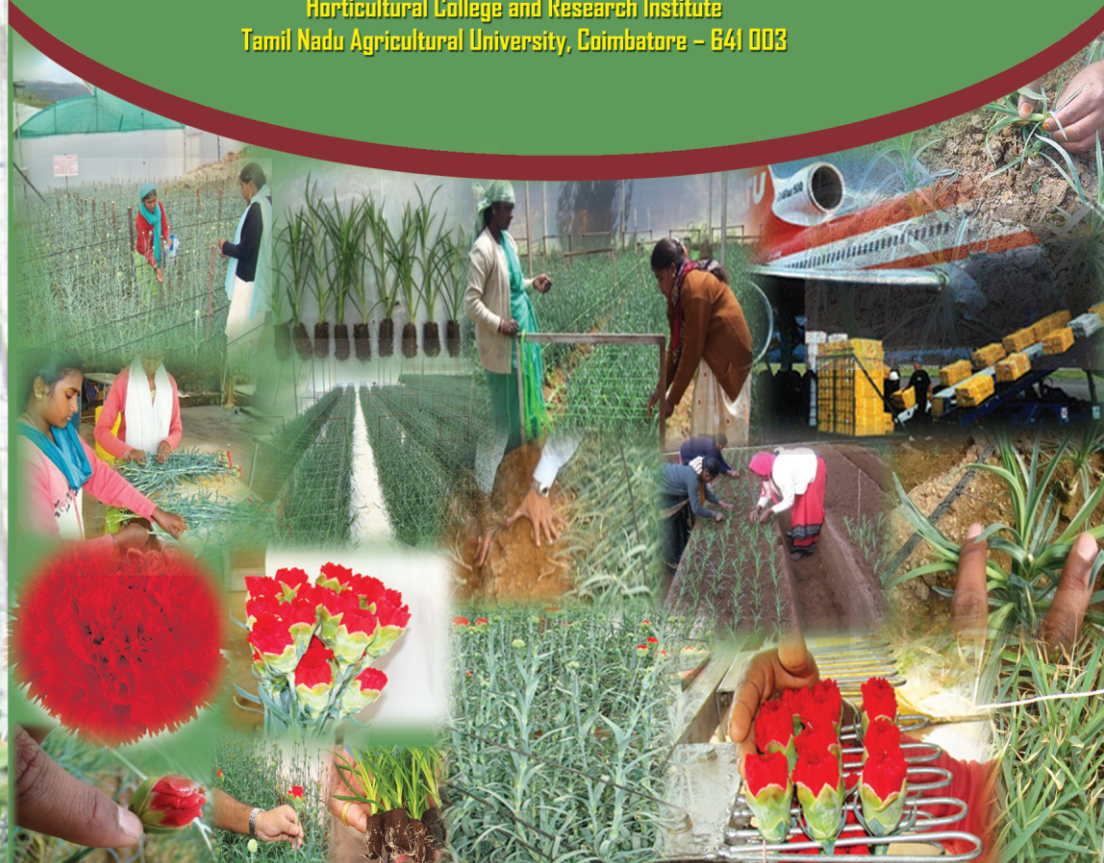




A TECHNICAL GUIDE ON CARNATION

M. Jawaharlal
M. Ganga
R. Padmadevi
V. Jegadeeswari
S. Karthikeyan

Department of Floriculture and Landscaping
Horticultural College and Research Institute
Tamil Nadu Agricultural University, Coimbatore - 641 003



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TAMIL NADU AGRICULTURAL UNIVERSITY

Coimbatore - 641003, Tamil Nadu, India

Dr. P. MURUGESA BOOPATHI

Vice-Chancellor

FOREWORD

Carnation is one of the most popular cut flowers of commercial importance in the world market ranking next only to rose. Excellent keeping qualities and wide range of forms and colours make carnation one of the most sought-after cut flowers. Of late, the area under carnation cultivation as well as the consumption rate of the flower are growing rapidly on account of its potential use in floral arrangements.

This book entitled “**A Technical Guide on Carnation**” authored by Dr.M.Jawaharlal, Dr.M.Ganga, Dr.K.Padmadevi, Dr.V.Jegadeeswari and Mr.S.Karthikeyan, is a complete guide on carnation cultivation, covering all the aspects including importance of the crop, botany, varietal status, growth and development, production and postharvest handling.

I congratulate the authors for their commendable efforts in bringing out this publication, which would serve as a complete guide on carnation to students, researchers, carnation growers and enthusiasts.

Dr. P. MURUGESA BOOPATHI

PREFACE

Carnations are excellent flowers for various purposes including cut flowers, bedding, pots, indoor boxes and rock gardens. They are associated with many sentiments and symbolisms and hence used in expressing love and gratitude towards parents, mother's undying love, admiration and gratitude to teachers and so on. Carnations rank among the most popular cut flowers in world trade, standing next only to rose.

This book is a compilation of all the aspects pertaining to cultivation of carnation including importance of the crop, origin and distribution, botany, species and varietal status, classification, growth and development, environmental and cultural requirements, plant protection strategies, harvesting and post harvest handling. We believe that this small piece of work which we dedicate to the carnation growers and enthusiasts would be helpful to them as a ready reference guide.

We wish to place on record our heartfelt gratitude to **Dr. P. Murugesu Boopathi, the Vice Chancellor of TNAU, Dr. N. Kumar, the Dean (Hort) of TNAU, Dr. M. Paramathma, the Director of Research of TNAU and Dr. R.K. Goyal, the National Co-ordinator of NAIP (Component II)** for encouraging us in bringing out this publication.

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The Authors

CONTENTS

S. No.	Chapter	Page No.
1.	Introduction	1
2.	Importance and uses	1
3.	Origin and distribution	3
4.	Botany	5
5.	Species	7
6.	Types of carnation	8
7.	Varieties	14
8.	Cultivation	
	i. Soil	15
	ii. Climate	16
	iii. Growing structures	18
	iv. Propagation	19
	v. Land preparation	23
	vi. Bed preparation	24
	vii. Planting	25
	viii. Grow-bag system of cultivation	26
	ix. Irrigation	27
	x. Plant supports	27
	xi. Nutrition	28
	xii. Weed management	32
	xiii. Special operations	32
	xiv. Plant protection	36
	xv. Physiological disorders	44
	xvi. Harvesting	47
	xvii. Post harvest technology	49
	xviii. Tips to reap good profits from carnation	53
9.	Index	55

1. INTRODUCTION

Carnation (*Dianthus caryophyllus* L.) is one among the most popular commercial cut flowers of the world, ranking second in commercial importance next only to rose. Carnation is preferred to roses and chrysanthemums by several exporting countries, on account of its excellent keeping quality, wide range of forms and colours and ability to withstand long distance transportation. Cut carnations, roses and chrysanthemums contribute close to 50% of the world cut flower trade.

Carnation belongs to the family Caryophyllaceae. The genus name '*Dianthus*' is derived from the Greek words 'dios' meaning 'God' or 'divine' and 'anthos' meaning 'flower' and hence known as 'Divine Flower'. The species name '*caryophyllus*' is derived from the Greek word 'caryan' meaning 'nut' and 'phyllon' meaning 'leaf'. The name '*caryophyllus*' has been chosen by Linnaeus after the genus name of clove, due to the clove-like fragrance of carnation. The common name 'carnation' probably must have come from the Greek word 'coronation' because these flowers were used in decorating the crown of Greek athletes. Carnation is the national flower of Spain.

2. IMPORTANCE AND USES

Carnations are excellent for cut flowers, bedding, pots, borders, edging, indoors and rock gardens. They give a unique softness to the rock gardens. Though cut carnations are traded in the world market year round, they are in

particular demand for the Valentine's Day, Easter, Mother's Day and Christmas. Miniature carnations are now gaining popularity for their potential use in floral arrangement.

Carnations are often worn on special occasions, especially Mother's Day and weddings. They were known as 'Jove's flower' in ancient Rome as a tribute to one of their beloved gods. Carnations are associated with some sentiments and symbolisms. In Korea, red and pink carnations are used in expressing love and gratitude towards parents on Parents' Day. Pink carnations are symbol of mother's undying love. Red carnations are worn on Mother's Day if one's mother is alive and a white one if she is not. Carnations are also used on Teachers' Day to express admiration and gratitude to teachers.

Light red carnations represent admiration, while dark red ones denote deep love and affection. White carnations represent pure love and good luck; striped carnations symbolize regret that a love cannot be shared. Green carnations are used as a secret gay code, while purple carnations indicate capriciousness. In French culture, carnations symbolize misfortune and bad luck. It is a traditional funeral flower in France, given in condolence for the death of a loved one.

The flower petals of carnation are candied, used as a garnish in salads and for flavouring fruit, fruit salads, etc. They are also used as a substitute for rose petals in making syrup after removing the bitter white base. Carnations are commercially utilized for extraction of perfume in France and the Netherlands. The volatile oil of carnation contains

40% benzyl benzoate, 30% eugenol, 7% phenylethyl alcohol, 5% benzyl salicylate and 1% methyl salicylate. About 100g of oil is obtained from 500kg of flowers. The flower heads are dried and used in pot-pourri, scented sachets and cosmetic products. The plant is quite rich in saponins. The leaves can be simmered in water and this water can be used as soap for cleaning skin, clothes, etc.

Carnation flowers due to their aromatic and stimulative properties had been used in tonic cordials in the past to treat fevers, though this use is now obsolete. In traditional European herbal medicine, carnation is prescribed to treat coronary and nervous disorders. The flowers are considered to be alexiteric, antispasmodic, cardiotoxic, diaphoretic and nervine. The whole plant has been used as a vermifuge in China and as an animal feed in Spain.

3. ORIGIN AND DISTRIBUTION

The *Dianthus* species are adapted to the cooler alpine regions of Europe and Asia and are also found in the Mediterranean coastal regions. Carnation is not seen in the wild except in some Mediterranean countries. This is consistent with records on floras indicating that the natural distribution of carnation is restricted to the Mediterranean regions of Greece, Italy, Sicily and Sardinia. It has been cultivated for over 2000 years and today commercial cultivation is the result of 200 years of improvement and breeding. It is believed that carnations were cultivated by the Muslims of Africa and introduced to Europe from Tunis in the 13th century. During 16th century, its improvement work was started in various countries. The gardens of Italy,

France, Germany, the Netherlands and England have contributed much to the development of cultivars. The major breakthrough in the carnation flower industry came with the evolution of the cultivar William Sim in 1938 by William Sim of USA. From this red variety there have been mutations to white, pink, orange and different variegated forms. The first genetically modified carnation variety 'Moon Dust' was developed in Australia by a plant biotechnology company called 'Florigene'.

In India, Sim carnations are reported to have been introduced first by the Maharaja of Patiala at his farm at Dochi. However, its cultivation could not be perpetuated in India due to lack of interest and technology for its growing. Later on, growing of Sim carnation was taken up in Ludhiana and Nasik and it spread to other places.

The natural climates for carnation cultivation occur near 30°N or S latitudes of the equator. Carnation growing countries are Spain, Kenya, Columbia, Israel, Ceylon, Poland, the Netherlands, France, Germany, Italy, Canary Islands, Australia, Valparaiso, Chile, USA and South Africa. An altitude of 2000-2500m is ideal for carnation cultivation.

In India, carnation is grown in Nasik, Pune, Kodaikanal, Nilgiris, Kalimpong, Darjeeling, Bangalore, Solan, Palampur, Shimla, Srinagar, Nainital and Chaubattia. The most suitable climate for commercial carnation flower production in India prevails in the Nilgiris and Kodaikanal of Tamil Nadu and parts of Himachal Pradesh.

4. BOTANY

The botanical classification of carnation is furnished below.

Kingdom	:	Plantae
Division	:	Magnoliophyta
Class	:	Magnoliopsida
Order	:	Caryophyllales
Family	:	Caryophyllaceae
Genus	:	<i>Dianthus</i>
Species	:	<i>caryophyllus</i>

Carnation is a semi hardy herbaceous perennial with thick, narrow, linear and succulent leaves. Leaf blades are simple, entire, linear, glaucous, arranged in pairs, keeled and five nerved and their colour varies from green to grey-blue or purple. The stems are hardy, shiny and have one to three angles with tumid joints. Each stem produces a terminal flower and hence inflorescence is generally a terminal cyme, sometimes racemiform. Flowers are bisexual and occasionally unisexual. The flower colour varies from white to pink or purple in colour. When grown in gardens, flowers grow between 6 and 8.5 cm in diameter. Some disbudded greenhouse grown plants for exhibition have flowers of up to 10 cm diameter. Petals are broad with frilled margins and calyx is cylindrical with bracts at the base. The stamens can occur in one or two whorls, in equal number or twice the number of the petals. The fruit is in the form of a capsule and contains many small seeds. The

fruit ripens within five weeks of pollination. The fruits contain an average of 40 seeds. On maturity the tubular capsule opens from top and releases the seeds.

Present day florist's carnations are the result of continuous genetic improvement and selection by many breeders throughout the world due to which most of them are fully double with their stamens transformed into petaloids.

The basic chromosome number in *Dianthus* is 15. Carnations are generally diploids ($2n=30$), though tetraploid forms ($4n= 60$) have also been identified. Triploid carnations were produced for commercial purpose, but the resulting plants were mostly aneuploid. The majority of cultivable carnations are diploid.

Flower colour in carnation is attributed to the presence of two major pigments *viz.*, carotenoids and flavonoids. The carotenoids are responsible for colour ranging from yellow to orange. However, many carnation plants do not have carotenoid pigments. Flavonoids are water soluble pigments such as anthocyanins. The major types of anthocyanins which contribute colour to carnation flowers are the cyanidins which are responsible for red or magenta colour and the pelargonidins which are responsible for orange, pink or brick red colour

Carnations do not have blue or mauve flowers because they lack that part of the anthocyanin biosynthetic pathway

that produces delphinidins or blue pigments.

The fragrance in carnation flower is predominantly due to eugenol, α -caryophyllene and benzoic acid derivatives. The level of these compounds increases during flower development.

5. SPECIES

The family Caryophyllaceae consists of 80 genera and 2000 species which are either annual or perennial and most of them occur in the northern hemisphere.

The genus *Dianthus* has about 300 species of which only a few are cultivated viz., *D. caryophyllus*, *D. barbatus* and *D. chinensis*. Modern day perpetual flowering carnation is a cross between *D. caryophyllus* and *D. chinensis*.

The species *barbatus* is commonly known as 'Sweet Williams', which grows readily from seeds. The stem in this species is glabrous, four angled and branched at the top. The leaves are opposite, broad and flat. The flowers are solitary, the petals are broad with frilled margins and the calyx is cylindrical with bracts at the base.

The species *chinensis* is commonly known as 'Indian Pink' or 'Japanese Pink'. The plants are glabrous more or less creeping at the base. The stems are pubescent and grooved. The leaves are flat and broad. The individual petals are hairy towards base. This species is excellent for beds, borders, edging, rock gardens, pots and cut flowers. The two most commonly grown varieties of this species are the

Japanese Pink (*D. chinensis* var. *heddewigii*) and the Fringed Pink (*D. chinensis* var. *lacinatus*).

Several other species including *D. arenarius*, *D. plumarius*, *D. gratianopolitanus*, *D. winteri*, *D. heddewigii*, *D. laciniatus*, *D. nobilis*, *D. superbus*, etc. were utilized for the development of modern carnation cultivars. The other *Dianthus* species are *D. attenuatus*, *D. caesius*, *D. callizonus*, *D. capitatus*, *D. carthusianorum*, *D. cinnabarinus*, *D. cruentus*, *D. deltoids*, *D. diadematus*, *D. frimbriatus*, *D. giganteus*, *D. glacialis*, *D. grandiflorus*, *D. hybridus*, *D. latifolius*, *D. monspessulanus*, *D. pancicii*, *D. petraeus*, *D. squarrosus*, *D. sylvestris*, *D. versicolor* and *D. viscidus*.

6. TYPES OF CARNATION

Based on the availability of large number of varieties and diversified cultural requirements, carnations are classified as Chabaud or Marguerite, Border and Picotee, Malmaison and Perpetuals.

i. Chabaud or Marguerite

These are annual carnations developed by crossing of *D. chinensis* with *D. caryophyllus*. Flowers are single or double, propagated by seeds. Flowers are large with fringed petals and have shorter post harvest life. The various kinds of Chabaud are Giant Chabaud, Compact Dwarf Chabaud, Entant de Nice, Fleur de Camelia and Margarita.



Giant Chabaud

ii. Border and Picotee

The flowers of border type carnations are symmetrical and are the easiest to grow. The flower colour varies from single to blended colour with irregular markings. The petals are broad and smooth edged. The flowers are generally frilled with open centers. During first year plant produces single stem and in subsequent years become bushy. In Picotee type ground colour is without spot or bars. The edges are regular and of bright colour. Border carnations are further subdivided according to colour of flowers as Selfs, Flakes, Bizarres and Fancies as indicated below.

- a) Selfs : The flowers are of a single colour
- b) Flakes : The flowers have a ground colour striped with another shade
- c) Bizarres : The flowers have a ground colour marked and flaked with two or three other tints
- d) Fancies : The flowers which do not come into the above subdivisions



Borders



Scarlet Bizarre



Cherry Picotee

iii. Malmaison

These are strong, sturdy and stiff plants with broad leaves. Flowers are large, double with well filled centres and are mainly pink coloured with good fragrance.



Malmaison

iv. Perpetuals

These are hybrids of different *Dianthus* species. The plants are not hardy and are generally treated as cool greenhouse plants. They bear flowers round the year with long stalks which make them suitable for cut flowers. They produce better quality flowers and withstand long distance transportation. These perpetuals are classified into two classes *viz.*, standard and spray carnations.

a) Standard carnations

Standard carnations produce larger blooms with longer stems, usually a single large flower on an individual stem.



Standard type

Few standard carnation varieties



Domingo



Master



Baltico



Dumas



Pink Dona



Algar



Fuente



Falicon

b) Spray carnations

Spray or miniature carnations produce smaller sized blooms with shorter stems in bunches. The flowers are borne on short branches of a single stalk.



Aveiro



Osiris



Fancy Fuego



Luxor



Picaro



Celebration



Abril



Belen

7. VARIETIES

i. Standard varieties

Flower colour	Varieties
Red	Guapo, Leopardii, Domingo, Master, Gaudina, Taureg, Turbo
White	Baltico, Madame Collette, Emotion, Angelica, White Dona
Pink	Navona, Varna, Pink Dover, Dumas
Light pink	Charmant, Cipro, Big Mama, Tonic Golem, Dona
Yellow	Kiro, Salamanca, Soto, Diana, Hermis
Orange	Malaga, Florgore, Solar, Star, Orange Prestige
Bicolour	Spencer, Swing, Madras, Giampi, Naxos, Guinea, Leila, Olympia, Wizard, Navidad, Happy Golem

IIHRP - 1

This variety is a standard carnation type developed by the Indian Institute of Horticultural Research, Bangalore. It is a mutant developed using ethyl methane sulphonate (EMS) at 0.25% concentration. It produces red flowers with smooth edged petals. The flower stalks are thick and straight with 65cm length. Flower buds open slowly and have a good keeping quality of 10-12 days. It is tolerant to nematode and fusarium wilt and it yields 300-360 flowers/m²/year (Tejaswini and Dhananjaya, 2007).

ii. Spray varieties

Flower colour	Varieties
Red	Red Eye, Red Fuego, Red Vital, Aveiro
White	White Prestige, Milky Way, Elvis, T-587
Pink	Rosa Bebe, Spur, Suprema, D- 925, Celebration, Osiris
Yellow	Stella, Prestige, Mila, Sonia, Abril
Orange	Sunshine, Autumn, Fancy Fuego, Disney, Eilat
Bicolour	Berry, Orbit Plus, Nadeja, Picaro

iii. Cultivars suitable for pot culture

Colour	Variety
Red	Charmptop
White	White Sunny
Pink	Davinci, Maldeves
Fancy	Cerratop

8. CULTIVATION

i. Soil

Sandy loam soils rich in organic matter content with pH of 5.5-6.5 are most ideal for carnation cultivation. Clay and silt soil can be improved by incorporating organic matter or compost. A soil EC of 0.8 - 1.2 dSm⁻¹ during the vegetative stage and 1.2 - 1.5 dSm⁻¹ during the generative stage is most ideal for carnation cultivation. The soil must be well drained because the crop is highly susceptible to fusarium wilt.

ii. Climate

Carnations grown outdoors as annuals in beds, border and pots are usually raised from seeds. When the climate is mild and almost free from rains, the seedling plants flower in 120-130 days after germination.

For commercial cut flower production, carnations are grown in greenhouses by maintaining optimum growing environment. The growth and flowering are usually influenced by plant genotype, light, temperature, carbon dioxide concentration of the environment and cultural practices.

a. Temperature

Temperature considerably influences growth and flowering of carnation. The optimum night temperature for carnation is 10-11°C during winter and 13-15.5°C in summer. The optimum day temperature range is 18-24°C. High day and night temperatures, especially during flowering of carnation result in abnormal flower opening and calyx splitting. Calyx splitting of flower can be minimized by regulating temperature of the polyhouse to 15.6°C on cool days and 18.3°C on sunny days. With increased temperature, stem length, mechanical strength of stem, flower size, number of petals per flower and keeping quality of carnation decrease considerably. On the other hand, very low temperature delays flower bud development markedly.

b. Light

Growth behaviour of carnation plants is influenced by duration and intensity of light. Genetically carnation is a quantitative long day plant. Long photoperiod usually promotes flowering while short days tend to delay it. Flower quality can be improved by providing long days only for a short period (4-6 weeks) when the shoots have 4-7 pairs of leaves. Many of the carnation cultivars respond to 15-21 days of lighting. Depending on the cultivars there are differences in requirement of photoperiod. The critical photoperiod for most standard and spray carnations is about 13 hours. The daily light integral affects the transition and flower initiation by means of direct effect on assimilate supply.

Research reports say that exposing carnations to artificial long day when the plants had 5-7 pair of leaves led to increased internodal length, reduced number of leaf pairs and a reduction in days taken for full bloom and final harvest (Ramesh Kumar and Kartar Singh, 2003), as indicated in the following table.

Table 1. Effect of artificial long day on growth and flowering of carnation

Photoperiod	Internodal length (cm)	No. of leaf pairs	Days for bloom	Days for final harvest
Normal	7.17	20.84	140.01	173.68
Long day	7.33	15.83	117.43	154.51
CD (5%)	0.15	1.94	2.40	2.28

c. Humidity

The plants must be protected from rain and dew during flowering. Wet buds and flowers are susceptible to fungal diseases. For commercial cultivation, the humidity of greenhouse should be maintained at 80-85% during beginning of vegetative growth and 60-65% during full growth stage.

d. Ventilation

Free circulation of air inside the greenhouse is essential. In uncooled greenhouses, vents have to be provided on the sides or roofs, whereas in cooled greenhouses, a fan-pad cooling system will cater to the needs of air circulation. A ventilation of 25-30% of the polyhouse ground area is ideal.

e. Carbon dioxide

Carbon dioxide level affects both plant growth and flower quality in greenhouse carnation. The effectiveness of the carbon dioxide treatment greatly depends on the temperature and light conditions. CO₂ feeding encourages more uniform production of flowers coupled with increased yield and reduced time between harvests. The best quality flowers can be produced when CO₂ concentration in the greenhouse is maintained at 500 - 750 ppm during day time under high light intensity and in a temperature range of 14-15°C. Under favourable conditions, additional carbon dioxide increases the flower production by 10-30%.

iii. Growing structures

Most of the cut carnations are commercially grown under protected conditions to ensure quality and yield.

Design and orientation of greenhouse are of great importance so as to ensure sufficient amount of light and proper ventilation. A greenhouse having ridges in the north - south direction is ideal for proper ventilation and light intensity. The plants are grown in beds running in the same direction. Poly greenhouse provided with fan and pad system can bring down the temperature by 8-10°C. However, top ridge and side ventilation also give fresh air exchange and thereby lower the temperature inside the greenhouse.



Carnation under polyhouse

iv. Propagation

Carnation can be propagated both by seeds and vegetative methods. Seed propagation is normally practiced to raise marguerite type carnation and for the purpose of hybridization. Cut carnations are multiplied vegetatively by means of terminal cuttings. Micropropagation techniques have also been standardized for large scale multiplication of disease free plants.

a. Seed propagation

Seeds are used for crop improvement programme and for raising annual types. Seeds are sown during July-August

and also extended up to October. In the hills, sowing is done in two seasons, August to October and March to April. Seeds are sown thinly in seed pans, seed boxes or seed beds filled with sterilized seed compost. The seeds should be covered with a thin layer of well decomposed leaf mould. The optimum temperature for seed germination is 21°C. Seeds germinate in about 5-8 days and at four leaf stage the seedlings are transplanted in nursery pots.

b. Vegetative propagation

Commercially, carnation is multiplied through terminal cuttings. Maintaining healthy mother plants in good vegetative condition is essential. These mother plants are grown under protected conditions and are supplied with nitrogen to promote vegetative growth. Foliar feeding of plants with micronutrients @ 2.5 g/lit and 15 ppm of ethrel after 3 - 4 days of every harvest of cuttings enhances the shoot production for cutting. Spraying of 0.1% each of Dithane M-45 and Bavistin at fortnightly intervals reduces incidence of diseases.

Terminal cuttings of about 10-15 cm with 4-5 pairs of leaves are harvested for multiplication. Harvesting all the cuttings from a plant at one time should be avoided to prevent the plant losing too much of the assimilating leaves. Adequate care in the preparation of cuttings is necessary to avoid spread of diseases. Cuttings taken from healthy plants fertilized with adequate nitrogen have been reported to root better. Further, cuttings taken from stock plants grown under short day and rooted under long day conditions at a temperature of 26.6°C and supplemented

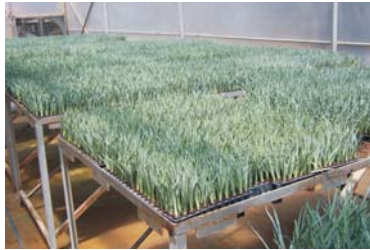
with CO₂ at 515 ppm have been reported to perform better. Cuttings can be stored at 1-3°C for several weeks before rooting. Cuttings are rooted in mist chambers or indigenously fabricated low cost propagation chambers. The low cost portable propagation tunnel of size 3m x 1.5m x 1.5m is covered with plastic cover. During summer, the plastic cover is removed in order to bring down the temperature. Full sunlight with misting promotes root formation in cuttings. Supplementary lighting may be necessary during winter when the light intensity is too low.

Treatment of cuttings with a combination of fungicides such as Dithane M-45 and Bavistin each @ 0.1% for half an hour before planting reduces the spread of fungal diseases during rooting. Treating the basal end of cuttings with NAA @ 500-1000 ppm before planting improves rooting of cuttings. The cuttings are planted in rooting medium at a distance of 3 x 3 cm. Water is sprinkled three to four times a day. More frequent misting is required during summer months.

Sand, perlite, vermiculite, cocopeat, sphagnum moss, etc. are used as rooting media for carnation cuttings. Mixtures of two or more materials are also used. In general, 20-35% moisture content, 60% porosity, 30-40% aeration and a pH ranging between 6.0 and 6.8 are the most favourable physical conditions of the rooting medium. The medium should be sterilized with formalin before planting of cuttings.

Protrays filled with growing media such as cocopeat are normally used for rooting of cuttings. Using protrays

offers the advantage of lower rooting media requirement, intact ball of earth while planting and uniformity of plants.



Rooting of cuttings in protrays

Planting time has significant influence on rooting of cuttings. The root formation is always better during cooler months. Cuttings planted during warm months root more rapidly than in other seasons. The propagating time usually depends on market demand.

Cuttings normally develop sufficient root system within 21 days of planting. During winter months, 100 watt incandescent bulbs are placed 1m above the cuttings at 1m interval during night hours, for maintaining a temperature of 20-30°C inside the propagation chamber. After rooting, the cuttings should be transferred to a hardening chamber containing sterilized media made of sand : soil : FYM in equal proportions.



Rooted cuttings

c. Micropropagation

Large scale multiplication of carnations can be done through tissue culture. The main aim of *in vitro* propagation is production of disease free planting material. Shoot tips are mainly used for micropropagation. Surface sterilization of explants with mercuric chloride at 0.1% for four minutes has been found ideal for shoot tips and nodal segments. Murashige and Skoog basic medium containing NAA (1 mM), Kinetin (20 mM), sucrose (15 g/lit) and agar (6 g/lit) is ideal for establishment and shoot multiplication and medium supplemented with NAA (1 mM), BA (3 mM) and IBA (5 mM) is ideal for rooting. The rooted plantlets are hardened on potting medium containing equal proportions of soil, perlite and organic manure.

v. Land preparation

Soil for growing carnation should be deeply ploughed to not less than 60 to 70 cm depth. Organic matter should be added to improve the aeration and fertility of soil. Generally, well decomposed FYM @ 25 kg, leaf mould @ 25 kg, neem cake @ 500gm and bone meal @ 200gm per m² can be added.

Adding cocopeat (3kg), humic acid granules (5g), seaweed granules (5g) and micronutrients (3g) per m² can improve the texture and nutrient status of the growing medium.

The organic manures should be mixed thoroughly with soil followed by pre-planting sterilization of soil either with steam or chemical fumigants so as to eradicate pathogens

and pests. Steam sterilization involves passing of aerated steam at 60-72°C through the soil covered with good quality plastic sheets. Of late, either Dazomet (30 - 40 g/m²), formaldehyde (2 litre/m² of a solution prepared with 1 litre/ 7 litres of water) or H₂O₂ (300ml/m²) is commonly used for soil sterilization. The soil is moistened first and then drenched with the fumigant and immediately covered with plastic. After 48 hrs the plastic cover should be removed and the soil should be thoroughly turned for proper aeration. The fumigant should be removed by leaching with plain water 3-4 times with turning of soil each time.

vi. Bed preparation

Generally, the basal fertilizer dose of single super phosphate @ 200 g/m², potassium sulphate @ 150 g/m², magnesium sulphate @ 50 g/m² and borax @ 2 g/m² should be evenly spread and thoroughly mixed with the media before bed preparation. Apart from the above fertilizers, bio-fertilizers and bio-control agents for the control of pest and diseases can be incorporated to soil at the time of bed preparation. Azospirillum, Phosphobacteria, *Trichoderma viridi*, *Pseudomonas fluorescens*, VAM each 1 kg can be added for 500m² area for enriching the soil.



Basal fertilizer application



Beds ready for planting

Bed layout depends on the orientation of the greenhouse. However, balanced development of the crop occurs when the beds are formed in the North - South direction. If the beds run East - West, the crop tends to crowd in the northern side. The ideal bed width and height are 75 -100 cm and 30 - 45 cm respectively. The bed length should not exceed 25 m. A path width of 45 - 50 cm is ideal.

vii. Planting

Planting time can be chosen depending on market demand. However, planting every 3-4 months is advisable to ensure regular supply of flowers. Before planting, drip lines and support netting are to be laid out. The bed should be moderately wet and drenched lightly with a fungicide (copper oxychloride or copper hydroxide @ 2 g/l) before planting.



25 days old rooted cuttings



Planting

Planting should be done preferably in the evening. A spacing of 15 x 15cm is followed. This will accommodate 30 - 33 plants/m² considering 75% as the net cropping area. In general four row or six row system of planting is adopted. The plants should be removed from the poly bags or rooting trays carefully without damaging the roots.

Planting should be done at shallow depth with part of the root zone exposed. Deep planting will lead to rotting.



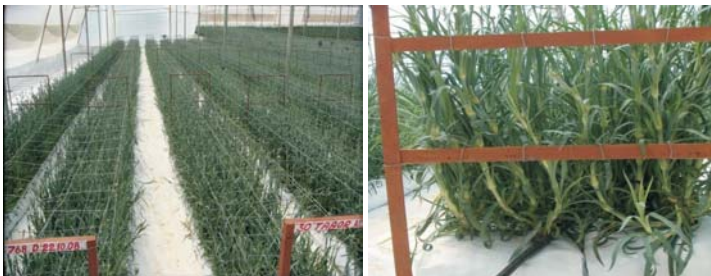
Four row system



Six row system

viii. Grow-bag system of cultivation

Grow-bag system is a recent innovation in carnation cultivation. Poly grow bags are made up of specially formulated plastic which has a longer life. The bags are available in various dimensions. The bags are filled with growing media, preferably inert media like cocopeat and used for planting. Grow-bags are recently being used in some parts of the Nilgiris for carnation cultivation.



Grow-bag system of cultivation

The grow-bag system of cultivation offers the following advantages.

1. Saving of time and labour required for soil preparation
2. Amenable for drip irrigation and fertigation
3. Helps to avoid repeated use of the same soil in the green house
4. High water use efficiency resulting from better water conservation
5. Complete weed control
6. Enhanced flower yield and quality

ix. Irrigation

Rooted cuttings should be watered immediately after planting. Spraying of water through misting has to be done for at least two weeks. After 3 weeks of planting, drip irrigation has to be adopted. Drip irrigation system is being followed in carnation cultivation. Laterals are laid out every alternate row and emitters are spaced at 30 cm intervals

The amount of water to be given per irrigation depends upon factors like air temperature, light intensity, humidity, soil type and soil temperature. Fully grown carnation plants require 4-5 lit of water/m²/day. It is advisable to check the irrigation water quality in terms of EC and pH. Stagnation of water should be avoided to minimize the incidence of diseases.

x. Plant supports

Both standard and spray carnations require support. Lack of support leads to bending of stems ultimately causing decline in market quality. Poorly supported

branches easily break, making them susceptible to diseases. Various kinds of plastic mesh, string, bamboo canes, etc. are used for plant support.

In recent times, nets are used for supporting carnation plants. The nets are usually laid out in 4 or 5 layers. Before planting, the first layer of netting should be laid out. The main frames can be fixed before bed making. The frames can be made from 'L' angles or pipes.

The netting can be done with GI wire of 16 gauge for length wise fixing and nylon threads for width. An increasing width of the meshes is used from bottom upwards. Generally, the bottom net is 7.5 x 7.5 cm, the subsequent nets are 10 x 10 cm, 12.5 x 12.5 cm and the upper net 15 x 15 cm. As the plants grow, the second, third and fourth layers can be put at 20 cm distance. Readymade nylon nets can also be used which will save labour and time.



Nylon



G.I. wire

Netting

xi. Nutrition

Carnation requires a high level of nutrition for optimum plant growth and flowering. The deficiency of one or more

of the major nutrients limits plant growth and flowering. The application of nutrients in small doses but more frequently favours better growth and flower production.

a. Nitrogen

Nitrogen is required by the plant for vegetative as well as reproductive growth. Deficiency of this nutrient limits plant growth, produces thin stem and stiff leaves which curves at the tip, particularly during winter and general yellowing of mature leaves occurs besides disturbing flower initiation. Excess nitrogen causes delayed flowering and reduces post harvest quality of flowers.

b. Phosphorus

Deficiency of phosphorus reduces growth and produces stunted plants. The leaves become narrower and the tips dry off and turn yellow. In severe cases, the whole plant turns yellow and dies prematurely. Phosphorus increases the flower number, diameter, weight and number of petals and flower colour.

c. Potassium

It improves the general health of the plant and is essential for nitrate changes which occur in the plant. Deficiency of potassium in carnation is characterized by scorching of leaf blade. In severe cases, white spots develop on foliage just below the flower; flowers become malformed and lose brightness; yellowing of calyx occurs. Deficiency of potassium also reduces flower yield, grade, stem strength and longevity.

d. Calcium

Calcium is considered as an important nutrient in carnation because of the relationship between calcium content and resistance to vascular diseases, especially fusarium wilt. As a constituent of cell wall, calcium decreases the susceptibility of cell walls to enzymatic pathogenic degradation. Deficiency of calcium produces thin and weak stems, small flowers, production of many sleepy flowers, appearance of crescent shaped necrotic lesions (2 to 5 cm) at the leaf tip and calyx scorch. Depending on the pH of the medium, limestone or gypsum is added to attain the desired calcium level.

e. Boron

Deficiency of boron in carnation is characterized by calyx splitting, bud abortion, reduced flower diameter and reduced flower production. Less than 20 to 25 ppm foliar boron levels cause shortened internodes, clubbiness, distorted flower buds and 'witch's broom' symptoms. On the other hand, excess boron (3000-5000 ppm) has been found toxic to the plants which expresses as leaf tip burn symptoms.

Carnation also needs magnesium, manganese, iron, zinc and copper in small amounts as they are catalysts for many plant processes.

f. General recommendation of nutrients

No nutrients are usually applied during the first three weeks after planting. Thereafter, nutrients are applied through fertigation.

Carnation growers of the Nilgiris District of Tamil Nadu adopt the fertigation schedule detailed below, in general, with required modifications based on soil and water test results.

Table 2. Fertigation schedule for carnation

Nutrients	Quantity in g/m ² /week
Till bud formation	
Tank-A (Monday and Thursday)	
Ammonium nitrate	3.0
Potassium nitrate	5.0
Monoammonium phosphate / Monopotassium phosphate	2.0
Magnesium nitrate (11:0:0:16 of N:P:K:Mg)	2.5
Boron	1.0
Trace elements / micronutrients	1.0
Tank-B (Tuesday and Friday)	
Potassium nitrate	5.0
Calcium nitrate	8.0
Bud formation to harvest	
Tank-A (Monday and Thursday)	
19 : 19 : 19	2.0
Potassium nitrate	7.5
Monoammonium phosphate (or) Monopotassium phosphate	2.0
Magnesium nitrate (11:0:0:16 of N:P:K:Mg)	2.5
Boron	0.1
Trace elements / Micronutrients	1.0
Tank-B (Tuesday and Friday)	
Potassium nitrate	5.0
Calcium nitrate	9.0

Plain water on Wednesday and Sunday and fungicide drench on Saturday are recommended. Incorporation of organic manures at regular intervals would give better results.

xii. Weed management

Weeding is a major problem during the early stages of crop growth. Weed growth will be suppressed when the plant covers the ground level. Only manual weeding is followed in carnation by using small hand hoes or forks. Soil loosening is combined with weeding for good aeration, water and nutrient percolation in to the root zone. It should be ensured that organic manures used should be free from weed seeds to avoid weeds.

xiii. Special operations

a. Training

Training is a very important and continuous operation in carnation cultivation. This operation helps in keeping the plants within the specified area in the net to grow straight without bending at the bottom.

b. Pinching

Pinching is an important operation which helps to ensure maximum number as well as quality of flowers. Some cultivars do not require pinching but sim cultivars require this operation to encourage branching. Pinching should be done approximately 3-4 weeks after planting. Three types of pinching are being adopted in carnation as detailed below.



Single pinching in standard carnation



Before pinching



After pinching



35 days after pinching



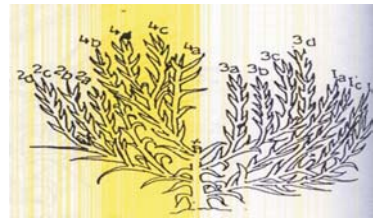
Pinch and a half (2 + 4 laterals)



Pinch and a half (2 + 6 laterals)



Double pinch (8 laterals)



Double pinch (16 laterals)

Courtesy : Carnation monograph edited by Y.C. Gupta



Pinching in spray carnation

★ **Single pinch**

In this method, the top of the main or leader shoot is removed leaving 5 pairs of leaves from which 4-5 lateral shoots develop. These lateral shoots will produce flowers at the same time. This method is particularly applicable to cultivars which produce higher proportion of quality blooms like the hybrid standard carnations.

★ **Pinch and-a-half**

This method is followed to regulate the supply of flowers throughout the year. It involves the removal of main stem tip to induce 4-5 lateral shoots. When these lateral shoots develop 5-6 pairs of leaves, only half the number of the lateral shoots are pinched. This method provides steady supply of flowers but reduces the quantity of the first crop.

★ **Double pinch**

In this method the main shoot is pinched once followed by pinching of all the lateral shoots arising from the first pinch when they are about 6-8 cm long or develop 5-6 pairs of leaves. This method produces larger number of flower bearing shoots but produce weak shoots and poor quality flowers. So this method is not commonly followed.

c. Deshooting

Unwanted secondary shoots on the flowering stems are removed when they are about 2-3 cm long.

d. Disbudding

Disbudding is practiced in standard and spray or miniature carnations. In standard carnations, disbudding is practiced for getting good quality flowers. The axillary / lateral buds are removed just after appearance, without damaging the leaves and stems. Usually those axillary buds about six nodes below the terminal flower buds are removed to encourage the development of the main flower bud. In spray or miniature carnations, the main flower bud (terminal bud) is removed to encourage the lateral flower buds to develop.



Disbudding

e. Calyx banding

Calyx splitting is a physiological disorder in carnation affecting the flower quality. This disorder can be minimized by calyx banding. Calyx banding is the practice of placing a rubber band or plastic tape around the calyx of the flower bud when it just begins to open.

f. Application of growth regulators

Growth regulators have been reported to significantly influence flower production and regulation in carnation. Two sprays of GA₃ @ 100 ppm each at first pinch and when axillary shoots are 8-10 cm long will produce early flowering and long stems. Growth retardants like chlormequat (CCC @ 0.25%) and diaminozide (SADH @ 0.4%) have been reported to promote flower initiation and increase flower yield. They also cause earlier flowering and improve flower quality by reducing calyx splitting. Application of Malic Hydrazide @ 500-1000 ppm also increases the number of flowers but delays flowering.

xiv. Plant protection

Maintenance of adequate aeration inside the polyhouse and proper hygiene of the beds, implements and workers would help in preventing most of the pest and diseases.

a. Pest management

★ Red spider mite

The red spider mite (*Tetranychus urticae*) is the most serious pest in carnation. The mites are minute red insects which live on the undersides of the leaf and suck the sap. The affected leaves turn pale and withered and shows severe webbing. The affected plants become stunted and distorted. The quality, yield and vase life of flowers decline with increasing mite population. Mites usually cause severe damage in hot dry conditions.

Proper ventilation and watering are the most important factors to prevent the mite attack. Cleanliness and elimination of weeds will also reduce the mite population. Spraying Dicofol @ 2 ml/l or Wettable sulphur @ 5g/l or Propargite @ 2 ml/l during initial stages and Abamectin 1.9 EC @ 0.5ml/l of water with sufficient amount of surfactants during severe infestation stages will bring desired results. Biological control by releasing the predatory mite *Phytoseiulus persimilis* has also been reported to be effective against mites.



Mite colony



Nymphs and eggs



Adult mite

★ Aphids

Aphids (*Myzus persicae*) suck the sap from the leaves of growing plants leading to reduce plant vigour. In severe conditions, they leave sticky deposits on the leaves and flower buds. They also transmit carnation ring spot and carnation mosaic viruses.



Aphid

Spraying the plants with Thiomethoxam 1 ml/l or Acetamiprid 1 ml/l or Imidacloprid 17.8 SL 0.1 g/l will effectively control aphids.

★ Thrips

Thrips (*Thrips tabaci*) suck the sap from the leaves, causing them to turn yellow and then patchy white, often with black specks and slight wrinkling. They also cause streaks on the flowers making them unmarketable.

Spraying Dimethoate 30 EC @ 1 ml/l or Fenitrothion 50 EC @ 3.5 ml/l or Malathion 50 EC @ 2 ml/l of water or application of Aldicarb 10G @ 5 g/m² will control thrips.



Thrips infested flower

★ Bud borer

The caterpillars of the bud borer (*Helicoverpa armigera*) mostly affect the flower buds. The moth lays eggs in the buds and the larvae eat into the buds completely damaging them. The larvae feed on leaves, flower buds and flowers. They make characteristic round holes in buds and flower

heads. The infested buds fail to open. The attack by this pest is more during warm conditions.



A larva feeding on flower bud



Adult moth of bud borer

Manual destruction of the caterpillars and spraying of Novaluron @ 3 ml/lit or Indoxacarp 14.5 SL @ 1 ml/l or Fenitrothion 50 EC at 1.5ml/hl will control the bud borer.

★ **Cut worm**

The cut worm moths (*Peridroma saucia*) lay eggs of about 50 or more on the stems or on the undersides of leaves. A full grown caterpillar is about 5.0 cm long. It climbs on the stems of carnations and feeds on the buds, often cutting off the stem just below. Young plants are often cut off at the surface of the ground. The worm is most prevalent in fields during June-July.

Application of Diazinon @ 0.2% to the soil prior to planting or spraying the plants with Sevin @ 0.15% will control the cutworm.

★ **Nematodes**

Carnation is host to about 21 nematodes. The most important nematodes affecting carnation are *Cricomemoides*

curvatum, *Cricomemoides xeroplex* and *Meloidogyne incognita*. The nematodes cause reduced root system, stunted shoot growth and reduction in the number of blooms. Nematodes can be eliminated by growing plants in fumigated soil. Application of Furadan, Aldicarp or Nemaphos @ 10gm/m² controls nematodes in carnation.

b. Disease management

Carnations are attacked by a number of diseases which are caused by fungi, bacteria and viruses.

★ Fusarium wilt

Fusarium wilt (caused by *Fusarium oxysporum* f.sp. *dianthi*) is one of the most serious diseases in carnation. Poorly drained soil and abnormally high temperature are conducive for the development of this disease. The affected plants show foliage wilting, often only on a few branches, followed by death. Rotting of the stem below ground level with internal brown streaking occurs. If the plants are pulled, they break off easily while the firm roots remain in the soil.

The best control measures are soil sterilization or chemical fumigation of the soil, soil solarization using clear transparent polyethylene film (0.1 mm thick) for 30 days, use of pathogen free planting materials and general greenhouse sanitation. Drenching the soil with Benomyl (0.1%) or Ridomil (0.2%) at three month intervals starting from two weeks after planting and spraying with Bavistin @ 0.1% will reduce the malady. Biological control with *Bacillus subtilis*, *Streptomyces* sp, *Trichoderma viride* and *Pseudomonas fluorescens* has also been reported to be effective

against Fusarium wilt. These agents are generally applied @ 10g/m² at monthly intervals till the end of the first flush.



Fusarium wilt affected plants



Rotting of stem



★ **Alternaria leaf spot**

Alternaria leaf spot (*Alternaria dianthi*) is a very common foliage disease in carnation. The pathogen causes spots on the leaves and stems and the affected leaves wither and die prematurely. The pathogen is present in the dead plant material and spreads by splashing water. Temperature above 23.8°C promotes growth of the pathogen.

Foliar application of Dithane M-45 @ 0.2% or Carbendazim @ 0.1% controls the disease.

Alternaria leaf spot



In leaves

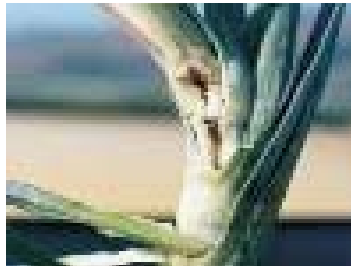


In flower bud

★ Bacterial wilt

Bacterial wilt (*Pseudomonas caryophylli*) occurs in places where the night temperature is below 23.8°C. It is more common in older plants. The prominent symptom is wilting of one or more branches or the entire plant. Leaves of the affected plants look dull and greyish green and then turn yellow and finally die.

Pseudomonas is a soil borne pathogen and hence soil sterilization and use of disease free planting material will minimize the disease incidence.



Bacterial wilt infected plant

★ Butt rot

This disease (caused by the fungus *Rhizoctonia solani*) affects the plants at the soil line causing wilting and yellowing of foliage followed by death of plants. Butts sometimes show a brown discolouration and cracking just below soil level. The brown rot can extend up to the stem. Fluffy, light brown fungal hyphae can sometimes be observed on the surface of the rotting tissue. Early stage of

the disease can be confused with Fusarium wilt, but it differs in that no internal brown streaking is observed.

The relative resistance of carnation plants to *R. solani* is increased by good air circulation and drainage and shallow planting of cuttings. The disease incidence can be reduced by drenching with Carbendazim @ 0.2% before planting.

★ Rust

Early infections of rust (*Uromyces dianthii*) appear as pale green blister-like swellings which release reddish to dark brown powdery masses of spores. Pustules can be up to 10 cm in length and occur on stems, leaves and calyx. Severely infected leaves may turn yellow and die. The disease is common under warm humid conditions.

Keeping the foliage dry and regular preventive spraying of Carbendazim @ 0.1% or Dithane M-45 @ 0.2% can control the disease.

★ Grey mould

Grey mould (*Botrytis cinerea*) is a storage disease that affects the petals. Initially a wet tan coloured blotch develops on petal tips which spread rapidly to produce a fluffy grey mould. This disease is favoured by high humidity.

Reduced humidity and maintenance of good ventilation and hygiene practices and avoiding injuries to flower can minimize the disease. Benlate @ 0.1% controls this disease.

★ Stem and root rot

The plants infected with stem and root rot (*Phytophthora* sp.) show withering and yellowing of foliage, leaf death, external browning of stems and internal browning at nodes. Wet conditions, over watering and badly drained soils favour development of this disease.

The disease can be controlled by avoiding over watering and poorly drained soils. Drenching with Benomyl @ 2.5g/lit can be recommended for controlling the disease.

★ Fairy ring spot

The disease (*Heterosporium echinulatum*) causes fairy ring-like spots which coalesce, extend and merge, eventually destroying the leaves.

Good aeration and spraying of Carbendazim @ 0.1% or Dithane M-45 @ 0.2% at 10 day intervals will reduce the disease infestation.

★ Viral diseases

Carnation is subjected to many viral diseases. The most common ones are streak, mosaic, mottle, ring spot, etched ring and vein mottle. Use of virus free planting material raised through shoot tip culture can eliminate viruses. Vectors can be controlled by spraying Thiomethoxan @ 0.1%.

xv. Physiological Disorders

a. Calyx splitting

Calyx splitting is an important disorder in carnation, which has been associated with many factors like genetic,

environmental, nutritional and other cultural practices. The cultivars with short and broad calyx are more susceptible than the ones with long and narrow calyx. Irregular or fluctuating temperature during flowering also induces calyx splitting. Low temperature below 10°C leads to the development of an extra whorl of petals inside the calyx. The calyx unable to hold these extra growing petals splits up. Nutritional make up of plants also influence calyx splitting. Low nitrogen, high ammoniacal nitrogen or low boron levels enhance calyx splitting. Closer spacing has also been reported to encourage calyx splitting.

Selection of cultivars that are less prone to calyx splitting, regulation of day (20-25°C) and night (12.5-15.5°C) temperatures and maintenance of optimal levels of nitrogen (25-40 ppm) and boron (20-25 ppm) in the growing medium can minimize this disorder. Spraying of borax @ 0.1% at fortnightly intervals will reduce the disorder. Calyx splitting can be reduced by placing a rubber band around the calyx of the flower which has started opening.



Calyx splitting

b. Sleepiness

Sleepiness causes huge post harvest losses in cut carnation. It occurs due to exposure of flowers to ethylene or water stress. Also, the incidence of sleepiness has been found to be higher when the flowers are stored for a longer period or when they are exposed to high temperature.

Spraying of STS 0.4 mM before harvesting the flowers will correct this disorder.

c. Grassiness

Grassiness refers to failure of plants to produce flowers. This is a genetic disorder which varies from variety to variety. Removal and destruction of affected plants is the only way of correcting this disorder.

d. Slabside

This disorder refers to uneven opening of flower buds resulting in the petals protruding on one side only, giving an asymmetrical and lopsided shape to the flower. It is common during cooler periods.

This can be overcome by gradually increasing the temperature to optimum level.

e. Calyx tip die back

Potassium deficiency and water stress cause tip die back. The disorder commences with browning of the calyx tip and it progresses downwards damaging a major part of the calyx. This disorder is often followed by occurrence of secondary fungal infection which makes the flower unmarketable.

Spraying of potassium chloride @ 5g/l two times at 10 days intervals and providing adequate water @ 4.5 l/m² can minimize this malady.

f. Internode splitting

Splitting of internodes affects the quality of cut flowers. Splitting is due to boron deficiency.

Application of borax @ 2g/m² will correct internode splitting.

xvi. Harvesting

Most of the carnation varieties will be ready for harvesting in about 105 to 120 days after planting. There are different stages of harvesting according to the market demand. The harvesting stage is fixed depending on the type of carnation and market demand. Bud size and petal growth are used to judge the stage of harvesting.

a. Harvesting stages based on market demand:

S.No.	Harvest stage	Target market
1.	Tight bud stage	This is for long distance markets. However, it is not practiced in commercial cultivation, since some of the flowers may not open at all after harvest.
2.	Paint brush stage	This stage is ideal for long distance markets or for use after a couple of days.
3.	Semi-open stage	This is ideal for short distance market. The flowers can be used in a day or two days after harvest.
4.	Open stage	This is ready-to-use harvest stage and not suitable for travel.

b. Harvesting stages based on type of carnation:

Type	Harvesting stage
Standard carnations	Paint brush stage, when petals have started to elongate outside the calyx
Spray carnations	With two flowers open and rest of them showing colour

Harvesting stage



Standard carnation



Spray carnation

c. Method of harvesting:

The best time of harvesting is morning. The best place of cutting stem is the area where leaves are well spaced and where at least two axillary shoots appear. The flowers are harvested by either snapping the stem off at a node or cutting off with a sharp knife or small shears. The cut given on the stem should be smooth to avoid injury to flower stem or to the mother plant. In the production period, flowers should be harvested at every two days interval. As soon as the flowers are harvested, the cut ends should be kept dipped in water or preservative solution (sodium hypochloride at 1 ml/10 l of water).

d. Yield

Yield of carnations depends on type and cultivar, growing region and environment, planting time, plant density, pinching methods and also the period of harvest. In general, spray carnations produce more flowers than standard carnations. The number of flowers in standard carnations ranges between 8 and 12 flowers/ plant / year.

In general 200-350 flowers/m² can be obtained from standard carnation, while 250 flowers/ m² can be obtain from spray carnation.

Type of carnation	Flower yield
Standard	300-350 flowers/m ² (8 -12 flowers/ plant)
Spray	250 flowers/m ²

xvii. Post harvest technology

a. Precooling

The harvested flowers are kept at a temperature of 4°C to 7°C soon after harvesting. Rapid precooling of flowers maintains quality as well as increases the longevity of flowers.

b. Grading

The flowers are graded to different classes according to their quality. Before grading the foliage at the bottom half of the stem should be removed (stripping). Standard

carnations are graded based on length, strength of stem and flower size. The Society of American Florists suggests the following parameters to ensure quality.

1. Flower and leaves should be bright, clean and firm
2. Flowers should have fairly tight petals at the centre
3. Flowers should be symmetrical in shape and size representative of the cultivar
4. Flowers should be free from calyx splitting
5. Flowers should be free of decay and mechanical damage
6. Flower stems should be free of lateral buds and suckers
7. Flower stems should be straight and have normal growth.

Based on minimum flower diameter and stem length, the Society of American Florists has developed the following grades.

S.No.	Parameters	Grade		
		Blue or Fancy	Red or Standard	Green or Short
1.	Bud diameter (mm)			
(a)	Tight	50	44	None
(b)	Fairly tight	62	56	None
(c)	Open	75	60	None
2.	Stem length (cm)	55	43	30

The European Economic Community has developed the following grades of carnation based on stem length.

Description code	Minimum and maximum stem length (cm)
0	Less than 5 cm or flowers without stem
5	5-10
10	10-15
15	15-20
20	20-30
30	30-40
40	40-50
50	50-60
60	60-80
80	80-100
100	100-120
120	>120

c. Bunching

After grading, the flowers are bunched in two layers with 20 flowers per bunch for standard carnation types and 10 stems per bunch (consisting of 35 opened or partially opened flowers) in each stem for spray carnation types.



Stripping



Bunching



Packing

d. Conditioning of flowers

Carnation flowers are very sensitive to ethylene. Conditioning the flowers after grading and bunching will increase the post harvest life of the flowers. After bunching the stem ends should be trimmed and placed in a preservative solution to extend the longevity of the flowers. The preservative solution is generally composed of a sugar, a germicide and growth hormones.

Usually 8-hydroxyquinoline sulphate (8-HQS) or 8-hydroxyquinoline citrate (8-HQC) @ 200 ppm, silver thiosulphate @ 0.2 mM, cytokinin @ 50-100 ppm, sucrose @ 2.0% and citric acid @ 50-100 ppm are used as flower preservatives. The pH of the preservative solution should be maintained at 4-5. The flowers should be placed in the solution at least for 4 hrs.

e. Packing

After conditioning, the flowers are wrapped with polythene or polypropylene sleeves to protect them from mechanical damage and to improve the appearance. Normally perforated sleeves are used as wrapping material. The basal ends of the stems can be placed in absorbent cotton saturated with water and enclosed in waxed paper or aluminium foils. Different types of corrugated fibre board boxes are used for packaging of carnation flowers. The boxes must be strong enough to withstand the weight of at least eight full boxes placed on top of one another under conditions of high humidity. For long distance transport, telescopic style boxes made up of corrugated fibre board

are recommended. Normally a box size of 122cm, 50cm and 30cm length, width and height respectively is used. Standard carnations are packed with 24, 28 or 32 bunches per box according to the grade. Spray carnations are packed with 100 bunches per telescopic corrugated carton. All gaps inside the boxes should be filled with shredded paper. Sides of box should have vent holes with flap. Total vent size should be equal to 4-5% of the area of the end wall of the box.

f. Storage and precooling

After packing, the flowers should be cooled immediately to bring a relatively cool condition inside the packed boxes. Forced air cooling is normally followed. Cool air is forced into the boxes through the vents of the boxes. In this method, the forced air will bring down the flower temperature to the air temperature of the cold room within an hour. The optimum storage temperature may vary depending on stage of flower harvest and method of storage. Generally standard carnations harvested at bud stage are stored at 0°C whereas open flowers are stored at 3-4°C. The humidity must be maintained at a high level of 90-95%. Refrigerated vans should be used for transporting the flowers.

xviii. Tips to reap good profits from carnations

- * Land preparation should be done in perfect manner.
- * Planting material should be free from pest and diseases and must have good vigour.
- * Soil and water analysis should be done at regular intervals to maintain optimum pH.

- * Support net should be provided at appropriate level and time.
- * More organics should be added to enrich the soil.
- * Pinching, training, disbudding, soil loosening should be done at appropriate intervals.
- * Scouting for diseases and pest to be taken up regularly.
- * Preventive sprays rather than curative sprays to be given.
- * Removal of infested plants and burning to be followed.
- * Proper post harvest handling to be adopted to reduce the loss during handling operations.
- * Good hygiene should be maintained throughout the cropping period.

INDEX

Alternaria leaf spot	41
Aphids	37
Application of growth regulators	36
Bacterial wilt	42
Border and Picotee	09
Boron	30
Bud borer	38
Bunching	51
Butt rot	42
Calcium	30
Calyx banding	35
Calyx splitting	44
Calyx tip die back	46
Carbon dioxide	18
Chabaud or Marguerite	08
Conditioning of flowers	52
Cultivars suitable for pot culture	15
Cutworm	39
Deshooting, Disbudding	35
Fairy ring spot	44
Fertigation schedule	31
Fusarium wilt	40
Grading	49
Grassiness	46
Grey mould	43
Harvesting stages based on market demand	47
Harvesting stages based on type of carnation	48
Humidity	18
IIHRP-1	14

Internode splitting	47
Light	17
Malmaison	10
Method of harvesting	48
Micropropagation	23
Nematodes	39
Nitrogen	29
Packing	52
Perpetuals	11
Phosphorus	29
Pinching	32
Potassium	29
Precooling	49
Red spider mite	36
Rust	43
Seed propagation	19
Single pinch, pinch and a half, double pinch	34
Slabside, Sleepiness	46
Spray varieties	15
Standard varieties	14
Stem and root rot	44
Storage and precooling	53
Temperature	16
Thrips	38
Training	32
Vegetative propagation	20
Ventilation	18
Viral diseases	44
Yield	49



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