Unit 2

Cultivation of Commercial Flower Crops–II

The aesthetic, social, and economic aspects of flowers, which got due attention in the second half of 20th century, directly influence humankind and human environment.

The offering and exchange of flowers on all social occasions of joy and sorrow, for adorning hair by womenfolk in different parts of the country, for home decoration and worshipping, is now becoming a standard practice for Indian society. Cultivation of flowers plays an important role in environmental planning of urban and rural areas for overcoming pollution, social and rural forestry, wasteland development, as well as outdoor and indoor landscaping. Its cultivation provides higher income, even from comparatively smaller areas with higher profitability than other crops. However, the advanced floriculture technology is capital intensive in view of the high cost of protected structures. Its cultivation generates gainful employment for women and other unemployed youths in sub-urban and rural areas.

On commercial level, in the Indian floriculture sector, the cultivation of various flowers has emerged as a profitable agribusiness in both domestic and export market. Apart from fresh flowers and live plants, the floriculture industry deals even with dry flowers and

value-added products such as bouquets, floral baskets, flower arrangement, garlands, and pot-pourris.

Loose flowers, *viz.*, rose, marigold, annual chrysanthemum, gaillardia, jasmine, barleria, crossandra, etc., have occupied more than 60 per cent of the area of flower cultivation. Selection of flower crops and its variety for commercial cultivation should be proper as per the soil, climatic condition, available resources, market demand cum consumer choice, and availability. Crop growth, flower yield, and quality are directly proportionate to the good management practices. Good agricultural practices (GAP), *viz.*, precise land preparation, raising of seedlings in protected condition, planting on raised and 'broad bed and furrow system', mulching, using of drip irrigation (per drop more crop), fertigation, soil-test-based fertiliser application, integrated pest management, and proper post harvest management ensure quality produce. These practices also reduce the cost of flower cultivation and maximise the profit of cultivators.

Session 1: Cultivation of Rose

Botanical name: *Rosa hybrida*

Family: Rosaceae

Roses are older than the human race on this earth and native to the temperate zone of the northern hemisphere, with a few species occurring even in the sub-temperate, sub-tropical, and tropical areas. It has hardly 120 species, out of which some 11 species are native to India. It is found in various sizes, shapes, and colours, and is globally known as 'Queen of the Flowers'. There are many species whose flowers are mildly to highly fragrant. It bears the most beautiful flowers, used in bouquets, as cut flowers, loose flowers and for preparing 'rose scents'. It can be grown as a pot plant, hedge, specimen plant, for making standards and sub-standards, as shrubs and climbers. Flowers are also used for the extraction of essential oil, for preparing *pankhuri* (petals), and for making conserves, rose vinegar, rose petal wine, jam, jellies, syrup, pot-pourri,

rose water, and *gulkand*. Its hips contain three times more ascorbic acid than that in oranges and about seven times more than tomatoes (Fig. 2.1).

Fig. 2.1: Rose

Major Rose Types

Modern roses

They have a complicated classification. Many of the modern roses have old garden roses in their ancestry with too much variation in their forms, and the classification is also based on the growth and flowering characteristics such as large-flowered bush (Hybrid Tea); cluster-flowered bush (Floribunda); dwarf cluster-flowered bush (Patio rose); miniature; ground-cover recurrent and non-recurrent; climbers and ramblers; and shrubs but commercially only four groups are recognised, that is, (i) cut flowers, (ii) miniature potted flowering holiday plants grown from stem cuttings, (iii) flowering pot-plants produced from bare-root plants, and (iv) potted garden plants produced from bare-root plants.

Hybrid Tea (HT)

It is the successor to the Hybrid Perpetual which possesses free-blooming habit. It has a long flowering season from June to October in the temperate regions and from December to April in the plains of tropical

and subtropical regions. It is the most popular type of usually vigorous, 75–180 cm tall, long, and strong-stemmed and solitary but nearly always double-flowered roses. It is most suitable for growing in greenhouses as cut flowers. Hybrid tea flowers almost continuously throughout the season, bearing large long-pointed buds having well-formed flowers which are attractive with almost all the colours, symmetrical, and mostly fragrant. They are susceptible to cool temperature so they require winter protection in areas experiencing severe cold during winter. The most popular varieties are Aalsmeer Gold, Abhisarika, Ace of Hearts, Alinka, Ambiance, Angelique, Belami, Blue Moon, Bulls Red, Cabaret, Calico, Century Two, Dr. Bharat Ram, Double Delight, Elegance, Elina, Escada, First Prize, First Red, Garden Party, Gladiator, Golden Gate, Golden Time, Grand Gala, Happiness, Happy Days, Lambada, Montezuma, Noblesse, Olympiad, Paradise, Pasadena, Pavarotti, Pink Supreme, Pusa Bahadur, Pusa Garima, Pusa Gaurav, Pusa Priya, Queen Elizabeth, Ravel, Saphir, Signora, Super Star, Teneke, Vivaldi, etc.

Floribunda

This rose has been derived basically from crosses between the Dwarf Polyantha and early HT roses. It grows up to 120 cm tall having more branched stems with variably prickly and hooked thorns than HT. Abundant flowers appear in clusters, bearing single to double flowers, with the plant type and flower colour similar to HTs though flower size may be smaller. Due to their profuse blooming and moderate maintenance, they are becoming more popular for mass planting in the landscaping and as cut flower. Varieties included in this type are Allgold, Angel Face, Anna Wheatcroft, Anne Harkness, Arabian Nights, Banjaran, Belinda, French Lace, Himroz, Impatient, Ivory, Iceberg, Fashion, Magic Red, Mercedez, Noorjahan, Pusa Barahmasi, Pusa Pitamber, Queen Elizabeth, Playboy, Playgirl, Sexy Rexy, etc.

Grandiflora

This is the result of crossing HTs with floribunda, attaining the plant height up to 180 cm. It produces

small clusters of large flowers more freely compared to HTs though less than floribundas. It is suitable for landscape planting, background ornamentals, and cut flowers. A few of its popular varieties are Candelabra, Caribbean, Centennial, Crimson Bouquet, New Year, Glowing Peace, Gold Medal, Love, Queen Elizabeth, etc.

Polyantha

This is a low-growing cum cold-hardy rose bearing large-clustered though smaller flowers than those of grandiflora and is excellent for mass planting, *vis-a-vis* edging. Some of the popular varieties are Anjani, Bonica, Cecile Brunner, May Wonder, Nartaki, Priti, Pusa Baramasi, Pusa Pitambar, Pusa Virangana, Rashmi, Rosa 'de Rescht', Rose du Roi, Swati, The Fairy, etc.

Miniatures

These are dwarf with high branching habit, deciduous, almost thornless, and hardy roses growing on their own roots, bearing quite little leaves and small flowers but during flowering the plants are fully adorned with blooms. These have derived from the dwarf semi-double China rose (*Rosa chinensis*). These are grown through cuttings always, as budding on to rootstocks may lose its dwarfism. These are excellent for container planting, in the rock garden, for patios, edging, in the borders, in deep window boxes and as small standards. Its leaves are mid-green with five to seven ovate and toothed leaflets. Small-clustered flowers appearing in June and July are semi-double or double with usually repeat flowering. These are of two types—those growing 30–38 cm high such as Baby Faurax, Baby Gold Star, Baby Masquerade, Coralin, Eleanor, Little Flirt, Perla de Alcanada (syn. Baby Crimson), Rosina (syn. Josephine Wheatcroft), Roulettii, Yellow Doll, etc., and other growing only up to 20–25 cm high such as Cinderella, Maid Marion, New Penny, Peon, Pixie (Little Princess), etc., so both the groups should be maintained separately. There are some climbing miniatures growing up to 1.8 m in height which make handsome specimens in the small gardens. Such roses are Magic Wand, Pink Cameo, Pompon de Paris, Showoff, etc. A few of the other noteworthy

miniatures are Aristocrat, Autumn Dawn, Black Jade, Child's Play, Creampuff, Delhi Starlet, Dreamglo, Fancy Pants, Golden Angel, Good Morning America, Honey Comb, Jean Kennedy, Kristen, Minnie Pearl, Mother's Love, My Valentine, Party Girl, Red Beauty, Santa Claus, Snow Bride, Twinkle Twinkle, etc.

Classification of Roses According to Utility

Prostrate roses

These are a small group of hardy deciduous plants with a short flowering season. These form the low hummocks or mats and make a dense cover so are quite useful for planting on the banks and on the old tree stumps. Some of the most popular varieties are *Rosa luciae wichuraiana*, 'Max Graf', 'Raubritter', etc.

Hedge roses

These are a group of roses quite suitable for planting either on a boundary or at a corner of the garden in the form of informal hedges. These are planted at usual spacing but to keep these in proper shape, these are pruned lightly. All the compact Floribundas are excellent for hedging and these are Chinatown, Dainty Maid, Frensham, Iceberg, Masquerade, Shepherd's Delight, etc. Among the old shrub roses, the Hybrid musks are quick spreading but make excellent hedges, such as Cornelia and Penelope. From the modern shrubs, Heidelberg and Queen Elizabeth (requiring regular shaping) are the best.

Shrub roses

These are strong, hardy, variably thorny or bristly deciduous hybrids chiefly between the species and old roses. These bear glossy pale to mid-green leaves with 5–7 ovate and toothed leaflets. Flowers are single or semi-double, some being fragrant, and borne as solitary or in small clusters. These grow up to 1.5 m in height and are suitable for hedging, for planting on the back of the herbaceous borders, among other shrubs and as specimen plants. Some of the popular varieties are Constance Spry, Fred Loads, Fritz Nobis,

Fruhlingsmorgen, Golden Chersonese, Golden Wings, Heidelberg, Iceberg, Joseph's Coat, Kassel, Munster, Uncle Walter, Wilhelm, Will Scarlet, etc.

Standard or tree rose

This is a man-made rose created by grafting a bush rose on a tall, sturdy and upright-growing rose plant so that it may mimic a small tree form, that is from 90 to 180 cm. Such plants provide a spectacular scene.

Weeping standards

These are made by grafting the climbers on usual rootstocks, as these grow into weeping standard roses, spreading out its branches to all the sides in cascading form. In fact, ramblers budded on a 1.2–1.8 m high stem of *Rosa canina* or *Rosa rugosa* require stakes, so the trailing stems droop to the ground as a floral skirt. These look quite spectacular when trained on an umbrella-shaped wire frame. A few varieties for the purpose are Alberic Barbier, Albertine, Crimson Shower, Emily Gray, Excelsa, Dorothy Perkins, etc.

Climbers and ramblers

These include a vast range of ascending and scrambling roses. These are normally quite vigorous plants with long spreading branches requiring support of the fence or trellis for upright and horizontal growth. Derived from roses species, these are exceptionally vigorous and quite suitable for growing on old trees and for clothing house walls with their large flower clusters for a short duration of maximum two months. Derived from Noisette roses and HTs, these are less vigorous so most suitable for growing over pillars, arbours, walls, pergolas, fences, and screens.

Ramblers are derived from *Rosa lucinae,* and are vigorous but supple-stemmed, so suitable for confined areas such as arbours, pergolas, and pillars. Climbers and ramblers may grow on their own roots or be grafted on some suitable rootstocks. Their flowering period is not as long as the HTs, but when in bloom, normally all the buds open within a few days covering the entire plant immensely. The common climbers and ramblers

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are Albertine, Blush Noisette, Caroline Testout, Casino, Chaplin's Pink Climber, Crimson Glory, Crimson Shower, Cupid, Danse du Feu, Dorothy Perkins, Dynamite, Elegance, Enna Harkness, Etoile de Hollande, Golden Showers, Marie Gouchaoult, Marechal Neil, Mermaid, New Dawn, School Girl, Summer Snow, Veilchenblau, etc.

Climate

Rose is a day neutral plant for flower initiation, and duration of light does not affect flowering. However, though for vegetative growth, it is a sun-loving plant, as during winter it requires bright sunshine at least for six hours daily and free ventilation. Temperature requirement is 24°–27°C during the daytime and 15°–17°C during night hours, that is optimum being 15°–27°C with 75 per cent relative humidity.

Soil

It has wide adaptability to soils. Deep sandy-loam with a pH range of 5.5 to 7.5 is the best soil. pH below 5.5 or above 7.5 is not congenial for growing rose. Salt-affected soils are not at all suitable for its growth. Those soils which are porous, light, water-retentive but not waterlogged and have sufficient organic matter are quite suitable for its growth. Very heavy and clayey soils can be improved through the addition of farmyard manure, coarse sand and gravel, however, the soils having a high water table should be avoided for growing rose. Alkaline soils can be improved through incorporation of organic materials.

Bed preparation

The bed preparation for rose planting should start well ahead of planting, that is, before monsoon so that applied farmyard manure or compost at 50 tonnes per hectare is well mixed and decomposed in the soil. Soil is ploughed at least thrice to a depth of 40 cm; after each ploughing the weeds, stubbles, polythene shreds and hard objects such as pieces of bricks, stones, etc., should be taken out and then planked. Third ploughing followed by planking is carried out during October, and

then beds are prepared by laying out irrigation channels and bunds.

Propagation

Roses can be propagated through seeds, cuttings, grafting, budding, and micro-propagation but commercially only through 'T' (or inverted 'T') or shield budding on appropriate rootstocks.

Seed

It is usually adopted for evolving the new cultivars, so that is the subject of the rose breeders and not of the rose growers or amateurs.

Root cuttings

Rosa blanda, Rosa nitida, and *Rosa virginiana* can be propagated even through root cuttings but usually this is not in practice.

Suckers

Own-rooting roses such as cultivars of *Rosa pimpinellifolia* and *Rosa rugosa* produce suckers, which after rooting, can be separated at the dormant stage and planted as separate plants.

Stem cuttings

Rootstocks, climbers, ramblers, polyanthas, miniatures, and all the species of rose are propagated through stem cuttings. It takes about three years to bloom from cuttings. Miniatures start flowering the same year when propagated by cutting.

Cuttings taken during the monsoon season and treated with 500–2000 ppm of IBA solution root very well. The length of softwood cuttings is roughly 10–15 cm, about 20–25 cm of hardwood cuttings and some 5–10 cm of miniatures. The cuttings should have at least three nodes, lower leaves should be removed, and one-third of the cutting should be inserted in the slanting position in the rooting medium with slanting cut to the lower side. To avoid damping off caused by *Cylindrocladium scoparium*, it is necessary to sterilise the medium.

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'T' or shield budding

Commercially, roses are propagated through 'T', inverted 'T', or shield budding as these are most popular and successful methods for rose multiplication at large scale. Best budding time in North India is from January to March, but in areas with mild climate it can be performed throughout the year. In temperate areas, the best time for budding is from mid to late summer when there is ample atmospheric humidity. In 'T' budding, the bud is inserted into a T-shaped incision on the rootstock made 7–10 cm above the ground level and tied with polythene strips. It takes 3–4 weeks for the buds to unite if temperature of the environment is 15–25°C. Original shoot is cut back 20–25 cm above the graft union after growth of the bud and emergence of new shoots.

Micropropagation

Explants taken from terminal buds, immature floral buds, and petals can be used for micropropagation. Surface sterilisation of axillary buds with 15% $HgCl_2$ for 15 minutes, then BAP 2 mg/l + 2, 4-D 1 mg/l for culture establishment, BAP 2 mg/l + GA_3 1 mg/l for shoot proliferation, and the full strength MS supplemented with 2 mg/l. IAA can be used for maximum rooting when culturing the rose plants through micropropagation, though there may be a slight difference from variety to variety.

Planting

Budded plants are planted at a suitable spacing in such a way that bud union remains 2.5–5.0 cm above the soil level. Planting should immediately be followed by thorough watering so that roots are properly settled. Planting should be carried out during October–December in South India, from October to February in the North Indian plains and Eastern India, and throughout the year in areas with mild climatic conditions. Planting in the temperate areas is done during autumn and spring.

Spacing

Miniatures are planted at 30 × 30 cm, HTs and Floribundas at 45 × 45 cm and 45 × 30 cm, and climbing roses at 1.0 m distance. Quite vigorous shrubs are planted at 75 × 75 cm and 60 × 60 cm. In polyhouses, the plant density maintained for cut flower production, is normally 7 plants/m^2 area with drip irrigation.

Nutrition

Usually, Indian soils are not deficient in potash, therefore, before the application of fertiliser, it is must to analyse the soil so that the nutrition may be applied appropriately for harvesting a good crop. As per general recommendations, for growing rose cv. 'Super Star' under open field conditions at Delhi, it should be done with 520:868:694 kg NPK/ha/year, for high density planting (30 × 30 cm). Half of the nitrogen and full doses of phosphorus and potash are supplied before planting and mixed thoroughly in the soil while the remaining dose of nitrogen can be applied after pruning, when the plants have started new growth, followed by watering.

Under protected cultivation, only liquid fertilisers are applied through manual or automated system called fertigation. Nitrogen [5:1 (nitrate: ammonium) in summer, and 10:1 in winter when soil or water has high pH] at 150–200 ppm is recommended.

Irrigation

Normally, a well grown rose plant requires 8–10 litres of water per square meter area. At no time the plants should be water-stressed, as the stress at the stage of leaf primordium formation delays the rose production cycle without disturbing the quality of the blooms. But the stress at the petal initiation stage reduces the floral bud length and number of well-formed petals, though stress before stamen initiation is most devastating as flower production may be reduced up to 70%. Irrigation intervals depend on the type of soil and season. During summer, the crop requires frequent irrigation at an interval of 4–6 days, while the crop can be irrigated after 8–10 days during winter. During rainy season, irrigate the crop if there is a long dry spell.

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Special Practices for Quality Produce and Maximum Yield of Flowers

Pruning

It is the most important practice for improving floral quality and its production. This starts right from planting so that if any root is broken, that is reduced along with the cane size, leaving only 3–4 dormant axillary buds, and after start of the new growth, a 'soft pinch' is carried out of the shoots below the second 5-leaflet shoot when floral buds are smaller than pea-size, and the 'hard pinch' when its floral bud size is larger than a pea-size. Pinching structures the plant in proper architectural form for producing quality blooms. Third pruning is carried out at flower harvesting time when one, two or three nodes on the stem are to be retained or removed just below the knuckle so that flowers with long stalks are produced. Fourth pruning is carried out 4–5 weeks prior to the requirement of the flowers, and the fifth pruning is drastic which is carried out when plants have finished flowering and this way the plant height, commensurate to the variety, may be maintained from 45–90 cm, and this is known as regular annual pruning. Annual pruning revitalises the plants before start of the new flush.

Hybrid Teas

These are subjected to hard pruning to induce taller and sturdy shoots, and in this case 3–5 shoots, each with 4–5 nodes or leaves are retained, the bud of the last node facing outward. Floribundas and Polyanthas are also hard-pruned retaining 5–7 branches, each with 1–2 buds, the uppermost facing outward so that these may produce precocious flowering in clusters on shorter stems for a longer duration at different heights. Standard roses require the pruning conforming to the varieties budded onto these, first year hard pruning but subsequently only moderate to induce plenty of blooms. Climbers and Miniatures usually do not require any pruning and if need be, the unwanted part is removed with the help of scissors just to keep the plants in proper shape. In case of Ramblers, after flowering the first year,

the plants are cut back above 30 cm height, the new shoots above 30 cm length in the second year, and so on, as these bear good flowers till the last year's growth. In any case, every cut portion is pasted with Bordeaux mixture or Blitox paste. Before sprouting of the buds, an effective pesticide should be sprayed. The fertiliser should be applied only after three weeks of pruning. However, the faded flowers are regularly removed for a better look of the garden.

Bending

It is a modification of pruning to induce more floral shoots with longer stems in case of cut flower varieties grown under protection. Here, the shoots are bent as and when required, which apart from inducing more floral buds, also maintains the height of the plant at a convenient level.

Wintering

It is a practice in open-field-grown roses where 10–15 days before the annual pruning, the soil around the plants in the periphery of 20–30 cm is dug out 10–15 cm deep to expose the weak, diseased, and infested roots, and also to expose the insect-pests present there, if any, so that these are picked up by the birds and other creatures. Exposure to sun also kills certain pathogens. Exposure of weak roots may further weaken the shoots which are cut back while pruning and plants are properly shaped, and then these are watered for recovery and to initiate new growth, however, fertilisers should be applied only after three weeks of the pruning exercise.

Desuckering

This is the removal of offshoots (suckers) arising from the basal portion of the plant. Suckers try to establish themselves parallel to the main plant and share the same nutrients, space, light, moisture (soil and atmospheric), and ventilation. This affects the vigour of the main plant. Therefore, these should be removed as soon as these emerge. Since this emerges from the base, thus it is a part of the rootstock, which grows quite vigorously and as it is of no use, so its removal is always beneficial to the main plant.

Intercultural Operations

Mulching

It is the covering of the exposed surface area of the beds with black polythene or one of the organic materials to avoid direct contact of sunlight with the soil, and hence, preventing evaporation. Mulching conserves soil moisture as well as checks growth of the weeds. It also enriches the soil with organic material and in the long run, it provides humus to the soil, and maintains a uniform level of soil temperature throughout the field, which ultimately results into healthy plants and good flowering. The thickness of mulch should be 5–10 cm and material used maybe sawdust, rice husks, groundnut husks, dried leaves, chopped straw, grass and bagasse and various other waste organic farm produce. Though, polythene works for up to three years but does not supply organic matter to the field, while organic mulches gradually decomposes and supplies nutrients to the plants. Though it may take a few years, however, continuous use helps in improving the soil texture and structure continuously.

Weeding

Weeds are a nuisance in the field. These being normally fast-growers, rob the plants of their nutrients, water (soil moisture), sunlight, ventilation, and harbour various insect-pests and pathogens, which are harmful to the major crop. If these are not controlled timely and effectively, the crop may fail utterly. Since roses are perennial plants, so these encounter all sorts of weeds whether it is summer or winter. Since manually it is very expensive, so Simazine or 3-phenyl carbamate can be used effectively to eradicate the weeds in the rose field without any ill-effect on rose plants.

Staking

In open field cultivation, the plants may be supported individually with strong stakes fastened with the plants to keep them straight even during strong winds. Staking

at the initial stage of standards is very necessary. In case of protected cultivation, the posts may be erected at 3 metre intervals on both sides of the beds, and along the bed sides, galvanised wire or jute strings are tied with the posts at 30–40 cm intervals which will support the plants.

Growth and flowering

Commercial cultivars, being grown at a definite temperature range to harvest the flowers throughout the year, have no dormancy as these are recurrent and day-neutral, especially the glasshouse roses, though open field grown roses have both the types— recurrent and non-recurrent. However, CO_2 concentration in the greenhouses, irradiance, and temperature influence rose growth and development as low day temperatures of $\leq 17^{o}C$ and low night temperatures of $\leq 14^{o}C$ produce the greatest stem diameter and delayed flowering, however, increased irradiance increases the quality of floral stalk and growth rate. During winter, when the light is utterly poor, roses are provided with supplemental lighting for proper growth and development and for this, high pressure sodium lamps (HPS) at 300–1000 foot-candle (fc) for 8–24 hours/day (depending upon the cultivars, season and intensity) are provided. To stimulate axillary bud development and adventitious shoots from stem bases, the rose plants are subjected to 2–4°C temperature for 4–6 weeks.

Harvesting

Flower stems are harvested at the tight bud stage after unfurling of 1–2 petals, as earlier harvesting may cause bent-neck of stems. One flower may last from 6 to 13 days in a vase with water indoors, depending upon the varieties chosen, prevailing climatic conditions, and postharvest treatments. Immediately after cutting, the cut ends are placed in a bucket filled with distilled water and taken to the coldhouse to remove the field heat, then graded as per the stem lengths and quality of flower.

Insect-pests, Diseases and Physiological Disorders

Insect-pests

Aphids (Macrosiphum rosae and various others)

These infest on the younger leaves, shoot tips, and floral buds by clustering in large colonies. Their nymphs and adults both infest on the plants and excrete honeydew which attracts ants, and sooty mould. These also spread viruses from one plant to the other. Heavy infestation affects plant growth, hence flower quality also becomes poor. These can be controlled through frequent organic sprays of derris, pyrethrum, or insecticidal soaps. Other effective insecticides which control these pests are dimethoate, fenitrothion, heptenophos with permethrin, malathion, pirimicarb, or pirimiphos methyl.

Thrips (Rhipiphorothrips cruentatus, Scirtothrips dorsalis, Thrips maginis)

They keep on sucking the plant sap mostly from the leaf undersides and floral buds, leaving silvery trails or patches. Their infestation deforms the leaves and buds. Both nymphs and adults can be controlled through spraying 0.2 ml/l fipronil or 1.5 ml/l monocrotophos.

Fig. 2.2: Leafhopper

Leafhoppers (Edwardsiana rosae)

These are some 3 mm long pale-yellow insects (broadest at the head-end and shortly narrowing towards the tail-end) feeding on the underside of leaves, so the upper leaf surface develops a whitish mottling. Their creamy-

white nymphs may also be found crawling on the underside of the leaves. Adults can be seen jumping around when disturbed. Effective insecticides against leafhoppers are dimethoate, fenitrothion, heptenophos with permethrin, malathion, permethrin, pirimiphos methyl, and pyrethrum.

Spider mites (Brevipalpus phoenicis, Tetranychus urticae, T. cinnabarinus, Typhlodromus confuseus)

These feed on the undersurface of the leaves by webbing around, which causes white specks on the leaves. Infestation of this pest causes leaf mottling, yellowing, and falling from the plant. Monocrotophos 1.5 ml/l, propargite 1 ml/l, or wettable sulphur 3 g/l is effective in their control.

Scale insect (Aulacaspis rosae, Aonidiella aurantii, Lindigaspsis rossi)

Its infestation is shown by the formation of reddish-brown encrustations on the lower part of old stems but with little infestation on the new stems. These encrustations can be removed with a hard toothbrush or a cotton swab dipped in methylated spirit. Use of phorate 10-G or carbofuran granules at the time of field preparation or in the soil around the plants, will control this pest.

Mealybugs (Pseudococcus spp.)

These are soft-bodied pink insects covered with greyish-white powdery substance. Their nymphs and adults cluster around the growing tips, leaf axils, bud stalks, and flowers and suck their sap which causes non-opening of the buds and withering of the flowers. These also secrete a white fluffy wax, so the infested plant parts become sticky and entice the development of sooty mould. Malathion or insecticidal soap spraying on the infested parts will control these pests, provided frequent spraying is carried out. Ladybird (*Cryptolaemus montrouzieri*) predates over these.

Whiteflies (Trialeurodes vaporariorum, Bemisia tabaci)

These are small insects whose bodies are covered with a white waxy powder, and are found feeding mostly

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on the leaves underside. With slight disturbance, these start flying around. Immature whiteflies are immobile and remain on the leaves underside, sucking their sap. It is very difficult to control them through chemical insecticides as these have developed resistance against many insecticides. Pyrethrum or insecticidal soap spraying thoroughly on the underside of the leaves may control these. Chemical insecticides—bifenthrin, permethrin, or pirimiphos methyl are also quite effective.

Leaf-rolling sawfly (Blemnocampa phyllocolpa)

It tightly rolls the leaflets in a fashion that the rolled leaflets often hang down. Female sawfly injects a chemical in the leaves to curl the leaflets, to insert their eggs inside the structure. Eggs are laid in the early summer, and its caterpillars start eating the leaflets after hatching, and soon these become pale-green and up to 10 mm long. Spraying of insecticides such as heptenophos with permethrin or pirimiphos methyl will control this pest.

Chafer beetle (Oxycetonia versicolor, Adoretus sp.)

Its adults feed on the floral buds, growing shoots, and leaves, while its grubs feed on the roots. Plant spraying with 0.2% carbaryl will control the adult beetles so treating the soil with 2.5 ml/l chlorpyriphos will control its grubs.

Ash beetle (Myllocerus spp.)

Its adult and grubs damage the plants similar to Chafer beetles, making irregular holes on the leaves. This may be controlled by the method used to control Chafer beetles.

Leaf cutting bees (Megachile sp.)

These nest in the hollow stems of roses, where the adults bring the stuffed leaves from roses and other plants to fill these holes to feed their larvae. While collecting the leaf pieces, they make semi-circular holes in rose leaves. These do not do extensive damage to the plants as only a few leaves are damaged but the look of the

plant is spoilt. After pruning, the cut ends of the stem should be pasted with Bordeaux paste mixed with some contact insecticide.

Termites or White ants (Odontotermes obesus, Microtermes obesi)

These are a voracious feeder of every organic matter as these inhabit large colonies much below the soil surface so the use of any effective insecticide is also unable to kill its deep-rooted queen. Water-flooding of the field is not that effective until and unless the water remains in the field for several days. Worker ants attack the plants right from planting to any further stage whenever a dry period exists. Drenching chlorpyriphos 0.5% or fipronil 0.2% near their colonies, or use of carbofuran granules at 5 g/m^2 followed by watering may prove quite effective. Neem cake is the best solution which can be used on the beds at the time of bed preparation or when mixing the nutrients in the pits.

Digger wasps (Crabro sp.)

These attack the plants after pruning by digging holes through the cut ends from where the pathogens causing dieback enter and infect the plants. Pouring a few drops of dimethoate in the hole or mixing Bordeaux paste will prevent the attack of digger wasp, and thus check the infection of dieback fungi.

Caterpillars (Helicoverpa armigera and *Spodoptera spp.)*

Its larvae feed voraciously on leaves and flowers and damage the crop seriously. If not checked timely, the whole plant may be defoliated and shoots eaten. Its attack is more devastating during the rainy season. Spraying malathion at 0.1% or cypermethrin at 0.1% is quite effective in controlling these. Their adults may be enticed towards feromone traps. HNPV (virus) also controls this pest.

Fig. 2.3: Caterpillar

Diseases

Dieback

This disease is caused by *Botryodiplodia theobromae, Colletotrichum spp., Fusarium spp., Diplodia rosarum, Leptosphaeria coniothyrium*, etc. It is a symptom of invasion by one or various pathogens, where rotting (blackening) starts in the rose plants from top to downwards, pathogens entering through the wounds inflicted by pruning or otherwise. Its initial symptoms are visible as blackening of the stem parts but afterwards, the whole plant dies. The entire affected part should immediately be cut off in one attempt with a sharp knife and should be sealed with Bordeaux paste or copper oxychloride. Spraying carbendazim 0.2% over the pruned parts will also save the plants.

Stem blight

It occurs due to the infection of any one of those fungi which cause dieback, apart from *Leptosphaeria coniothyrium*, which is well known for causing rose canker. This enters the plant through wounds inflicted at the base of the plant or elsewhere. Its infection causes the stems to show a purple or blackish patch of discolouration, and ultimate death of the plant. Such plants do not grow during spring. To solve this problem, the diseased parts are removed and burnt, the field is kept clean, excess soil or mulch kept away from the base of the plants, and proper cultivation practices followed.

Grey mould, Blossom blight or Botrytis blight (Botrytis cinerea)

From grey to grey-brown or off-white growth develops on the plants and/or its parts during humid and cold weathers, killing the blossoms and leaves, *vis-à-vis* new shoots. This fungus lives on plant debris and living part, and enters the plants through wounds or the parts which have been weakened due to burning or frost. Plant growth above the infection point is badly affected with leaf yellowing and wilting. During dry weather, petal edges shrivel, so flowers become unfit

for sale. Its spores spread due to water splash and air currents. All the dead and injured parts should be removed, debris collected, and burnt, and carbendazim at 0.2% should be sprayed to save the plants.

Black spot (Diplocarpon rosae)

It occurs on rose leaves in the form of diffused purple-black blotches which causes the leaves turn yellow and fall premature. Species roses also show small spots on their stems which may afterwards enlarge and coalesce. Occurrence of early spots on the leaves weaken the plants severely. The fungus overwinters on fallen leaves, on the bud scales, and on stem lesions. Proper sanitation should be maintained, and stems showing lesions should be pruned in spring, followed immediately by spraying of fungicides such as carbendazim, copper with ammonium hydroxide, mancozeb, penconazole, or triforine with bupirimate. Fungicides should be used repeatedly until it is completely eliminated.

Fig. 2.4: Black spot

Alternaria leaf spot (Alternaria alternata)

It causes heavy losses to the crop during the rainy season, which can be controlled by weekly spraying of azoxystrobin 0.075% or carbendazim 0.1%.

Powdery mildew (Sphaerotheca pannosa var. rosae)

It is characterised by a white powdery fungal growth appearing first on the upper leaf surface, then covering even the lower surface, the stems, thorns, and the floral buds during dry conditions. Affected

leaves may fall prematurely and the buds fail to open. The fungus overwinters in the infected stems and dormant buds. When the conditions turn favourable for the fungus again, it spreads by air. Badly infected stems should be pruned out and the plants should be sprayed with 0.2% carbendazim, mancozeb, and sulphur.

Downy mildew (Peronospora sparsa)

Its presence on roses becomes a problematic malady under tropical conditions during spring especially in the polyhouses during extended winter periods. When the weather is humid and cold and aeration around the plant is poor, its infection can be noticed. Its attack initially causes irregular purplish-red to black spots that turn yellow afterwards, followed by the falling of leaves. Its severe infection causes complete plant defoliation. To control this problem, overhead irrigation should be avoided, provision for proper aeration should be created, and the plants should be sprayed with 0.075% azoxystrobin, 0.2% mancozeb, or 0.05% metalaxyl.

Rust (Phragmidium tuberculatum, P. mucronatum)

It appears only in the temperate regions on both sides of the leaves, especially on species roses, as bright orange clustering of spores during summer and rainy seasons and the leaves fall off prematurely. During autumn, this produces winter spores to replace the summer ones. These also infect the stems at the broken point more seriously during rains. Such stems are likely to wither. The spores may overwinter on the soil surface, the plant debris and infected stems. To get rid of this problem, the air circulation should be improved in the planting, and the stems showing spring infections should be pruned out promptly. Further, the plants should be sprayed with mancozeb, myclobutanil, penconazole, or triforine with bupirimate.

Crown gall (Agrobacterium tumefaciens)

It is a soil-borne and mechanically transmitted bacterial pathogen which got introduced in India through the introduction of planting material. Its infection causes plant stunting and brownish gall formation at the crown of the plant. To get rid of such problems, the plants

should be dipped before planting for two hours in 500 ppm streptomycin solution. Infected plants should be uprooted and burnt.

Viral diseases

One such disease attacking roses is 'rose wilt', which after infection, produces recurved and brittle leaflets at the tip of the young shoots, and in severe cases even in the stems. Such leaves turn yellow and fall off whereas stem infection causes the death of the entire plant. For controlling the spread of viruses, regular control of visiting insects, especially the aphids is necessary. It would be better to uproot and burn such plants to avoid further spread.

Physiological Disorders

Rose balling

Complete or partial failure of the opening of the rose buds is called rose balling. In this case, outer petals on an unopened or partially opened bud become pale-brown, papery, and dry. Inner petals are initially unaffected but later on they may also die after the invasion of the secondary organisms. This occurs generally in damp weather when entire bud is covered with a grey mould. Possible cause is due to rains followed by bright and hot sunlight which causes scorching of the petals. To minimise this problem, only basal watering is to be done during the evening hours and not during hot sunny days. Such buds should immediately be pruned off.

Blindshoot

It is a phenomenon where new shoots emerging from the axillary buds of the previous floral stem, are without a floral bud. This occurs due to insufficient light intensity, lower temperature, and poor nutrient status of the medium.

Bent neck or Neck drooping

It is the bending of the floral buds on one side of the pedicel from the neck which occurs due to the weakening of the tissues at the neck because of the air blockage,

or microbial plugging of water-conducting vessels, thereby the water absorption is unable to match the transpiration rate, hence this problem.

Petal blackening

It occurs mostly in the case of red to maroon roses where the outer petals show blackening when exposed to strong sunlight, or in greenhouse roses when the covering sheet has no UV-B radiation protection. This occurs as the yellow pigments in red roses wither due to UV-B radiation, hence the red pigments become darker.

Nutrient deficiency symptoms

Nitrogen deficiency

It causes the leaves to turn from light green to yellow so lime may be applied when the soil pH is below 6. Nitrogen is to be applied to such plants only when pH in the field is optimum.

Phosphorus deficiency

It causes dark red to purple colouration of leaves so P_2O_5 at optimum pH may be applied, though in the case of lower pH, lime should be applied.

Potassium deficiency

It appears as drying of the leaf edges, in this case 10 g KNO_3/5 litres of water/plant should be applied and if pH is less, Ca should be applied.

Copper deficiency

Copper deficient plants show continuous wilting of young leaves so in such cases, 1.0–1.25 g copper sulphate/5 litres of water per bush should be applied.

Ferrous deficiency

It appears as yellowing of leaves with the main veins being light green. In such cases, iron chelate at 1–1.25 g/5 litres of water per bush should be applied.

Zinc deficiency

It causes large areas of dead tissues at tips and between the veins which may be corrected by correcting the soil pH and by applying zinc chelate.

Calcium deficiency

It causes hooked leaves and abortion of terminal buds which may be corrected by using calcium nitrate at 10g/5 litres of water per plant.

Magnesium deficiency

It shows leaf yellowing from the centre with the tissues dying there. This malady can be corrected by applying magnesium sulphate at 10 g/5 litres of water per plant.

Boron deficiency

It causes light green colouration of the leaves at the base along with their twisting coupled with the death of terminal buds which can be corrected by applying 5 g borax per bush.

Sulphur deficiency

It causes the leaves to turn light green, along with lighter green veins. This can be corrected by applying sulphur-containing fertiliser.

Practical Exercise

Activity 1

Identification of major rose groups.

Material required

Flowers of different groups, practical file, pen and/or pencil, etc.

Procedure

- Identify rose flowers of different groups on the basis of the following characteristics:

S. No.	Rose group	Characteristics
1.	Hybrid tea	Flower appears on solitary long cane with elongated buds, that open slowly
2.	Floribunda	Flowers are clustered but larger than polyantha

3.	Miniature	Neat, compact, and dwarf plant with clustered but smaller blooms where flowering occurs for a longer period
4.	Climber	Long canes need support to keep upright, suitable for arches, against walls, pillars, etc.
5.	Shrub roses	Perpetual flowering rose taller than bush but shorter than climbers

Activity 2

T-budding (shield budding) in rose.

Material Required

Budding knife, polyethylene strips, desired scion and rootstock

Procedure

Preparation of scion

- Take out the scion along with the bud and leaf.
- Remove the thorns and cut off the leaf leaving a portion of petiole.
- Remove the shield-shaped bud measuring 2.5 cm in length along with a chip of bud.
- Remove the chip of wood from the budding eye; the leaf petiole acts as a handle.

Preparation on rootstock

- Make a T-shaped incision about 2.5 cm long on the rootstock just below a node.
- Open the incision to facilitate the insertion of the budding eye.
- Insert the budding eye in a T-shape cut properly.
- Secure the eye by wrapping polythene tape, leaving the eye unwrapped.

Check Your Progress

A. Fill in the Blanks

1. Approximately _____ species of roses are native to India.
2. Rose hips are a rich source of vitamin _____.
3. Rose hips contain _____ times more ascorbic acid than those of oranges.

4. The result of crossing between Dwarf Polyantha and early HT roses is _____
5. The resultant class developed by crossing HTs with Floribunda is known as _____.
6. Quite cold-hardy low-growing rose, bearing large-clustered smaller flowers is _____.
7. The roses growing on its own roots are known as _____.
8. Complete or partial failure of rose bud opening is known as _____.
9. A phenomenon where new shoots emerging from the axillary buds of the previous floral stem having no floral bud is known as _____.

B. Multiple Choice Questions

1. Proper harvesting stage of rose is _____.
   (a) tight bud (b) slightly loose
   (c) half open (d) None of these
2. Bluing of rose petals is due to _____.
   (a) the accumulation of ammonia
   (b) more salt
   (c) less sugar
   (d) bacterial infection
3. Which of the following is less sensitive to chilling injury?
   (a) Rose (b) Bird of paradise
   (c) Gaillardia (d) Marigold
4. Which flower is acclaimed as the 'King of Flowers'?
   (a) Tulip (b) Rose
   (c) Carnation (d) Gladiolus
5. The time for budding in roses in North Indian plains is _____.
   (a) September–October (b) November–December
   (c) April–May (d) July–August
6. Wintering of roses in India is done normally in the month of _____.
   (a) July (b) October
   (c) January (d) April
7. Which of the following is a long stem cut rose grown in India?
   (a) Raktagandha (b) Anurag
   (c) Dr. Homi Bhabha (d) Mother Teresa

C. Subjective Questions

1. What are the deficiency symptoms of the following nutrients?
   (a) Nitrogen, (b) Phosphorus, (c) Potash, (d) Boron,
   (e) Zinc

NOTES

2. Discuss the classification of rose plants according to their utility.

3. Describe the cultural operations in rose.

4. Describe the important insect-pests and diseases of rose.

D. Match the Columns

A	B
1. Super Star	(a) Floribunda
2. Pusa Pitamber	(b) HT
3. Gold Medal	(c) Polyantha
4. Twinkle Twinkle	(d) Grandiflora
5. Pusa Barahmasi	(e) Miniature rose
6. Albertine	(f) Climber

SESSION 2: CULTIVATION OF GAILLARDIA

Botanical name: *Gaillardia pulchella*

Family: Asteraceae

Gaillardia pulchella, commonly known as blanket flower, is a native of Central United States, which is though perennial, but is grown as an annual flower.

It can be grown in gardens for bedding, at borders, on window sills, in pots, and as loose as well as cut flowers. It is grown throughout the year for landscaping, garden display, and for loose flower production (Fig. 2.5).

Fig. 2.5: Gaillardia

Varieties

Baby Cole (red flowers with yellow margin), Burgundy (wine red), Copper Beauty (orange yellow), Dazzler (bright orange-yellow petals, centre maroon-red), Firebrand (orange and maroon), Goblin (yellow and red), Golden Goblin (golden-yellow), Ipswich Beauty (orange and brown-red), Kobold (red, margined yellow), Lollypops (red or red and yellow, free-flowering), Mandarin (flame-orange and red), Picta (brown-red and golden-yellow), Picta Aurea (yellow), Red Plume (bright red), The Bride (cream-white), The Sun (golden-yellow), etc.

Climate

Gaillardia requires sunny spots for better performance. It is a long day plant but requires short days (10–12 hours) for a good vegetative growth, while long days (12–16 hours/day) with high light intensity for flower initiation, so in winters it requires supplementary lighting. It stands well to heat and drought conditions. It grows well at the temperature range of 20–30°C. The perennial

types are quite hardy and tolerate temperatures as low as –4°C. It can be grown throughout the year in plains.

Soil

It prefers soil of medium fertility with a pH range of 5.5–7.8, though survives well even up to the pH 8.5. It can be grown in various types of soils but a well-drained medium loam is best for its cultivation. Heavy soils can be improved by the addition of 20% coarse sand.

Propagation

Commercially, gaillardias are propagated by seeds, whether it is annual or perennial types, though a few of the perennial types are also multiplied through division, and root or stem cuttings. Gaillardia seeds have no dormancy, and remain viable up to 31 months, provided moisture content has been brought down to less than 9%.

Seedbed preparation

Some 15 cm raised seedbeds should be prepared for growing gaillardia. Soil should be thoroughly mixed with 4–5 kg/m^2 FYM or vermicompost, and then the soil should be made to a fine tilth through repeated ploughings, and then all the perennial rootstocks should be taken out along with other hard materials such as wood pieces, stone, crocks, polythene shreds, etc. In heavy soils, fresh coarse sand should also be mixed. The soil should be sterilised by drenching with 2% formalin and then covering it with black polythene sheets for 2–3 days and then exposed fully for a minimum of one week further before planting. Beds of convenient sizes (normally 60–100 cm width and the length as per requirement but not more than 6 metres) should be prepared and properly levelled.

Sowing of seeds

Just before sowing, the seeds should be treated with 0.2% Captan to save the plants from being attacked by damping off pathogens. The seeds should be sown thinly and evenly (3–4 cm apart in the rows, and the rows being spaced 5 cm apart) as thick sowing may cause yellowing

of seedlings, *vis-à-vis* seedlings may become prone to the infection of those pathogens that cause damping off. After sowing, the seeds are thinly covered with a finely sieved leaf mould, and then a covering of straw over it, to check the displacement of sown seeds when watering. Light watering through a fine rose nozzle by the evening must be carried out over the covering of straw. When germination starts appearing, immediately the straw is removed, otherwise seedling will become lanky and crooked. It takes about 7–10 days for germination. In nursery bed, there should be proper watering and timely removal of weeds. For winter-cropping, these are sown in September–October and for summer cropping in February–March. The seeds can also be sown in earthen pots, seed pans, or wooden seed trays.

Planting and transplanting

Seedlings are transplanted in well-prepared beds 30–45 days after seed sowing, as at this time, the seedlings have attained four-leaf stage. For bed preparation, the soil is thoroughly mixed with about 40 tonnes of well-rotten farmyard manure, ploughed deeply thrice, each time followed with planking. Polythene shreds, pebbles, brick pieces, stubbles, and perennial weed-rootstocks must be taken out before levelling and then beds of convenient sizes must be prepared. Transplanting at a distance of 45 × 45 cm is generally done either on a cloudy day or in the evening. Transplanting in the evening is always better as cool night temperatures help in establishing the plants properly. After planting, the transplants are watered immediately. Light watering every day in the early morning or late in the afternoon is required for about a week for the proper establishment of the seedlings.

Nutrition

Along with the above recommended FYM or compost (40 tonnes), 25g urea, 60–120g superphosphate, and 30–60g muriate of potash per square meter area must also be added for better results. Full dose of farmyard manure or compost along with half quantity of urea and full dose of superphosphate and muriate of potash

should also be applied at the time of bed preparation, preferably at the time of third ploughing. It can be grown best if its soil contains 15–30% clay and 0–15% bark, perlite, or sand, incorporated with 1–3 kg/m^3 complete balanced fertiliser and a little quantity of iron chelates along with other necessary micronutrients.

Irrigation

Winter crop is watered after every 10–12 days, though in summer, after every 5–7 days, looking into prevailing weather conditions and the soil types. Heavy soils require light irrigation while light soils require deep irrigation with higher frequency. Base irrigation is always better whether it is flooding or drip, though overhead irrigation is avoided for producing a healthy crop.

Intercultural operations

Plants should be supported with pegs and strings so that flowers may not be damaged through lodging. If seed production is not objective, spent flowers should be removed to promote further continuous and quality blooms. Weeds should not be allowed to flourish. For proper root aeration, the soil should also be hoed 2–3 times while taking out the weeds. Gaillardias start flowering in 90–120 days after seed sowing. Flowering during very hot summer of May–June and in the chilly weather of winter, that is December–January is utterly poor, otherwise this continues flowering throughout the year. Flowering is advanced when winter temperature is increased while continuous lighting stimulates flowering and accelerates the ageing process. Use of chlormequat and daminozide at 500 ppm or TIBA 200 ppm and kinetin 50 ppm increases the flower and seed yield.

Harvesting and display

Gaillardia flowers are harvested early in the morning, when they are fully open. For cut flower use, they are harvested with long and sturdy stems, while for loose flowers, these are harvested without stalks. For cut flowers, after harvesting, the cut ends are kept in palatable water. In vases, these remain fresh for up to

one week. For sale, the flowers are graded and bunched keeping 12 flowers per bunch. Sucrose 1% or $AgNO_3$, followed by sucrose and BA (benzyl adenine) improves the vase life considerably. For loose flowers, these are packed in large baskets and sent to the market.

Insect-pests and diseases

Four-lined plant bugs (*Poecilocapsus lineatus*), leaf hoppers (*Macrosteles fascifrons*), thrips, white flies, aphids, Japanese beetles, spider mites, and slugs and snails feed on various plant parts. Caterpillars of *Helicoverpa armigera, Plusia orichalsia,* and *Spodoptera litura* have been found feeding on gaillardia in Maharashtra. These pests maybe controlled by spraying 0.2% Rogor, Kelthane, or Malathion but slugs and snails should be trapped by spreading vegetable refuge nearby or should be killed through the use of metaldehyde baits.

Root rot or Damping off

It is caused mostly at seedling stage due to pathogens (*Alternaria alternata, Botrytis cinerea, Aspergillus, Curvularia pallescens, Dreschslera,* and *Fusarium*) present in the soil, former two causing foliar infection while others affecting seeds and seedling mortality. Dithane M-45 at 0.3% seed treatment is quite effective against all these pathogens.

Root and Stem rot

It occurs due to the infection of *Pythium, Sclerotinia, Thielaviopsis,* or *Rhizoctonia* where the lower portion of the stem becomes tan to dark brown, sometimes with white webbing of the fungal growth. Mulching that is too thick and close to the plant, as well as overwatering, should be avoided. *Sphaerotheca* and *Erysiphe cichoracearum* cause powdery wilt and in this case, both sides of the leaves are covered with powdery coating. This can be controlled through sulphur dusting and use of colloidal copper fungicide. Potassium sulphide at 0.2% spraying is also quite effective. *Entyloma* causes white smut on gaillardia plants, first appearing as light green spots on the foliage or with coloured spots in the centre, which

become dark brown at a later stage. To avoid further infection, all the plant debris and fallen leaves should be destroyed. *Septoria gaillardiae* causes brown-flecked leaf spots with reddish-purple borders which afterwards turn ash-grey, followed by shot-holes. Infected leaves should be collected and burnt and such plants should be sprayed with Bordeaux mixture or dusted with copper fungicide. *Pseudomonas* causes interveinal leaf discolouration and bacterial leaf spots, followed by foliage turning dark-brown and the collapse of the entire plant. Aerial irrigation should be avoided and infected plant parts should be removed and burnt. If viruses such as impatiens necrotic spot, tomato spotted wilt, and CMV infect this crop, they must be uprooted and destroyed.

Practical Exercise

Activity 1

Transplanting of gaillardia seedling

Material Required

Khurpi, plastic tub, watering cane, marker, etc.

Procedure

- Water the nursery bed 24 hours before the lifting of seedling.
- Lift the seedlings with the help of a *khurpi*.
- Mark on prepared field at recommended spacing 45 × 45 cm.
- Plant the seedlings at marked spaces, probably during evening.
- Water the planted seedlings.

Check Your Progress

A. Fill in the Blanks

1. Gaillardia flowers are also known as _____.
2. Gaillardia can be grown in gardens for _____ or _____.
3. Commercially gaillardia is propagated by _____.
4. Gaillardia seeds have no dormancy and remain viable up to _____.
5. Gaillardia seeds germinate within _____.
6. Gaillardias start flowering in _____ to _____ days after seed sowing.

B. Multiple Choice Questions

1. Seed sowing in gaillardia during summer season is done in _____.
   (a) October–November (b) February–March
   (c) June–July (d) any month
2. Gaillardia is generally propagated through _____.
   (a) seed (b) roots
   (c) cutting (d) bulb
3. Gaillardia is native to _____.
   (a) Japan (b) Korea
   (c) China (d) Central United States
4. Blanket flower is harvested when they are _____.
   (a) fully open (b) half open
   (c) at bud stage (d) showing flower colour
5. The colour of gaillardia var. 'The Bride' flower is _____.
   (a) red (b) yellow
   (c) cream-white (d) orange-yellow

C. Subjective Questions

1. Discuss the climatic requirement for cultivation of gaillardia.

   _____

   _____

   _____

2. Write about the important varieties of gaillardia.

   _____

   _____

   _____

3. Write about the planting of gaillardia.

   _____

   _____

   _____

4. How is gaillardia propagated?

   _____

   _____

   _____

5. Describe the methods of bed preparation for planting gaillardia.

   _____

   _____

   _____

NOTES

6. How are the flowers of gaillardia harvested?

_____

_____

_____

7. What are the different insect-pests of gaillardia and how are they controlled?

_____

_____

_____

D. Match the Columns

A	B
1. Copper Beauty	(a) red flowers, yellow margin
2. Wine red	(b) 8.5
3. Survive up to pH range	(c) Burgundy
4. Baby Cole	(d) orange yellow

SESSION 3: CULTIVATION OF MARIGOLD

Botanical names: African: *Tagetes erecta*
French: *T. patula*

Family: Asteraceae

Marigolds (common Indian name— *gainda*) originated in Central and South America, especially Mexico, and in India, it is mostly home grown for loose flower production. They are extensively used for bedding out and on borders, for pot culture, as offerings to gods and goddesses, for making garlands, for extraction of lutein (a pharmaceutical product), as a poultry feed to increase the intensity of yolk yellowing, and also to repel and reduce the population of root-knot nematodes in the soil.

African marigold is almost a hardy, erect, and branched annual plant growing up to 90 cm tall. Its leaves are pinnatifid, composed of lanceolate, and serrated leaflets. It has single to double flowers with

large and globular heads. The flower colour ranges from lemon-yellow to yellow and orange in various shades, that is, light yellow, golden yellow, bright yellow, deep orange, golden orange, and bright orange. The florets are quilled or two-lipped.

French marigold is comparatively shorter in height (up to 60 cm), hardy, has more branches and are bushy. The shorter ones are available which grow below 30 cm in height, coming up in globular form, full of flowers, and most suitable for edging. Its stems are reddish, leaves are dark green, and pinnately divided, and the leaflets are linear-lanceolate and serrated. Flowers are small single to double. Flowers are of yellow and orange colours in various shades and crimson, light red, bicolour such as light yellow with maroon blotches, deep crimson edged yellow, gold and red, etc.

Fig. 2.6: Marigold

Varieties

African Marigold

African Orange, Apricot, Eskimo, Fire Glow, Golden Age, Golden Climax, Happy Face, Pusa Basanti Gainda, Pusa Narangi Gainda, Sunset, etc.

French marigold

Bolero, Bovita, Burpees, Butter Nugget, Cupid Yellow, Harmony, Melody, Midget, Orange Flame, Petite Gold, Red and Gold, Spun Gold, etc.

Climate

Marigolds are hardy in nature. They can grow well almost throughout the year under tropical and subtropical conditions, requiring mild climate for proper plant growth and profuse flowering. It grows well under the temperature range of 14.5 to 28°C in open area, though mostly it is grown during the winter season.

Soil

This adjusts well to a wide range of soils but with pH range of 7.0–7.5. Deep soil rich in organic matter with sandy-loam texture is most suitable for its growth.

Propagation

To maintain uniformity, under humid conditions, the varieties maybe propagated through tip-cuttings taken from vegetative plants but the easiest and best method is propagating it through seeds. It produces copious seeds so when the plants have started senescing, their mature heads having black seeds are collected, sun-dried, and the seeds are extracted. After drying, the seeds are packed in non-absorbent paper bags and stored. In the growing season, these are taken out, nursery-sown and then transplanted. Generally, 0.7–1.0 kg seeds are required for planting one hectare of land.

Seedbed preparation and seed sowing

Some 15 cm raised, 60–100 cm wide, and about 6m long seedbeds are prepared and fully pulverised soil is thoroughly mixed with sieved FYM at the rate of 4–5 kg/m^2 and fresh coarse sand must commensurate to the requirement of the soil. Nursery soil is treated with 5% formalin, followed by black polythene covering, for two days, and then full exposure for more than one week prior to seed sowing. Before sowing, the seeds

are treated with 0.2% Captan to protect the seedlings from the infection of fungi causing damping off in the nursery. Seeds are sown thinly at a distance of 3–4 cm in rows that are drawn some 5 cm apart through fingers, and thinly covered with finely sieved and well rotten FYM or leaf mould, over which straw is spread so that seeds may not be displaced while watering. Watering through fine nozzles of rose can is given each evening directly over the littered straw. After 3–4 days, the bed is regularly checked in the morning and if the nursery soil has started cracking, the straw is immediately removed to avoid the seedlings becoming etiolated or crooked. Germination usually occurs in 7–10 days of sowing if atmospheric temperature ranges between 18° to 20°C and the beds are properly exposed to sunlight. When seedlings are some 30 days old or about 10 cm high, the bed is lightly watered, and seedlings are gently removed for transplanting in the prepared beds.

Transplanting

After mixing of 40–50 tonnes/ha of well rotten organic manure or 40 quintals of vermicompost in the soil, the soil of the field is worked to a fine tilth by three ploughings or spading, followed by planking each time. Rootstocks of all the perennial weeds, stubbles, and hard objects such as pieces of woods, bricks, stones, pebbles, and grits, *vis-à-vis* polythene shreds are thoroughly removed. Field is now divided into various beds of convenient sizes, usually 1.6m wide and the length depending upon the evenness of the beds, by keeping proper provision for bunds and trenches for movement and irrigation, and then the beds are properly levelled. Planting is carried out usually during cloudy weather or in the afternoon, followed by watering so that plants recover from the lifting shock and roots establish well. For about one week, light watering should be carried out regularly to avoid any casualty. Planting is carried out at 40 × 40 cm for African marigolds, and 30 × 30 cm for French marigolds, in mid-July for obtaining flowers during autumn, in mid-October for winter flowering and in February for flowering during summer and rainy

season, however, nursery sowing of seeds is carried out one month prior to transplanting.

Nutrition

Marigolds are not a heavy feeder so if at the time of field preparation, full dose of organic manure has been applied, its fertiliser requirement afterwards becomes limited. At the time of the bed preparation, the basal dose of 80 kg of NPK per hectare can be applied in the soil, followed by transplanting. However, 60 kg of nitrogen can be applied after 40 days of transplanting and remaining 60 kg at the time when the flower buds have started coming up.

Irrigation

Frequency and timing of irrigation depends upon the prevailing weather conditions and soil type. Sandy-loam soils require more frequent irrigation than heavy soils, and summer crops require abundance of water than the winter crop when transpiration and evaporation are quite restricted. Immediately after transplanting, the crop is copiously irrigated so that its roots are well settled by the night. However, if watering has been done from plant to plant through rose can, these require daily watering at least for one week, while for summer crop, they are watered at 5–7 days interval and during winter at 10–12 days.

Pinching

Marigold plants are initially straight growing but afterwards due to emergence of many lateral branches these expand horizontally. If the terminal shoot is removed after 40 days of transplanting, side branches start emerging earlier and more number of good quality uniform flowers are produced. If the flowering is required to be delayed, the tips of all these axillary shoots are also removed which will force these shoots to form precocious tertiary shoots so more flowers will be produced, albeit the flowering will be delayed by about 10 days.

Weed control

In India, 2–3 manual weedings are required for the entire crop period. If, for up to two months of transplanting, the weeds have been controlled, due to precocious lateral branching in the marigold plants, weeds do not get the opportunity to germinate and flourish, so for only the first two months of transplanting the weeding is required. In the first fortnight, weeding is not required as the field remains already clean at the planting stage. Chemical weed control with granular formulation of Simazine 2.0 kg/ha or Chlormequat at 5.0 kg/ha applied as post-planting, has been found effective in controlling almost all the weeds.

Harvesting

Flowers in marigold are harvested manually at fully-open stage, though still compact, usually by the evening when the weather has become cool but dew has completely dried up.

Depending upon the varieties planted, prevailing climatic conditions and cultural practices adopted, yield of flowers in African marigold ranges from 11–22 tonnes/ha (1.5–2.5 millions/ha) and 6–15 tonnes/ha (8–12 millions/ha) in French marigold.

To avoid dehydration, after harvesting the flowers are covered with moist hessian cloth/gunny bags when stored only for a night and next day taken to the market, however, at 8°–10°C these can be stored for up to three days. For local markets, these are either taken in large polythene or gunny bags but for distant markets, they are taken in the baskets of various sizes. The shelf life of loose flowers can be extended by soaking them in 0.1% Aluminium sulphate [$Al_2(SO_4)_3$] for two hours.

Insect-pests

Red spider mites *(Tetranychus urticae)*

These are brown and red spinning creatures which become a nuisance during the dry and hot weather in the outdoor plantings. These continue sucking the cell

Notes

sap of the tender plant parts. Their attack causes plants to look dusty and discoloured. These can be controlled by spraying with kelthane at 2ml/l of water.

Bud boring

Young larvae bore into the growing flowers and feed on various floral parts and foliage. Hand-picking and killing is effective when these are first seen but when these are in plenty, the plants are sprayed with 0.1% methyl parathion.

Hairy caterpillar *(Diacrizia obliqua)*

It is a polyphagus insect, its caterpillars feed on every part of the plant. It is controlled by spraying with Malathian or Dimethoate 2ml/l.

Aphids *(Aphis gossypii)*

These are tiny sap-sucking insects clustering at the tender plant parts, and produce honey dew to attract sooty mould. Its infestation causes deformity on the infested parts and spreads the virus infection. These can be controlled through forced water spraying and spraying with Malathion 0.2% or Dimethoate 0.03% at 10–15 days interval.

Thrips *(Frankliniella occidentalis)*

These also feed on the plants by sucking the sap, and spreading tomato spotted wilt virus. Controlling the aphids will control the thrips also.

Leafhopper *(Empoasca fabae and Macrosteles fascifrons)*

These are hopping insects and survive by sucking the sap of the plants. Their infestation causes leaf rolling and curling at the edges and when the attack is serious, tip wiltings are observed. At initial infestation, spraying Malathion or Dimethoate 2ml/l twice or thrice is quite effective.

Diseases

Alternaria leaf spot *(Alternaria tagetica)*

It appears as minute, purplish-brown, and circular spots on leaves and stems which enlarge afterwards

and girdle the stem. Mancozeb at 0.25% spraying will control it effectively.

Flower bud rot *(Alternaria dianthi)*

It appears as rot of the floral buds and its infection causes older leaves to develop a few deep brown necrotic spots, and in humid weather, its infection becomes serious. This is controlled with 0.2% Dithane M-45 spraying at fortnightly intervals. Flower bud rot is also caused through the infection of *A. alternata*. This becomes serious in humid weather. Its control is the same as that of *A. dianthi*.

Marigold blight *(Colletotrichum capsici)*

It infects petiole, peduncle, and branches. Dithane 0.2% spraying will control this problem.

Septoria leaf spot *(Septoria tageticola)*

It causes oval to irregular and gray to black spots with tiny dots of fungal fruiting structures from lower to upper leaves. It is controlled with 0.2% mancozeb spraying.

Cercospora leaf spot *(Cercospora thunbergiae)*

It produces brown and circular-oblong spots on the leaves of *Tagetes erecta*. However, leaf-spot or blight (*Cercospora tageticola*) on French marigolds causes dark brown circular spots with a prominent grey margin. On French marigold, leafspot or blight (*C. tagetis*) causes indefinite, irregular, and blackish coalescent spots. All these can be controlled by spraying 0.2% mancozeb.

Fusarium wilt *(Fusarium oxysporum)*

It occurs in the field. To some extent, this infection can be checked by drenching the plants with carbendazim 2g/litre. Thiride at 0.2% drenching may control this pathogen.

Rhizoctonia solani

The symptoms appear as brown necrotic spots and girdling of the radicle which extends later to plumule and thus, pre-emergence mortality of seedlings takes place. Under post-emergence symptoms, lower part of

hypocotyls develops water-soaked, brown, and necrotic rings leading to the death of seedlings. In these seedlings, the root system is partially or fully decayed. For control, ensure proper drainage in the nursery beds, and nursery soil should be drenched with Brassicol at 0.3%.

Powdery mildew

It is caused by fungus *Oidium* sp. and *Leveillula taurica*, which appear as whitish and tiny superficial spots on leaves, which later on spread to the whole aerial parts, ultimately covering the entire plant with whitish powder. It is effectively controlled through 0.5% Karathane (40 E.C.) spraying or dusting of the plants with wettable sulphur at an interval of 15 days.

Bacterial leaf spot

It is caused by *Pseudomonas cinereal,* which can be controlled through spraying with 0.03% streptomycin.

Virus

CMV causes mosaic pattern, and MLOs cause 'aster yellows'. These appear as yellowing or clearing of the veins in leaves, shortening of the internodal regions of the main stem, and production of long axillary breaks so it looks like witch's broom, and sometimes forming even phyllody where floral parts convert to greening. Its vectors are leafhoppers. CMV is a serious problem during the rainy season which causes streaking or mottling of leaves and growth stunting. Its vector is aphid, so its control with Malathion or dimethoate at 2 ml/l at regular intervals will keep this malady under check.

Physiological disorders

Bronze speckling

It appears on African marigold cvs 'First Lady' and 'Voyager', probably due to iron toxicity, where chlorosis and necrosis, along with the downward curling and cupping of leaves takes place. The iron level in the leaf tissue should not exceed 500 ppm to avoid iron toxicity.

Leaf burn

It appears as yellowing and death of the tips and margins of the leaves due to excess of boron, manganese, or molybdenum. Leaf tissue levels of Mn, Mo, and B should not exceed 55 ppm, 24 ppm, and 3 ppm, respectively.

Practical Exercise

Activity 1

Identification of marigold species

Material required

Practical file, pen, pencil, plant material, etc.

Procedure

- Identify marigold species on the basis of the following characteristics.

S.No.	Marigold Species	Characteristics
1.	African marigold Tagetes erecta	• Plants are erect and tall in height up to 90 cm. • Leaves are light green. • Stem is greyish. • Flowers are globe shaped and large. • Size of flowers maybe up to 13 cm across. • Colour of flowers is yellow, orange but not red.
2.	French marigold Tagetes patula	• Plants are bushy and short in height, up to 60 cm. • Its stem is reddish. • Its leaves are dark green. • The colours of flowers are red, orange, and yellow. Red and orange bi-colour patterns are also found. • Flowers are smaller (5 cm across).

Activity 2

Pinching operation in Marigold

Material required

Forceps, Marigold crop, practical file, pen, pencil, etc.

Procedure

- Pinching operation at 20th, 30th and 40th day after transplanting.
- Select plants in the field for pinching.
- Record the observations as per specification.

Take the observation on the basis of given parameters

S.No.	Parameters	Observation
1.	Plant height (cm)	
2.	Number of branches (no.)	
3.	Days taken for first flower bud initiation	
4.	Duration of flowering	
5.	Size of flower	
6.	Weight of flower (g)	
7.	Number of flowers per plant	
8.	Flower yield (g)	

Result: On delaying pinching operations, various parameters differed in their values such as _____.

Check Your Progress

A. Fill in the Blanks

1. Botanical name of French marigold is _____.
2. Marigold belongs to family _____.
3. Planting marigold in the field reduces the population of _____ in the soil.
4. Marigold can be vegetatively propagated through _____.
5. Commercially marigold is propagated through _____.
6. About _____ kg seeds of marigold are required for planting one hectare of area.

B. Multiple Choice Questions

1. Among the following, who is associated with Marigold breeding in India?
   (a) B. Singh (b) R.L. Misra
   (c) M.L. Choudhary (d) S.P.S. Raghava
2. Nugget is a cultivar of _____.
   (a) Marigold (b) Rose
   (c) Tulip (d) Carnation
3. Native place of Marigold is _____.
   (a) Russia (b) South Africa
   (c) Mexico (d) India

4. Recommended seed rate of marigold is _____.
   (a) 0.7–1.0 kg/ha (b) 2–3 kg/ha
   (c) 3–5 kg/ha (d) 7–8 kg/ha
5. Optimum temperature required for Marigold cultivation is _____.
   (a) 6–14°C (b) 15–28°C
   (c) 30–42°C (d) All of these
6. Among the following, which one is the African marigold variety?
   (a) Orange flame (b) Melody
   (c) Bolero (d) Golden climax

C. Subjective Questions

1. Differentiate between African marigold and French marigold.

   _____
   _____
   _____

2. How useful is pinching in marigold?

   _____
   _____
   _____

3. Describe the harvesting of marigold.

   _____
   _____
   _____

4. Write about the bronze speckling of marigold.

   _____
   _____
   _____

5. Give the symptoms and causes of leaf burn in marigold.

   _____
   _____
   _____

D. Match the Columns

A	B
1. Planting stage	(a) Tagetes patula
2. French marigold	(b) 4 leaf stage
3. Pusa Basanati gainda	(c) Wettable sulphur
4. Powdery mildew	(d) African marigold

NOTES

Session 4: Cultivation of Jasmine

Botanical name: *Jasminum auriculatum, J. grandiflorum, J. officinale, J. sambac, etc.*

Family: Oleaceae

Jasmine, a native of tropical and sub-tropical regions, is one of the most important traditional cum loose flowers, valued for its intense fragrance in the country and for extraction of essential oil. The species is available in both shrubby and climbing forms. Out of about a total of 40 species, India accounts for 20 species. Its flowers and flower buds are used for making garlands, *gajra*, *veni*, vis-a-vis for religious offerings. Their flowers also yield a high grade essential oil which is used in manufacturing perfumes, cosmetics, creams, hair oils, soaps and shampoos. From economic point of view in India, four species, *viz.*, *Jasminum auriculatum, J. grandiflorum, J. officinale,* and *J. sambac* are the most important as these contain a high percentage of essential oil. However, *J. arborescens, J. calophyllum, J. flexile, J. humile,* and *J. pubescens* also have high ornamental value (Fig. 2.7).

Fig. 2.7: Jasmine

Varieties

Jasminum auriculatum

Aureum, Co-1 Mullai, Co-2 Mullai, Long Point, Long Round, Madanban, Medium Point, Mogra, Motia, Palampur, Parimullai, Short Point, and Short Round. Parimullai is a clonal selection with 0.29% concrete recovery while Co-1 Mullai has 0.34% concrete recovery.

Jasminum officinale

Affine and Aureum (Aureum Variegatum)

Jasminum grandiflorum

Arka Surabhi, which is drought tolerant and has 0.35% concrete

recovery, Bangalore, Coimbatore, Co-1 Pitchi, Co-2 Pitchi with 0.3% concrete recovery, Lucknow, Pintype, Thimmapuram, Thrumtype, and Triploid.

Jasminum sambac

Arka Aradhana, Bela, Ramabanam, Double Mogra, Gundumalli, Hazara, Single Mogra, Iruvatchi, Kasthurimalli, Khoya, Madanban, Motia, Oosimalli, Eai Japanese, and Soojimalli.

Climate

Though most of the species are native to tropical and sub-tropical regions but a few are hardy as are recorded from temperate regions so accordingly these can be grown in the country having conditions akin to their requirement. However, in general, mild tropical climate with warm summer and mild winter, that is, 14–27°C temperature is excellent for proper plant growth and flower production in most species.

Soil

Any soil which is fully exposed, well-drained, aerated, and rich in organic matter is suitable for jasmine cultivation. However, optimum soil is that which has sandy-loam texture with a pH range of 5.0 to 8.0.

Propagation

Jasmine can be propagated through seeds, though seed-setting is very rare and also seed-raising is the job of a breeder for developing new varieties. It is commercially propagated through cuttings and layering.

Commercially, cuttings are the easiest way of producing a number of plants from one plant. Softwood central cuttings having at least two leaves and 15–20 cm length are taken mainly in March and also in June, July, September, or October and inserted in the propagation media [sand, vermiculite, sphagnum moss, peat, or various combinations of these, best being coarse sand, followed by sand + moss (1:1 to 1:3)] at an illuminated place. It takes 6–10 weeks for rooting, depending upon the species or cultivar chosen and prevailing climatic conditions. In case of layering, it is

simple layering, practised from June/July to October/ November, and it takes 90–120 days for removal. Since, it is time-consuming and only a few plants are prepared from one plant, as after bending the shoots are buried in the soil and pegged to remain in the position so one shoot yields only one layer. As in *Jasminum auriculatum* and *J. grandiflorum,* the propagation through cutting, is not so successful, these are propagated through grafting and patch budding.

Land preparation

The field is deeply cultivated to a depth of about 40 cm and the soil is fully pulverised after thoroughly mixing 40–50 tonnes/ha of FYM/compost in the soil. All the stubbles, rootstocks of perennial weeds, hard objects such as pieces of woods, bricks, stone tiles, and shredded polythene sheets are removed while preparing the beds. Depending upon the growth size of the species and varieties, the pits are prepared of 45–90 cm^3 and then these are filled with topsoil mixed with about 100 grams of carbofuran per pit and then exposed for a week. In case the beds are not fortified with FYM at the time of field preparation, at the time of pit-filling, some 10–25 kg of FYM is added per pit and mixed thoroughly with the soil.

Planting

Usually the planting is carried out during the rainy season when the soil has sufficient moisture and air is quite humid so that plants are saved from casuality. Density of the plant depends upon the species, cultivar, and the soil and environment of the growing area. The spacing provided for various popular species and their varieties are 1.2×1.2 m for *Jasminum sambac*, 1.5×1.5 m for *J. Grandiflorum,* and 1.8×1.8 m for *J. auriculatum.*

Nutrition

At the time of pit-filling, more than 10 kg of FYM is added per pit, along with 120–240 g N and equal quantity of potassium, better if nitrogen is given in split doses. P_2O_5 requirement is almost double that of nitrogen. Since this is a perennial crop and remains in the field in every season so it is better if all the fertilisers are applied in

two split doses, once in February and the other in July. However, split application in case of *J. grandiflorum* and *J. sambac* is not so responsive.

Irrigation

Since these become dormant during winter in the subtropical regions of India, so usually, they do not require regular watering, however, care should be taken that soil does not become completely dry, otherwise this may prove disastrous for the plants. Therefore, occasional light watering at 20 days intervals maybe applied. In summer, especially May and June, it is quite hot so, at this time, these require copious cum frequent watering at 5–7 days intervals. During the rains, the same depends on the weather conditions, but if there is no rain, March–April and again during autumn too, These can be watered weekly. When it begins to grow during spring, it should be watered copiously.

Weed control

Weeds are the greatest trouble in the crop during the initial growth period so if not controlled timely, they may cause enormous crop loss. Weeding in jasmine plantation in India is carried out only manually, though it is quite expensive. However, thick organic mulching is very effective in keeping the jasmine weeds under check, which together provides humus to the soil through gradual decomposition. Use of Oryzalin weedicide is quite economic which controls the weeds for up to 70 days, by then the crop is almost fully grown, and then the weeds do not get a chance to grow. Paraquat at 2 kg/ha are also quite effective.

Pruning

It regulates plant growth and flowering. For pruning, the watering is first withheld and then, all the past season shoots are pruned along with straggling and diseased branches to promote the emergence of new shoots on which flowers are produced. Immediately after pruning, the injured plant parts should be pasted with Bordeaux paste so that no pathogen may enter through the pruned parts. Bordeaux paste should be applied on the cut ends to check the entry of the pathogens.

For pruning, certain defoliants such as paraquat dichloride, pentachlorophenol, potassiumchloride, and sodium chloride can be used to some extent. *Jasminum auriculatum* should be pruned prior to 15 days of it taking new growth, that is the middle of February, while in case of *J. grandiflorum*, the pruning may be carried out in any month to obtain a good flower yield, however, the best time being the last week of December. *J. sambac* can be pruned from October to January for harvesting to get the highest flower yield. Pruning is carried out from 15 to 90 cm from the base having 3 to 13 nodes intact on the plant, and pruning at 90 cm length from the base with 13 nodes produces more number of branches with improved yield in case of *J. grandiflorum*. However, *J. sambac* requires only low pruning.

Harvesting and yield

Flowering in jasmine may start in the first year of its planting but usually it starts from the second year, though economic yield is obtained usually from the third year. The stage of flower harvesting depends upon the purpose for which flowers are required. Picking is always carried out early in the morning. For use as fresh flowers, fully developed but little opened flower buds are picked, whereas fully opened flowers are picked for extraction of concrete. In India, jasmine flowers are harvested through the hand picking method though in other countries these may be harvested through suction harvester. For marketing, these are packed loosely in small bamboo baskets for local markets, and in corrugated cardboard boxes for distant markets.

Flower and concrete yield may vary as per the species used, cultivars grown, and management practices followed. In general, the flower yield in jasmine is 8,000–10,000 kg/ha, in case of *J. auriculatum* it is 4,700–9,000 kg/ha with concrete recovery of 0.26–0.28%; in case of *J. grandiflorum* the flower yield is 4,000–10,000 kg/ha with concrete recovery of 0.25–0.32%; and in case of *J. sambac,* the flower yield is 7,000–8,000 kg/ha with concrete recovery of 0.14–0.19%. It is only *J. grandiflorum,* which has international market for its concrete and its variety 'Co. 1 Pitchi' which produces

over 10 tonnes of flowers per hectare with an estimated concrete yield of 29 kg with a recovery of 0.29%.

Insect-pests and Diseases

Insect-pests

Budworm (Hendecasis duplifascialis)

Its caterpillars bore the blossoms and feed on developing petals, especially in *J. sambac,* and fill the excreta in the hole of the buds so the buds become pink and fall prematurely. This can be controlled through spraying with 5% neem kernel extract, and during the off period the soil should be exposed so that the birds and predatory insects may feed over the exposed pupae.

Galleryworm/ shootworm/ budworm (Elasmopalpus jasminophagus)

It is a serious pest on *J. auriculatum,* and its larvae feed inside the buds making exit holes at the base. It webs the terminal leaves, shoots, and flowers.

Shoot borer (Sycophila sp.)

Its larvae infest on *J. grandiflorum,* making tunnels inside the shoots and pupating there. This is controlled through spraying with 0.02% Nuvacron.

Leaf webworm (Nausinoe geometralis) and leafroller (Glyphodes celsalis)

Its caterpillars feed on the lower leaves during rains and on the terminal shoots during dry seasons. These are controlled through 2 ml/l spraying of Hostathion during the peak period of infestation.

The nymphs and adults of tingid bug (*Corythuma ayyari*), jasmine bug (*Antestiopsis cruoiata*), and green plant hopper (*Flata oellata*) feed on the plant cell sap of the tender parts, by which leaf yellowing and falling are caused. All these are automatically controlled while controlling the leaf webworm.

Blossom midge/ gall fly (Contarinia maculipennis)

This infests on *J. auriculatum* and *J. sambac*. Its maggots enter through corolla bases and destroy the buds. This is controlled by spraying with 0.1% Flufenoxuron 10DS.

NOTES

Nymph and adult thrips (Isothrips orientalis, syn. Thrips orientalis)

These suck the plant sap from the buds and flowers causing brown streaking on the petals and their falling off. Control measures are the same as in case of worms.

Cyclamen mites (Steneotarsonemus pallidus, Tetranychus urticae)

These feed on *J. sambac* and eriophyid mites (*Aceria jasmini*) feed on *J. auriculatum* and *J. pubescens,* these continue feeding on the leaves, buds, and tender stems so the plant growth is hampered and flower production is reduced. Gall mite (*Eriophyes* spp.) is a havoc in South India and devastates *J. auriculatum* crop during the rainy and winter seasons by burrowing under the epidermis of the leaves and tender shoots causing whitish bloated galls which coalesce later, causing drastic reduction in the flower yield. 'Parimullai' is resistant to this pest. Spraying and rubbing of Rogor on the affected parts will control these pests.

Root-knot nematodes (Meloidogyne incognita)

These have been found feeding and galling on jasmine roots, thereby causing foliage yellowing, and in severe attack, the plants even die. It can be controlled by the application of neem cake at 1t/ha or Carbofuran granules at 2.5 kg/ha in the soil, followed by watering.

Diseases

Leaf blight (Alternaria jasmini and Cercospora jasminicola)

It causes brown spots on the leaves, irrespective of their age, though young branches present clear symptoms. During humid conditions, these spots coalesce, blight, leaf margins curl inward, and finally the leaves fall off prematurely. This problem is very serious for *J. grandiflorum.* Immediately after appearance of the disease, the crop should be sprayed at 'run off' stage with mancozeb 0.2% or carbendazim 0.1% and repeated once after 7–10 days. Soil application of *Pseudomonas fluorescens* at 25 g/m^2 and its 0.5% foliar spraying at 25–30 days intervals will effectively control the disease.

Leaf spot (Curvularia paradisi)

It causes brown spots and leaf defoliation which may be controlled through a fortnightly spraying of 0.2% Dithane Z–78.

Wilt/ root rot (Fusarium solani, Sclerotium rolfsii, Clitocybe tabescens)

It appears as whitish colony having abundance of micro and macro conidia with chlamydospores. Twice drenching fortnightly with benomyl 0.1% + copper oxychloride 0.3% and carbendazim 0.2% + copper oxychloride 0.3% will control this problem.

Powdery mildew (Oidium jasmini)

It spreads through wind-borne conidia and appears as white powdery patches on the upper leaf surface. These patches afterwards coalesce and cover the entire leaf surface. Wettable sulphur at 0.2 per cent or carbendazim at 0.1 per cent spraying will control this disease.

Rust (Uromyces hobsoni)

It appears on both sides of the leaves (lower side being more conspicuous), and sometimes on stems during humid weather, leaves showing orange aecial cups, and after sometime the entire leaf becomes yellow and crinkled, and the stems start splitting of bark and finally the branches die. It is controlled with 0.15% copper oxychloride or 0.2% zineb spraying.

Chlorotic ring spot virus

It spreads through whitefly (*Bemisia tabaci*) and grafting, but not through the sap and is characterised by the development of typical mosaic symptoms consisting of yellow chlorotic spots on the leaves. The disease is controlled by controlling the vector through Acetamiprid 20 SP at 15–20 g a.i./ha spraying. Jasmine mosaic virus causes little leaf, mottling, and chlorotic flecking, *vis-a-vis* stunting and yellowing of the entire plant. The disease spreads through insects and grafting, therefore, it is essential to control the vectors. Phyllody (mycoplasma) transforms the flowers into malformed and reduced greenish flower-like structures with greenish and ovate corolla lobes. Such plants are not suitable for taking

further cuttings for multiplication. The disease can be controlled through spraying with 250 ppm of tetracyclin hydrochloride. Virus infected plants should be rogued out and burnt.

Practical Exercise

Activity 1

Identification and collection of different species of jasmine.

Material required

Herbarium files, transparent sticking tape, sketch pen.

Procedure

- Identify different species through their leaf and floral characteristics.
- Collect the sample of different jamine species.
- Dry the sample of species separately.
- Stick the sample on herbarium page.
- Write the special characters of the species beside the pasted sample.
- Keep the herbarium file in a dry and cool place.

Activity 2

Calculate the cost of cultivation of jasmine per hectare.

Procedure

- Collect the data from the cultivator.
- Summarise the data in the table.
- Calculate the cost of cultivation of jasmine per hectare.

Particulars	Cost (₹)
A. Land lease cost (₹ _____/ hectare)	
B. Material cost	
• Planting material (_____cuttings/hectare; ₹ _____ /cutting)	
• Farmyard manure (_____kg/_____; ₹ _____/kg)	
• Fertilisers/hectare — N (____ kg @ ₹___/kg); P_2O_5 (_____ kg @ ₹ _____/kg); K_2O (_____ kg @ ₹ _____/kg); other fertilisers (_____@ ₹_____/kg)	
• Charges for irrigation	
• Weed management (₹_____/hectare)	
• Plant protection chemicals (₹____/hectare)	
• Fencing (Live Hedge)	
C. Operation and labour (excluding labour on harvesting) _____ man days/hectare; ₹ ____/ man days	

D. Harvesting charges (₹ _____ /kg of flowers)	
E. Transportation cost ₹ _____	
F. Miscellaneous (₹_____/ha)	
G. Production (_____kg/hectare)	
H. Total income (production _____ kg/hectare _____ @ ₹_____ /kg)	
Total cost: (A to F ₹_____/hectare)	
Net income: (Total income – Total cost) ₹_____/ hectare	
Benefit cost ratio (B:C): Total Income/Total Cost	

Conclusion: On the basis of Total income and Total cost, calculate cost and benefit ratio.

Check Your Progress

A. Fill in the Blanks

1. In India, about _____ species of jasmine are found.
2. For its concrete, _____ has an international market.
3. Jasmine is propagated by _____.
4. Dormancy in most of the *Jasminum* species is observed during _____.
5. The easiest way of propagating jasmine is _____.
6. Seedlings of jasmine can be planted during the _____.
7. Yield of Jasmine flower is _____ tonnes/ha.

B. Multiple Choice Questions

1. Among the following, which one is the substitute for saffron?
   (a) Jasmine (b) Tulip
   (c) Rose (d) Carnation
2. Climate requirement for jasmine is _____.
   (a) temperate (b) tropical
   (c) sub-tropical (d) All the above
3. For jasmine oil extraction, which stage of flower is suitable for plucking?
   (a) Tight (b) Half open
   (c) Fully open (d) None of these

NOTES

4. Jasmine is propagated through _____.
   (a) soft wood cutting
   (b) semi-hardwood cutting
   (c) hardwood cutting
   (d) seed

C. Subjective Questions

1. Write down the importance of jasmine.

_____
_____
_____
_____

2. Describe jasmine propagation.

_____
_____
_____
_____

3. Discuss flower harvesting of jasmine.

_____
_____
_____
_____

4. Describe jasmine pruning.

_____
_____
_____
_____

5. Explain planting spacing for different jasmine species.

_____
_____
_____
_____

D. Match the Columns

A	B
1. Parimullai	(a) Fully open flower picked
2. For extraction of concrete	(b) *J. sambac*
3. Arka Aradhana	(c) *J. grandiflorum*
4. Arka Surabhi	(d) *J. auriculatum*

Session 5: Cultivation of Crossandra

Botanical name: *Crossandra infundibuliformis*

Family: *Acanthaceae*

Crossandra, commonly known as 'Firecracker plant', due to the cracking sound produced during the splitting of seed-pod, is an important loose flower crop, especially in South and East India. About 50 species are there but only *Crossandra flava* (bright yellow flowers), *C. infundibuliformis* (orange), *C. guineensis* (pale-lilac to white bracts), *C. mucronata* (bright orange to dark red), *C. nilotica* (yellow-orange to brick red), *C. pungens* (orange or yellow), *C. subacaulis,* and *C. undulaefolia* (calyx bright orange and bracts salmon to scarlet-orange) are in cultivation. It is native to Arabian Peninsula, Tropical Africa, Madagascar, India, and Sri Lanka. In South India, where it is a commercial crop, its cultivation is estimated to be more than 4,000 hectares. This is also a valuable pot flower in Denmark, Sweden, Hungary, and Sri Lanka. In Denmark, commercially they grow only cv. 'Deep Orange' (a triploid).

It is a small, evergreen, and herbaceous shrub for tropical regions which has the ability to produce beautiful flowers with a remarkable range of colours, almost round the year. In India, crossandra ranks fourth next to rose, jasmine, and tuberose in loose flower production. Flowers though are very attractive, light, and durable but not fragrant; therefore its flowers are mixed with jasmine for hair adornment, besides being used for making garlands either alone or with jasmine flowers. Crossandra can be grown in pots, home gardens, rockeries, and in herbaceous borders. It starts flowering 2–3 months after planting, flowers throughout the year, with a drop in the rainy season.

Varieties

Three forms such as yellow, deep orange, and subacaulis red are grown to a small extent. The deep orange type being triploid does not set seed, as is the case with Mona Wallhead, a cultivar, which is grown in Denmark. Variation available in crossandra is very

low as compared to other flowers even then there is a remarkable range of colours, varying from yellow to red via pink to orange, and double coloured blue types with white throat. Recently white, light green, and violet types have become popular. Important varieties of crossandra developed by various agencies are:

Fig. 2.8: Crossandra

Mona Wallhead

An introduction from Sweden, it grows up to 50 cm tall with compact growth habit where leaves are shiny black-green and the irregularly-shaped flowers are deep salmon to pink with prominent bracts. Fortuna, bearing quite glossy foliage, and bearing attractive bright flowers for a longer duration is a selection which has extended the plant life. It is quite resistant to temperature fluctuations due to greatly improved root system and tolerates temperatures as low as 10°C.

Diane

A new and robust form of the species, *C. infundibuliform* has a compact growth bearing large and wide leaves, flowers dark salmon-orange, and petals much larger and rounded than the commonly cultivated variety.

Savindi

It is a pink-flowered mutant.

Danica

It has orange flowers, developed through *in vitro* gamma irradiation.

Lakshmi

It is a high yielding (up to 75 kg flowers per day per hectare from the second year of planting) gamma irradiated mutant developed through cv. Delhi, and bears large orange flowers.

Maruvur Arasi

It is a high yielding bright deep-red variety with longer floral stalks, bearing over 75 flowers per stalk, developed through cv. Delhi by gamma irradiation.

Dr. A.P.J. Abdul Kalam

It is a deep red variety developed through cv. Delhi by gamma irradiation, which is resistant to major pests and flowers round the year.

Kanakadhara

It is a mutant of cv. Delhi developed through chemical mutagenesis (sodium azide). It is a vegetatively propagated crossandra, which produces brilliant orange flowers yielding 25% more flowers than the mother cultivar.

Vijaya Kanakambaram

It is a tall mutant of free-branching and profusely flowering type having stout stems, bearing long inflorescences with large light reddish-orange flowers. It was developed through seed treatment of a local cultivar with colchicine, which yields 75 kg flowers per day per hectare 90 days after planting.

Raj Kanakambaram

It is a leaf-variegated mutant of cv. Delhi with deep orange flowers bearing 15 cm long inflorescence and has the potential of producing up to 75 kg flowers daily per hectare through proper management practices.

Subasu

It is a mutant of cv. Delhi with long inflorescences bearing light orange flowers of medium size.

Neelambari

It is a mutant of Local Yellow cultivar, bearing dense green foliage and normal size of flowers on long inflorescences.

Arka Ambara

It is a cross of Local with *Lakshmi* with large flowers, where flower weight is roughly double of the cv. Local.

Arka Kanaka

It is a cross of Local Yellow with Delhi with large and showy orange flowers which weigh roughly double of the mother parent.

Tropic Flame

It is an orange-flowered cultivar evolved in USA which multiplies through seeds.

Florida Series

It is more tolerant to cold than others, is vegetatively propagated and has four colours, *viz.*, yellow, orange, red-orange and red.

Aboli

It is a variety of *C. undulaefolia* and is grown in Andaman and Nicobar Islands.

Climate

Crossandra is a crop suited to tropical areas as it cannot tolerate temperature below 13°C and dies when frost occurs. It performs well in warm and humid areas with temperature ranging from 20 to 32°C. luxurious growth occurs at 30°C. A temperature of 25–28°C is most ideal for seed germination, while for cotyledon emergence and true leaf expansion, a temperature of 21–22°C is required. It can survive the optimum minimum night temperature of 18–24°C, while the minimum day temperature requirement is 21–28°C. Warm temperatures and long summer days encourage the flowering.

Soil

Crossandra can be grown in almost all types of soils. However, well-drained loamy soils rich in organic matter with a pH of 6.0–7.5 are most suited. Wherever it is to be grown, the soil should be free from nematodes. Alkaline, saline, clay, or heavy soils are not suitable as in the former two types of soils plants develop deficiency symptoms, such as chlorosis leading to improper growth of plant and poor flower production, and in the latter two cases, waterlogging may cause death of plants. Plants raised through seeds require 31 weeks to attain marketable size, though from liners, it requires 12–14 weeks, albeit it takes additional 6–7 weeks for producing liners from rooted cuttings.

Propagation

Crossandra is propagated through seeds, stem cuttings, and layering. Triploid varieties are propagated only through cuttings as these do not set seeds. For one hectare of planting it requires 2.0–2.5 kg of seeds as in one gramme, it contains some 140–200 seeds. A spacing of 50 × 50 cm has been reported as ideal for seed production. Physiological maturity in crossandra seeds is attained in 55–60 days after flowering and these can be stored for up to six months after treating with Captan at 2g/kg of seeds, otherwise these will remain viable only for three months. However, fresh extracted seeds are the best for nursery raising.

Layering

Triploid crossandras do not set seeds hence, can be propagated only through ground layering. Well-conditioned layers can be planted from June to July in pits of 15 × 15 × 15 cm at a spacing of 90 × 90 cm. About 12,500 layers are needed to cover one-hectare. Plants will start flowering within a month of planting.

Softwood tip cuttings

Cuttings of 5–8 cm length are taken during March–June when day and night temperatures are 29°C and 21°C respectively and light intensity is 1500–1800 foot-candle

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(fc), treated with some rooting hormone and planted in 6.5 cm pots or directly under mist, where rooting occurs in 3–4 weeks, and these, in fact, are called liners. During summer, white plastic tents should be used.

Triploids are also commercially multiplied only through cuttings which are transplanted when sufficient roots have developed. For better results, rooting hormone IBA at 3000 ppm can be used.

Micropropagation

Propagation by cutting has lower rates of multiplication and hence these are multiplied through micropropagation. Multiple shoots from shoot tips have been regenerated on full-strength MS medium fortified with BAP 1 mg/l. Callus induction from leaf bits has been reported on full MS medium fortified with 2,4-D 1 mg+BAP 0.5mg/1.

Preparation of land

The land is thoroughly ploughed twice or thrice after mixing about 25 tonnes of FYM in the soil at the time of first ploughing, all the foreign materials are taken out, field is levelled, and beds of convenient sizes are made with proper provision of bunds for walking and trenches for watering.

Sowing of seeds

Seeds are sown at the rate of 2.0–2.5 kg/ha in the nursery beds in June–July on 10 cm raised beds having 1 metre width or in polythene bags, and lightly covered with 3 mm of medium. Temperatures at this time being 26°C day and 21°C at night are quite congenial and there these germinate within 3–4 weeks though optimum temperature range for better growth is considered 18–20°C. Cabaryl 15% dusting of the seed-sown beds will protect the seedlings against cutworm infestation in the nursery beds.

Planting and Transplanting

Thirty days old seedlings are transplanted in the prepared field when these attain 4–5 leaf stage in the nursery. For better growth cum development along with

higher flower yield, these should be planted with proper spacing. Spacing of a plant depends on the growth and spread of a variety, though commonly, those having normal spread at 50 × 30 cm spacing while others with more spread at 60 × 40 cm distances, where in the former case some 66,666 seedlings per hectare are accommodated, though in latter case some 41,667 plants are grown. Latter spacing is being practiced in Andhra Pradesh. However, the spacing of 45 × 30 cm is recommended for rooted cuttings of cv. 'Delhi'. In yellow crossandra, the spacing followed is 90 × 90 cm. For pot culture, as is being done in Denmark, seedlings and cuttings are transplanted into 6.25 cm pots singly, and the liners which are transplanted into 10 cm, 11 cm or 15 cm pots with final spacing of 16.5 × 18.0, 18.0 × 118.0 or 23.0 × 23.0 cm respectively, are kept pot-to-pot, commercially, until shipped.

Weeding

Weeding, application of manure, fertilisers and earthing up are combined for easy upkeep of crop and labour saving. Application of Metachlor 1.25 kg per hectare can control weed population. Mulching can be done to check weeds and to save water.

Pinching and pruning

Pinching is an important practice in crossandra to make the plant bushy with more axillary branches. In Denmark, under greenhouse conditions, pinching of *Crossandra infundibuliformis* cv. Mona Wallhead is carried out four weeks after planting, leaving three pairs of leaves, to induce more lateral shoots so that inflorescence numbers are increased. Pinching in crossandra is carried out three weeks after the final potting so that 5–6 leaves remain on the plants. However, disbudding is not required in this crop. Pruning of crossandra is carried out to improve plant vigour and flower quality. Light pruning is followed in late winter, after flowering. Once the seeds are formed and reach the advanced stage of development, growth and flowering decline. When the flowering is over, the spent spikes are removed regularly.

Nutrition

For increased growth and flowering in crossandra, application of farmyard manure 25 t/ha is needed. Application of 25 kg N, 20 kg P_2O_5, and 75 kg K_2O per hectare per year is sufficient for this crop. Entire P and K are applied in the field before planting. After the cuttings have rooted, a high dose of nutrient is required for good vegetative growth. A complete liquid fertiliser with 200 ppm N should be regularly provided. In Andhra Pradesh, they recommend FYM 25 t/ha + 5 t/ha neem cake, 38 kg N, 62 kg of P_2O_5, and 62 kg of K_2O/ha. Nitrogen should be applied in two split doses — 60 days and 120 days after planting. Fe, Mn, and Mg being critical nutrients should also be applied. Foliar application of $ZnSO_4$ at the rate of 0.5% once in 60 days is recommended for better quality flowers.

Fe deficiency is a common problem in crossandra. In fact, Fe fertilisation interferes with P nutrition while it does not affect K and Ca nutrition. Foliar application of 1% Fe_2SO_4 + 2% urea is recommended once in every 30 days. Application of 100% NPK + *Azospirillum* + phosphobacteria (41.72 g/plant) increases flower yield with maximum returns. Twenty five per cent reduced rate of application of inorganic nutrients is sufficient if applied along with *Azospirillum* to get yield on par with blanket recommendation of inorganic fertilisers in crossandra.

Irrigation

Crossandra needs adequate moisture in soil immediately after planting. It requires irrigation once in 4–5 days. Crossandra is drought tolerant but requires free watering (for a better yield), there should not be water scarcity at the time when the plants are flowering. But over-watering is detrimental due to the root being susceptible to *Rhizoctonia* whereas starved watering burns the leaves.

Harvesting

Crossandra commences flowering 70–75 days after planting and continues to flower throughout the year

with a drop in production during the rainy season. Flowers start appearing from the base of the spike, and at the same time, two diagonally opposite flowers open on the plant and it takes about two days for complete opening. Flowers are harvested on alternate days in the early morning by pulling corolla out of the calyx. The flowers are ethylene sensitive. After flowering is over, dried spikes are removed.

For local market, flowers are packed in cloth or polythene bags. Its potted flowering plants can be transported under ethylene-free atmosphere at 10–13°C temperature, as temperatures higher than 18°C are damaging and lower than 6°C blacken the leaves. If 1000 foot-candle (fc) light is being provided, a flowering crossandra plant will last up to one month, though ethylene is damaging, causing buds to abscise, so 0.4–0.5 mM STS can be used to negate its effect and to prolong the flower longevity.

Yield of flowers depends on the fertility status of soil, cultural operations, variety, and climate of the area. There is a drop in the production during the rainy season. With a plant population of 40,000 per hectare with spacing of 50 × 50 cm, a yield of 4.5 tonnes per hectare can be obtained. 'Delhi' crossandra yields 6–7 tonnes per hectare. However, the high yielding cultivars may yield up to 7–9 tonnes per hectare. Crossandra flowers are very light and on an average about 15,000 flowers make one kilogram. The crop can be retained in the field for about three years after which it has to be removed as it becomes uneconomical.

While fully opened flowers may remain fresh for about three days on the plants, the harvested flowers will fade within two days; though soaking flowers in 0.5% boric acid or in 1% aluminium sulphate can extend their shelf life by three more hours. Freshly harvested flowers can be packed in cloth or polythene bags for local market.

Insect-pests

Colonies of nymphs and mature females of scales [(brown scale, *Saissetia nigra*; white scale, *Orthezia insignis*); *Saissalia viridis*] infest the leaves, stems, and flowers. They feed on sap and excrete honeydew, which

makes plants sticky, and encourages the growth of sooty moulds. Application of Malathion at 0.3–0.6 kg a.i./ha kills the scale insects.

Adults and eggs of whitefly (*Lipaleyrodes* sp.) infest on the underside of the leaves and the upper surfaces are often fouled with a sticky honeydew and sooty moulds, *vis-à-vis* leaf chlorosis. Infestation reduces the plant vigour, while sooty moulds make the plants unsightly. Yellow spots and other discolourations develop on the leaves. Contact insecticide, Malathion at 0.5/ha or systemic insecticides such as dimethoate at 0.4 kg/ha at weekly intervals will be quite effective.

Sorghum midge *(Contarinia maculipennis)*

It is a small fly which lays eggs within the floral buds. After hatching, orange crawling maggots start feeding developing buds and ovaries causing the failure of bud opening, their rotting in severe cases and pupating therein. The nymphs and adults of pentomid bug (*Gynencia affinis*) infest the shoots and flowers during winter causing brown lesions on the infested parts. Control measures for both the pests are the same as for the white fly. Spider mites and aphids can also cause problems in crossandra cultivation, especially under greenhouse. Mites have also been found infesting the crossandras in Andhra Pradesh which can be controlled through an effective miticide, viz., Kelthane at 25 EC mi/l.

Nematodes

Commonly infesting on crossandra, the nematodes are *Meloidogyne incognita, M. arenaria, M. javanica* (all root-knot nematodes), *Pratylenchus delattrei* (lesion nematode), and *Longidorus africanus* (needle nematode). The roots exhibit brown to black lesions and prominent galls. The needle nematode causes forking and clubbing of the root tips. It causes chlorotic leaves which ultimately turn white at the advanced stage of infestation. In case of severe attack, plants become stunted without any side shoots and remain defoliated. Application of Phorate at 1g/plant weekly, after planting, checks the nematodes.

Diseases

Wilt

In crossandra, wilt is caused by *Phytophthora* spp. and *Fusarium solani* whose infection is expressed as paling of the leaves with pinkish-brown margins, followed by drooping. Discolouration may extend up to the midrib within 7–10 days. Stems also shrivel and the dark lesions can be seen on the roots extending to the collar region, and at this time, the invasion by *Pratylenchus* nematodes will predispose the plants to the fungus, causing severe wilting. To get rid of this problem, the crossandras must not be grown in nematode infested soils; however, nematodes can be controlled by soil application of Phorate at 1 g/plant after 10 days of transplanting. Crop rotation with marigold will also reduce nematode population in the field. Soil drenching with carbendasim 0.1% or copper oxychloride 0.25% at 30 days interval will control the disease effectively. Pulling and destroying the infected plants will also minimise the disease occurrence. Application of *Trichoderma viride* and *T. harzianum* cultured in FYM or on neem cake before transplanting effectively reduces the incidence of *Fusarium oxysporum*.

Collar rot *(Sclerotium rolfsii)*

It occurs in the soil as the pathogen is soil-borne, so usually infects the plants at the time of transplanting. It causes brown and sunken spots on the bark of the collar region which later on extends to the roots and its brown to black discolouration is seen after the peeling of such barks. The leaves of the infected plants show pink discolouration and fall off. Seedling root dip with 0.1% thiram and in a mixture of *Pseudomonas* sp. + *Trichoderma viride* will control this problem.

Stem rot

It occurs in the form of pre-emergence damping off through rotting of the stems and roots. Brown to black lesions develop on the stem just above the soil level and girdle the stem. Lesions extend to the upper part of the stem and result in the collapse of seedlings. Fortnightly

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spraying of benomyl at 0.2% and Captan at 0.25% at early stage of infection controls the disease.

Root and Crown rot

It is caused by *Phytophthora nicotianae*, the soil-borne pathogen, which enters the plants through damaged tissues. It causes violet discolouration of leaves and the basal regions of plants rot. It is better to destroy the affected plants.

Black root rot (*Rhizoctonia spp. and Thielaviopsis spp.)*

It may be a serious problem during and after propagation, so deep planting should not be followed to avoid incidence including that of its *Pythium*.

Flower rot

It is caused by *Fusarium pallidoroseum* where the leaves turn purplish, most prominently on the veins, the internodes become shortened and flowers decay with cottony colonies of the fungus. These symptoms begin on the older leaves and extend upward into the younger leaves towards the apical branches. The branchlets also turn purple.

Leaf blight

It is caused by *Colletotrichum crossandrae,* and in its infection, the leaf margins are slightly rolled up with brownish to reddish and depressed necrotic areas, more prominently on the lower leaves and that too near the margins. Such leaves shrivel and drop off leaving a whorl of young leaves only at the top. Proper sanitation, removal of affected parts, sulphur spraying at 7–10 days interval at its first appearance, and spraying with 0.1% benomyl, carbendazim, or 0.2% mancozeb will control this malady effectively.

Practical Exercise

Activity 1

Demonstrate the ground layering in Crossandra.

Material required

Knife, stone piece, hook, or pegs, polythene bags, secateurs, matchstick.

Procedure

- Select the flexible branches which can reach the ground level.
- Bend down the flexible branch.
- Make a 2 cm slit with the help of a knife under the node.
- Insert a matchstick in the slit.
- Remove the leaves of the portion that goes underground.
- Place the operated portion (slit-tongue) below the soil.
- Follow the recommended practices for nutrition and irrigation to the mother plant.
- Layered plant is detached after the formation of sufficient roots.
- Layered plant is placed in a polythene bag with the soil mixure for growing.
- Light irrigation is provided to the new plant.

Check Your Progress

A. Fill in the Blanks

1. Crossandra is commonly known as _____.
2. A high yielding variety of crossandra is _____.
3. Seed rate of crossandra is _____ per hectare.
4. Triploid crossandras can be propagated by _____.
5. Crossandra commences flowering after _____ days of planting.
6. Crossandra flowers are _____ sensitive.

B. Multiple Choice Questions

1. Crossandra belongs to _____ family.
   (a) Asteraceae (b) Rosaceae
   (c) Acanthaceae (d) Irridaceae
2. Among the following, which one is the native place of Crossandra?
   (a) Asia (b) Europe
   (c) Australia (d) Mexico
3. Which of the following climate is suitable for crossandra growing?
   (a) Temperate (b) Tropical
   (c) Sub-tropical (d) All the above
4. Mona Wallhead variety of Crossandra was introduced in India from which country?
   (a) USA (b) Brazil
   (c) Sweden (d) Sri Lanka

5. Crossandra is planted at spacing of _____.
   (a) 20 × 20 cm (b) 30 × 30 cm
   (c) 50 × 50 cm (d) 75 × 75 cm
6. Shelf life of Crossandra flower is _____.
   (a) 2–3 days (b) 5–6 days
   (c) 7–8 days (d) 9–10 days

C. Subjective questions

1. What is the importance of the crossandra flower?

   _____
   _____
   _____
   _____

2. How is propagation of crossandra done through seeds?

   _____
   _____
   _____
   _____

3. How is ground layering done in crossandra?

   _____
   _____
   _____
   _____

4. How is planting of crossandra done?

   _____
   _____
   _____
   _____

5. Describe flower harvesting of crossandra.

   _____
   _____
   _____
   _____

D. Match the Columns

A	B
1. Kanakadhara	(a) A leaf-variegated mutant
2. Raj Kanakambaram	(b) Chemical mutagenesis (sodium azide)
3. Subasu	(c) Gamma irradiation
4. Neelambari	(d) Dense green foliage
5. Dr. A.P.J. Abdul Kalam	(e) Long inflorescences