bulbs (vii) how to harvest and store them for future use. Each trainee farmer was given 100 bubllets as material to work with so that they can brush up their lessons learnt during training. Apart from trainee farmers 13 farmers were chosen and each was given 500 bulblets of 4-5 cultivars of Lilium under Farmers' Participatory Programme of the Centre.

Fig. 20. Trainee farmers learn scaling technique for propgation of Lilium NRCODC

Fig. 21. Trainee farmers are learning about planting of bulb scales of *Lilium*

Fig. 22. Distribution of plantlets of *Lilium* to the trainee farmers by by Director, NRCO and Dr. N.K. Tyagi, Member ASRB

Fig. 23. District Horticulture Officer, Darjeeling distributes *Lilium* bulblets to farmers of Darjeeling

Fig. 24. Farmers of 'Farmer Participatory Programme' on *Lilium* Cultivation.

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