# EVALUATION OF DIFFERENT GENOTYPES OF CARNATION (*Dianthus caryophyllus* L.) IN RESPONSE TO ORGANIC AND INORGANIC FERTILIZATION MODULES

*Thesis*

**by**


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# CERTIFICATE-I

This is to certify that the thesis titled, **"Evaluation of different genotypes of carnation (*Dianthus caryophyllus* L.) in response to organic and inorganic fertilization modules"**, submitted in partial fulfilment of the requirements for the award of the degree of **Doctor of Philosophy Floriculture and Landscape Architecture** in the discipline of **Horticultural Sciences** to Dr Yashwant Singh Parmar University of Horticulture and Forestry, (Nauni) Solan (HP) – 173 230 is a bonafide research work carried out by **Ms Rachel Vanlalhruaii (H-2019-05-D)** daughter of Mr V Lalrobiaka under my supervision and that no part of this thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been fully acknowledged.

**Place: Nauni (Solan)**
**Date:**

**Dr SR Dhiman**
**Major Advisor**

# CERTIFICATE-II

This is to certify that the thesis titled, **"Evaluation of different genotypes of carnation (*Dianthus caryophyllus* L.) in response to organic and inorganic fertilization modules"**, submitted by **Ms Rachel Vanlalhruaii (H-2019-05-D)** daughter of Mr V Lalrobiaka to the Dr Yashwant Singh Parmar University of Horticulture and Forestry, (Nauni) Solan (HP) – 173 230 India in partial fulfilment of the requirements for the degree of **Doctor of Philosophy Floriculture and Landscape Architecture** in the discipline of **Horticultural Sciences** has been approved by the Advisory Committee after an oral examination of the student in collaboration with an External Examiner.

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*I solely claim the responsibility for all the errors and limitations in this work.*

**Place: Nauni, Solan**
**Dated:** **(Rachel Vanlalhruaii)**

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# ABBREVIATIONS USED

| | | |
|---|---|---|
| % | : | Per cent |
| @ | : | At the rate of |
| < | : | Less than |
| > | : | Greater than |
| ANOVA | : | Analysis of Variance |
| CD | : | Critical difference |
| cfu | : | Colony forming unit |
| cm | : | Centimetre |
| $cm^2$ | : | Square centimetre |
| cv. | : | Cultivar |
| $dSm^{-1}$ | : | Deci Siemens per metre |
| EC | : | Electrical Conductivity |
| et al. | : | Co- worker |
| etc. | : | Et cetera |
| FYM | : | Farm Yard Manure |
| g | : | Gram |
| $GA_3$ | : | Gibberellic Acid |
| ha | : | Hectare |
| HP | : | Himachal Pradesh |
| i.e. | : | That is |
| IAA | : | Indole Acetic Acid |
| K | : | Potassium |
| kg | : | Kilogram |
| l | : | Litre |
| L. | : | Linnaeus |
| LxBxH | : | Length x Breadth x Height |
| m | : | Metre |
| $m^2$ | : | Square metre |
| mg | : | Milligram |
| mg/g | : | Milligram per gram |
| ml | : | Millilitre |
| mm | : | Millimetre |
| N | : | Nitrogen |

| | | |
|---|---|---|
| NS | : | Non significant |
| °C | : | Degree Celsius |
| P | : | Phosphorous |
| pH | : | Potential of hydrogen |
| ppm | : | Parts per million |
| q | : | Quintal |
| RBD | : | Randomized Block Design |
| RDF | : | Recommended Dose of Fertilizers |
| spp/sp. | : | Species |
| var. | : | Variety |
| VC | : | Vermicompost |
| viz. | : | Videlicet (namely) |

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# *Chapter-1*

# INTRODUCTION

Carnation (*Dianthus caryophyllus* L.), a member of the Caryophyllaceae family, is a highly sought-after flower in global trade. With a diploid chromosome number of 2n=30, it is cherished for its vibrant range of colours, exceptional longevity and resilience during long-distance transportation. There are two main types; standard carnation, featuring a single flower per stem and the spray carnation, boasting multiple flowers on each stem. The cut flower industry primarily utilizes standard carnations.

Native to the Mediterranean region, carnations are highly valued as cut flowers for its continuous blooming characteristic. Its large-scale commercial cultivation takes place in various countries such as Italy, Spain, Colombia, Kenya, Sri Lanka, Canary Islands, France, Holland, Germany, India and the USA. Notably, India has major carnation production centers in and around Bangalore, Pune, Delhi, Trivandrum, Andhra Pradesh and Himachal Pradesh. Carnations thrive well in regions with mild climates, making places like Solan, Shimla, Kullu, Kalimpong, Kodaikanal, Srinagar, Ooty and Yercaud suitable locations for their commercial growth (Jawaharlal et al., 2009).

Genetically carnation is a quantitative long day plant, but the present-day Florist's carnations are considered to be relatively insensitive to photoperiod. Long photoperiods promote flowering while short days tend to delay it (Jawaharlal et al., 2009). Cut flowers of carnations are sensitive to ethylene and senescence is accomplished by sequential rise in ethylene production by different flower parts (Nichols et al., 1983). Growing environment plays a major role in the growth and development of carnation. Carnation requires an optimum day temperature of 18.3ºC whereas, the optimum range of night temperature during winter is 10-11ºC while in summers it ranges from 13-15.4ºC with more than 21.5 kilo lux light intensity, cyclic lighting or continuous lighting from dusk to dawn hastens flowering (Blake, 1955). $CO_2$ enrichment in greenhouse enhanced the flower quality (Cox, 1967). The best quality flowers were produced when $CO_2$ concentration in the greenhouse was maintained at 500 ppm along with a day temperature of 14-15.4 ºC (Holley et al., 1964). Though there are different types of greenhouses, naturally ventilated polyhouses are preferred in mild climate in which temperature is reduced by ventilation (Ryagi et al., 2007). The fluctuation in temperature results in calyx splitting and reduction in flower yield.

The lucrative and flourishing business of cut flowers has led to uncontrolled and indiscriminate use of chemical fertilizers, insecticides, fungicides and growth promoters. There is a need to reduce the mineral fertilizers consumption due to unprecedented hike in price of fertilizers, non-availability and also causing soil and water pollution which aggravates the problem of soil health. Potential alternatives or supplements and eco-friendly products have to be tested and popularized to educate the farming community so that they can minimize the use of chemical fertilizers by relying on organic and eco-friendly supplements.

The term “fertigation” coined with two words i.e., fertilizer and irrigation is introduced with micro irrigation. Fertigation is well recognized as the most effective and convenient means of maintaining optimum fertility level and water supply according to the specific requirements of the crop and soil, resulting into higher yields and better quality. The fertilizers applied through the micro irrigation system is available in the root zone at field capacity state and gets easily absorbed by the plant. Fertigation caused a great effect on fertilizer saving. Research has revealed that more than 40 percent saving of fertilizer can be achieved by fertigation through drip system with a substantial increase in yield. Water is also saved ranging from 39% to 62% along with an increase in production. The irrigation efficiency of micro irrigation system has been reported to the tune of 90% to 95%. In contrast, the irrigation efficiency of the traditional method is hardly 60% to 70% because of greater loss due to leaching and surface runoff (Nirala et al., 2018).

As organic agriculture is finding place in the mainstream of development and shows great promise commercially, socially and environmentally, Natural Farming is being adopted which utilizes liquid formulation like jeevamrit- a fermented product made of cow products namely dung and urine and other ingredients like gram flour and jaggery which are used as plant growth enhancing substances prepared with material available with farmers and other organic formulations like Agniastra and Bhramastra for plant protection against pests. Jeevamrit promotes immense biological activity in soil and makes the nutrients available to crop (Devakumar et al., 2008). Jeevamrit contains huge amount of microbial population which multiply and act as a stimulant for improving soil health, intensify microbial activities in soil and ultimately ensures higher availability and uptake of nutrients by the crops (Palekar, 2006). Jeevamrit is considered to be a rich source of beneficial micro flora which support, stimulate the plant growth, enhances the biological efficiency of crops and help in getting better vegetative growth and also good quality yield.

The performance of carnation varieties, yield and quality varies with genotypes, region, season and growing environment. Keeping in view the importance and popularity of carnation and lack of database regarding organic cultivation of this crop, the present study on evaluation of different genotypes of carnation (*Dianthus caryophyllus* L.) in response to organic and inorganic fertilization modules has been taken up with the following specific objectives.

i) To find out the possibility of organic cultivation of carnation.

ii) To identify suitable genotype(s) for organic and inorganic cultivation of carnation.

# *Chapter-2*

# REVIEW OF LITERATURE

This chapter is a brief review of the work done with respect to genotypes evaluation, chemical fertilization and biostimulant (jeevamrit) in relation to growth and flowering of carnation. Carnation is a popular cut flower crop with a wide range of cultivars available for cultivation. New cultivars are constantly being introduced to meet consumer demand. The performance of carnation cultivars can vary in terms of vegetative and floral characteristics due to factors such as region, season, genetic composition, soil conditions and climate. It is crucial to assess the suitability and adaptability of these varieties to specific regions, considering parameters such as flowering, flower quality and yield, in order to ensure optimal results before recommending them for commercial cultivation to growers and farmers.

Chemical fertilizers play a significant role in modern agriculture as they provide immediate nutrient availability, promote plant growth and increase agricultural productivity, while organic fertilization promotes soil health, environmental sustainability and long-term soil fertility. The choice between chemical and organic fertilizers depends on various factors, including specific crop requirements, environmental considerations and sustainable farming practices. A balanced approach that combines the benefits of both types of fertilizers may be the most suitable option for sustainable and efficient agriculture.

There is limited scientific research available on the use of jeevamrit in flower crops. However, there have been studies on the use of organic inputs in flower cultivation, which provide some insight into the potential benefits of jeevamrit. While the specific effects of jeevamrit on flower crops have not been extensively studied, it is reasonable to expect that they may have similar benefits to other organic inputs due to their high nutrient content and soil-building properties. The available literature has been reviewed under following heads:

**2.1 Evaluation of genotypes**

**2.2 Effect of chemical fertilizers**

**2.3 Effect of jeevamrit**

## 2.1 Evaluation of genotypes

Baweja and Brahma (2001) evaluated sixteen carnation cultivars at HRS, Kandaghat in Solan, Himachal Pradesh, India during 1999-2000. They reported that the plants of cultivar 'Charmeur' were found with maximum plant height (62.28 cm) and stem length (58.76 cm). The number of stems per plant was highest in cultivar 'Irma' 9.14. Cultivar 'Parini' recorded the largest flower size (8.01 cm). Minimum days taken to flowering (160.47 days) and maximum flowering duration (24.15 days) was recorded in cultivars 'Red Corso'.

Mahant (2003) evaluated four cultivars of carnation, namely; 'Impala', 'Super Star', 'Veleta' and 'Fantasia' and reported that cultivar 'Impala' attained maximum plant height (76.89 cm) and stem length (67.47 cm) while flower size (6.05 cm) was maximum of cultivar 'Super Star'. However, duration of flowering was maximum in 'Fantasia' (23.21 days). It was also observed that the vase life of standard cultivars 'Impala' and 'Super Star' (7.46days) was more than spray cultivars 'Veleta' and 'Fantasia' (5.79 days).

Dwivedi and Abdul Kareem (2004) evaluated fifteen carnation cultivars under cold conditions of Ladakh, India. The height of the plants varied, with 'New Espana' being the shortest at 47.65 cm and 'Arthur Sim' being the tallest at 57.66 cm. The cultivar 'Corpalmor' exhibited the minimum days to flowering of 115.8 days, while 'Red Carmo' took minimum days to flowering of 130.66 days. 'Cabaret' exhibited minimum stalk length of 19.65 cm, whereas 'Dunty Pink' had maximum stalk length of 27.00 cm. The number of flowers per plant varied significantly, ranging from 4.3 flowers in 'New Espana' to 6.3 flowers in 'Red Carmo'. Flower size varied from 5.0 to 5.9 cm in cultivars 'Candy' and 'Corplamor', respectively. Despite having more petals and larger flower size, no calyx splitting was observed in any of the cultivars. Among the cultivars, 'Flair' had the longest flowering duration, lasting 34.30 days, followed by 'Atora' with a duration of 33.00 days.

Six cultivars, namely; 'Cobra', 'Gaudina', 'Montezuma', 'Niva', 'Salsa' and 'Super Green' were assessed for their growth and flowering performance under polyhouse conditions in Nagpur, Maharashtra, India. All six cultivars exhibited satisfactory performance across various growth and flowering parameters. 'Salsa' demonstrated the minimumn duration for bud initiation and flower opening, taking only 99.55 days compared to other cultivars. 'Super Green' displayed the longest vase life, lasting for 9.5 days. The highest yield, with 5.8 flowers per plant, was achieved with the cultivar 'Cobra'. 'Gaudina' recorded maximum plants height of 85.72 cm and the highest leaf count with an average of 93.76 leaves (Shankar et al., 2004).

Shiragur et al. (2004) conducted a study in Arabhavi, Karnataka, to assess nine different carnation varieties. The research demonstrated significant variations in the growth and flowering performance among these cultivars. The cultivars 'Desio', 'Sorisso' and 'Madame Collette' exhibited early flowering. 'Aicardi', 'Alma', 'Candy', 'West Pretty' and 'Madame Collette' had the longest duration of flowering. Among the cultivars, 'Pirandillo' had the maximum flower stalk length, while 'Sugar Baby' had the thickest flower stalk girth. The cultivar 'Alma' had maximum number of flower petals. Regarding the number of flowers per plant, 'Madame Collette', 'West Pretty', 'Desio' and 'Aicardi' proved to be superior.

Karrow (2008) evaluated twenty cultivars of carnation under protected condition at the experimental farm of the Department of Floriculture and Landscape Architecture, Dr. YSPUHF, Nauni, Solan, Himachal Pradesh during the year 2007-08. The study revealed that cv. 'Master' obtained maximum plant height (85.66 cm) and stem length (76.72 cm) while 'Riberra' recorded maximum number of flowers per plant (7.12), flower size (7.26cm) and stem thickness (14.79 mm). Earliest flowering was recorded in cultivar 'Lavender Lace' whereas maximum flowering duration was observed in 'Lady Green'.

Sharma and Srivastava (2008) conducted an evaluation of sixteen carnation genotypes. The study revealed that the variety 'Master' had the maximum plant height and stem length. 'Ferato' exhibited the highest number of leaf pairs per stem. In terms of flowering characteristics, 'Piax Dover' took minimum days to bud opening, while 'Tabour' displayed the largest flower diameter, longest flower duration and the lowest percentage of insect pest damage.

The performance of carnation cultivars concerning growth, flowering, flower yield, flower quality and vase life was investigated by Dalal et al. (2009) under semi-controlled polyhouse environment. The findings revealed that the cultivars 'Domingo' and 'Master' exhibited the highest growth. In terms of early flower bud appearance, flower yield, flower quality and vase life, the cultivars 'Master' and 'Paolo' demonstrated superior performance.

Gharge (2009) conducted a study under naturally ventilated polyhouse condition at Hi-tech Horticulture Unit, University of Agricultural Sciences, Dharwad from February to

August, 2008, to assess ten different cultivars of carnation (*Dianthus caryophyllus* L.) in terms of their growth, quality and economic value. The results showed significant and diverse variations among the various carnation cultivars. Based on the outcomes, the best performers for growth, early flowering, flower yield and quality were 'Yellow Firato', 'Diana Firato', 'Aicardi' and 'Pink Shiva'.

Dilta and Gupta (2010) evaluated different carnation cultivars at RHFS, Bhota, Hamirpur, HP and found that six cutlivars, namely; 'Impala', 'Lavender Lace', 'Parendillo', 'Tempo', 'Madras' and 'Sunrise' performed well in terms of both quantitative and qualitative parameters. Based on the results, these cultivars could be recommended for commercial cultivation in Hamirpur region.

Gharge et al. (2011) evaluated ten cultivars of carnation (*Dianthus caryophyllus* L.) for various growth and flowering parameters under naturally ventilated polyhouse condition at Hi-tech Horticulture Unit, University of Agricultural Sciences, Dharwad during February to August, 2008. Wide and significant variations for all the parameters were observed among the different Carnation varieties. Varieties 'Yellow Firato', 'Firato', 'Diana' and 'Gaudina' were superior with respect to growth parameters like plant height and stem girth. Varieties 'Diana', 'Yellow Firato' and 'Aicardi' were early to initiate flower buds and also recorded longer duration of flowering as compared to other varieties. The flower stalk length was highest in 'Yellow Firato' and maximum flower diameter was observed in variety 'Gaudina'. Based on the findings, they concluded that the varieties 'Yellow Firato', 'Diana', 'Firato', 'Aicardi' and 'Pink Shiva' performed best with respect to growth, earliness in flowering, flower yield and quality under naturally ventilated polyhouse.

Verma et al. (2012) conducted a study on fifteen carnation cultivars to evaluate their performance in agro-climatic conditions of Chhattisgarh, College of Agriculture and Research Station from 2006-2008. Their investigation revealed difference in performance among all the cultivars studied. The cultivar 'Sissagree' (67.50 cm) recorded maximum plant height at bud emergence stage while maximum flower stalk length was recorded in 'New Tempo' (50.50 cm). Maximum number of flowers per plant and superior flower size were observed in cultivars 'Tikar' (6.50) and 'Sunrise' (5.40 cm), respectively. The cultivar 'Madras' (57.00 days) had the minimum number of days for flower bud emergence.

Singh et al. (2013) evaluated eight carnation cultivars in naturally ventilated greenhouse in mid hills of Kumaon Himalaya at Research station and KVK, GBPUA&T, Pantnagar, Uttarakhand from 2010-2012. The cultivar 'Red King' was found to be best in terms of number of flowers per plant (35.60), flower diameter (7.83 cm) and vase life (29.30 days). Based on their findings, they concluded that cultivar 'Red King' to be best with respect to all the vegetative and quality parameters for mid hills of Kumaon Himalayas.

Karthikeyan et al. (2013) conducted a study to observe the performance of four carnation cultivars namely; 'Gaudina', 'Dona', 'Bizet' and 'Malaga' in two different environments viz., wooden frame structure and steel frame structure during the year 2010-2012 at Horticulture Research Station, Ooty, Tamil Nadu Agriculture University. The study found that the longevity and performance of crop was better inside the naturally ventilated steel structure polyhouse. Among the cultivars evaluated, cultivar 'Gaudina' exhibited the best overall performance with regards to plant height (69.50 cm), early flower bud appearance (140.00 days), flower yield per metre square (223.20) and duration of flowering (90.50 days) under naturally ventilated steel frame structure polyhouse.

Maitra and Roychowdhury (2013) examined the suitability of ten standard carnation cultivars in the plains of West Bengal at Bidhan Chandra Krishi Vishvavidyalaya, Mohanpur, Nadia, West Bengal. Results indicated that cultivar 'Dark Red' showed the maximum plant height and flower stalk length, cultivar 'Lilac Terres' had the earliest flower bud initiation, cultivar 'Bright Red' had the maximum flower diameter and cultivar 'Dark Red' produced maximum number of flowers per plant.

Roni et al. (2014) conducted an experiment at Horticultural Farm, Sher-e-Bangla Agricultural University, Bangladesh during September 2013 to March 2014 on five carnation varieties viz., 'White angel', 'Red carpet', 'M-red', 'Pink purple' and 'Rainbow pink'. The results revealed that maximum plant height (81.1 cm), number of shoot (7.5/plant), number of internode (18.3/plant), first flowering (73.1 days), flower stalk length (74.5 cm), flower diameter (6.2 cm), number of petal (22.4), bud length (3.3 cm) and diameter (9.1 mm), fresh weight (29.7 gm) and flower per plant (8.1) were observed in the variety 'Red carpet'.

Mehmood et al. (2014) evaluated five carnation cultivars namely; 'Grand Salam', 'Nelson', 'Kaly', 'Cinderella' and 'Tempo' with respect to growth, yield and quality characteristics under lath house conditions at the Directorate of Floriculture, Lahore, Pakistan during 2011 and the results showed that cultivars 'Nelson' and 'Tempo' were found superior with respect to growth, flower yield and vase life characteristics under lath house conditions.

Tarannum and Naik (2014) conducted a study in a naturally ventilated polyhouse during 2011-2012 to evaluate eight carnation genotypes viz., 'Dona', 'White Dona', 'Harish', 'Big Mama', 'Soto', 'Liber', 'Golem' and 'Big Net'. They reported that among the genotypes, 'Soto', 'Dona' and 'White Dona' exhibited superior vegetative growth, while 'Soto', 'Golem' and 'White Dona' showed better flowering parameters. In terms of flower quality, 'Soto' and 'Big Mama' obtained the longest flower stalk length while 'Dona', 'White Dona' and 'Soto' recorded the maximum stem girth. The genotypes 'Dona', 'White Dona', 'Harish', 'Big Mama' and 'Soto' performed best in terms of flower diameter and flower stalk weight.

Hosure (2015) conducted a study in Dharwad to evaluate the performance of ten cultivars of carnation *(Dianthus caryophyllus* L.) in terms of growth, quality, yield, and economics within a naturally ventilated polyhouse environment. The results revealed significant variations among the different carnation varieties for all the parameters examined. Notably, 'Liberty' and 'Gwen' exhibited superior flower yield compared to other genotypes, possibly due to their advantageous yield-contributing traits and lower incidences of calyx splitting and plant mortality. 'Liberty' and 'Gwen' also showed early initiation and opening of flower buds. The variety 'Harmony' had the longest flower stalk length, although the desired stalk length was observed in 'Liberty'. 'Harmony' displayed the largest flower diameter, while 'Farida' had the maximum flower weight. 'Orange Viana' demonstrated the longest vase life. However, 'Jurano' exhibited susceptibility to calyx splitting and plant mortality.

Nacho (2016) conducted an assessment on the growth and flowering attributes of newly developed genotypes of carnation (*Dianthus caryophyllus* L.). The study was aimed to determine the optimal planting time for different genotypes and to assess the variation (PCV and GCV), heritability, genetic advance, genetic gain and correlation among different traits. The study involved ten diverse genotypes planted on two different dates (12 February and 12 April). The results showed that April 12 planting yielded greater plant height (78.54 cm), flower diameter (6.64 cm), bud size (17.47 mm), stem length, 'A' grade flowers, thickness of flower stem (4.98 mm) and duration of flowering (79.33 days). On the other hand, the February 12 planting resulted in less time taken for bud formation (106.24 days) and flowering (154.79 days) and more flower yield (127.0). 'UHFSCar-6' had the longest duration of flowering, largest flower size, days taken to bud formation and flowering while 'Tempo' had maximum plant height, length of cut flower stem and 'A' grade flowers.

Sarkar and Sharma (2016) evaluated fourteen carnation varieties, namely; 'Malga', 'Bright Randevouz', 'Rubesco', 'Madras', 'Tasman', 'Purple Kamsus', 'Dover', 'East Light', 'Cherry Solar', 'Sisagri', 'New Tempo', 'Charment', 'Marathona' and 'Saleya' during 2012-2013 in the hilly region of West Bengal under low cost polyhouse. The results showed that amongst the fourteen varieties of standard carnation studied 'Malga', 'Rubesco', 'Dover' and 'Charment' performed better for quality flower production.

Genetic studies on carnation (*Dianthus caryophyllus* L.) was carried out by Chauhan et al. (2017). Fifty diverse genotypes were evaluated for various growth and flowering parameters to assess the extent of variability, heritability, genetic divergence and the morphological characterization of these genotypes. Genotypes 'Snow Storm', 'Don Pedro', 'Hermes', 'Cinderella', 'Kleos', 'UHFSCar Col.-1' and 'UHFSCar Col.-4' were found to be superior with respect to plant height, stem length and flower size. Early flowering was recorded in genotypes 'UHFSCar Col.-9', 'UHFSCar Col.-11', 'Tempo', 'Madras' and 'Liberty' whereas, maximum number of flowers per plant was recorded in genotypes 'UHFSCar Col.-9', 'Madame Colette', 'Liberty', 'Tamarind' and 'Baltico'.

Jose et al. (2017) evaluated nine varieties of carnations for vegetative, quality and yield parameters under naturally ventilated poly house condition in Allahabad agro-climatic condition. The results revealed that variety 'Irene' was superior in terms of plant height plant height (109.49 cm), number of shoots per plant (8.46), intermodal length (8.12 cm), days to bud initiation (79.53 days), days to bud opening (14.85 days), flower length (5.91cm), number of cut flower stalk per plant (8.06) and number of cut flower stalks per meter square (193.44) and vase life (13.93 days).

Sultanpuri (2018) evaluated three cultivars of carnation, namely; 'Dumas', 'Kiro' and 'Master' and reported that the cultivar 'Dumas' was the most profitable with maximum plant height (83.18 cm), stem length (78.70 cm), bud length (34.93 mm), bud width (21.55 mm), maximum flower diameter (8.29 cm), number of cut flower stems per plant (7.04) and cut flower stems per meter square (175.87). It was also reported that highest gross returns were obtained from cultivar 'Dumas' (Rs. 210856.70/500 $m^2$) when planted in the month of April

2015 followed by March 2015 (Rs. 206801.50/500 $m^2$) planting of the same cultivar. The cultivar ‘Dumas’ resulted in maximum benefit cost ratio of 4.05:1 and 4.16:1 respectively.

Medeo et al. (2019) evaluated eight varieties of carnation, namely, ‘Krakatoa’, ‘Kino’, ‘Loris’, ‘Hillary’, ‘Madame Colette’, ‘Kitaro’, ‘Davinci’ and ‘Cinderella’ under naturally ventilated polyhouse conditions in Prayagraj during December, 2018 to April, 2019 respect to vegetative, qualitative, yield and economic parameters. The results revealed that variety ‘Davinci’ recorded maximum plant height (73.59 cm), number of shoots per plant (7.44), number of internodes (15.443), internodal length (6.153cm), stalk length (66.1cm), earliness (89 days), number of cut flower stalks per plant (7.55), number of cut flower stalks per square meter (181.2) and benefit cost ratio of 3.73. Variety ‘Hillary’ (174.99) was recorded with maximum number of leaves, maximum flower length (5.4cm) and maximum flower diameter (6.27cm). Maximum bud length (3.17cm), maximum bud diameter (2.23cm), flower stalk girth (21.33) and maximum vase life (10.67) were recorded in the variety ‘Cinderella’. Minimum days taken to bud opening was recorded in the variety ‘Kino’ (15.67).

Evaluation for growth and flowering parameters of twenty different genotypes of carnation was carried out by Sharma (2020). The results revealed that the genotype ‘UHFSCar-43’ exhibited the maximum plant height and ‘A’ grade stem length. The largest flower size was observed in genotype ‘UHFSCar-41’. ‘UHFSCar-22’ produced the highest number of marketable flowers per plant and per square meter. Genotype ‘UHFSCar-35’ showed the maximum thickness of flower stem and flowering duration. Both ‘UHFSCar-19’ and ‘UHFSCar-35’ had the longest vase life.

Anand et al. (2021) evaluated eleven cultivars of carnation viz., ‘Big one’, ‘Turbo’, ‘Solex’, ‘Hunza’, ‘Easy Golem’, ‘Express Golem’, ‘Red King’, ‘Golem’, ‘Gioele’, ‘Big mama’ and ‘Happy Golem’ at Horticultural Research Station, Tamil Nadu Agricultural University, the Nilgiris, India and reported that ‘Happy Golem’ recorded maximum plant height, while ‘Golem’ had the minimum plant height. ‘Gioele’ obtained maximum number of shoots per plant, highest stalk length and produced the maximum number of ‘A’ and ‘B’ grade flower stems. It was also reported that in terms of yield parameters, ‘Gioele’ had the maximum number of flowers per plant followed by ‘Red King’ and ‘Hunza’.

## 2.2 Effect of chemical fertilizers

Sharaf and El-Naggar (2003) conducted a field experiment in a greenhouse to examine the impact of foliar fertilizer application on carnation cv. ‘White William Sim’. Orthophosphoric acid was applied at various concentrations (0, 50, 100, 200, or 400 mg per liter as $P_2O_5$), either alone or in combination with boric acid at different levels (0, 25, or 50 mg per liter as B). The most favorable results for vegetative growth were achieved when carnation plants were treated with a foliar application of 200 mg $P_2O_5$ combined with 50 mg per liter B. The data demonstrated that foliar application of $P_2O_5$ alone or in combination with different levels of B stimulated various vegetative growth characteristics, including stem length, stem diameter, stem dry weight, number of leaves per branch and leaf dry weight.

Bhatia et al. (2004) studied the effect of growing media and fertilizers on growth and flowering of carnation under protected condition and reported that soil+FYM+cocopeat (2:1:1) performed the best for important parameters such as plant height, flower bud diameter, stem length and vase life when combined with the biofertilizers and fertigation using water-soluble fertilizers [N and K were applied through 60 ppm nitrate N (41 ppm $KNO_3$ and 19 ppm $Ca(NO_3)_2$) and 40 ppm ammoniacal nitrogen (urea)]. The longest number of days taken to first flowering was observed in the soil+FYM+sand (2:1:1) medium when fertigated with commercial-straight fertilizers [N and K were applied through 60 ppm nitrate N (40 ppm multi K and 20 ppm $Ca(NO_3)_2$) and ammoniacal N (urea)].

Singh et al. (2005) investigated the influence of pinching ($P_1$ - single pinching, $P_2$ - pinch and a half, $P_3$ - double pinching) and its combination with nitrogen treatments ($N_1$ - 200 ppm and $N_2$ - 500 ppm) on the growth of carnation cv. ‘Tasman’. The combination of double pinching ($P_3$) and 500 ppm nitrogen ($N_2$) resulted in maximum number of branches (9.5) and maximum plant spread (31.2 cm).

El-Naggar (2009) investigated the influence of different concentrations (0.0, 0.2, 0.4, 0.6, 0.8 and 1.0 %) of foliar fertilizer (Sangral) contains macro-elements (20%N, 20% P, 20% K, 0. 12% Mg) and micro-elements (70 ppm Fe, 14 ppm Zn, 16 ppm Cu, 42 ppm Mn, 72ppm B and 24 ppm Mo) on the growth, flowering and chemical analysis of leaves of *Dianthus caryophyllus* cv. ‘Red Sim’ at Nubaria Region, West of Alexandria City, Egypt, during 2006 and 2007 and applied foliar fertilizer five times during the growing period. The results revealed that plant treated with 0.6% foliar nutrition showed significant increased in the growth characteristics like stem length, stem diameter, stem fresh and dry weight, number of leaves/ plant, fresh and dry weight of leaves.

The impact of varying concentrations of $GA_3$ (0, 25, 50 and 100 ppm) in combination with different rates of orthophosphoric acid ($H_3PO_3$) (0, 50, 100 and 200 ppm of $P_2O_5$) on the growth and quality of carnation cv. 'Red Sim' plants was examined by El-Naggar et al. (2009). The findings showed that spraying the plants with $GA_3$ alone or in combination with different levels of phosphorus fertilizer stimulated plant growth compared to the control group. The most significant improvements in vegetative growth characteristics, such as stem diameter (0.94 cm), stem fresh weight (77.53 g), stem dry weight (4.19 g), stem length (88.35 cm) and number of leaves per branch (26.18) were observed with the application of 50 ppm $GA_3$ combined with 100 ppm $P_2O_5$.

Gopinath and Chandrashekar (2012) investigated how levels of fertigation and sources of nutrients affect the growth, flowering and quality of carnation var. 'Trendy' in a cost-effective greenhouse at Gandhi Krishi Vigyan Kendra, Bangalore (Karnataka). Two sources of fertilizers - straight (urea, single super phosphate and muriate of potash) and water-soluble (Kemira Limited, Finland) were applied at three levels (100%, 80% and 60%) of fertigation. Significant differences were found among the levels of fertigation for the height of plants at 105 and 120 days after pruning and during the winter. The application of 80% recommended dose of fertilizers resulted in higher numbers of laterals per plant at 105 days after planting and during winter (6.28 and 4.35 laterals per plant, respectively) and longer length of flower buds during winter (1.93 cm), thicker flower buds during winter and summer (1.34 mm and 1.80 mm, respectively), longer length and thicker growth of flower stalks during rainy and summer (58.31 cm and 2.99 mm, respectively), higher numbers of petals per flower head during rainy and winter (68.11 and 63.38 petals/flower head, respectively) and increased diameter of cut-flowers during all three seasons - rainy, winter, and summer (6.94 cm, 5.52 cm, and 5.23 cm, respectively).

Momin et al. (2012) investigated the effect of nutrient management on cutting production of carnation (*Dianthus caryophyllus* L.) and revealed that fertilizer module $FM_5$ comprising of 20-5-5 g/$m^2$ NPK as basal application along with 200 ppm N + 280 ppm K as fertigation given twice a week resulted in the production of cuttings with maximum stem diameter (0.75 cm), weight of cutting (5.22 g), number of cuttings/plant/harvest (4.25), total number of cuttings (16.98) and yield of cuttings/square metre (152.78). Amongst the cultivars, 'Madras' exhibited the maximum stem diameter (0.82 cm), weight of cutting (4.60 g), number of cuttings/plant/harvest (3.80), total number of cuttings/plant (15.12) and yield of cuttings/square metre (152.78), while, cultivar 'White Wedding' recorded minimum stem diameter. Interaction effect revealed that module $FM_5$ was found to be best in getting good quality cuttings in cultivars 'Farida', 'Niva' and 'Madras' which gave the maximum number of cuttings/plant/harvest, total number of cuttings/plant, yield of cuttings/metre square and weight of the unrooted cuttings. In cultivar 'White Wedding', fertilizer modules $FM_4$ consisting of 20-15-10 $g/m^2$ NPK (as basal) along with 175 ppm N and 245 ppm K (fertigation twice a week) gave the best quality cuttings. The time taken for first and successive harvesting of cuttings varied with the season with minimum days during summer and maximum days during winter.

Sahib and Abbas (2012) examined the impact of phosphorus mineral fertilizers (0, 100, 200 mg $P_2O_5$/l) and/or potassium mineral fertilizers (0, 100, 200 mg $K_2O$/l) on the growth and flowering of carnation plants (*Dianthus caryophyllus* L.). The results indicated that the addition of phosphorus and/or potassium at 100 or 200 mg/l improved both the growth and flowering of the carnation plants. The interaction between phosphorus and potassium treatments yielded the most favourable outcomes, including increased plant height (61.40 cm), number of branches per plant (8.19), carbohydrate content (17.78 mg/g dry weight), nitrogen (N) content (19.63 mg/g), phosphorus (P) content (2.81 mg/g) and potassium (K) content (17.28 mg/g). Moreover, the application of these mineral fertilizers resulted in an enhancement of flower diameter, increased number of flowers, and extended vase life.

Ali and Muhammad (2013) conducted an experiment at the Agricultural Technical Institute of Bakrajo-Sulaymaniah Polytechnic University, Kurdistan, Iraq during 2011-2012 growing season. The aim of the experiment was to investigate the impact of different concentrations of soil fertilizer containing nitrogen, phosphorus, and potassium on the growth and flowering of *Dianthus caryophyllus*. The four treatments consisted of different concentrations (0.0, 0.5, 0.7, 1 gm/plant) of soil fertilizer. The soil fertilizer was applied three times during the growing period. Analysis of variance indicated that the NPK treatment had a significant effect on the plant height, number of branches, number of leaves, stem diameter, number of flowers, and flower diameter of *Dianthus caryophyllus*. Furthermore, correlation analysis showed that the number of branches had the strongest positive and significant correlation with flower diameter (0.641) followed by the number of branches and stem diameter (0.574).

Dhinesh et al. (2014) investigaed the impact of the different fertigation levels on physiology, nutrient uptake and flowering characters of *Dianthus caryophyllus* cv. ‘Gaudina’ under aero dynamic polyhouse condition in the Nilgiris. The results revealed that plants treated with a fertigation dose @ 80: 20: 110 g NPK/$m^2$ (100%) at weekly intervals along with foliar application of EDTA micronutrient mixture @ 0.2% at forth night intervals showed significant increase in total leaf area (538.54; 973.58; 1248.47$cm^2$), total chlorophyll (0.94;1.19;1.14 mg/g) and total dry matter production (22.92; 41.31; 82.00 g $plant^{-1}$) during vegetative, flower bud appearance and peak flowering stage respectively compared to control. It was also reported that uptake of plant nutrients NPK on vegetative stage (29.34; 6.88; 40.39 g $plant^{-1}$), flower bud appearance stage (63.62; 12.64; 127.23 g $plant^{-1}$), peak flowering stage (113.98; 26.90; 256.17 g $plant^{-1}$) and flowering parameters viz., days taken for flower bud opening (139.40 days), length of flower stalk (82.24 cm), girth of flower stalk (2.78 cm), opened flower diameter (7.02 cm), number of flower buds $plant^{-1}$ (7.50) and flower yield $m^{-2}$ (268.50) were superior than untreated plants (control).

Madhuri et al. (2014) conducted an experiment on standardization of foliar nutrients (NPK) spray in carnation (*Dianthus caryophyllus* L.) varieties under protected condition and revealed that variety ‘Don Pedro Rapido’ with nutrient level 6000 N: 4000 $P_2O_5$ : 2000 $K_2O$ ppm recorded maximum plant height, fresh and dry weight of plant, internodes per stem and internodal length, harvesting span, fresh and dry weight of single cut flower, number of petals per flower, vase life of cut flower, *in-situ* longevity of flower, length of flower stalk, number of flowers per plant, square metre and hectare, minimum days taken to flower bud initiation and open of first flower. Whereas, only stalk thickness was observed in variety ‘Madame Colette’ with 6000 N: 4000 $P_2O_5$: 2000 $K_2O$ ppm treatment.

Singh et al. (2015) conducted an experiment on the effects of fertilization on quality flower production and foliar nutrient content of carnation (*Dianthus caryophyllus* L.) cv. ‘Master’ and reported that plants fertilized with 250 ppm N and K fertigation through urea and MOP + 250 ppm NPK foliar spray through a water soluble fertilizer Sujala (19 : 19 : 19 NPK) once a week improved the flowering as well as quality parameters and proved superior over the earlier recommended practices and the rest of the treatments.

Akram et al. (2017) reported that 5:10:10 g pot/sup$^{-1}$/ NPK showed positive correlation for morpho-physiological and bio-chemical traits like plant height, number of branches per plant, length of branches, number of leaves per plant, chlorophyll contents, NPK estimation and bud diameter by showing maximum values for the attributes with comparison to other treatments.

Dalawai and Naik (2017) conducted a study with the aim to determine the best integrated nutrient approach for carnation plants and it involved testing eleven treatment combinations, with RDF (250:80:200 g NPK + 2 kg FYM/m$^2$) as the check. The treatments included the use of Azospirillum (60 g/m$^2$), PSB (60 g/m$^2$), FYM (2 kg/m$^2$), and vermicompost (500 g/m$^2$) together with 75% RDF ($T_{11}$). After 150 days of planting, treatment $T_{11}$ showed the best results, with increased plant height (96.55 cm), plant spread (36.86 cm), leaf area (1646.33 cm2), and leaf area index (7.92). The same treatment also resulted in maximum chlorophyll content (1.71 mg/g) in the leaves and the lowest mortality rates due to insect pests (1.87%) and disease (3.41%). Treatment $T_{10}$ (Azospirillum + PSB + VC + 75% RDF) had the highest available nitrogen (263.15 kg/ha), phosphorus (37.97 kg/ha), and potassium (126.27 kg/ha) in the soil and the highest total nitrogen (6.83%), phosphorus (0.69%) and potassium (3.97%) content in the plants. The check treatment resulted in the lowest values for all the parameters measured.

Nirala et al. (2018) evaluated the fertigation effect in carnation under polyhouse in North Bihar agro-climatic conditions and revealed that among different varieties, the variety 'Pingu' recorded maximum number of branches (9.80), minimum days for bud initiation (89.83 days) and flowering (164.83 days), maximum flower diameter (7.83cm) and stalk length (60.22cm) and girth (4.43 mm) as well as maximum number of flowers per m$^2$ area (353). The fertigation treatment 120% fertigation of RDF of NPK resulted maximum plant heights 87.18cm at 210 DAT, number of branches (11.59), minimum time for bud formation (87.89 days), minimum days to flowering (165.11 days), maximum stalk length (57.83cm) and girth (4.91mm) as well as maximum number of flower per m$^2$ area (353.22). The b/c ratio was also found highest in treatment 120% fertigation of RDF of NPK i.e. 2.60, 2.56 and 2.59 for 'Loris', 'Pingu' and 'Gioele', respectively.

Madhuri and Barad (2018) investigated the effect of NPK nutrients through foliar spray on vegetative growth parameters of carnation (*Dianthus caryophyllus* L.) varieties under protected condition and the results revealed that the variety 'Don Pedro Rapido' was found best with five spray of nutrients 6000 N: 4000 $P_2O_5$ : 2000 $K_2O$ ppm at an interval of 25 days after first pinching of the plants.

An investigation conducted by Manikandan and Deshmukh (2018) with the response of carnation variety 'Kiro' to potassium fertilizer sources and levels under polyhouse conditions at College of Agriculture, Pune. The treatments involved three sources of potassium (K) - KCl, $K_2SO_4$, and $KNO_3$ - and four levels of $K_2O$- 75, 225; 100, 250; 125, 275 and 150, 300 mg $K_2O$ per plant during vegetative and flowering period, respectively. The results showed that KCl had a significant positive effect on plant growth compared to $KNO_3$ and $K_2SO_4$. However, $K_2SO_4$ performed better than KCl and $KNO_3$ in terms of flower yield, quality, vase life, and the benefit cost ratio. The study also found that applying $K_2SO_4$ at 100 mg $K_2O$ per plant during vegetative growth and 250 mg $K_2O$ per plant after flowering, along with nitrogen and phosphorus, yielded superior results compared to KCl and $KNO_3$ for carnation cultivation.

Thakulla et al. (2018) investigated the adaptability of exotic variety of carnation (*Dianthus caryophyllus* var. Chabaud) under different doses of nitrogen and revealed that maximum flower number (9.83) was recorded at 400 kg N/ha and minimum day to flowering was recorded with 300 kg N/ha. Maximum plant height, length of flower stalk, number of branches and plant width were recorded at the rate of 400 kg N/ha except flower width which was maximum at the rate of 300 kg N/ha. The results suggested that increasing the doses of N has positive effect on most of the growth and flowering attributing parameters while excess N causes delay in flowering.

### 2.3 Effect of jeevamrit

Yadav and Mowade (2004) reported that the use of fermented liquid organics (panchgavya, jeevamrit, beejamrit, vermiwash, amrutpani, etc.) prepared from cow dung, urine, leguminous leaves or vermiwash were effective in rapid build-up of soil fertility through enhanced activity of soil micro-flora and fauna.

According to Palekar (2006), jeevamrit is a fermented liquid product prepared by mixing up cow dung (10.00 kg) with cow urine (10.00 litre), jaggery (2.00 kg), legume flour (2.00 kg) and handful of soil brought from the bunds of the lands where cultivation is to be taken up. It contains enormous amount of microbial load which multiply and act as a soil tonic. It is said to enhance microbial activity in soil and ultimately ensuring the availability and uptake of nutrients by the crops.

The presence of beneficial microorganisms in these liquid formulations might be mainly due to their constituents such as: cow dung, cow urine, legume flour and jaggery containing both macro and essential micro nutrients, many vitamins, essential amino acids, growth promoting substances like indole acetic acid (IAA), gibberlic acid ($GA_3$) and beneficial microorganisms. Jeevamrit is a low cost improvised preparation that enriches the soil with indigenous microorganisms, therefore required for mineralization (Palekar, 2006; Gore and Sreenivasa, 2011).

The organic liquid manures viz., panchagavya, beejamruth and jeevamruth prepared by using cow products are known to contain beneficial microflora like *Azospirillum*, *Azotobacter*, phosphobacteria, *Pseudomonas*, lactic acid bacteria and methylotrophs in abundant numbers and also contain some useful fungi and actinomyctes (Sreenivasa et al., 2009 and Palekar, 2006).

Vasanthkumar (2006) reported that jeevaamrit is not just a source of nutrients but it is a fermented liquid product containing huge amount of microbial load and which enhances soil bio-mass application to soil even at very lesser rate as it act as a tonic to soil besides improving soil health.

Jeevamrit containing *Azospirillum* ($2\times10^6$ cfu), PSB (Phosphorous Solubilizing Micro-organism) ($2\times10^6$ cfu), *Pseudomonas* ($2\times10^2$ cfu), *Trichoderma* ($2\times10^6$ cfu), yeast and moulds ($2\times10^7$ cfu) per ml of sample, in the samples being analyzed after 5 days of incubation (Pathak and Ram, 2007).

Manjunatha et al. (2009) reported that sunflower plants when treated with FYM at 7.5 t/ha + Recommended Dose of Fertilizer (RDF), significantly increased the 1000 seed weight (49.26 g), head diameter (17.71 cm), seed weight/head (31.91 g), seed yield (1774 kg/ha) and stalk yield (4.21 t/ha) than RDF (45.56 g, 16.40 cm, 28.97 g, 1611 kg/ha, 3.29 t/ha, respectively) and was at par with application of FYM at 7.5 t/ha + jeevamrit. Further they also reported the effects of farm yard manure treated with jeevamrit on soil properties and yield of sunflower. They found that the application of jeevamrit had significantly increased the activities of microbes by solubilization and uptake of nutrients was also enhanced.

Renukaradya et al. (2011) conducted an experiment on integrated nutrient management in carnation cv. 'Desio' and revealed that the 50% RDF + vermicompost + 3% Manchurian tea + 3% panchagavya helped in reducing the application of inorganic nutrients by about 50% without any yield reduction.

Chadha et al. (2012) carried out an experiment to investigate the efficiency of some vedic krishi inputs (viz., beejamrit, jeevamrit, panchgavya, matka khad and vermiwash as well as compost tea) for managing the essential nutrients and suppression of plant diseases on eco-friendly basis. The findings revealed that jeevamrit, matka khad and compost tea had significant positive impacts on increasing production per unit area and reducing the occurrence of pathogens.

George (2012) reported that application of 75% recommended dose of nitrogen + phosphorus + 100% potassium + bio fertilizers + vermicompost + panchagavya + jeevamrit + *Trichoderma harzianum* in *Gerbera jamesonii* Bolus cv. 'Galileo Red' significantly improved growth, flowering and yield attributes.

Aulakh et al. (2013) found that the pH of jeevamrit prepared from dung and urine of buffalo, Indian cow and hybrid cow was 3.86, 3.65 and 3.56, respectively after 5 days of incubation, which initially was 8.32, 7.89 and 7.71, respectively. This was attributed to the increased activity of acid producing microorganisms and the nutrient contents were 0.22, 0.04 and 0.60 g N, 0.11, 0.04 and 0.06 g P, 1.09, 0.28 and 0.75 g K and 0.46, 0.43 and 0.39 g S/l, respectively.

Devakumar et al. (2014) reported that jeevamrit formulation have a pH of 4.92, contained nutrients like nitrogen, phosphorus and potassium (1.96%, 0.173% and 0.280%, respectively), Mg (46 ppm) and Cu (51 ppm). They also reported that there was less microbial load on the day of jeevamrit preparation and later it reached to maximum on the $10^{th}$ day of its preparation. After that it started to decline as the days passed by. Maximum cfu/ml of jeevamrit recorded were bacteria ($855\times10^5$), fungi ($29\times10^4$), actinomycetes ($8\times10^3$), N-fixers ($69\times10^4$) and P-solubilizer ($80\times10^4$) on the $10^{th}$ day of its preparation. Further, they concluded that the presence of beneficial microorganisms in jeevamrit might be due to its constituents viz., cow dung, cow urine, legume flour and jaggery which contain macro and micro nutrients, vitamins, essential amino acids, growth promoting substances like Gibberllic Acid ($GA_3$), Indole Acetic Acid (IAA) and beneficial microorganisms.

Vemaraju (2014) recorded pH of 6.25, primary nutrients viz., nitrogen, phosphorous and potassium (0.50%, 0.30% and 0.42%, respectively) and bacteria 81.66 x 105 cfu/g and fungi 42.33×103 cfu/g, in jeevamrit.

Halder et al. (2015) studied the incidence of amaranthus foliage feeders in relation to different organic soil amendments and concluded that lowest leaf damage with the application of 50% FYM + panchagavya + biofertilizers (Azotobacter and PSB) which is a par with application of 50% vermicompost + jeevamrit + biofertilizers (Azotobacter and PSB).

Singh et al. (2015) reported that all parameters for vegetative and reproductive growth like plant height, plant spread, number of branches per plant, stem diameter, number of leaves per plant, leaf length, days to first flower bud initiation, flower bud diameter, bud length, number of flowers per plant and flower diameter in case of marigold, when grown in media containing sand + soil + vermicompost (1:1:2) + biodynamic amendment (jeevamrit) proved better over control i.e. Sand + Soil + FYM (1:1:1).

Application of 75% recommended dose of nitrogen and phosphorus and 100% potassium + *Azospirillum brasilense* + *Glomus fasciculatum* (VAM Fungi) + *Trichoderma harzianum* + *Bacillus megaterium* + vermicompost + panchagavya + jeevamrit in carnation (*Dianthus caryophyllus* L.) cv. 'Big Mama' notably improved growth, flowering and yield attributes (Harshavardhan et al., 2016).

Control Released Fertilizer (11.2 g/pot) + jeevamrit @ 5% found effective in increasing the plant height, plant spread, number of side shoots per plant, number of flowers per plant and reduced the number of days taken for visible bud formation, days taken for peak flowering, days taken for the stage of marketability and also increased the pot presentability score of potted chrysanthemums (Koppala, 2018).

Pamya (2018) conducted an experiment on the effect of organic fertilizers in conjunction with chemical fertilizers on the growth and flowering of gerbera (*Gerbera jamesonii* Bolus ex. Hook) at the experimental farm, Department of Floriculture and Landscape Architecture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan during 2017 to 2018. Findings revealed that best integrated nutrient management schedule for growth and flower production of gerbera cultivars 'Salvador' and 'Goliath' was 80% of $T_1$ (NPK @ 10:15:20g/$m^2$ ) + PSB + Azotobacter + Jeevamrit. It was also reported that soil application of jeevamrit 5% at monthly intervals @ 250 ml/plant once in a month was found to be beneficial in most of the growth and flowering parameters.

An experiment on the effect of jeevamrit and different growing media on growth and flowering of gerbera (*Gerbera jamesonii* Bolus ex. Hook) was carried out by Singh (2018) at Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) and reported that the use of cocopeat and vermicompost (1:1) along with application of jeevamrit at 20 days interval was the best combination for better growth, flowering and yield parameters in gerbera.

A field experiment was conducted by Pathania (2019) to study the effect of jeevamrit on flower and seed yield of China aster cv. 'Kamini'. Different concentrations of jeevamrit for drenching and spraying was used and concluded that the application of Jeevamrit @ 5% (Drench) + Foliar application of Jeevamrit @ 10% resulted in maximum plant height, plant spread, number of flowers per plant and number of flowers per plot.

Bisht (2020) conducted an experiment on studies on application of natural farming modules on flowering and seed production of African marigold (*Tagetes erecta* L.) and reported that drenching with Jeevamrit @ 100 ml/$m^2$ + foliar application of Jeevamrit @ 20% at 15 days interval + Neemastra @ 2.5% and Brahmastra @ 2.5% at 7 days intervals, alternatively exhibited highest viable microbial count i.e. bacteria ($119.17 \times 10^5$ cfu/g soil), fungi ($17.33 \times 10^3$ cfu/g soil) and actinomycetes ($14.00 \times 10^2$ cfu/g soil) as well as maximum benefit: cost ratio (3.69:1).

Koundal (2020) worked on doses of jeevamrit for seed production in sweet William (*Dianthus barbatus* L.) at Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) and reported that the earliest flowering (103.21 days), maximum values for plant height (48.81 cm), plant spread (36.81 cm), number of inflorescences per plant (12.02), diameter of inflorescence (10.14 cm), number of florets per plant (265.37), duration of flowering (46.81 days), number of seeded capsules per plant (235.14), number of seeds per capsule (54.01), seed yield per plant (11.43 g), seed yield per plot (102.87 g), 1000 seed weight (0.98 g) as well as minimum number of non-seeded capsules per plant (31.84) were recorded in treatment module $M_5$ {Drenching with Jeevamrit @ 100% at monthly interval + Foliar application of Jeevamrit @ 30% at 15 days interval + Brahmastra @ 2.5% and Drekastra @ 2.5% at 10-12 days interval, alternatively}. The highest viable microbial count i.e. bacteria (41.61 × $10^7$ cfu/g soil), fungi (12.76 × $10^2$ cfu/g soil) and actinomycetes (32.78 × $10^3$ cfu/g soil) were found under treatment module $M_5$.

In petunia (*Petunia hybrida* Vilm.), drench application of jeevamrit at 10% at fortnight interval resulted in maximum plant height (23.44 cm), plant spread (34.03), minimum days taken to peak flowering (48.75), maximum duration of flowering (57.60 days) and highest pot presentability score (96.93), while spray application at fortnight interval of jeevamrit at 10% resulted in maximum flower diameter (Sharma, 2020)

Lohia (2021) reported that the applications of $T_{10}$ (jeevamrit @ 30%) and $T_{11}$ (jeevamrit @ 35%) enhanced the plant growth, flowering and production of quality seeds and also contributed significantly in enriching the soil with huge load of beneficial bacteria, fungi and actinomycetes in annual chrysanthemum (*Glebionis coronaria* (L.).

Choudhary et al. (2021) conducted an experiment on the effect of jeevamrit on growth and flowering of marigold at Department of Floriculture and Landscape Architecture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (H.P) during 2018-19 and reported that among different jeevamrit treatments, maximum plant height (70.45 cm), plant spread (48.55 cm), number of side shoots (5.90), number of flowers per plant (20.05), number of flowers per square meter (180.45), individual flower weight (14.94 g), flower weight per plant (279.37 g), flower weight per square meter (2.52 kg), flower diameter (5.29 cm) and duration of flowering (19.05 days) were recorded with application of jeevamrit @ 2 litre/$m^2$ at 15 days interval.

Vanlalhruaii et al. (2022) conducted an experiment on the effect of different dozes of jeevamrit for frond growth, production and longevity of *Nephrolepis exaltata* at the Research Farm of Department of Floriculture and Landscape Architecture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (H.P) under polyhouse condition. Results revealed that the application of jeevamrit at different concentrations (drench and foliar spray) influenced the growth and productivity of Boston fern and Jeevamrit @ 5% (Drench) + Foliar application of Jeevamrit @ 10% at 15 days interval, alternatively, significantly improved the frond length, number of frond per plant, lamina length, frond width, plant spread, leaf area, number of pinnae per frond, weight of frond, number of frond yield per square metre and vase life and chlorophyll content of Boston fern.

An experiment on effect of liquid jeevamrutha on growth yield and quality of China aster (*Callistephus chinensis* [L.] Nees.) was carried Hegde et al. (2023) and reported that application of liquid jeevamrutha at 1500 liter per hectare at an interval of 7 days registered significantly the highest vegetative growth like plant height (47.98 cm and 58.78 cm at 60 and 90 DAT, respectively), number of primary branches (7.45 and 10.28 at 60 and 90 DAT, respectively), floral characters like number of flowers per plant (38.42), flower yield (111.39 g/plant, 5.41 kg/plot and 8.06 t/ha, respectively), flower diameter (5.76 cm), individual flower weight (3.04 g), shelf life (3.43 days) and vase life (8.79 days).

Thakur et al. (2023) investigated the effect of jeevamrit on growth and flowering of iris (*Iris orientalis* Mill.) cv. 'Frigia' at Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during 2019-2020. The results showed that the 5.0% Jeevamrit drenching and 10.0% Jeevamrit foliar spray, resulted in the highest values for various growth and flowering characteristics. These included maximum plant height (87.22 cm), spike length (64.57 cm), number of florets per spike (3.87), floret size (13.39 cm), stem diameter (6.80 mm), vase life (11.53 days), duration of flowering (10.17 days) and number of propagules (3.11). Further, 7.5% Jeevamrit drenching + 15.0% Jeevamrit foliar spray registered maximum viable bacterial count ($75.63 \times 10^6$ cfu/g soil), viable fungi count ($28.57 \times 10^4$ cfu/g soil) and viable actinomycetes count ($45.90 \times 10^3$ cfu/g soil).

Studies on the impact of foliar application of biostimulants in carnation to improve the flower yield and quality (*Dianthus caryophyllus* L.) cv. 'Malaga' was carried out by Punitha et al. (2023) and reported that in the preharvest treatments, Panchagavya @ 2% + Manchurian mushroom tea @ 4% with RDF (NPK 19:19:19 @ 8 g, calcium nitrate 1.5 g, potassium nitrate 1.0 g, mono potassium phosphate 1.5 g, borax 0.5 g, magnesium sulphate (2.5 g) proved superior in respect of flower yield and quality viz., number of flowers per plant (11.53), number of flowers (415.20 per $m^2$ ) was high with 'A' grade (410.7), 'B' grade (3.0) and 'C' grade (1.5) and longest vase life (14.46 days). The incidence of calyx splitting (3.18%) and degrees of deviation was low. They also reported that the physiological parameters of chlorophyll a (1.69 mg/g), chlorophyll b (0.65 mg/g), total chlorophyll (2.45 mg/g), leaf nutrient content viz., nitrogen (4.52%), phosphorus (0.80%) and potassium (4.08%) were higher in the treatment Panchagavya @ 2% + Manchurian mushroom tea 4%.

# *Chapter-3*

# MATERIALS AND METHODS

The present investigation on **“Evaluation of different genotypes of carnation (*Dianthus caryophyllus* L.) in response to organic and inorganic fertilization modules”** was carried out at the experimental farm of the Department of Floriculture and Landscape Architecture of Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during 2020-2022. The details of the materials used and techniques employed during the course of investigation are presented in this chapter.

## 3.1. EXPERIMENTAL SITE

The experimental farm is located at an elevation of 1276 m above mean sea level at a latitude of $30^{o}51'0''$ North and longitude of $77^{o}11'30''$ East. The area falls in the mid hill zone of Himachal Pradesh.

## 3.2 CLIMATE

The climate of the area is typically sub-temperate to sub-tropical and is characterized by mild summers and cool winters. May and June are the hottest months while January and February are the coldest. Maximum rainfall is received during July to September (Monsoon season). The mean monthly data pertaining to the experimental period have been presented in Appendix-I.

## 3.3 PLANT MATERIAL

Out of the 14 genotypes selected for the present investigation, 8 genotypes were developed through *in vitro* mutagenesis in the department of Floriculture and Landscape Architecture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP, namely; ‘UHFSCar-1’, ‘UHFSCar-2’, ‘UHFSCar-3’, ‘UHFSCar-4’, ‘UHFSCar-5’, ‘UHFSCar-6’, ‘UHFSCar-7’ and ‘UHFSCar-11’, 3 genotypes were developed at Bhabha Atomic Research Centre (BARC), Mumbai, Maharashtra, namely; ‘PM-1’, ‘PM-2’ and ‘PM-3’ and another 3 genotypes namely; ‘Bizet’, ‘Tempo’ and ‘Raggio-de-Sole’ were the parents used to raised the genotypes for *in vitro* mutagenesis. The planting material (unrooted cuttings) of these genotypes was procured from the carnation germplasm block of the

Department of Floriculture and Landscape Architecture of Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan.

## 3.4 GENERAL PROCEDURE

### 3.4.1 Preparation of cutting and planting for rooting

Terminal cuttings (8-10 cm) were harvested from healthy and disease free mother plant during morning hours and were put in clean water and prepared for rooting in a shady place. Cuttings were prepared by removing lower most 1-2 pair of leaves and dipped in a solution of Dithane M-45 (0.2%) and Bavistin (0.1%) for 30 minutes as a fungicidal dip treatment. The lower cut ends were then treated with NAA (500 ppm) solution following quick-dip method before planting in pro-trays filled with cocopeat as rooting medium (Package of Practices, Department of Floriculture and Landscape Architecture, UHF, Nauni, Solan). The pro-trays were then placed in a trench which was dug out upto a depth of 1.5 feet and the trench was covered with polythene sheet for rooting. After 30 days, the polythene sheet was removed and the cuttings were ready for transplanting (Plate 2b).

### 3.4.2 Bed preparation

The land was thoroughly prepared and was brought to a good tilth by ploughing, harrowing and levelling. Stones, pebbles and weeds were removed manually from the experimental area. Raised beds of 1.20 m x 0.80 m x 15 cm (L x B x H) were prepared and levelled properly. Well rotten Farm Yard Manure (5 kg/$m^2$) was mixed in the beds before planting. The beds were separated from one another by a path of 30 cm width.

### 3.4.3 Planting

The healthy rooted cuttings were planted on 15$^{th}$ December 2020 at a spacing of 20 cm x 20 cm accommodating 24 plants/$m^2$. Light irrigation was given immediately after transplanting for better establishment of the plants. Application of vermicompost was done 30 days (once in each flush) after planting at the rate of one kg/$m^2$ for both the treatments.

## 3.5 APPLICATION OF FERTILIZATION MODULES

For inorganic fertilization module, after the preparation of beds the basal doze of chemical fertilizer was incorporated in the beds through 10-10-10 g/$m^2$ each of NPK through urea- 21.7 g/$m^2$, SSP- 62.5 g/$m^2$ and MOP- 16.6 g/$m^2$. Besides the application of basal dose of N, P and K, fertigation was given twice a week which was started after 30 days of planting when the plants were established in the growing medium by applying 150 to 250 ml of fertilizer solution depending upon the age of the plant in the root zone of the plant manually. Different fertilizers like; multi-K (13-0-45), calcium nitrate (commercial grade) and urea were used as source of nitrogen and potassium. For supplying 100 ppm of nitrogen, 60 ppm was applied as nitrate N [potassium nitrate (multi K) - 40 ppm and $Ca(NO_3)_2$ - 20 ppm] by dissolving 311 mg of multiK and 129 mg of $Ca(NO_3)_2$ in 1 litre of water. Remaining 40 ppm N was supplied as ammonical form through urea by dissolving 87 mg of it in 1 litre of water. For the supply of $K_2O$ in all the treatments, the entire quantity of $K_2O$ was met through the application of multi-K.

For organic fertilization module, drenching with Jeevamrit was done at a rate of 20 ml/plant which was started at 30 days after transplanting. Jeevamrit was prepared by mixing cow dung- 1 kg, cow urine- 1 litre, jaggery- 200 g, pulse flour- 200 g and a handful soil and water was added to make up to a volume of 20 litres which was then allowed to ferment for four days. On the fifth day, drenching was done at 20 ml per plant at 1:4 dilutions.

## 3.6 INTERCULTURAL OPERATIONS

Routine intercultural operations were done as per the requirement. The details regarding the various intercultural operations carried out during the course of investigation are furnished below.

### 3.6.1 Irrigation

The field was irrigated immediately after planting. Irrigation was given at an interval of two to three days during winter season and on alternate days during summer season depending on the requirement.

### 3.6.2 Gap filling

Gap filling was done to ensure maximum crop population in the experimental plot. The plants which did not survive after one week of transplanting were removed and gap filling was done with healthy uniform sized plants.

### 3.6.3 Pinching

In order to produce multi-stemmed plants, soft pinching by removing apical portion of the plants was done when the plants attained a height of 12-15 cm. Single pinching was done at the $3^{rd}$ node with hand.

### 3.6.1 Weeding and Hoeing

The occurrence of weeds namely; *Trifolium repens, Oxalis latifolia, Cyperus rotundus*, etc. were observed during the cultivation. The plots were kept free from weeds throughout the cropping period. Hand weeding was done as and when required to avoid crop weed competition. First weeding was done after 20 days of planting and later as and when required. Hoeing was practised as and when hard crust formed over the soil surface to provide better aeration to the roots of the plants.

### 3.6.2 Deshooting

For producing single flower bud per shoot, all other emerging axillary shoots were removed by hand.

### 3.6.3 Disbudding

All the lateral flower buds below the terminal were removed with hand when these could be handled between forefinger and thumb easily.

### 3.6.4 Staking

It was done by making a network of plastic nets on each plot individually by wire mesh system (4 x 4 inch mesh) supported by stakes of iron fixed 4 m apart at the corners of the beds. Four layers of mesh were inserted and laid on the soil surface after 45 days of planting. As the plants grew up, the layers were generally raised so that the lower most layer was about 15 cm above the ground and upper layers were about 20 cm apart from each other.

### 3.6.7 Control of insect-pest and diseases

For inorganic fertilization module, Simba (0.1%) was sprayed on the plants to control red spider mite attack during the month of April and May. The field was also kept moist during hot summer months to prevent the attack of red spider mite. For the control of *Spodoptera littoralis* during the month of April and May, the plants were sprayed with and Cypermenthrin (0.1%) and for the control of aphids the plants were sprayed with Imidacloprid (0.05%). To keep the crop disease free, plants were drenched with fungicides Bavistin (0.1 %) and Dithane M-45 (0.2 %).

For organic fertilization module, Agniastra and Bramhastra were sprayed alternatively at one week intervals when infestation was observed on the plants at a rate of 2.5% for the control of insect pests and diseases.

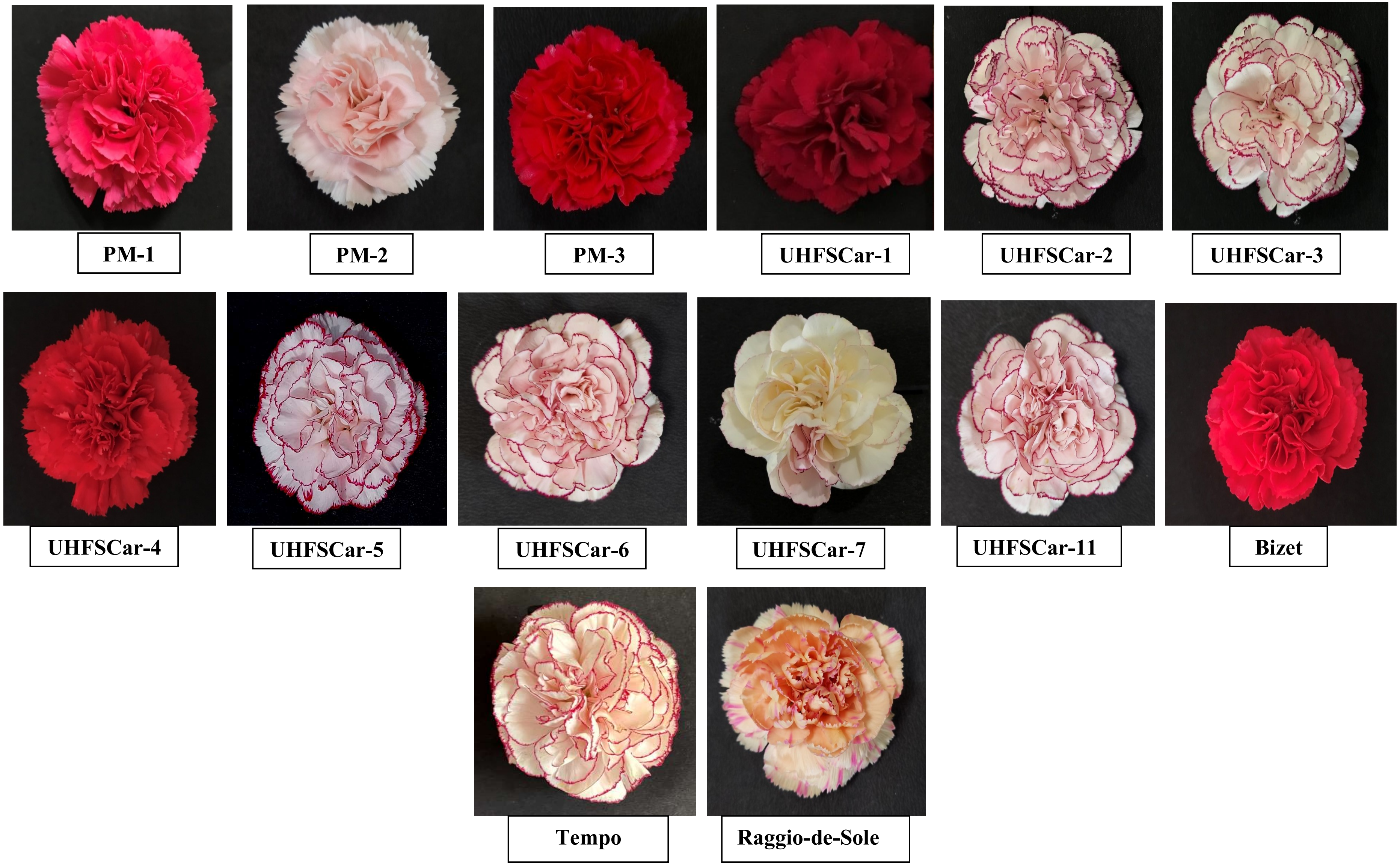



**Plate 1: Different genotypes of carnation under study**

### 3.7 HARVESTING

Harvesting of carnation flowers was done at paint brush stage during morning hours with the help of secateurs avoiding any shock or damage to the plants.

### 3.8 EXPERIMENTAL DETAILS

A. Genotypes : 14 (Plate 1)

Among the 14 genotypes selected, 8 genotypes were developed through *in vitro* mutagenesis in the department of Floriculture and Landscape Architecture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP, namely; 'UHFSCar-1', 'UHFSCar-2', 'UHFSCar-3', 'UHFSCar-4', 'UHFSCar-5', 'UHFSCar-6', 'UHFSCar-7' and 'UHFSCar-11'. 3 genotypes were developed at Bhabha Atomic Research Centre (BARC), Mumbai, Maharashtra, namely; 'PM-1', 'PM-2' and 'PM-3' and 3 genotypes namely; 'Bizet', 'Tempo' and 'Raggio-de-Sole' were the parents used to raised the genotypes for *in vitro* mutagenesis

B. Fertilization modules : Two (as below)

i) Inorganic fertilization module : 10-10-10 g/$m^2$ NPK (as basal) + 100 ppm N + 140 ppm K (as fertigation- twice a week)

ii) Organic fertilization module : Jeevamrit @ 20 ml/plant as drenching at 30 days intervals

C. Number of replications : 3

D. Total treatment combinations : 14 x 2= 28

E. Plot size : 1.20 m x 0.80 m

F. Spacing : 20 cm x 20 cm

G. Number of plants per plot : 24

H. Experimental design : Randomized Block Design (Factorial)

**Ingredients and composition of Jeevamrit and bio-pesticides**

**Table 3.1 Composition of Jeevamrit** (Department of Soil Science and Water Management, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP)

| Ingredients | Quantity |
|---|---|
| Cow dung | 10 kg |
| Cow urine | 10 litres |
| Jaggery | 2 kg |
| Pulse flour | 2 kg |
| Live soil | A handfull |
| Water | 200 litres |

**Flow chart of preparation of Jeevamrit**

Add fresh cow dung + cow urine in water

↓

Mix jaggery + pulse flour and live soil in water

↓

Mix the above both and stir properly (morning and evening) for 4 days

↓

On the fifth day, the solution and filtrate is ready for soil drenching/ spray

**Table 3.2 Composition of Agniastra** (Department of Soil Science and Water Management, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP)

| Ingredients | Quantity |
|---|---|
| Cow urine | 10 litres |
| Tobacco | 1 kg |
| Green chilli | 500 g |
| Garlic | 500 g |
| Neem leaves | 5 kg |

*Dilution of 2.5 litres of agniastra in 100 litres of water for spray.

**Flow chart of preparation of Agniastra**

Crush tobacco in cow urine

↓

Add crush green chilli, garlic and neem leaves

↓

Boil the solution 5 times at some interval till it become half

↓

Ferment for 24 hours and then filter the extract

**Cow Dung (10 kg)**

**Cow Urine (10 L)**

**Jaggery (2 kg)**

**Pulse flour (2 kg)**

**Soil (handful)**

**+ Water (200 L)**

**Jeevamrit**

**Plate 2a: Preparation of Jeevamrit**

a. Harvesting of terminal portion of the plant

b. Smooth cutting off the basal portion of the cutting

c. Dipping of cutting in Dithane M-45 + Bavistin solution

d. Quick dipping in NAA @ 500ppm solution

e. Planting of the cuttings in portrays with cocopeat as rooting media

f. Rooted cutting of carnation

**Plate 2b. Preparation of carnation cuttings for rooting**

**Table 3.3 Composition of Bramhastra** (Department of Soil Science and Water Management, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan, HP)

| Ingredients | Quantity |
|---|---|
| Cow urine | 10 litres |
| Neem leaves | 3kg |
| Custard apple leaves | 2 kg |
| Papaya leaves | 2 kg |
| Pomegranate leaves | 2 kg |
| Guava leaves | 2 kg |

*Dilution of 2.5 litres of Bramhastra in 100 litres of water for spray.

**Flow chart of preparation of Bramhastra**

Crush neem leaves in cow urine

↓

Add crush custard apple leaves, papaya leaves, pomegranate leaves and guava leaves

↓

Boil 4 times at some interval till it become half

↓

Keep for 48 hours and then filter the extract

## 3.9 OBSERVATIONS RECORDED

### 3.9.1 Plant height (cm)

Plant height was recorded at peak flowering stage from the ground level to the tip of the flower of the longest shoot with the help of a meter rod.

### 3.9.2 Stem length (cm)

Stem length was measured from the base of the flower to the node of the stem up to which it remained straight. Cut flower stems were divided into 3 grades according to their stem length, i.e., 'A' grade (>55 cm), 'B' grade (45 cm - <55 cm) and 'C' grade (30 cm - <45 cm), and percentage of individual grade was calculated.

### 3.9.3 Thickness of flower stem (mm)

Thickness of flower stem was measured with the help of vernier calliper at 5$^{th}$ internode directly below flower at harvesting stage.

### 3.9.4 Strength of flower stem/sturdiness of stem (degree)

Stem strength was noted by measuring the level of sturdiness. Observation was taken by holding the cut stem of 30 cm horizontally above the cut end and measuring the angle of deviation of flower head below the horizontal plane with the natural curvature of the stem Based upon the degree of the angle following three grades were given to the stems and percentage of differentgrades was calculated.

A Grade : $< 15^0$

B Grade : $15^0$ - $30^0$

C Grade : $>30^0$

### 3.9.5 Number of days taken for flower bud formation

Observation was recorded from the date of transplanting of rooted cuttings to the stage when flower buds become visible.

### 3.9.6 Bud width (mm)

Bud width was recorded by measuring the diameter (mm) of the bud at paint brush stage with the help of vernier calliper.

### 3.9.7 Bud length (mm)

It was measured by recording the length (mm) of the bud at paint brush stage with the help of vernier calliper.

### 3.9.8 Flower size (cm)

Flower size was recorded at full bloom stage by averaging the lengths from north to south and east to west directions with the help of measuring scale.

### 3.9.9 Flower colour

Flower colour was identified using ‘Royal Horticultural Society Colour Charts’ at peak flowering stage.

### 3.9.10 Number of petals per flower

Number of petals per flower was recorded by working out the average number of petals from five flowers selected at random in each replication of all the genotypes.

### 3.9.11 Number of flowers per plant and per square metre

Number of flowers per plant was counted at peak flowering stage. Number of flowers per square meter was worked out by totalling the number of flowers harvested from one square metre area.

### 3.9.12 Days taken for harvesting of cut stems

Observation was recorded from the date of transplanting of rooted cuttings in the polyhouse till the appearance of paint brush stage.

### 3.9.13 Duration of flowering (days)

Duration of flowering in days was counted from the appearance of first paint brush stage to the harvesting of last flower in paint brush stage on the plant of each genotype.

### 3.9.14 Vase life (days)

Vase life was recorded by placing 30 cm cut stems at paint brush stage in distilled water and kept at ambient room temperature till the flowers remained presentable.

### 3.9.15 Calyx splitting (%)

Calyx splitting was recorded as number of flowers with split calyces per plant and percentage of such flowers were calculated. The genotypes were categorized showing high, medium or low calyx splitting depending upon the percentage.

High : 60% and above
Medium : 30-60%
Low : less than 30%

### 3.9.16 Incidence of insect-pest and disease (%)

The plants were investigated throughout growing period for appearance of any insect pest and disease symptoms. Per cent incidence of insect-pest and diseases were computed as follows:

$$\text{Per cent incidence} = \frac{\text{Number of plants infected}}{\text{Total number of plants}} \times 100$$

### 3.9.17 Physico-chemical properties of soil

The composite soil samples from 0-15 cm soil depth was collected before the start of the experiment and after termination of experiment. Soil from furrow slice was collected to ascertain the effect of organic and inorganic inputs on pH, organic carbon and available N, P, K. Collected soil samples were air dried in shade and ground with the help of pestle and mortar, passed through 2 mm sieve and stored in polythene bags for further analysis as per the method given below:

| **Particular** | **Method employed** | **Reference(s)** |
|---|---|---|
| pH | 1:2 soil : water suspension, with the help of digital pH meter | Jackson (1973) |
| EC | 1:2 soil : water suspension, with the help of digital EC meter | Jackson (1973) |
| Organic Carbon | Rapid titration method | Walkely and Black (1934) |
| Available N | Alkaline potassium permanganate method | Subbiah and Asija (1956) |
| Available P | Olsen's method | Olsen et al. (1954) |
| Available K | Ammonium acetate method | Merwin and Peech (1951) |

### 3.9.18 Viable microbial count

The soil microbial count was recorded before the start of the experiment and after the termination of experiment by adopting the serial dilution standard spread plate technique as described by Subbarao (1999) on nutrient agar (NA) medium, Potato Dextrose Agar and Kenknight and Munaier's medium. The population was expressed as colony forming units per gram of soil (cfu $g^{-1}$ soil).

**a) Composition of nutrient agar medium:**

| | | | | | |
|---|---|---|---|---|---|
| Peptone | : | 5 g | Agar-agar | : | 1.5-2% |
| NaCl | : | 5 g | Water | : | 1000 ml |
| Beef extract | : | 3 g | pH | : | 6.8 ± 0.2 |

**b) Composition of potato dextrose medium:**

| | | | | | |
|---|---|---|---|---|---|
| Potato, peeled and diced | : | 200 g | Agar | : | 15 g |
| D-Glucose | : | 20 g | Distilled water | : | 1 litre |

**c) Composition of Kenknight and Munaier's medium:**

| | | | | | |
|---|---|---|---|---|---|
| Dextrose | : | 1.00 g | $MgSO_4.7H_2O$ | : | 0.10 g |
| $KH_2PO_4$ | : | 0.10 g | Agar | : | 15.00 g |
| $NaNO_3$ | : | 0.10 g | Distilled water | : | 1000 ml |
| KCl | : | 0.10 g | pH | : | 5.4± 0.2 |

**Plate 3a. General overview of prepared field**

**Plate 3b. Overview of the field at the day of transplanting**

### 3.9.19 Cost analysis

The cost benefit ratio was worked out on the basis of input and output involved. The cost of labour and various inputs was taken as per the local market rates. Gross monetary return and net return (Rs/500 $m^2$) wasworked out using the following formula.

Gross monetary return (Rs/500 $m^2$) = value of cut flower

Net returns (Rs/500$m^2$) = Gross monetary returns – Total cost of production

$$\text{Cost Benefit Ratio} = \frac{\text{Net Returns}}{\text{Total Expenditure}}$$

## 3.10 STATISTICAL ANALYSIS

The data recorded was analyzed by using MS-Excel and OPSTAT. The statistical analysis for Randomized Block Design was done as per design of the experiment suggested by Gomez and Gomez (1984).

**ANOVA for RBD is as follows:**

| Source of variance | Degree of freedom | Sum of squares | Mean sum of squares | $F_{cal}$ |
|---|---|---|---|---|
| Treatments | (t-1) | $S_t$ | $M_t = \frac{S_t}{(t-1)}$ | $\frac{M_t}{M_e}$ |
| Replications | (r-1) | $S_r$ | $M_r = \frac{S_r}{(r-1)}$ | $\frac{M_r}{M_e}$ |
| Error | $(r-1)(t-1)$ | $S_e$ | $M_e = \frac{S_e}{(r-1)(t-1)}$ | |
| Total | $(rt-1)$ | $S_T$ | | |

where,

r = Number of replications

t = Number of treatments

$S_r$ = Sum of squares due to replications

$S_t$ = Sum of squares due to treatments

$S_e$ = Sum of squares due to error

$S_T$ = Total sum of squares

$M_r$ = Mean sum of squares due to replications

$M_t$ = Mean sum of squares due to treatments

$M_e$ = Mean sum of squares due to error

The replication and treatment mean sum of square were tested against mean sum of squares due to error by 'F' test at (r-1), (r-1) × (t-1) and (t-1), (r-1) × (t-1) degree of freedom for RBD at 5% level of significance. The calculated F-values were compared with tabulated F-value. When F-test was found significant, critical difference was calculated to find out the superiority of one treatment over the others.

**Critical difference (CD) was calculated as follows:**

$CD_{0.05}$ = S.E. (d) x $t_{(0.05)}$ (r-1) (t-1) df

SE (d) ± = $\sqrt{\frac{2 \times M_e}{r}}$

SE (m) ± = $\sqrt{\frac{M_e}{r}}$

where,

$CD_{0.05}$ = Critical difference at 5 per cent level of significance

SE (d) ± = Standard error of difference of mean

SE (m) ± = Standard error of mean

# *Chapter-4*

# RESULTS AND DISCUSSION

The present investigation on **"Evaluation of different genotypes of carnation (*Dianthus caryophyllus* L.) in response to organic and inorganic fertilization modules"** was done at the experimental farm of the Department of Floriculture and Landscape Architecture of Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during 2020-2022. Data recorded on different parameters were analyzed statistically and the results have been presented and discussed in this chapter.

Analysis of variance (Appendix-II) has shown significant and non-significant effects of the fertilization modules on growth and yield parameters of different genotypes of carnation. The observations on the effect of the fertilization modules on the growth and yield of different genotypes of carnation have been presented.

## 4.1 Plant height (cm)

Plant height was recorded at the time of peak flowering stage (Table 4.1). During year 2020-2021 significant differences in plant height were observed among different genotypes and fertilization modules. Among different genotypes, maximum plant height was observed in genotype 'Bizet' (96.38 cm) which was statistically at par with genotype 'PM-3' (95.65 cm) while it was minimum in genotype 'UHFSCar-4' (72.03 cm). The organic fertilization module (82.86 cm) attained higher plant height as compared to inorganic fertilization module (82.76 cm). However, it was found to be non-significant.

Data recorded during 2021-2022 revealed that among different genotypes, maximum plant height was also recorded in genotype 'Bizet' (102.90 cm) which was statistically at par with genotype 'PM-3' (101.00 cm) whereas it was minimum in genotype 'UHFSCar-4' (77.17 cm) which was found to be statistically at par with genotype 'UHFSCar-1' (81.67 cm), 'UHFSCar-2' (82.17 cm) and 'UHFSCar-3' (81.67 cm). Of the two fertilization modules, organic fertilization module (88.91 cm) recorded higher plant height over inorganic fertilization module (86.05 cm).

**Table 4.1: Effect of different genotypes of carnation on plant height (cm) in response to inorganic and organic fertilization modules**

| Genotypes | 2020-2021 | | | 2021-2022 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean |
| PM-1 | 86.27 | 86.60 | 86.43 | 97.47 | 96.73 | 97.10 | 91.87 | 91.67 | 91.77 |
| PM-2 | 86.27 | 91.69 | 88.98 | 91.87 | 92.93 | 92.40 | 89.07 | 92.31 | 90.69 |
| PM-3 | 97.53 | 93.76 | 95.65 | 100.07 | 101.93 | 101.00 | 98.80 | 97.85 | 98.32 |
| UHFSCar-1 | 78.27 | 76.73 | 77.50 | 79.80 | 83.53 | 81.67 | 79.03 | 80.13 | 79.58 |
| UHFSCar-2 | 81.33 | 79.74 | 80.54 | 82.34 | 82.00 | 82.17 | 81.84 | 80.87 | 81.36 |
| UHFSCar-3 | 79.73 | 81.20 | 80.47 | 80.67 | 82.67 | 81.67 | 80.20 | 81.93 | 81.07 |
| UHFSCar-4 | 73.80 | 70.27 | 72.03 | 74.87 | 79.47 | 77.17 | 74.33 | 74.87 | 74.60 |
| UHFSCar-5 | 82.33 | 83.06 | 82.70 | 82.37 | 86.33 | 84.35 | 82.35 | 84.70 | 83.52 |
| UHFSCar-6 | 80.27 | 81.43 | 80.85 | 83.07 | 85.00 | 84.03 | 81.67 | 83.21 | 82.44 |
| UHFSCar-7 | 77.20 | 76.54 | 76.87 | 80.00 | 84.93 | 82.47 | 78.60 | 80.74 | 79.67 |
| UHFSCar-11 | 78.73 | 80.68 | 79.71 | 83.10 | 86.80 | 84.95 | 80.92 | 83.74 | 82.33 |
| Bizet | 96.07 | 96.70 | 96.38 | 101.20 | 104.60 | 102.90 | 98.63 | 100.65 | 99.64 |
| Tempo | 82.60 | 83.24 | 82.92 | 85.00 | 87.07 | 86.03 | 83.80 | 85.15 | 84.48 |
| Raggio-de-Sole | 78.20 | 78.40 | 78.30 | 82.93 | 90.67 | 86.80 | 80.57 | 84.53 | 82.55 |
| **Mean** | 82.76 | 82.86 | 82.81 | 86.05 | 88.91 | 87.48 | 84.41 | 85.88 | |
| **$CD_{0.05}$** | Genotypes : 3.67<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS | | | Genotypes : 5.13<br>Fertilization modules : 1.94<br>Genotypes x Fertilization modules : NS | | | Genotypes : 3.19<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS<br>Years : 1.21<br>Years x Fertilization modules : 1.70<br>Years x Genotypes : NS<br>Years x Genotype x Fertilization modules : NS | | |

On pooling the data of plant height of two years, it was observed that among different genotypes the maximum plant height was recorded in genotype 'Bizet' (99.64 cm) which was found to be at par with genotype 'PM-3' (98.32 cm) while minimum plant height was recorded in genotype 'UHFSCar-4' (74.60 cm). The fertilization modules were found to be non-significant; however, more plant height was obtained in organic fertilization module (85.88 cm) in contrast to inorganic fertilization module (84.41 cm).

In general, plant height during 2021-2022 (87.48 cm) was greater than during 2020-2021 (82.81 cm). Interaction between years and fertilization modules showed maximum plant height in organic fertilization module (88.91 cm) during 2021-2022. In contrast, minimum plant height was recorded in inorganic fertilization module (82.76 cm) during 2020-2021.

The plant height varied significantly due to the difference in the genetic makeup of the genotypes and their interaction with climate particularly temperature which was variable during different months (Appendix I). The results are in agreement with the findings of Gharge et al. (2011), Roychowdhury and Tah (2011), Verma et al. (2012) Mehmood et al. (2014), Chauhan et al. (2017) and Sharma (2020) in carnation.

Jeevamrit increased the availability of nutrients due to build up of soil microflora resulting in increased enzymatic activity (Vemaraju, 2014). The increased in the activities of microbes by solubilization and uptake of nutrients mainly nitrogen which plays a vital role in the vegetative growth and presence of growth regulatory substances such as IAA and $GA_3$ which increases the plant height by the application of jeevamrit which is also supported with the findings of Singh et al. (2015) in marigold, Pamya (2018) in gerbera, Choudhary et al. (2021) in marigold, Vanlalhruaii et al. (2022) in Boston fern and Thakur et al. (2023) in iris.

### 4.2 Stem length (cm)

Stem length is an important attribute of grading in carnation and Table 4.2 shows the variation in the stem length. During 2020-2021, maximum stem length among the genotypes was obtained in genotype 'PM-3' (81.90 cm) which was statistically at par with genotype 'Bizet' (81.40 cm) while genotype 'UHFSCar-4' (63.32 cm) recorded minimum stem length among the genotypes which was at par with genotypes 'UHFSCar-1' (64.93 cm) and 'UHFSCar-7' (63.50 cm). Between the two fertilization modules, inorganic fertilization module (72.55 cm) recorded greater stem length over organic fertilization module (70.78 cm). However, the fertilization modules for stem length was found to be no significant.

During 2021-2022, maximum stem length among the genotypes was recorded in genotype ‘Bizet’ (88.50 cm) which was found to be at par with genotype ‘PM-3’ (86.33 cm). In contrast, minimum stem length among the genotypes was recorded in genotype ‘UHFSCar-4’ (65.53 cm) which was found to be at par with genotypes ‘UHFSCar-1’ (69.57 cm) and ‘UHFSCar-7’ (69.07 cm). Organic fertilization module (77.94 cm) recorded greater stem length as compared to inorganic fertilization module (74.14 cm).

The two years pooled data of stem length revealed that among different genotypes of carnation the maximum stem length was recorded in genotype ‘Bizet’ (84.95 cm) which was statistically at par with genotype ‘PM-3’ (84.12 cm) while minimum stem length was recorded in genotype ‘UHFSCar-4’ (64.43 cm) which was found to be at par with genotypes ‘UHFSCar-1’ (67.25 cm) and ‘UHFSCar-7’ (66.28 cm). The fertilization modules were found to be non-significant; however, greater stem length was obtained in organic fertilization module (74.36 cm) in contrast to inorganic fertilization module (73.35 cm).

In general, stem length during 2021-2022 (76.04 cm) was greater than during 2020-2021 (71.67 cm). All interactions were found to be non-significant.

As the stem length of all the genotypes were found to be above 55 cm, all the genotypes under study fell under ‘A’ grade.

The stem length also varied significantly as the plant height due to the difference in the genetic makeup of the genotypes. Similar results in carnation were reported by Shankar et al. (2004), Dilta and Gupta (2010), Nacho (2016) and Chauhan et al. (2017).

This might be due to the genetic composition of the different genotypes and the significant result in year 2021-2022 might be due to the accumulation of macro and micro nutrients in the soil through the application of jeevamrit in the form of drenching. Since nitrogen is a constituent of chlorophyll, the increase of which resulted in increased synthesis of photosynthates, leading to better vigour. The second major nutrient phosphorus being essential constituent of cellular protein and nucleic acid might have encouraged meristematic activity of plants resulting in increased stem length. The other major nutrient potassium is an activator of enzymes involved in protein and carbohydrate metabolism and

**Table 4.2: Effect of different genotypes of carnation on stem length (cm) in response to inorganic and organic fertilization modules**

| Genotypes | 2020-2021 | | | 2021-2022 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean |
| PM-1 | 77.20 | 74.13 | 75.67 | 82.69 | 83.73 | 83.21 | 79.95 | 78.93 | 79.44 |
| PM-2 | 75.73 | 77.80 | 76.77 | 77.33 | 82.13 | 79.73 | 76.53 | 79.97 | 78.25 |
| PM-3 | 83.73 | 80.07 | 81.90 | 85.40 | 87.27 | 86.33 | 84.57 | 83.67 | 84.12 |
| UHFSCar-1 | 65.73 | 64.13 | 64.93 | 66.73 | 72.40 | 69.57 | 66.23 | 68.27 | 67.25 |
| UHFSCar-2 | 72.87 | 67.60 | 70.23 | 72.13 | 77.27 | 74.70 | 72.50 | 72.43 | 72.47 |
| UHFSCar-3 | 70.60 | 73.93 | 72.27 | 70.00 | 70.47 | 70.23 | 70.30 | 72.20 | 71.25 |
| UHFSCar-4 | 65.23 | 61.40 | 63.32 | 64.47 | 66.60 | 65.53 | 64.85 | 64.00 | 64.43 |
| UHFSCar-5 | 72.47 | 71.00 | 71.73 | 71.60 | 77.40 | 74.50 | 72.03 | 74.20 | 73.12 |
| UHFSCar-6 | 73.73 | 69.73 | 71.73 | 71.93 | 80.20 | 76.07 | 72.83 | 74.97 | 73.90 |
| UHFSCar-7 | 64.00 | 63.00 | 63.50 | 68.47 | 69.67 | 69.07 | 66.23 | 66.33 | 66.28 |
| UHFSCar-11 | 69.80 | 70.00 | 69.90 | 74.00 | 74.87 | 74.43 | 71.90 | 72.43 | 72.17 |
| Bizet | 84.93 | 77.87 | 81.40 | 83.80 | 93.20 | 88.50 | 84.37 | 85.53 | 84.95 |
| Tempo | 70.87 | 69.53 | 70.20 | 77.60 | 78.27 | 77.93 | 74.23 | 73.90 | 74.07 |
| Raggio-de-Sole | 68.80 | 70.67 | 69.73 | 71.80 | 77.67 | 74.73 | 70.30 | 74.17 | 72.23 |
| **Mean** | 72.55 | 70.78 | 71.67 | 74.14 | 77.94 | 76.04 | 73.35 | 74.36 | |
| **$CD_{0.05}$** | Genotypes : 4.68<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS | | | Genotypes : 4.34<br>Fertilization modules : 1.64<br>Genotypes x Fertilization modules : NS | | | Genotypes : 3.12<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS<br>Years : 1.18<br>Years x Fertilization modules : NS<br>Years x Genotypes : NS<br>Years x Genotype x Fertilization modules : NS | | |

improved health and growth of plant, enabling it to withstand adverse climatic condition. These results are in accordance with those of Pamya (2018) in gerbera, Choudhary et al. (2021) in marigold and Thakur et al. (2023) in iris who reported that the stem length of the crops increased with the application of jeevamrit.

## 4.3 Stem thickness (mm)

Data pertaining to thickness of stem is presented in Table 4.3. During 2020-2021, maximum stem thickness was obtained in genotypes 'UHFSCar-1' (5.95 mm) which was found to be statistically at par with genotypes 'PM-1' (5.55 mm), 'UHFSCar-2' (5.83 mm), 'UHFSCar-3' (5.77 mm), 'UHFSCar-4' (5.73 mm), 'UHFSCar-5' (5.89 mm), 'UHFSCar-6' (5.67 mm), 'UHFSCar-7' (5.78 mm), 'Bizet' (5.91 mm), 'Tempo' (5.77 mm) and 'Raggio-de-Sole' (5.71 mm). In contrast, minimum stem thickness was recorded in genotype 'UHFSCar-11' (5.09 mm) which was found to be at par with genotypes 'PM-2' (5.35 mm) and 'PM-3' (5.42 mm). The fertilization modules for stem thickness was found to be non-significant.

During 2021-2022, maximum stem thickness was recorded in genotype 'Bizet' (5.91 mm) which was statistically at par with genotypes 'PM-1' (5.67 mm), 'UHFSCar-1' (5.68 mm), 'UHFSCar-3' (5.66 mm), 'UHFSCar-4' (5.70 mm), 'UHFSCar-5' (5.76 mm), 'UHFSCar-6' (5.83 mm), 'UHFSCar-11' (5.83 mm) and 'Raggio-de-Sole' (5.63 mm) while it was recorded minimum in genotype 'PM-2' (5.29 mm) which was at par with genotypes 'PM-3' (5.54 mm), 'UHFSCar-7' (5.55 mm) and 'Tempo' (5.58 mm). Organic fertilization module (5.74 mm) recorded greater stem thickness over inorganic fertilization module (5.58).

The pooled analysis of stem thickness of two years revealed that among different genotypes 'Bizet' (5.91 mm) obtained the maximum stem thickness which was found to be statistically at par with genotypes 'UHFSCar-1' (5.81 mm), 'UHFSCar-2' (5.72 mm), 'UHFSCar-3' (5.72mm), 'UHFSCar-4' (5.72 mm), 'UHFSCar-5' (5.82 mm), 'UHFSCar-6' (5.75 mm), 'UHFSCar-7' (5.66 mm), 'Tempo' (5.68 mm) and 'Raggio-de-Sole' (5.67 mm). In contrast, minimum stem thickness was recorded in genotype 'PM-2' (5.32 mm) which was at par with genotypes 'PM-3' (5.48 mm) and 'UHFSCar-11' (5.46 mm). Of the two fertilization modules, organic fertilization module (5.75 mm) recorded greater stem thickness in contrast to inorganic fertilization module (5.58 mm).

**Table 4.3: Effect of different genotypes of carnation on stem thickness (mm) in response to inorganic and organic fertilization modules**

| Genotypes | 2020-2021 | | | 2021-2022 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Inorganic fertilization module** | **Organic fertilization module** | **Mean** | **Inorganic fertilization module** | **Organic fertilization module** | **Mean** | **Inorganic fertilization module** | **Organic fertilization module** | **Mean** |
| PM-1 | 5.33 | 5.76 | 5.55 | 5.65 | 5.70 | 5.67 | 5.49 | 5.73 | 5.61 |
| PM-2 | 5.03 | 5.66 | 5.35 | 5.32 | 5.27 | 5.29 | 5.17 | 5.47 | 5.32 |
| PM-3 | 5.37 | 5.48 | 5.42 | 5.33 | 5.74 | 5.54 | 5.35 | 5.61 | 5.48 |
| UHFSCar-1 | 5.95 | 5.96 | 5.95 | 5.39 | 5.96 | 5.68 | 5.67 | 5.96 | 5.81 |
| UHFSCar-2 | 5.83 | 5.83 | 5.83 | 5.66 | 5.55 | 5.60 | 5.75 | 5.69 | 5.72 |
| UHFSCar-3 | 5.73 | 5.81 | 5.77 | 5.45 | 5.88 | 5.66 | 5.59 | 5.84 | 5.72 |
| UHFSCar-4 | 5.81 | 5.66 | 5.73 | 5.66 | 5.74 | 5.70 | 5.74 | 5.70 | 5.72 |
| UHFSCar-5 | 5.87 | 5.91 | 5.89 | 5.62 | 5.89 | 5.76 | 5.74 | 5.90 | 5.82 |
| UHFSCar-6 | 5.44 | 5.89 | 5.67 | 5.82 | 5.83 | 5.83 | 5.63 | 5.86 | 5.75 |
| UHFSCar-7 | 5.66 | 5.89 | 5.78 | 5.58 | 5.53 | 5.55 | 5.62 | 5.71 | 5.66 |
| UHFSCar-11 | 5.01 | 5.17 | 5.09 | 5.86 | 5.81 | 5.83 | 5.44 | 5.49 | 5.46 |
| Bizet | 5.90 | 5.92 | 5.91 | 5.88 | 5.94 | 5.91 | 5.89 | 5.93 | 5.91 |
| Tempo | 5.70 | 5.84 | 5.77 | 5.39 | 5.77 | 5.58 | 5.55 | 5.81 | 5.68 |
| Raggio-de-Sole | 5.52 | 5.90 | 5.71 | 5.54 | 5.73 | 5.63 | 5.53 | 5.81 | 5.67 |
| **Mean** | 5.58 | 5.76 | 5.67 | 5.58 | 5.74 | 5.66 | 5.58 | 5.75 | |
| **$CD_{0.05}$** | Genotypes : 0.40<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS | | | Genotypes : 0.30<br>Fertilization modules : 0.11<br>Genotypes x Fertilization modules : NS | | | Genotypes : 0.25<br>Fertilization modules : 0.09<br>Genotypes x Fertilization modules : NS<br>Years : NS<br>Years x Fertilization modules : NS<br>Years x Genotypes : 0.35<br>Years x Genotype x Fertilization modules : NS | | |

Interaction data of years and genotypes revealed that genotype 'UHFSCar-1' (5.95 mm) during 2020-2021 recorded maximum stem thickness which was found to be at par with genotypes 'PM-1' (5.55 mm), 'UHFSCar-2' (5.83 mm), 'UHFSCar-3' (5.77 mm), 'UHFSCar-4' (5.73 mm), 'UHFSCar-5' (5.89 mm), 'UHFSCar-6' (5.67 mm), 'UHFSCar-7' (5.78 mm), 'Bizet' (5.91 mm), 'Tempo' (5.77 mm) and 'Raggio-de-Sole' (5.71 mm) during 2020-2021 and 'PM-1' (5.67 mm), 'UHFSCar-1' (5.68 mm), 'UHFSCar-2' (5.60 mm), 'UHFSCar-3' (5.66 mm), 'UHFSCar-4' (5.70 mm), 'UHFSCar-5' (5.76 mm), 'UHFSCar-6' (5.83 mm), 'UHFSCar-11' (5.83 mm), 'Bizet' (5.91 mm) and 'Raggio-de-Sole' (5.63 mm) during 2021-2022. Whereas, minimum stem thickness was found in genotype 'UHFSCar-11' (5.09 mm) during 2020-2021 which was found to be at par with genotypes 'PM-2' (5.35 mm) and 'PM-3' (5.42 mm) of the same year and 'PM-2' (5.29 mm) during 2021-2022.

The variations in the stem thickness could be attributed to the different genetic composition of the genotypes. The work done in carnations by Dilta and Gupta (2010), Karthikeyan et al. (2013), Nacho (2016), Sharma (2020) and Anand et al. (2021) suggested the same.

The better result in organic fertilization module might be due to the accumulation of constituents and nutrients from jeevamrit containing 0.16% nitrogen, 0.02% phosphorus and 0.123% potassium (Chadha et al., 2012) which resulted in stimulated cell division in the meristematic tissue and ultimately increase in the stem thickness with the application of jeevamrit. Jeevamrit is also known to contain micronutrients apart from the major nutrients. Therefore, the availability of higher quantity of nutrients, improvement in physical properties of soil and increased microbial activity might have helped in increasing the stem thickness. These findings are in line with those of Singh et al. (2015) in marigold, Vanlalhruaii et al. (2022) in Boston fern and Thakur et al. (2023) in iris.

### 4.4 Strength of flower stem/sturdiness of stem (degree)

Stem sturdiness was measured as the angle of deviation from the horizontal plane. More is the angle of deviation, lesser will be the sturdiness of the stem and vice-versa. Likewise, the evaluation of the cut stems was done of all the genotypes under study during both the years and data is presented in Table 4.4. Data clearly indicated that the differences in the angle of deviation due to genotypes were found to be significant. The sturdiest stem in general was noticed in case of 'Bizet' (6.17°) during 2020-2021. Other genotypes producing

**Table 4.4: Effect of different genotypes of carnation on stem sturdiness (º) in response to inorganic and organic fertilization modules**

| Genotypes | 2020-2021 | | | 2021-2022 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | Inorganic | Organic | Mean | Inorganic | Organic | Mean | Inorganic | Organic | Mean |
| PM-1 | 10.00 | 8.53 | 9.27 | 8.00 | 6.58 | 7.29 | 9.00 | 7.56 | 8.28 |
| PM-2 | 10.00 | 10.87 | 10.43 | 11.50 | 11.00 | 11.25 | 10.75 | 10.93 | 10.84 |
| PM-3 | 9.00 | 9.67 | 9.33 | 9.67 | 10.17 | 9.92 | 9.33 | 9.92 | 9.63 |
| UHFS Car-1 | 9.93 | 10.73 | 10.33 | 9.33 | 6.58 | 7.96 | 9.63 | 8.66 | 9.15 |
| UHFS Car-2 | 10.00 | 9.00 | 9.50 | 8.00 | 11.08 | 9.54 | 9.00 | 10.04 | 9.52 |
| UHFS Car-3 | 9.20 | 5.13 | 7.17 | 6.42 | 8.50 | 7.46 | 7.81 | 6.82 | 7.31 |
| UHFS Car-4 | 9.67 | 7.00 | 8.33 | 9.75 | 9.42 | 9.58 | 9.71 | 8.21 | 8.96 |
| UHFS Car-5 | 8.47 | 8.33 | 8.40 | 8.92 | 5.67 | 7.29 | 6.99 | 6.47 | 6.73 |
| UHFS Car-6 | 7.67 | 9.20 | 8.43 | 6.17 | 6.00 | 6.08 | 6.92 | 7.60 | 7.26 |
| UHFS Car-7 | 10.40 | 9.67 | 10.03 | 8.17 | 8.83 | 8.50 | 9.28 | 9.25 | 9.27 |
| UHFS Car-11 | 10.20 | 8.67 | 9.43 | 9.17 | 9.33 | 9.25 | 9.68 | 9.00 | 9.34 |
| Bizet | 5.07 | 7.27 | 6.17 | 8.83 | 7.92 | 8.38 | 8.65 | 8.13 | 8.39 |
| Tempo | 9.60 | 9.40 | 9.50 | 8.00 | 8.67 | 8.33 | 8.80 | 9.03 | 8.92 |
| Reggio-de-Sole | 8.87 | 8.47 | 8.67 | 7.92 | 8.75 | 8.33 | 8.39 | 8.61 | 8.50 |
| **Mean** | 9.15 | 8.71 | 8.93 | 8.56 | 8.46 | 8.51 | 8.85 | 8.59 | |
| **$CD_{0.05}$** | Genotypes : 2.06<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS | | | Genotypes : 2.00<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS | | | Genotypes : 1.41<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS<br>Years : NS<br>Years x Fertilization modules : NS<br>Years x Genotypes : NS<br>Years x Genotype x Fertilization modules : 2.83 | | |


**Plate 4a: Overview of the field during vegetative growth**


**Plate 4b: Overview of the field during flowering stage**

similar type of sturdier stem was ‘UHFSCar-3’with 7.17° deviation from the horizontal plane.

During 2021-2022, the sturdiest stems were noticed in case of ‘UHFSCar-6’ (6.08°) with least angle of deviation which was found to be at par with ‘PM-1’(7.29°), ‘UHFSCar-1’ (7.96°), ‘UHFSCar-3’ (7.46°) and ‘UHFSCar-5’ (7.29°). Interestingly, during both the years all genotypes produced cut stems having less than 15° angle of deviation from the horizontal plane indicating that they all fall in the category of ‘A’ grade stems.

The difference in stem sturdiness due to fertilization modules and all interactions except years, genotypes and fertilization modules were found to be non-significant (Appendix-II). Interaction between years, genotypes and fertilization modules revealed that the best stem sturdiness was recorded in ‘Bizet’ (5.07°) with least deviation in inorganic fertilization module during 2020-2021 which was found to be at par with genotypes ‘UHFSCar-6’ (7.67°) in inorganic fertilization module and ‘UHFSCar-3’ (5.13°), ‘UHFSCar-4’ (7.00°) in organic fertilization module during 2020-2021 and ‘UHFSCar-6’ (6.17°) in inorganic fertilization module and PM-1’ (6.58°),‘UHFSCar-1’ (6.58°),‘UHFSCar-5’ (5.67°) and ‘UHFSCar-6’ (6.00°) in organic fertilization module during 2021-2022. In contrast, stem sturdiness was worst in ‘PM-2’ (11.50°) with largest deviation in inorganic fertilization module during 2021-2022.

This could be due to the genetic makeup of the genotypes understudy and the continuous supply of nutrients in the form of urea, mult-K and $Ca(NO_3)_2$ in inorganic fertilization modules and jeevamrit in organic fertilization module. Since nitrogen is a constituent of chlorophyll, the increase of which resulted in increased synthesis of photosynthates, leading to better vigour. The second major nutrient phosphorus being essential constituent of cellular protein and nucleic acid might have encouraged meristematic activity of plants helping in the sturdiness of stems. The other major nutrient potassium is an activator of enzymes involved in protein and carbohydrate metabolism and improved health and growth of plant, resulting in strengthening the stems. Similar results have been reported by Nacho (2016) and Sultanpuri (2018).

## 4.5 Number of days taken for bud formation

Perusal data presented in Table 4.5 showed the number of days taken for bud formation of different genotypes of carnation in response to organic and inorganic fertilization modules. During 2020-2021, genotype ‘PM-2’ (113.83 days) took minimum days for bud formation whereas genotype ‘UHFSCar- 6’ (150.67 days) took maximum days for bud formation which was found to be statistically at par with genotypes ‘UHFSCar- 1’ (148.00 days), ‘UHFSCar- 2’ (146.50 days), ‘UHFSCar- 3’ (148.17 days), ‘UHFSCar- 4’ (142.33 days), ‘UHFSCar- 7’ (140.00 days), ‘UHFSCar- 11’ (146.47 days) and ‘Tempo’ (142.17 days). The organic fertilization module (135.45 days) took lesser number of days for bud formation as compared to inorganic fertilization module (140.02 days).

During 2021-2022, minimum number of days taken for bud formation was recorded in genotype ‘PM-2’ (113.83 days) while maximum number of days taken for bud formation was observed in genotype ‘Raggio-de-Sole’ (191.67 days). Between the fertilization modules, organic fertilization module (162.83 days) recorded lesser number of days taken for bud formation over inorganic fertilization module (171.31 days).

The pooled analysis of number of days taken for bud formation during 2020-2021 and 2021-2022 revealed that genotype ‘PM-2’ (123.33 days) took minimum days for bud formation whereas genotype ‘UHFSCar- 2’ (162.58 days) took maximum days for bud formation which was found to be statistically at par with genotypes ‘UHFSCar- 1’ (158.08 days), ‘UHFSCar- 3’ (161.17 days), ‘UHFSCar- 4’ (159.25 days), ‘UHFSCar- 6’ (159.50 days), ‘UHFSCar- 7’ (156.83 days), ‘UHFSCar- 11’ (158.92 days) and ‘Raggio-de-Sole’ (158.67 days). Between the fertilization modules, organic fertilization module (149.14 days) recorded lesser number of days for bud formation as compared to inorganic fertilization module (155.67 days).

From both the years, the number of days taken for bud formation during 2020-2021 (137.74 days) was lesser over number of days taken for bud formation during 2021-2022 (167.07 days). The interaction between years and genotypes revealed that genotype ‘PM-2’ (113.83 days) during 2020-2021 recorded minimum days taken for bud formation whereas maximum days taken for bud formation was recorded in genotype ‘Raggio-de-Sole’ (191.67 days) during 2021-2022.

The variations in the number of days taken for bud formation might be due to the difference in the genetic makeup of the genotypes. The results were supported by the findings of Roni et al. (2014), Nacho (2016), Chauhan et al. (2017) and Medeo et al. (2019).

**Table 4.5: Effect of different genotypes of carnation on number of days taken for bud formation in response to inorganic and organic fertilization modules**

| Genotypes | 2020-2021 | | | 2021-2022 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean |
| PM-1 | 128.00 | 130.33 | 129.17 | 163.67 | 159.33 | 161.50 | 145.83 | 144.83 | 145.33 |
| PM-2 | 114.67 | 113.00 | 113.83 | 137.33 | 127.67 | 132.50 | 126.00 | 120.33 | 123.17 |
| PM-3 | 127.00 | 133.33 | 130.17 | 159.00 | 158.33 | 158.67 | 143.00 | 145.83 | 144.42 |
| UHFSCar-1 | 156.00 | 140.00 | 148.00 | 172.67 | 163.67 | 168.17 | 164.33 | 151.83 | 158.08 |
| UHFSCar-2 | 144.00 | 149.00 | 146.50 | 187.67 | 169.67 | 178.67 | 165.83 | 159.33 | 162.58 |
| UHFSCar-3 | 156.33 | 140.00 | 148.17 | 170.33 | 178.00 | 174.17 | 163.33 | 159.00 | 161.17 |
| UHFSCar-4 | 146.33 | 138.33 | 142.33 | 179.33 | 173.00 | 176.17 | 162.83 | 155.67 | 159.25 |
| UHFSCar-5 | 140.67 | 129.67 | 135.17 | 178.67 | 164.67 | 171.67 | 159.67 | 147.17 | 153.42 |
| UHFSCar-6 | 150.33 | 151.00 | 150.67 | 178.33 | 158.33 | 168.33 | 164.33 | 154.67 | 159.50 |
| UHFSCar-7 | 146.00 | 134.00 | 140.00 | 182.00 | 165.33 | 173.67 | 164.00 | 149.67 | 156.83 |
| UHFSCar-11 | 148.00 | 145.33 | 146.67 | 176.00 | 166.33 | 171.17 | 162.00 | 155.83 | 158.92 |
| Bizet | 129.00 | 130.67 | 129.83 | 152.33 | 143.33 | 147.83 | 140.67 | 137.00 | 138.83 |
| Tempo | 141.33 | 143.00 | 142.17 | 168.33 | 161.33 | 164.83 | 154.83 | 152.17 | 153.50 |
| Raggio-de-Sole | 132.67 | 118.67 | 125.67 | 192.67 | 190.67 | 191.67 | 162.67 | 154.67 | 158.67 |
| **Mean** | 140.02 | 135.45 | 137.74 | 171.31 | 162.83 | 167.07 | 155.67 | 149.14 | |
| **$CD_{0.05}$** | Genotypes : 11.49<br>Fertilization modules : 4.35<br>Genotypes x Fertilization modules : NS | | | Genotypes : 11.33<br>Fertilization modules : 4.28<br>Genotypes x Fertilization modules : NS | | | Genotypes : 8.06<br>Fertilization modules : 3.05<br>Genotypes x Fertilization modules : NS<br>Years : 3.05<br>Years x Fertilization modules : NS<br>Years x Genotypes : 11.39<br>Years x Genotype x Fertilization modules : NS | | |

However, the organic fertilization module in both the years performed better as compared to the inorganic fertilization module. This could be due to the constituents of jeevamrit which contain both essential macro and micro nutrients, essential amino acids, many vitamins, growth promoting substances like Gibberllic Acid ($GA_3$), Indole Acetic Acid (IAA) and beneficial microorganisms (Gore and Sreenivasa, 2011) and increased synthesis of photosynthates, which is responsible for the growth of plants and might have helped in bud formation. These results are supported by the findings of Pamya (2018) in gerbera, Choudhary et al. (2021) in marigold and Thakur et al. (2023) in iris.

### 4.6 Bud width (mm)

The data presented in Table 4.6 showed the bud width of different genotypes of carnation. During 2020-2021, the fertilization modules had significant effect on different genotypes of carnation. Maximum bud width was obtained in genotype 'Bizet' (20.82 mm) while minimum bud width was recorded in genotype 'PM-2' (18.22 mm) which was found to be at par with genotypes 'UHFSCar-1' (18.51 mm), 'UHFSCar-3' (18.80 mm), 'UHFSCar-5' (18.85 mm) and 'UHFSCar-11' (18.56 mm). The organic fertilization module (19.61 mm) attained greater bud width as compared to inorganic fertilization module (18.96 mm).

During 2021-2022, genotype 'Bizet' (22.32 mm) obtained maximum bud width while genotype 'PM-2' (18.52 mm) attained minimum bud width which was found to be at par with genotypes 'UHFSCar-1' (18.54 mm), 'UHFSCar-3' (19.30 mm), 'UHFSCar-4' (18.84 mm), 'UHFSCar-5' (18.83mm), 'UHFSCar-6' (19.20 mm), 'UHFSCar-7' (18.79 mm), 'UHFSCar-11' (18.84 mm) and 'Tempo' (19.42 mm).

The pooled data of bud with of two years revealed that genotype 'Bizet' (21.57 mm) obtained maximum bud width whereas genotype 'PM-2' (18.37 mm) recorded minimum bud width which was found to be at par with genotypes 'UHFSCar-1' (18.52 mm), 'UHFSCar-3' (19.05 mm), 'UHFSCar-4' (19.00 mm), 'UHFSCar-5' (18.84 mm) and 'UHFSCar-11' (18.70 mm). Between the fertilization modules, organic fertilization module (19.61 mm) attained greater bud width over inorganic fertilization module (19.21 mm).

Interaction between years, genotypes and fertilization modules revealed that genotype 'UHFSCar-11' (23.76 mm) in organic fertilization module during 2021-2022 recorded maximum bud width whereas minimum bud width was recorded in genotype 'PM-2' (16.93 mm) in inorganic fertilization module during 2020-2021 which was found to be at par with

**Table 4.6: Effect of different genotypes of carnation on bud width (mm) in response to inorganic and organic fertilization modules**

| Genotypes | 2020-2021 | | | 2021-2022 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean |
| PM-1 | 19.24 | 20.04 | 19.64 | 19.31 | 20.48 | 19.89 | 19.28 | 20.26 | 19.77 |
| PM-2 | 16.93 | 19.50 | 18.22 | 18.52 | 18.51 | 18.52 | 17.73 | 19.01 | 18.37 |
| PM-3 | 19.82 | 19.58 | 19.70 | 20.64 | 20.88 | 20.76 | 20.23 | 20.23 | 20.23 |
| UHFSCar-1 | 17.79 | 19.23 | 18.51 | 19.08 | 18.00 | 18.54 | 18.43 | 18.61 | 18.52 |
| UHFSCar-2 | 18.83 | 19.83 | 19.33 | 20.32 | 19.47 | 19.89 | 19.57 | 19.65 | 19.61 |
| UHFSCar-3 | 18.31 | 19.29 | 18.80 | 19.36 | 19.24 | 19.30 | 18.83 | 19.27 | 19.05 |
| UHFSCar-4 | 18.88 | 19.42 | 19.15 | 18.96 | 18.72 | 18.84 | 18.92 | 19.07 | 19.00 |
| UHFSCar-5 | 17.99 | 19.71 | 18.85 | 18.66 | 19.01 | 18.83 | 18.32 | 19.36 | 18.84 |
| UHFSCar-6 | 19.55 | 19.76 | 19.65 | 19.87 | 18.53 | 19.20 | 19.71 | 19.15 | 19.43 |
| UHFSCar-7 | 18.98 | 20.17 | 19.58 | 19.13 | 18.44 | 18.79 | 19.06 | 19.31 | 19.18 |
| UHFSCar-11 | 18.33 | 18.79 | 18.56 | 18.86 | 18.83 | 18.84 | 18.59 | 18.81 | 18.70 |
| Bizet | 21.18 | 20.45 | 20.82 | 20.88 | 23.76 | 22.32 | 21.03 | 22.10 | 21.57 |
| Tempo | 19.37 | 19.11 | 19.24 | 19.03 | 19.80 | 19.42 | 19.20 | 19.46 | 19.33 |
| Raggio-de-Sole | 20.30 | 19.61 | 19.95 | 19.69 | 20.76 | 20.22 | 19.99 | 20.18 | 20.09 |
| **Mean** | 18.96 | 19.61 | 19.29 | 19.45 | 19.60 | 19.53 | 19.21 | 19.61 | |
| **$CD_{0.05}$** | Genotypes : 0.81<br>Fertilization modules : 0.31<br>Genotypes x Fertilization modules : NS | | | Genotypes : 1.30<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS | | | Genotypes : 0.79<br>Fertilization modules : 0.30<br>Genotypes x Fertilization modules : NS<br>Years : NS<br>Years x Fertilization modules : NS<br>Years x Genotypes : NS<br>Years x Genotype x Fertilization modules : 1.57 | | |

genotypes ‘UHFSCar-1’ (17.79 mm), ‘UHFSCar-3’ (18.31 mm), ‘UHFSCar-5’ (17.99 mm) and ‘UHFSCar-11’ (18.33 mm) in inorganic fertilization module during 2020-2021 and ‘UHFSCar-1’ (18.00 mm) and ‘UHFSCar-7’ (18.44 mm) in organic fertilization module during 2021-2022.

The variations for flower bud formation may be attributed to genetic makeup of the genotypes under investigation. Similar variations in carnation due to genotypes were also observed by Roni et al. (2014), Nacho (2016) and Medeo et al. (2019).

Application of jeevamrit improved soil physical conditions, which might have resulted in better growth, nutrient absorption (Devakumar et al., 2014) and better development which eventually helps with the bud development. The other possible reason for increased bud width might be due to good vegetative growth of the plants which resulted in more photosynthesis and food accumulation, which ultimately increased the bud width. These results are in confirmation with the findings of Singh et al. (2015) in marigold.

### 4.7 Bud length (mm)

The data pertaining to bud length of different genotypes of carnation is shown in Table 4.7 which was found to be non-significant. However, during 2020-2021 maximum bud length was found in ‘Bizet’ (39.74 mm) whereas minimum bud length was recorded in ‘UHFSCar-1’ (36.56 mm). During 2021-2022, maximum bud length was observed in ‘Bizet’ (40.60 mm) while minimum bud length was recorded in ‘UHFSCar-1’ (37.98 mm). In both the years, organic fertilization module (38.72 mm and 39.11 mm) recorded larger bud length as to inorganic fertilization module (38.43 mm and 39.10 mm).

### 4.8 Flower size (cm)

Perusal of data presented in Table 4.8 revealed the flower size of different genotypes of carnation in response to organic and inorganic fertilization modules. During 2020-2021, the genotype ‘Raggio-de-Sole’ (6.26 cm) recorded maximum flower size whereas genotype ‘PM-2’ (5.61 cm) attained the minimum flower size which was found to be statistically at par with genotypes ‘PM-1’ (5.65 cm), ‘PM-3’ (5.74 cm), ‘UHFSCar-1’ (5.73 cm), ‘UHFSCar-3’ (5.73 cm), ‘UHFSCar-4’ (5.68 cm), ‘UHFSCar-5’ (5.72 cm), ‘UHFSCar-6’ (5.78 cm), ‘UHFSCar-7’ (5.81 cm) and ‘UHFSCar-11’ (5.72 cm). The fertilization modules and interaction between fertilization modules and genotypes were non-significant.

The maximum flower size recorded during 2021-2022 was in genotype 'Raggio-de-Sole' (6.49 cm) which was found to be at par with genotypes 'UHFSCar-4' (5.33 cm) and 'Bizet' (5.42 cm) while minimum flower size was recorded in genotype 'PM-2' (5.60 cm) which was found to be statistically at par with genotypes 'UHFSCar-2' (5.70 cm), 'UHFSCar-5' (5.71 cm), 'UHFSCar-7' (5.88 cm) and 'UHFSCar-11' (5.66 cm). Between the fertilization modules, organic fertilization module (6.10 cm) recorded greater flower size in contrast to inorganic fertilization module (5.90 cm).

On pooling the data of flower size of two years, maximum flower size was recorded in genotype 'Raggio-de-Sole' (6.37 cm) whereas genotype 'PM-2' (5.60 cm) attained the minimum flower size which was statistically at par with genotypes 'UHFSCar-5' (5.71 cm) and 'UHFSCar-11' (5.69 cm).

Interaction between genotypes and fertilization modules showed significant result. The data showed that maximum flower size was observed in genotype 'Raggio-de-Sole' in inorganic fertilization module (6.54 cm) whereas the flower size was recorded minimum in genotype 'PM-2' (5.55 cm) in inorganic fertilization module which was at par with genotypes 'UHFSCar-5' (5.65 cm), 'UHFSCar-6' (5.71 cm), 'UHFSCar-7' (5.70 cm) and 'UHFSCar-11' (5.58 cm) in inorganic fertilization module and 'PM-2' (5.66 cm), 'UHFSCar-2' (5.72 cm), 'UHFSCar-5' (5.78 cm) and 'UHFSCar-11' (5.80 cm) in organic fertilization module.

In general, the flower size during 2021-2022 (6.00 cm) was greater than during 2020-2021 (5.80 cm). Interaction between years and genotypes revealed that maximum flower size was recorded in genotype 'Raggio-de-Sole' (6.49 cm) during 2021-2022 which was at par with 'UHFSCar-4' (6.33 cm) and 'Bizet' (6.42 cm) during 2021-2022 and 'Raggio-de-Sole' (6.26 cm) during 2020-2021. While flower size was minimum in genotype 'PM-2' (5.60 cm) during 2021-2022 which was found to be statistically at par with genotypes 'UHFSCar-2' (5.70 cm), 'UHFSCar-5' (5.71 cm) and 'UHFSCar-11' (5.66 cm) during 2021-2022 and 'PM-1' (5.65 cm), 'PM-2' (5.61 cm), 'PM-3' (5.74 cm), 'UHFSCar-1' (5.73 cm), 'UHFSCar-3' (5.73 cm), 'UHFSCar-4' (5.68 cm), 'UHFSCar-5' (5.72 cm), 'UHFSCar-6' (5.78 cm), 'UHFSCar-7' (5.81 cm) and 'UHFSCar-11' (5.72 cm).

The interaction between years and fertilization modules showed that organic fertilization module (6.10 cm) during 2021-2022 recorded maximum flower size whereas minimum flower size was recorded in organic fertilization module (5.75 cm) during 2020-2021 which was  at par with inorganic fertilization module (5.84 cm) during the same year.

**Table 4.7: Effect of different genotypes of carnation on bud length (mm) in response to inorganic and organic fertilization modules**

| Genotypes | 2020-2021 | | | 2021-2022 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean |
| PM-1 | 39.26 | 38.21 | 38.74 | 38.53 | 38.23 | 38.38 | 38.90 | 38.22 | 38.56 |
| PM-2 | 37.89 | 38.23 | 38.06 | 39.79 | 39.37 | 39.58 | 38.84 | 38.80 | 38.82 |
| PM-3 | 37.95 | 38.59 | 38.27 | 38.24 | 39.10 | 38.67 | 38.10 | 38.84 | 38.47 |
| UHFSCar-1 | 35.82 | 37.30 | 36.56 | 37.79 | 39.31 | 38.55 | 36.81 | 38.31 | 37.56 |
| UHFSCar-2 | 38.70 | 38.28 | 38.49 | 38.26 | 38.39 | 38.32 | 38.48 | 38.33 | 38.40 |
| UHFSCar-3 | 39.12 | 39.48 | 39.30 | 39.10 | 38.94 | 39.02 | 39.11 | 39.21 | 39.16 |
| UHFSCar-4 | 37.19 | 39.10 | 38.15 | 38.61 | 37.36 | 37.98 | 37.90 | 38.23 | 38.06 |
| UHFSCar-5 | 38.86 | 38.08 | 38.47 | 39.01 | 38.32 | 38.67 | 38.94 | 38.20 | 38.57 |
| UHFSCar-6 | 39.20 | 38.71 | 38.96 | 38.68 | 39.87 | 39.27 | 38.94 | 39.29 | 39.11 |
| UHFSCar-7 | 38.94 | 38.30 | 38.62 | 39.70 | 39.88 | 39.79 | 39.32 | 39.09 | 39.21 |
| UHFSCar-11 | 38.84 | 39.17 | 39.00 | 39.45 | 39.45 | 39.45 | 39.14 | 39.31 | 39.23 |
| Bizet | 39.54 | 39.93 | 39.74 | 40.65 | 40.54 | 40.60 | 40.10 | 40.24 | 40.17 |
| Tempo | 37.66 | 38.48 | 38.07 | 39.74 | 38.84 | 39.29 | 38.70 | 38.66 | 38.68 |
| Raggio-de-Sole | 39.06 | 40.23 | 39.64 | 39.88 | 39.92 | 39.90 | 39.47 | 40.07 | 39.77 |
| **Mean** | 38.43 | 38.72 | 38.58 | 39.10 | 39.11 | 39.11 | 38.77 | 38.91 | |
| **$CD_{0.05}$** | Genotypes : NS<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS | | | Genotypes : NS<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS | | | Genotypes : NS<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS<br>Years : NS<br>Years x Fertilization modules : NS<br>Years x Genotypes : NS<br>Years x Genotype x Fertilization modules : NS | | |

**Table 4.8: Effect of different genotypes of carnation on flower size (cm) in response to inorganic and organic fertilization modules**

| Genotypes | 2020-2021 | | | 2021-2022 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Inorganic fertilization module** | **Organic fertilization module** | **Mean** | **Inorganic fertilization module** | **Organic fertilization module** | **Mean** | **Inorganic fertilization module** | **Organic fertilization module** | **Mean** |
| PM-1 | 5.66 | 5.63 | 5.65 | 5.77 | 6.25 | 6.01 | 5.72 | 5.94 | 5.83 |
| PM-2 | 5.63 | 5.59 | 5.61 | 5.47 | 5.72 | 5.60 | 5.55 | 5.66 | 5.60 |
| PM-3 | 5.73 | 5.75 | 5.74 | 6.00 | 6.20 | 6.10 | 5.87 | 5.97 | 5.92 |
| UHFSCar-1 | 5.68 | 5.78 | 5.73 | 6.25 | 5.99 | 6.12 | 5.97 | 5.89 | 5.93 |
| UHFSCar-2 | 6.15 | 5.71 | 5.93 | 5.68 | 5.72 | 5.70 | 5.91 | 5.72 | 5.81 |
| UHFSCar-3 | 5.80 | 5.66 | 5.73 | 6.00 | 6.15 | 6.08 | 5.90 | 5.91 | 5.90 |
| UHFSCar-4 | 5.69 | 5.66 | 5.68 | 6.39 | 6.26 | 6.33 | 6.04 | 5.96 | 6.00 |
| UHFSCar-5 | 5.66 | 5.77 | 5.72 | 5.63 | 5.78 | 5.71 | 5.65 | 5.78 | 5.71 |
| UHFSCar-6 | 5.76 | 5.80 | 5.78 | 5.65 | 6.15 | 5.90 | 5.71 | 5.97 | 5.84 |
| UHFSCar-7 | 5.86 | 5.75 | 5.81 | 5.53 | 6.23 | 5.88 | 5.70 | 5.99 | 5.84 |
| UHFSCar-11 | 5.72 | 5.71 | 5.72 | 5.44 | 5.89 | 5.66 | 5.58 | 5.80 | 5.69 |
| Bizet | 5.81 | 5.94 | 5.88 | 6.23 | 6.61 | 6.42 | 6.02 | 6.28 | 6.15 |
| Tempo | 5.98 | 5.79 | 5.89 | 6.02 | 6.04 | 6.03 | 6.00 | 5.92 | 5.96 |
| Raggio-de-Sole | 6.56 | 5.95 | 6.26 | 6.52 | 6.46 | 6.49 | 6.54 | 6.21 | 6.37 |
| **Mean** | 5.84 | 5.75 | 5.80 | 5.90 | 6.10 | 6.00 | 5.87 | 5.93 | |
| **$CD_{0.05}$** | Genotypes : 0.23<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS | | | Genotypes : 0.28<br>Fertilization modules : 0.11<br>Genotypes x Fertilization modules : NS | | | Genotypes : 0.18<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : 0.25<br>Years : 0.07<br>Years x Fertilization modules : 0.10<br>Years x Genotypes : 0.25<br>Years x Genotype x Fertilization modules : NS | | |

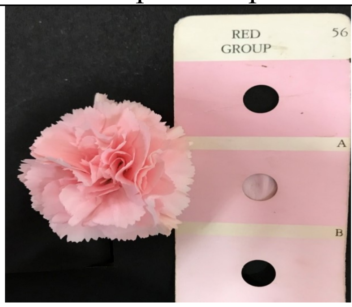
| Genotypes | Petal: Primary colour/ Main colour of petal | Petal: Secondary colour/ Colour of petal margin |
|---|---|---|
| **PM-1** |  Red-Purple Group 58B | |
| **PM-2** |  Red Group 56B | |
| **PM-3** |  Red-Purple Group 58B | |
| **UHFSCar-1** |  Red-Purple Group 60A | |
| **UHFSCar-2** |  Red Group 56D |  Red-Purple Group 59B |

**Plate 5a: Different colours of carnation according to RHS Colour Charts**

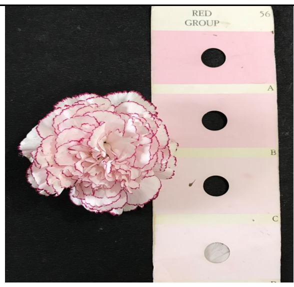
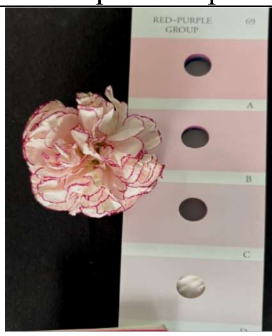
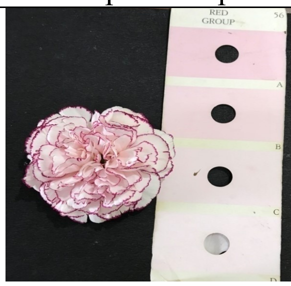
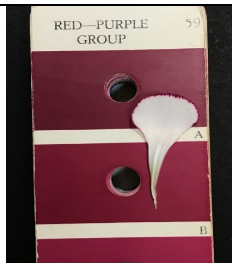
| | | |
|---|---|---|
| **UHFSCar-3** |  Red Group 56D |  Red-Purple Group 59B |
| **UHFSCar-4** |  Red-Purple Group 60A | |
| **UHFSCar-5** |  Red-Purple Group 69D |  Red-Purple Group 59A |
| **UHFSCar-6** |  Red Group 56D |  Red-Purple Group 59A |
| **UHFSCar-7** |  White Group 155C |  Red Group 51C |

**Plate 5b: Different colours of carnation according to RHS Colour Charts**

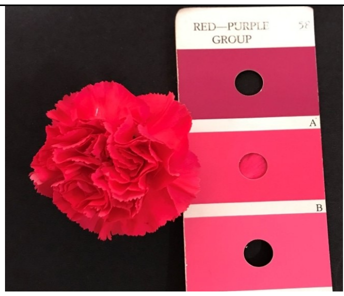
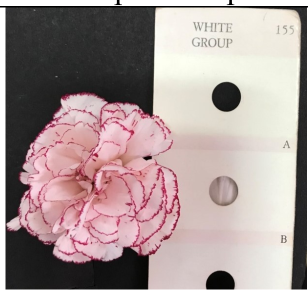
| | | |
|---|---|---|
| **UHFSCar-11** |   Red-Purple Group 69D |   Red-Purple Group 71A |
| **Bizet** |   Red-Purple Group 58B | |
| **Tempo** |   White Group 155B |   Red-Purple Group 59B |
| **Raggio-de-Sole** |   Yellow-Orange Group 23D |   Red-Purple Group 64C |

**Plate 5c: Different colours of carnation according to RHS Colour Charts**

The difference in flower size maybe ascribed to the genetic makeup of the genotypes. Similar results have been reported by Shiragur et al. (2004), Tarannum and Naik (2014), Nacho (2016) and Chauhan et al. (2017).

The greater flower size in organic fertilization module might be due to increased availability of nutrients due to build up of soil microflora resulting in increased enzymatic activity through the application of jeevamrit (Harshavardhan et al., 2016). This result is in confirmation with Singh et al. (2015) in marigold, Singh (2018) in gerbera, Pathania (2019) and Hegde et al. (2023) both in China aster.

### 4.9 Flower colour

Flower colour was identified using 'Royal Horticultural Society Colour Charts' at peak stage of flowering (Table 4.9 and Plate 5a-5c). The colour with the largest total surface area is the primary colour or main colour whereas, colour with the second largest total surface area is the secondary colour or colour of petal margin which may or may not be present. Colour determinations were made in the middle of the day in a room without direct sunlight by using colour charts. For the determination of colour flowers were placed against a contrasting background.

**Table 4.9: Variation in flower colour of different carnation genotypes as per 'Royal Horticultural Society (RHS) Colour Charts**

| Genotypes | Petal: Primary colour/ Main colour of petal | Petal: Secondary colour/ Colour of petal margin |
|---|---|---|
| **PM-1** | Red-Purple Group 58B | - |
| **PM-2** | Red Group 56B | - |
| **PM-3** | Red-Purple Group 58B | - |
| **UHFSCar-1** | Red-Purple Group 60A | - |
| **UHFSCar-2** | Red Group 56D | Red-Purple Group 59B |
| **UHFSCar-3** | Red Group 56D | Red-Purple Group 59B |
| **UHFSCar-4** | Red-Purple Group 60A | - |
| **UHFSCar-5** | Red-Purple Group 69D | Red-Purple Group 59A |
| **UHFSCar-6** | Red Group 56D | Red-Purple Group 59A |
| **UHFSCar-7** | White Group 155C | Red Group 51C |
| **UHFSCar-11** | Red-Purple Group 69D | Red-Purple Group 71A |
| **Bizet** | Red-Purple Group 58B | - |
| **Tempo** | White Group 155B | Red-Purple Group 59B |
| **Raggio-de-Sole** | Yellow-Orange Group 23D | Red-Purple Group 64C |

## 4.10 Number of petals per flower

The number of petals per flower is also an important factor for the compactness of the flower and the differences in the number of petals per plant is presented in Table 4.10. During 2020-2021, genotype 'Raggio-de-Sole' (77.77) recorded maximum number of petals per flower which was found to be at par with genotypes 'UHFSCar-6' (74.37), 'UHFSCar-7' (74.37) and 'UHFSCar-11' (73.03) whereas genotype 'PM-2' (40.77) recorded minimum number of petals per flower. The fertilization modules was however, found to be non-significant.

The interaction between genotypes and fertilization modules revealed that genotype 'Raggio-de-Sole' (83.13) in inorganic fertilization module obtained maximum number of petals per flower which was at par with genotypes 'UHFSCar-6' (76.47) in the same fertilization module and 'UHFSCar-7' (74.37) in organic fertilization module whereas the genotype 'PM-2' (35.73) in inorganic fertilization module recorded minimum number of petals per flower.

During 2021-2022, maximum number of petals per flower was recorded in genotype 'Raggio-de-Sole' (104.27) while maximum number of petals per flower was recorded in genotype 'PM-2' (43.87).

The interaction between genotypes and fertilization modules showed that genotype 'Raggio-de-Sole' (104.87) in organic fertilization module obtained maximum number of petals per flower which was found to be at par with the same genotype in inorganic fertilization module (103.67). In contrast, minimum number of petals per flower was recorded in genotype 'PM-2' (43.33) in inorganic fertilization module which was at par with the same genotype in organic fertilization module (44.40).

The pooled data for 2020-2021 and 2021-2022 revealed that genotype 'Raggio-de-Sole' (91.02) attained maximum number of petals per plant while it was recorded minimum in genotype 'PM-2' (42.32).

The interaction between genotypes and fertilization modules revealed that genotype 'Raggio-de-Sole' (93.40) in inorganic fertilization module obtained maximum number of petals per flower which was found to be at par with the same genotype in organic fertilization module (88.63) whereas genotype 'PM-2' (39.53) in inorganic fertilization module recorded

**Table 4.10: Effect of different genotypes of carnation on number of petals per flower in response to inorganic and organic fertilization modules**

| Genotypes | 2020-2021 | | | 2021-2022 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean |
| PM-1 | 49.67 | 45.93 | 47.80 | 59.40 | 60.60 | 60.00 | 54.53 | 53.27 | 53.90 |
| PM-2 | 35.73 | 45.80 | 40.77 | 43.33 | 44.40 | 43.87 | 39.53 | 45.10 | 42.32 |
| PM-3 | 50.80 | 49.27 | 50.03 | 58.80 | 61.40 | 60.10 | 54.80 | 55.33 | 55.07 |
| UHFSCar-1 | 63.47 | 67.40 | 65.43 | 60.13 | 55.67 | 57.90 | 61.80 | 61.53 | 61.67 |
| UHFSCar-2 | 70.73 | 71.47 | 71.10 | 62.73 | 68.80 | 65.77 | 66.73 | 70.13 | 68.43 |
| UHFSCar-3 | 57.80 | 60.47 | 59.13 | 66.80 | 61.60 | 64.20 | 62.30 | 61.03 | 61.67 |
| UHFSCar-4 | 64.00 | 64.87 | 64.43 | 61.27 | 62.33 | 61.80 | 62.63 | 63.60 | 63.12 |
| UHFSCar-5 | 57.33 | 66.33 | 61.83 | 58.80 | 57.53 | 58.17 | 58.07 | 61.93 | 60.00 |
| UHFSCar-6 | 76.47 | 72.27 | 74.37 | 64.93 | 57.13 | 61.03 | 70.70 | 64.70 | 67.70 |
| UHFSCar-7 | 70.27 | 78.47 | 74.37 | 64.07 | 59.93 | 62.00 | 67.17 | 69.20 | 68.18 |
| UHFSCar-11 | 72.67 | 73.40 | 73.03 | 62.53 | 60.20 | 61.37 | 67.60 | 66.80 | 67.20 |
| Bizet | 50.73 | 52.73 | 51.73 | 54.47 | 55.13 | 54.80 | 52.60 | 53.93 | 53.27 |
| Tempo | 59.53 | 72.40 | 65.97 | 57.40 | 62.27 | 59.83 | 58.47 | 67.33 | 62.90 |
| Raggio-de-Sole | 83.13 | 72.40 | 77.77 | 103.67 | 104.87 | 104.27 | 93.40 | 88.63 | 91.02 |
| **Mean** | 61.59 | 63.80 | 62.70 | 62.74 | 62.28 | 62.51 | 62.17 | 63.04 | |
| **$CD_{0.05}$** | Genotypes : 6.36<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : 8.99 | | | Genotypes : 3.19<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : 4.51 | | | Genotypes : 3.56<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : 4.99<br>Years : NS<br>Years x Fertilization modules : NS<br>Years x Genotypes : 4.99<br>Years x Genotype x Fertilization modules : 7.06 | | |

minimum number of petals per flower which was at par with the same genotype in organic fertilization module (45.10).

The interaction between years and genotypes showed that maximum number of petals per flower was recorded in genotype ‘Raggio-de-Sole’ (104.27) during 2021-2022 whereas minimum number of petals per flower was recorded in genotype ‘PM-2’ (40.77) during 2020-2021 which was at par with the same genotype during 2021-2022 (43.87).

Interaction between years, genotypes and fertilization modules revealed that maximum number of petals per flower was observed in genotype ‘Raggio-de-Sole’ (104.87) in organic fertilization module during 2021-2022 which was found to be at par with ‘Raggio-de-Sole’ (103.67) in inorganic fertilization module of the same year. In contrast, minimum number of petals per flower was recorded in genotype ‘PM-2’ (35.73) in inorganic fertilization module during 2020-2021.

Genetic factors play a crucial role in determining the number of petals per flower. Different genotypes have genetic variations that result in variations in petal number. Some genotypes have a genetic predisposition to produce more petals in subsequent flushes. In addition, environmental conditions can significantly impact floral development and petal formation. Factors such as temperature, light intensity, humidity, and nutrient availability can influence the number of petals per flower. Favorable environmental conditions during subsequent flushes may provide optimal conditions for petal development, leading to an increased in petal number.

## 4.11 Number of flowers per plant

Flower yield is an important factor in deciding the suitability of a particular cultivar for commercial cultivation, which ultimately reflects the cost of cultivation. Data pertaining to number of flowers per plant is presented in Table 4.11. During 2020-2021, genotype ‘Bizet’ (4.83) recorded maximum number of flowers per plant which was found to be at par with ‘Tempo’ (4.60) and ‘Raggio-de-Sole’ (4.70) whereas minimum number of flowers per plant recorded was recorded in genotype ‘UHFSCar-7’ (4.03) which was statistically at par with genotypes ‘PM-1’ (4.10), ‘PM-2’ (4.23), ‘PM-3’ (4.17), ‘UHFSCar-1’(4.25), ‘UHFSCar-2’ (4.27), ‘UHFSCar-3’ (4.07), ‘UHFSCar-4’ (4.27), ‘UHFSCar-6’ (4.13) and ‘UHFSCar-11’ (4.10). The fertilization modules were found to be non-significant; however,

**Table 4.11: Effect of different genotypes of carnation on number of flowers per plant in response to inorganic and organic fertilization modules**

| Genotypes | 2020-2021 | | | 2021-2022 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Inorganic fertilization module** | **Organic fertilization module** | **Mean** | **Inorganic fertilization module** | **Organic fertilization module** | **Mean** | **Inorganic fertilization module** | **Organic fertilization module** | **Mean** |
| PM-1 | 4.07 | 4.13 | 4.10 | 6.67 | 7.07 | 6.87 | 5.37 | 5.60 | 5.48 |
| PM-2 | 4.20 | 4.27 | 4.23 | 6.40 | 6.73 | 6.57 | 5.30 | 5.50 | 5.40 |
| PM-3 | 4.07 | 4.27 | 4.17 | 6.73 | 7.13 | 6.93 | 5.40 | 5.70 | 5.55 |
| UHFSCar-1 | 4.22 | 4.27 | 4.25 | 6.33 | 6.47 | 6.40 | 5.28 | 5.37 | 5.32 |
| UHFSCar-2 | 4.33 | 4.20 | 4.27 | 6.07 | 6.13 | 6.10 | 5.20 | 5.17 | 5.18 |
| UHFSCar-3 | 4.07 | 4.07 | 4.07 | 6.73 | 6.80 | 6.77 | 5.40 | 5.43 | 5.42 |
| UHFSCar-4 | 4.20 | 4.33 | 4.27 | 6.27 | 6.27 | 6.27 | 5.23 | 5.30 | 5.27 |
| UHFSCar-5 | 4.47 | 4.40 | 4.43 | 6.27 | 7.00 | 6.63 | 5.37 | 5.70 | 5.53 |
| UHFSCar-6 | 4.07 | 4.20 | 4.13 | 6.20 | 6.93 | 6.57 | 5.13 | 5.57 | 5.35 |
| UHFSCar-7 | 4.00 | 4.07 | 4.03 | 6.20 | 6.27 | 6.23 | 5.10 | 5.17 | 5.13 |
| UHFSCar-11 | 4.00 | 4.20 | 4.10 | 6.27 | 6.60 | 6.43 | 5.13 | 5.40 | 5.27 |
| Bizet | 4.73 | 4.93 | 4.83 | 7.13 | 7.33 | 7.23 | 5.93 | 6.13 | 6.03 |
| Tempo | 4.60 | 4.60 | 4.60 | 6.60 | 6.87 | 6.73 | 5.60 | 5.73 | 5.67 |
| Raggio-de-Sole | 4.67 | 4.73 | 4.70 | 7.20 | 7.13 | 7.17 | 5.93 | 5.93 | 5.93 |
| **Mean** | 4.26 | 4.33 | 4.30 | 6.51 | 6.77 | 6.64 | 5.38 | 5.55 | |
| **$CD_{0.05}$** | Genotypes : 0.43<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS | | | Genotypes : 0.32<br>Fertilization modules : 0.12<br>Genotypes x Fertilization modules : NS | | | Genotypes : 0.27<br>Fertilization modules : 0.10<br>Genotypes x Fertilization modules : NS<br>Years : 0.10<br>Years x Fertilization modules : NS<br>Years x Genotypes : 0.38<br>Years x Genotype x Fertilization modules : NS | | |

organic fertilization module (4.33) recorded a greater number of flowers per plant as compared to inorganic fertilization module (4.26).

During 2021-2022, that maximum number of flowers per plant was recorded in genotype ‘Bizet’ (7.23) which was found to be at par with genotypes ‘PM-3’ (6.93) and ‘Raggio-de-Sole’ (7.17) whereas ‘UHFSCar-2’ (6.10) obtained the minimum number of flowers per plant which was at par with ‘UHFSCar-7’ (6.23). Between the fertilization modules, organic fertilization module (6.77) recorded greater number of flowers per plant over inorganic fertilization module (6.51).

Pooled analysis of the two years revealed that maximum number of flowers per plant was obtained in genotype ‘Bizet’ (6.03) which was found to be at par with ‘Raggio-de-Sole’ (5.93) whereas genotype ‘UHFSCar-7’ (5.13) obtained the minimum number of flowers per plant which was found to be at par with genotypes ‘PM-2’ (5.40), ‘UHFSCar-1’ (5.32), ‘UHFSCar-2’ (5.18), ‘UHFSCar-4’ (5.27), ‘UHFSCar-6’ (5.35) and ‘UHFSCar-11’ (5.27). The organic fertilization module (5.55) recorded greater number of flowers per plant over inorganic fertilization module (5.38).

In general, number of flowers per plant during 2021-2022 (6.64) was greater over during 2020-2021 (4.30). The interaction years and genotypes revealed that maximum number of flowers per plant was obtained in genotype ‘Bizet’ (7.23) during 2021-2022 which was found to be at par with genotypes ‘PM-1’ (6.87), ‘PM-3’ (6.93) and ‘Raggio-de-Sole’ (7.17) of the same year whereas minimum number of flowers per plant recorded was obtained in genotype ‘UHFSCar-7’ (4.03) during 2020-2021 which was statistically at par with genotypes ‘PM-1’ (4.10), ‘PM-2’ (4.23), ‘PM-3’ (4.17), ‘UHFSCar-1’(4.25), ‘UHFSCar-2’ (4.27), ‘UHFSCar-3’ (4.07), ‘UHFSCar-4’ (4.27), ‘UHFSCar-6’ (4.13) and ‘UHFSCar-11’ (4.10) during 2020-2021.

The increased in yield mainly depends on the number of branches that emerged after pinching. Improvement in yield might be due to stimulation in growth by nutrients viz., N (1.96%), P (0.173%) and K (0.280%) in jeevamrit (Devakumar et al., 2014) due to the application of jeevamrit at regular intervals. These findings are in line with those reported by Singh (2018) who reported better growth and yield parameters in gerbera with the application of jeevamrit at 20 days intervals. Pathania (2019) and Choudhary et al. (2021) also reported that jeevamrit application significantly increases the growth and yield parameters in China aster and marigold, respectively.

## 4.12 Number of flowers per square metre

Data pertaining to number of flowers per square metre is presented in Table 4.12. During 2020-2021, genotype ‘Bizet’ (116.00) recorded maximum number of flowers per square metre which was found to be at par with ‘Tempo’ (110.40) and ‘Raggio-de-Sole’ (112.80) whereas minimum number of flowers per square metre was recorded in genotype ‘UHFSCar-7’ (96.80) which was statistically at par with genotypes ‘PM-1’ (98.40), ‘PM-2’ (101.60), ‘PM-3’ (100.00), ‘UHFSCar-1’(101.88), ‘UHFSCar-2’ (102.40), ‘UHFSCar-3’ (97.60), ‘UHFSCar-4’ (102.40), ‘UHFSCar-6’ (99.20) and ‘UHFSCar-11’ (98.40). The fertilization modules were found to be non-significant; however, organic fertilization module (104.00) recorded a greater number of flowers per square metre as compared to inorganic fertilization module (102.33).

During 2021-2022, that maximum number of flowers per square metre was recorded in genotype ‘Bizet’ (173.60) which was found to be at par with genotypes ‘PM-3’ (166.40) and ‘Raggio-de-Sole’ (172.00) whereas ‘UHFSCar-2’ (146.40) obtained the minimum number of flowers per square metre which was at par with ‘UHFSCar-7’ (149.60). Between the fertilization modules, organic fertilization module (162.40) recorded greater number of flowers per square metre over inorganic fertilization module (156.11).

Pooled analysis of the two years revealed that maximum number of flowers per square metre was obtained in genotype ‘Bizet’ (144.80) which was found to be at par with ‘Raggio-de-Sole’ (142.40) whereas genotypes ‘UHFSCar-7’ (123.20) obtained the minimum number of flowers per square metre which was found to be at par with genotypes ‘PM-2’ (129.60), ‘UHFSCar-1’ (127.74), ‘UHFSCar-2’ (124.40), ‘UHFSCar-4’ (126.40), ‘UHFSCar-6’ (128.40) and ‘UHFSCar-11’ (126.40). The organic fertilization module (133.20) recorded greater number of flowers per square metre over inorganic fertilization module (129.22).

In general, number of flowers per plant during 2021-2022 (159.26) was greater over during 2020-2021 (103.17). The interaction years and genotypes revealed that maximum number of flowers per square metre was obtained in genotype ‘Bizet’ (173.60) during 2021-2022 which was found to be at par with genotypes ‘PM-1’ (164.80), ‘PM-3’ (166.40) and ‘Raggio-de-Sole’ (172.00) of the same year whereas minimum number of flowers per square metre recorded was obtained in genotype ‘UHFSCar-7’ (116.00) during 2020-2021 which was statistically at par with genotypes ‘PM-1’ (98.40), ‘PM-2’ (101.60), ‘PM-3’ (100.00),

**Table 4.12: Effect of different genotypes of carnation on number of flowers per square metre in response to inorganic and organic fertilization modules**

| Genotypes | 2020-2021 | | | 2021-2022 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean |
| PM-1 | 97.60 | 99.20 | 98.40 | 160.00 | 169.60 | 164.80 | 128.80 | 134.40 | 131.60 |
| PM-2 | 100.80 | 102.40 | 101.60 | 153.60 | 161.60 | 157.60 | 127.20 | 132.00 | 129.60 |
| PM-3 | 97.60 | 102.40 | 100.00 | 161.60 | 171.20 | 166.40 | 129.60 | 136.80 | 133.20 |
| UHFSCar-1 | 101.36 | 102.40 | 101.88 | 152.00 | 155.20 | 153.60 | 126.68 | 128.80 | 127.74 |
| UHFSCar-2 | 104.00 | 100.80 | 102.40 | 145.60 | 147.20 | 146.40 | 124.80 | 124.00 | 124.40 |
| UHFSCar-3 | 97.60 | 97.60 | 97.60 | 161.60 | 163.20 | 162.40 | 129.60 | 130.40 | 130.00 |
| UHFSCar-4 | 100.80 | 104.00 | 102.40 | 150.40 | 150.40 | 150.40 | 125.60 | 127.20 | 126.40 |
| UHFSCar-5 | 107.20 | 105.60 | 106.40 | 150.40 | 168.00 | 159.20 | 128.80 | 136.80 | 132.80 |
| UHFSCar-6 | 97.60 | 100.80 | 99.20 | 148.80 | 166.40 | 157.60 | 123.20 | 133.60 | 128.40 |
| UHFSCar-7 | 96.00 | 97.60 | 96.80 | 148.80 | 150.40 | 149.60 | 122.40 | 124.00 | 123.20 |
| UHFSCar-11 | 96.00 | 100.80 | 98.40 | 150.40 | 158.40 | 154.40 | 123.20 | 129.60 | 126.40 |
| Bizet | 113.60 | 118.40 | 116.00 | 171.20 | 176.00 | 173.60 | 142.40 | 147.20 | 144.80 |
| Tempo | 110.40 | 110.40 | 110.40 | 158.40 | 164.80 | 161.60 | 134.40 | 137.60 | 136.00 |
| Raggio-de-Sole | 112.00 | 113.60 | 112.80 | 172.80 | 171.20 | 172.00 | 142.40 | 142.40 | 142.40 |
| **Mean** | 102.33 | 104.00 | 103.17 | 156.11 | 162.40 | 159.26 | 129.22 | 133.20 | |
| **$CD_{0.05}$** | Genotypes : 10.34<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS | | | Genotypes : 7.65<br>Fertilization modules : 2.89<br>Genotypes x Fertilization modules : NS | | | Genotypes : 6.52<br>Fertilization modules : 2.47<br>Genotypes x Fertilization modules : NS<br>Years : 2.47<br>Years x Fertilization modules : NS<br>Years x Genotypes : 9.22<br>Years x Genotype x Fertilization modules : NS | | |

‘UHFSCar-1’ (101.88), ‘UHFSCar-2’ (102.40), ‘UHFSCar-3’ (97.60), ‘UHFSCar-4’ (102.40), ‘UHFSCar-6’ (99.40) and ‘UHFSCar-11’ (98.40) during 2020-2021.

### 4.13 Number of days taken for harvesting of cut stem

The data attaining to the number of days taken for harvesting of cut stem is presented in Table 4.13. During 2020-2021, genotype ‘PM-2’ (146.67 days) recorded minimum day taken for harvesting of cut stem while genotype ‘UHFSCar-6’ (177.50 days) recorded maximum days taken for harvesting of cut stem which was found to be at par with genotypes ‘UHFSCar-1’ (175.17 days), ‘UHFSCar-2’ (172.00 days), ‘UHFSCar-3’ (173.83 days), ‘UHFSCar-4’ (172.83 days), ‘UHFSCar-11’ (171.67 days) and ‘Tempo’ (169.67 days). Of the two fertilization module, organic fertilization module (163.07 days) took lesser days for harvesting of cut stem in contrast to inorganic fertilization module (169.55 days).

During 2021-2022, genotypes followed the same trend as during 2020-2021 where the minimum days taken for harvesting of cut stem was registered in ‘PM-2’ (166.17 days) whereas maximum days taken for harvesting of cut stem was recorded in genotype ‘Raggio-de-Sole’ (219.33 days) which was found to be at par with genotype ‘UHFSCar-2’ (211.50 days). The organic fertilization module (195.73 days) took lesser days for harvesting of cut stem in contrast to inorganic fertilization module (202.41 days).

From the two years pooled data, it was shown that genotype ‘PM-2’ (156.42 days) recorded minimum days taken for harvesting of cut stem whereas genotype ‘UHFSCar-2’ (191.75 days) recorded maximum days taken for harvesting of cut stem which was found to be at par with genotypes ‘UHFSCar-1’ (186.58 days), ‘UHFSCar-3’ (188.67 days), ‘UHFSCar-4’ (189.42 days), ‘UHFSCar-5’ (184.58 days), ‘UHFSCar-6’ (189.00 days), ‘UHFSCar-7’ (186.00 days), ‘UHFSCar-11’ (187.17 days), ‘Tempo’ (182.25 days) and ‘Raggio-de-Sole’ (189.50 days). Between the organic fertilization modules, organic fertilization module (179.43 days) took lesser days for harvesting of cut stem in contrast to inorganic fertilization module (185.98 days).

Overall, the days taken for harvesting of cut stem were lesser during 2020-2021 (166.31 days) over during 2021-2022 (199.10 days). Interaction between years and genotype revealed that genotype ‘PM-2’ (146.67 days) during 2020-2021 recorded minimum days taken for harvesting of cut stem which was statistically at par with genotype ‘PM-1’ (157.83 days) during the same year. In contrast, maximum days taken for harvesting of cut stem was

**Table 4.13: Effect of different genotypes of carnation on number of days taken for harvesting of cut stem in response to inorganic and organic fertilization modules**

| Genotypes | 2020-2021 | | | 2021-2022 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean |
| PM-1 | 158.33 | 157.33 | 157.83 | 194.67 | 194.67 | 194.67 | 176.50 | 176.00 | 176.25 |
| PM-2 | 148.67 | 144.67 | 146.67 | 167.00 | 165.33 | 166.17 | 157.83 | 155.00 | 156.42 |
| PM-3 | 160.67 | 163.00 | 161.83 | 193.33 | 195.67 | 194.50 | 177.00 | 179.33 | 178.17 |
| UHFSCar-1 | 184.33 | 166.00 | 175.17 | 200.33 | 195.67 | 198.00 | 192.33 | 180.83 | 186.58 |
| UHFSCar-2 | 171.00 | 173.00 | 172.00 | 219.00 | 204.00 | 211.50 | 195.00 | 188.50 | 191.75 |
| UHFSCar-3 | 182.67 | 165.00 | 173.83 | 202.00 | 205.00 | 203.50 | 192.33 | 185.00 | 188.67 |
| UHFSCar-4 | 181.33 | 164.33 | 172.83 | 209.33 | 202.67 | 206.00 | 195.33 | 183.50 | 189.42 |
| UHFSCar-5 | 169.67 | 155.67 | 162.67 | 214.33 | 198.67 | 206.50 | 192.00 | 177.17 | 184.58 |
| UHFSCar-6 | 178.00 | 177.00 | 177.50 | 207.33 | 193.67 | 200.50 | 192.67 | 185.33 | 189.00 |
| UHFSCar-7 | 170.33 | 164.00 | 167.17 | 213.67 | 196.00 | 204.83 | 192.00 | 180.00 | 186.00 |
| UHFSCar-11 | 169.67 | 173.67 | 171.67 | 202.67 | 202.67 | 202.67 | 186.17 | 188.17 | 187.17 |
| Bizet | 159.67 | 160.00 | 159.83 | 192.67 | 176.00 | 184.33 | 176.17 | 168.00 | 172.08 |
| Tempo | 170.33 | 169.00 | 169.67 | 195.00 | 194.67 | 194.83 | 182.67 | 181.83 | 182.25 |
| Raggio-de-Sole | 169.00 | 150.33 | 159.67 | 222.33 | 216.33 | 219.33 | 195.67 | 183.33 | 189.50 |
| **Mean** | 169.55 | 163.07 | 166.31 | 202.41 | 195.79 | 199.10 | 185.98 | 179.43 | |
| **$CD_{0.05}$** | Genotypes : 9.86<br>Fertilization modules : 3.73<br>Genotypes x Fertilization modules : NS | | | Genotypes : 10.49<br>Fertilization modules : 3.97<br>Genotypes x Fertilization modules : NS | | | Genotypes : 10.08<br>Fertilization modules : 2.69<br>Genotypes x Fertilization modules : NS<br>Years : 2.69<br>Years x Fertilization modules : NS<br>Years x Genotypes : 11.39<br>Years x Genotype x Fertilization modules : NS | | |

registered in genotype 'Raggio-de-Sole' (219.33 days) during 2021-2022 which was found to be at par with genotype 'UHFSCar-2' (211.50 days) during the same year.

The genotypes varied significantly with the number of days taken for harvesting of cut stem because of the differences in their genetic makeup and their interaction with environmental factors particularly temperatures (Appendix I). The results are in agreement with the findings of Baweja and Brahma (2001), Chauhan et al. (2017) and Medeo et al. (2019).

Jeevamrit contains both macro and essential micro nutrients, many vitamins, essential amino acids, growth promoting substances like indole acetic acid (IAA), gibberlic acid (GA) and beneficial microorganisms mineralization (Palekar, 2006; Gore and Sreenivasa, 2011) which hastened the days taken for harvesting of cut stem. Koppala (2018) in potted chrysanthemums supported the present findings.

### 4.14 Duration of flowering (days)

The duration of flowering of different genotypes of carnation in response to organic and inorganic fertilization is presented in Table 4.14. During 2020-2021, genotype 'PM-1' (83.83 days) recorded maximum duration of flowering which was found to be at par with genotypes 'PM-3' (79.00 days), 'UHFSCar-5' (79.33 days) and 'Bizet' (80.67 days). In contrast, minimum duration of flowering was recorded in genotype 'UHFSCar-6' (64.50 days) which was found to be at par with genotypes 'PM-2' (71.33 days), 'UHFSCar-1' (66.50 days), 'UHFSCar-2' (69.50 days), 'UHFSCar-3' (67.83 days), 'UHFSCar-4' (69.00 days), 'UHFSCar-11' (70.17 days), 'Tempo' (71.83 days) and 'Raggio-de-Sole' (71.33 days). The organic fertilization module (75.38 days) recorded longer duration of flowering in contrast to inorganic fertilization module (70.14 days).

Interaction between genotype and fertilization modules revealed that maximum duration of flowering was observed in genotype 'UHFSCar-5' (86.33 days) in organic fertilization module which was found to be at par with genotypes 'PM-1' (84.33 days), 'PM-3' (78.33 days), 'UHFSCar-1' (76.00 days), 'UHFSCar-3' (77.00 days), 'UHFSCar-4' (77.33 days), 'UHFSCar-7' (76.67 days), 'Bizet' (80.33 days) and 'Raggio-de-Sole' (76.33 days) in organic fertilization module and genotypes 'PM-1' (83.33 days), 'PM-2' (75.33 days), 'PM-3' (79.67 days) and 'Bizet' (80.33 days) in inorganic fertilization module. In contrast,

**Table 4.14: Effect of different genotypes of carnation on duration of flowering (days) in response to inorganic and organic fertilization modules**

| Genotypes | 2020-2021 | | | 2021-2022 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean | Inorganic fertilization module | Organic fertilization module | Mean |
| PM-1 | 83.33 | 84.33 | 83.83 | 71.67 | 71.67 | 71.67 | 77.50 | 78.00 | 77.75 |
| PM-2 | 75.33 | 67.33 | 71.33 | 75.00 | 80.33 | 77.67 | 75.17 | 73.83 | 74.50 |
| PM-3 | 79.67 | 78.33 | 79.00 | 72.33 | 70.67 | 71.50 | 76.00 | 74.50 | 75.25 |
| UHFSCar-1 | 57.00 | 76.00 | 66.50 | 50.00 | 62.33 | 56.17 | 53.50 | 69.17 | 61.33 |
| UHFSCar-2 | 70.00 | 69.00 | 69.50 | 65.67 | 71.33 | 68.50 | 67.83 | 70.17 | 69.00 |
| UHFSCar-3 | 58.67 | 77.00 | 67.83 | 64.33 | 62.00 | 63.17 | 61.50 | 69.50 | 65.50 |
| UHFSCar-4 | 60.67 | 77.33 | 69.00 | 57.00 | 63.33 | 60.17 | 58.83 | 70.33 | 64.58 |
| UHFSCar-5 | 72.33 | 86.33 | 79.33 | 51.67 | 67.67 | 59.67 | 62.00 | 77.00 | 69.50 |
| UHFSCar-6 | 64.00 | 65.00 | 64.50 | 48.00 | 72.67 | 60.33 | 56.00 | 68.83 | 62.42 |
| UHFSCar-7 | 71.00 | 76.67 | 73.83 | 52.67 | 70.00 | 61.33 | 61.83 | 73.33 | 67.58 |
| UHFSCar-11 | 71.33 | 69.00 | 70.17 | 65.00 | 64.00 | 64.50 | 68.17 | 66.50 | 67.33 |
| Bizet | 81.00 | 80.33 | 80.67 | 73.33 | 77.33 | 75.33 | 77.17 | 78.83 | 78.00 |
| Tempo | 71.33 | 72.33 | 71.83 | 71.00 | 72.33 | 71.67 | 71.17 | 72.33 | 71.75 |
| Raggio-de-Sole | 66.33 | 76.33 | 71.33 | 58.67 | 60.67 | 59.67 | 62.50 | 68.50 | 65.50 |
| **Mean** | 70.14 | 75.38 | 72.76 | 62.60 | 69.02 | 65.90 | 66.37 | 72.20 | |
| **$CD_{0.05}$** | Genotypes : 8.65<br>Fertilization modules : 3.27<br>Genotypes x Fertilization modules : 12.24 | | | Genotypes : 10.50<br>Fertilization modules : 3.97<br>Genotypes x Fertilization modules : NS | | | Genotypes : 6.68<br>Fertilization modules : 2.52<br>Genotypes x Fertilization modules : 9.44<br>Years : 2.52<br>Years x Fertilization modules : NS<br>Years x Genotypes : NS<br>Years x Genotype x Fertilization modules : NS | | |

minimum duration of flowering was recorded in genotype 'UHFSCar-1' (57.00 days) in inorganic fertilization module which was found to be at par with genotypes 'UHFSCar-3' (58.67 days), 'UHFSCar-4' (60.67 days), 'UHFSCar-6' (64.00 days) and 'Raggio-de-Sole' (66.33 days) in inorganic fertilization module and genotypes 'PM-2' (67.33 days), 'UHFSCar-2' (69.00 days), 'UHFSCar-6' (65.00 days) and 'UHFSCar-11' (69.00 days) in organic fertilization module.

During 2021-2022, maximum duration of flowering was observed in genotype 'PM-2' (77.67 days) which was at par with genotypes 'PM-1' (71.67 days), 'PM-3' (71.50 days), 'UHFSCar-2' (68.50 days), 'Bizet' (75.33 days) and 'Tempo' (71.67 days) while it was recorded minimum in genotype 'UHFSCar-1' (56.17 days) which was at par with genotypes 'UHFSCar-3' (63.17 days), 'UHFSCar-4' (60.17 days), 'UHFSCar-5' (59.67 days), 'UHFS Car-6' (60.33 days), 'UHFSCar-7' (61.33 days), 'UHFSCar-11' (64.50 days) and 'Raggio-de-Sole' (59.67 days). The organic fertilization module (69.02 days) recorded longer duration of flowering over inorganic fertilization module (62.60 days).

The pooled data of two years showed that genotype 'Bizet' (78.00 days) recorded maximum duration of flowering which was statistically at par with genotypes 'PM-1' (77.75 days), 'PM-2' (74.50 days), 'PM-3' (75.25 days) and 'Tempo' (71.75 days). In contrast, genotype 'UHFSCar-1' (61.33 days) obtained minimum duration of flowering which was found to be at par with genotypes 'UHFSCar-3' (65.50 days), 'UHFSCar-4' (64.58 days), 'UHFSCar-6' (62.42 days), 'UHFSCar-7' (67.58 days), 'UHFSCar-11' (67.33 days) and 'Raggio-de-Sole' (65.50 days). From the two fertilization modules, organic fertilization module (72.20 days) recorded longer duration of flowering as compared to inorganic fertilization module (66.37 days).

The interaction between genotypes and fertilization modules revealed that genotype 'Bizet' (78.83 days) in organic fertilization module recorded maximum duration of flowering which was foundstatistically at par with genotypes 'PM-1' (78.88 days), 'PM-2' (73.83 days), 'PM-3' (74.50 days), 'UHFSCar-2' (70.17 days), 'UHFSCar-3' (69.50 days), 'UHFSCar-4' (70.33 days), 'UHFSCar-5' (77.00 days), 'UHFSCar-7' (73.33 days) and 'Tempo' (72.33 days) in organic fertilization module and genotypes 'PM-1' (77.50 days), 'PM-2' (75.17 days), 'PM-3' (76.00 days), 'Bizet' (77.17 days) and 'Tempo' (71.17 days) in inorganic fertilization module. Whereas, minimum duration of flowering was recorded in genotype 'UHFSCar-1' (53.50 days) in inorganic fertilization module which was at par with genotypes

'UHFSCar-3' (61.50 days), 'UHFSCar-4' (58.83 days), 'UHFSCar-5' (62.00 days), 'UHFSCar-6' (56.00 days), 'UHFSCar-7' (61.83 days) and 'Raggio-de-Sole' (59.67 days). The organic fertilization module (69.02 days) recorded longer duration of flowering over inorganic fertilization module (62.60 days) of the same fertilization module.

The duration of flowering varied significantly with the genotypes which might be due to the different genetic composition of the genotypes which are in accordance with the findings of Karthikeyan et al. (2013), Nacho (2016), Chauhan et al. (2017) and Sharma (2020). Further, the trends of duration of flowering was decreased from 2020-2021 (72.76 days) to 2021-2022 (65.90 days) which could be due to the congenial environmental conditions during flowering in 2021-2022 (Appendix I).

Supply of macro and essential micro nutrients, many vitamins, essential amino acids, growth promoting substances like indole acetic acid (IAA), gibberlic acid (GA) and beneficial microorganisms present in jeevamrit might be responsible for longer duration of flowering in organic fertilization module. These results are in line with the findings of Singh (2018) in gerbera, Choudhary et al. (2021) in marigold and Thakur et al. (2023) in iris.

### 4.15 Vase life (days)

Perusal of Table 4.15 and Plates 6a-6d showed the influence of organic and inorganic fertilization modules on the vase life of different genotypes of carnation. During 2020-2021, genotype 'Tempo' (9.00 days) recorded maximum days of vase life which was statistically at par with genotypes 'UHFSCar-5' (8.63 days), 'UHFSCar-6' (8.30 days) and 'Bizet' (8.50 days) while genotype 'Raggio-de-Sole' (5.93 days) recorded the minimum vase life.

During 2021-2022, maximum vase life was attained by genotype 'Bizet' (7.70 days) which was found to be at par with genotypes 'PM-1' (6.93 days), 'PM-3' (6.90 days), 'UHFSCar-1' (7.13 days), 'UHFSCar-3' (7.03 days) and 'UHFSCar-5' (7.30 days) whereas vase life was recorded minimum in genotype 'Raggio-de-Sole' (5.80 days) which was found to be at par with genotypes 'UHFSCar-2' (6.20 days), 'UHFSCar-4' (6.33 days), 'UHFSCar-7' (6.30 days) and 'Tempo' (6.43 days).

The two years pooled data revealed that among different genotypes of carnation, maximum vase life was recorded in genotype 'Bizet' (8.10 days) which was statistically at par with genotypes 'UHFSCar-1' (7.62 days), 'UHFSCar-5' (7.97 days) and 'Tempo' (7.72 days) whereas it was recorded minimum in genotype 'Raggio-de-Sole' (5.87 days).

| Genotypes | At 0 day | After 7 days | |
|---|---|---|---|
| | Initial | Inorganic fertilization module | Organic fertilization module |
| PM-1 |  |  |  |
| PM-2 |  |  |  |
| PM-3 |  |  |  |
| UHFSCar-1 |  |  |  |

**Plate 6a: Studies on the vase life of different genotypes of carnation**

| | | | |
|---|---|---|---|
| **UHFSCar-2** |  |  |  |
| **UHFSCar-3** |  |  |  |
| **UHFSCar-4** |  |  |  |
| **UHFSCar-5** |  |  |  |

**Plate 6b: Studies on the vase life of different genotypes of carnation**

| | | | |
|---|---|---|---|
| **UHFSCar-6** |  |  |  |
| **UHFSCar-7** |  |  |  |
| **UHFSCar-11** |  |  |  |
| **Bizet** |  |  |  |

**Plate 6c: Studies on the vase life of different genotypes of carnation**

| | | | |
|---|---|---|---|
| **Tempo** |  |  |  |
| **Raggio-de-Sole** |  |  |  |

**Plate 6d: Studies on the vase life of different genotypes of carnation**

**Table 4.15: Effect of different genotypes of carnation on vase life (days) in response to inorganic and organic fertilization modules**

| Genotypes | 2020-2021 | | | 2021-2022 | | | Pooled | | |
|---|---|---|---|---|---|---|---|---|---|
| | **Inorganic fertilization module** | **Organic fertilization module** | **Mean** | **Inorganic fertilization module** | **Organic fertilization module** | **Mean** | **Inorganic fertilization module** | **Organic fertilization module** | **Mean** |
| PM-1 | 6.93 | 7.40 | 7.17 | 6.93 | 6.93 | 6.93 | 6.93 | 7.17 | 7.05 |
| PM-2 | 6.87 | 7.20 | 7.03 | 6.67 | 6.70 | 6.68 | 6.77 | 6.95 | 6.86 |
| PM-3 | 7.47 | 6.93 | 7.20 | 6.87 | 6.93 | 6.90 | 7.17 | 6.93 | 7.05 |
| UHFSCar-1 | 8.07 | 8.13 | 8.10 | 7.13 | 7.13 | 7.13 | 7.60 | 7.63 | 7.62 |
| UHFSCar-2 | 8.00 | 7.53 | 7.77 | 5.93 | 6.47 | 6.20 | 6.97 | 7.00 | 6.98 |
| UHFSCar-3 | 7.33 | 7.87 | 7.60 | 7.73 | 6.33 | 7.03 | 7.53 | 7.10 | 7.32 |
| UHFSCar-4 | 8.47 | 7.87 | 8.17 | 6.13 | 6.53 | 6.33 | 7.30 | 7.20 | 7.25 |
| UHFSCar-5 | 9.00 | 8.27 | 8.63 | 6.87 | 7.73 | 7.30 | 7.93 | 8.00 | 7.97 |
| UHFSCar-6 | 8.00 | 8.60 | 8.30 | 6.53 | 7.00 | 6.77 | 7.27 | 7.80 | 7.53 |
| UHFSCar-7 | 8.13 | 8.13 | 8.13 | 6.20 | 6.40 | 6.30 | 7.17 | 7.27 | 7.22 |
| UHFSCar-11 | 7.80 | 7.67 | 7.73 | 7.07 | 6.53 | 6.80 | 7.43 | 7.10 | 7.27 |
| Bizet | 8.60 | 8.40 | 8.50 | 7.73 | 7.67 | 7.70 | 8.17 | 8.03 | 8.10 |
| Tempo | 9.00 | 9.00 | 9.00 | 6.20 | 6.67 | 6.43 | 7.60 | 7.83 | 7.72 |
| Raggio-de-Sole | 6.07 | 5.80 | 5.93 | 5.87 | 5.73 | 5.80 | 5.97 | 5.77 | 5.87 |
| **Mean** | 7.84 | 7.77 | 7.81 | 6.71 | 6.77 | 6.74 | 7.27 | 7.27 | |
| **$CD_{0.05}$** | Genotypes : 0.73<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS | | | Genotypes : 0.81<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS | | | Genotypes : 0.54<br>Fertilization modules : NS<br>Genotypes x Fertilization modules : NS<br>Years : 0.21<br>Years x Fertilization modules : NS<br>Years x Genotypes : 0.76<br>Years x Genotype x Fertilization modules : NS | | |

In general, during 2020-2021 (7.81 days) the vase life was recorded longer over during 2021-2022 (6.74 days). The interaction between years and genotypes revealed that maximum vase life was attained in genotype 'Tempo' (9.00 days) during 2020-2021 which was found to be at par with genotypes 'UHFSCar-5' (8.63 days), 'UHFSCar-6' (8.30 days) and 'Bizet' (8.50 days) during the same year. In contrast, minimum vase life was recorded in genotype 'Raggio-de-Sole' (5.80 days) during 2021-2022 which was found to be at par with genotypes 'UHFSCar-2' (6.20 days), 'UHFSCar-4' (6.33 days), 'UHFSCar-7' (6.30 days) and 'Tempo' (6.43 days) of the same year and 'Raggio-de-Sole' (5.93 days) during 2020-2021.

The difference on the vase life is attributed to the differences in the genetic makeup of the genotypes understudy. The work done by Hosure (2015), Jose et al. (2017), Medeo et al. (2019) and Sharma (2020) supported the present findings.

### 4.16 Calyx splitting

Calyx splitting is a major physiological disorder in carnation in which the calyx may split down either half or completely and that further causes bending of the petals which destroys the shape and structure of the flower. Calyx splitting may occur due to low temperature (<10°C) during the growth of flower bud and an extra whorl of petals is developed inside the calyx which causes splitting of calyx. In the present investigation, genotypes and fertilization modules had no significant effect on the incidence of calyx splitting. Hence, no calyx splitting was reported.

### 4.17 Insect pest and Disease incidence

Mild attack of insect pest and diseases was observed but was controlled with the following: for inorganic fertilization module, Simba (0.1%) was sprayed on the plants to control red spider mite attack. The field was also kept moist during hot summer months to prevent the attack of red spider mite. For the control of *Spodoptera littoralis,* the plants were sprayed with Cypermenthrin (0.1%) and for the control of aphids the plants were sprayed with Imidacloprid (0.05%). To keep the crop disease free, plants were drenched with fungicides Bavistin (0.1 %) and Dithane M-45 (0.2 %).

For organic fertilization module, Agniastra and Bramhastra were sprayed alternatively at one week intervals when infestation was observed on the plants at a rate of 2.5% for the control of insect pests and diseases.

**Inorganic fertilization module** | **Organic fertilization module**

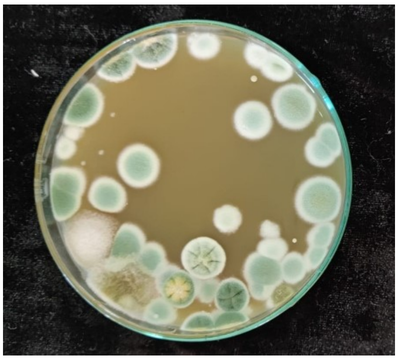
Bacteria (x $10^7$ cfu $g^{-1}$ soil)

Bacteria (x $10^7$ cfu $g^{-1}$ soil)

Actinomycetes (x $10^2$ cfu $g^{-1}$ soil)

Actinomycetes (x $10^2$ cfu $g^{-1}$ soil)

Fungi (x $10^2$ cfu $g^{-1}$ soil)



Fungi(x $10^2$ cfu $g^{-1}$ soil)

**Plate 7: Viable microbial count of the soil**

### 4.18 Viable microbial properties of the soil

The data presented in Table 4.16 and Plate 7 shows the viable microbial properties of the soil from both the fertilization modules. The viable microbial properties of the soil were taken for bacteria, actinomycetes and fungi. The initial value of viable microbial count was taken before planting and the final reading was taken after the termination of the research. The fertilization modules increased the bacterial count at $10^7$ dilution from the initial value (97.67 cfu $g^{-1}$), the inorganic fertilization module obtained 103.33 cfu $g^{-1}$ whereas, organic fertilization module attained 122.33 cfu $g^{-1}$. The actinomycetes count at $10^2$ dilution also increased from the initial value (37.67 cfu $g^{-1}$) to inorganic fertilization module (55.33 cfu $g^{-1}$) and organic fertilization module (57.67 cfu $g^{-1}$). The initial fungal count at $10^2$ dilution was 26.33 cfu $g^{-1}$ and the final value of both inorganic and organic fertilization module was 28.33 cfu $g^{-1}$.

The fertility of soil not only depends on its chemical composition, but also on the qualitative and quantitative nature of microorganism harbouring it. As organic liquid manures like jeevamrit is reported to supply nutrients which enhances soil bio-mass application to soil even at very lesser rate as it acts as a tonic to soil besides improving soil health (Vasanthkumar, 2006) which could be the reason for increased in the soil viable microbial count. This suggested that the organic fertilization module (jeevamrit) resulted in more microbial organisms of the soil which contribute to more fertile soil and ultimately to the better performance of the plants. Pathak and Ram (2007), Devakumar et al. (2014) and Vemaraju (2014) also reported that the application of jeevamrit increased the viable microbial count of soil.

**Table 4.16: Microbiological properties of inorganic and organic fertilized soil**

| Viable Microbial count (cfu $g^{-1}$ soil) | Initial value | Inorganic fertilized soil | Organic fertilized soil |
|---|---|---|---|
| **Bacterial count (x $10^7$)** | 97.67 | 103.33 | 122.33 |
| **Actinomycetes count (x $10^2$)** | 37.67 | 55.33 | 57.67 |
| **Fungal count (x $10^2$)** | 26.33 | 28.33 | 28.33 |

## 4.19 Physico-chemical and available NPK (kg/ha) content of soil

Table 4.17 presented the physico-chemical and available NPK content of the soil taken from both the fertilization modules. The initial pH of the soil was 6.57 and the final pH of the soil was higher in inorganic fertilization module (6.55) as compared to organic fertilization module (6.52). The pH values indicate slightly acidic soil conditions. The slight decrease in pH in the organic fertilization module could be due to the decomposition of organic materials, which may release acidic compounds. The difference between the pH values of the two modules is minimal and may not have significant practical implications.

The initial electrical conductivity of the soil was 0.176 $dSm^{-1}$ and the final electrical conductivity was higher in inorganic fertilization module (0.192 $dSm^{-1}$) as compared to organic fertilization module (0.169 $dSm^{-1}$). The increase in electrical conductivity in the inorganic fertilization module suggests a higher concentration of soluble salts, which may be attributed to the use of inorganic fertilizers. The lower EC in the organic fertilization module could be due to the lower salt content in organic fertilizers.

The initial organic carbon content of the soil was 1.98% and the final organic carbon was higher in organic fertilization module (2.02%) as compared to organic fertilization module (1.99%). The increase in organic carbon content in the organic fertilization module indicates that the application of organic fertilizers contributed to the addition of organic matter to the soil. Organic fertilizers often contain organic compounds that enhance soil organic carbon content and improve soil fertility and structure.

The initial available nitrogen content of the soil was 313.5 kg/ha and the final available nitrogen was higher in inorganic fertilization module (368.9 kg/ha) as compared to organic fertilization module (348.5 kg/ha). The higher available nitrogen content in the inorganic fertilization module suggests that the inorganic fertilizers used released nitrogen more readily or provided a higher amount of available nitrogen compared to organic fertilizers. However, both modules showed an increase in available nitrogen, indicating the fertilization had a positive effect on nutrient availability.

The initial available phosphorus content of the soil was 42.5 kg/ha and the final available phosphorus was higher in inorganic fertilization module (53.2 kg/ha) as compared to organic fertilization module (49.3 kg/ha). The higher available phosphorus content in the inorganic fertilization module suggests that the inorganic fertilizers used contributed to the availability of phosphorus in the soil. However, both modules showed an increase in available phosphorus, indicating that both types of fertilizers had a positive impact on phosphorus availability.

The initial available potassium content of the soil was 522.2 kg/ha and the final available potassium was higher in inorganic fertilization module (698.6 kg/ha) as compared to organic fertilization module (647.7 kg/ha). The higher available potassium content in the inorganic fertilization module suggests that the inorganic fertilizers used contributed to the availability of potassium in the soil. However, both modules showed an increase in available potassium, indicating that both types of fertilizers had a positive impact on potassium availability.

Overall, the findings indicate that both inorganic and organic fertilization had positive effects on soil parameters and nutrient availability. The inorganic fertilization module showed slightly higher values for pH, electrical conductivity, available nitrogen, phosphorus and potassium compared to the organic fertilization module. The organic fertilization module, on the other hand, resulted in a slightly higher organic carbon content. These results suggest that both types of fertilizers can contribute to soil fertility, but the specific choice of fertilizer depends on various factors such as crop requirements, environmental considerations and sustainable farming practices.

**Table 4.17: Physico-chemical characteristics and available NPK (kg/ha) content of inorganic and organic fertilized soil**

| Soil properties | Initial value | Inorganic fertilized soil | Organic fertilized soil |
|---|---|---|---|
| **Soil pH (1:25)** | 6.57 | 6.55 | 6.52 |
| **EC ($dSm^{-1}$)** | 0.176 | 0.192 | 0.169 |
| **Organic Carbon (%)** | 1.98 | 1.99 | 2.02 |
| **Avail. N** | 313.5 | 368.9 | 348.5 |
| **Avail. P** | 42.5 | 53.2 | 49.3 |
| **Avail. K** | 522.2 | 698.6 | 647.7 |

### 4.20 Cost of cultivation

Cost of cultivation was calculated following the production techniques and treatments followed in conducting the experiment. It was calculated for an area of 500 $m^2$. The cost benefit ratio was worked out on the basis of input and output involved. The cost of labour and various inputs was taken as per the local market rates. Gross monetary return and net return (Rs/500 $m^2$) was worked out using the following formula.

Gross monetary return (Rs/500 $m^2$) = value of cut flower

Net returns (Rs/500$m^2$) = Gross monetary returns – Total cost of production

$$\text{Cost Benefit Ratio} = \frac{\text{Net Returns}}{\text{Total Expenditure}}$$

Carnation genotypes were evaluated based on their input cost, gross return, net return and benefit cost ratio. Based on the data, the genotypes 'Bizet' and 'Raggio-de-Sole' exhibited the highest profitability among the carnation genotypes in inorganic fertilization module during 2020-2021 (1st year). They had the highest net returns and benefit cost ratios, indicating strong financial performance. Both the genotypes had a net return of Rs. 1,00,577.61 and Rs. 97,805.61 and a benefit cost ratio of 0.89 and 0.87, respectively. 'Tempo' also showed relatively good profitability with a net return of Rs. 95,063.61 and a benefit cost ratio of 0.85. 'UHFSCar-5' demonstrated moderate profitability with a net return of Rs. 89,549.61 and a benefit cost ratio of 0.80. The remaining genotypes had lower net returns and benefit cost ratios ranging from approximately Rs. 70,145.61 to Rs. 79,431.81 and 0.64 to 0.71, respectively.

**Table 4.18: Cost of cultivation of carnation and net returns on an area of 500 $m^2$ in inorganic fertilization module during 2020-2021 (1st year)**

| **A. Input Cost** | | | |
|---|---|---|---|
| **Particulars** | **Manday(s) required (No.)** | **Rate (Rs.)** | **Total cost (Rs.)** |
| **i) Labour** | | | |
| a. Bed preparation, mixing of farm yard manure and basal dose of fertilizer and planting | 5 | 350/manday | 1,750.00 |
| b. Irrigations | 20 | 350/manday | 7,000.00 |
| c. Pinching | 2 | 350/manday | 700.00 |
| d. Weeding and hoeing | 12 | 350/manday | 4,200.00 |
| e. Fertigation/ Drenching and Spraying | 20 | 350/manday | 7,000.00 |
| f. Disbudding and deshooting | 8 | 350/manday | 2,800.00 |
| g. Staking | 2 | 350/manday | 700.00 |
| h. Harvesting of flowers, grading, packaging and loading for transportation | 12 | 350/manday | 4,200.00 |
| **Total** | **81** | | **28,350.00** |
| **ii) Planting material** | **Quantity** | **Rate (Rs.)** | **Total cost (Rs.)** |

| | required (No.) | | |
|---|---|---|---|
| Rooted cuttings considering total planting area as 375 $m^2$ and planting density of 24 plants/ $m^2$ | 24 x 375 = 9000 | 6/ plant | **54,000.00** |
| **iii) Manures and fertilizers** | | | |
| a. Farm yard manure | 1875 kg | 1.50/kg | 2,812.50 |
| b. Vermicompost | 375 kg | 5.00/kg | 1,875.00 |
| c. Urea | 16.22 kg | 320/50 kg | 103.81 |
| d. Single Super Phosphate (SSP) | 23.44 kg | 300/50 kg | 140.64 |
| e. Muriate of Potash (MOP) | 6.23 kg | 800/50 kg | 99.68 |
| f. Multi-K | 28.88 kg | 4750/50 kg | 2,743.60 |
| g. Calcium nitrate | 11.98 kg | 1300/25 kg | 622.96 |
| **Total** | | | **8,398.19** |
| **iv) Plant protection chemicals** | | | |
| a. Insecticides | | | |
| Cypermethrin (1ml/l) | 90 x 2 = 180 ml | 450/litre | 81.00 |
| Imidachloprid (0.5 ml/l) | 45 x 2 = 90 ml | 1500/litre | 135.00 |
| Simba (1 ml/l) | 90 x 2 = 180 ml | 890/litre | 160.20 |
| **Total** | | | **376.20** |
| b. Fungicides | | | |
| Dithane M-45 (2g/l, drenched thrice) | 1.5 kg | 360/kg | 540.00 |
| Bavistin (1g/l, drenched thrice) | 0.75 kg | 1180/kg | 885.00 |
| **Total** | | | **1425.00** |
| **v) Staking material** | | | |
| a. Iron poles (cost for 6 months considering total life for 15 years) | 200 poles | 150/pole | 1,000.00 |
| b. Nets | | | |
| • 4x4 inch size of mesh, 2 bottom rows (cost for 6 months considering total life for 5 years) | 750 $m^2$ | 16.80/ $m^2$ | 1,260.00 |
| • 5x5 inch size of mesh, 2 upper rows (cost for 6 months considering total life for 5 years) | 750 $m^2$ | 15.00/ $m^2$ | 1,125.00 |
| **Total** | | | **3,385.00** |
| **vi) Transportation and packaging cost** | | | |
| **a) Boxes required (Box size = 95 cm x 40 cm x 22 cm)** | | | |

| Carnation genotypes | No. | Rate/Box (Rs.) | Total cost (Rs.) |
|---|---|---|---|
| PM-1 | 36.60 | 80 | 2,928.00 |
| PM-2 | 37.80 | 80 | 3,024.00 |
| PM-3 | 36.60 | 80 | 2,928.00 |
| UHFSCar-1 | 38.01 | 80 | 3,040.80 |
| UHFSCar-2 | 39.00 | 80 | 3,120.00 |
| UHFSCar-3 | 36.60 | 80 | 2,928.00 |
| UHFSCar-4 | 37.80 | 80 | 3,024.00 |
| UHFSCar-5 | 40.20 | 80 | 3,216.00 |
| UHFSCar-6 | 36.60 | 80 | 2,928.00 |
| UHFSCar-7 | 36.00 | 80 | 2,880.00 |
| UHFSCar-11 | 36.00 | 80 | 2,880.00 |
| Bizet | 42.60 | 80 | 3,408.00 |
| Tempo | 41.40 | 80 | 3,312.00 |
| Raggio-de-Sole | 42.00 | 80 | 3,360.00 |

| **b) Cellophane paper required** | | | |
|---|---|---|---|
| **Carnation genotypes** | **Kilo gram** | **Rate (300 Rs/kg)** | **Total cost (Rs.)** |
| PM-1 | 0.8 | 300 | 240.00 |
| PM-2 | 0.9 | 300 | 270.00 |
| PM-3 | 0.8 | 300 | 240.00 |
| UHFSCar-1 | 0.8 | 300 | 240.00 |
| UHFSCar-2 | 0.8 | 300 | 240.00 |
| UHFSCar-3 | 0.8 | 300 | 240.00 |
| UHFSCar-4 | 0.8 | 300 | 240.00 |
| UHFSCar-5 | 0.8 | 300 | 240.00 |
| UHFSCar-6 | 0.8 | 300 | 240.00 |
| UHFSCar-7 | 0.8 | 300 | 240.00 |
| UHFSCar-11 | 0.8 | 300 | 240.00 |
| Bizet | 1.0 | 300 | 300.00 |
| Tempo | 0.9 | 300 | 270.00 |
| Raggio-de-Sole | 1.0 | 300 | 300.00 |
| **c) Vehicle charges up to Delhi flower market** | | | |
| **Carnation genotypes** | | | |
| PM-1 | 36.60 | 300 | 10,980.00 |
| PM-2 | 37.80 | 300 | 11,340.00 |
| PM-3 | 36.60 | 300 | 10,980.00 |
| UHFSCar-1 | 38.01 | 300 | 11,403.00 |
| UHFSCar-2 | 39.00 | 300 | 11,700.00 |
| UHFSCar-3 | 36.60 | 300 | 10,980.00 |
| UHFSCar-4 | 37.80 | 300 | 11,340.00 |
| UHFSCar-5 | 40.20 | 300 | 12,060.00 |
| UHFSCar-6 | 36.60 | 300 | 10,980.00 |
| UHFSCar-7 | 36.00 | 300 | 10,800.00 |
| UHFSCar-11 | 36.00 | 300 | 10,800.00 |
| Bizet | 42.60 | 300 | 12,780.00 |
| Tempo | 41.40 | 300 | 12,420.00 |
| Raggio-de-Sole | 42.00 | 300 | 12,600.00 |

| **B. Returns** | | | |
|---|---|---|---|
| **Carnation genotypes** | **Yield (no. of cut flowers)** | **Market price of cut stem during the flowering time (Rs.)** | **Gross returns (Rs.)** |
| PM-1 | 36600 | 5 | 1,83,000.00 |
| PM-2 | 37800 | 5 | 1,89,000.00 |
| PM-3 | 36600 | 5 | 1,83,000.00 |
| UHFSCar-1 | 38010 | 5 | 1,90,050.00 |
| UHFSCar-2 | 39000 | 5 | 1,95,000.00 |
| UHFSCar-3 | 36600 | 5 | 1,83,000.00 |
| UHFSCar-4 | 37800 | 5 | 1,89,000.00 |
| UHFSCar-5 | 40200 | 5 | 2,01,000.00 |
| UHFSCar-6 | 36600 | 5 | 1,83,000.00 |
| UHFSCar-7 | 36000 | 5 | 1,80,000.00 |
| UHFSCar-11 | 36000 | 5 | 1,80,000.00 |
| Bizet | 42600 | 5 | 2,13,000.00 |
| Tempo | 41400 | 5 | 2,07,000.00 |
| Raggio-de-Sole | 42000 | 5 | 2,10,000.00 |

| C. Gross Returns (Rs.) | | | | |
|---|---|---|---|---|
| **Carnation genotypes** | **Input cost (A)(i)+(ii)+(iii)+ (iv)+(v)+(vi)(a+ b+c)** | **Gross return (Rs.)** | **Net return (Rs.)** | **Benefit cost ratio** |
| PM-1 | 1,10,082.39 | 1,83,000.00 | 72,917.61 | 0.66 |
| PM-2 | 1,10,568.39 | 1,89,000.00 | 78,431.61 | 0.71 |
| PM-3 | 1,10,082.39 | 1,83,000.00 | 72,917.61 | 0.66 |
| UHFSCar-1 | 1,10,618.19 | 1,90,050.00 | 79,431.81 | 0.72 |
| UHFSCar-2 | 1,10,994.39 | 1,95,000.00 | 84,005.61 | 0.76 |
| UHFSCar-3 | 1,10,082.39 | 1,83,000.00 | 72,917.61 | 0.66 |
| UHFSCar-4 | 1,10,538.39 | 1,89,000.00 | 78,461.61 | 0.71 |
| UHFSCar-5 | 1,11,450.39 | 2,01,000.00 | 89,549.61 | 0.80 |
| UHFSCar-6 | 1,10,082.39 | 1,83,000.00 | 72,917.61 | 0.66 |
| UHFSCar-7 | 1,09,854.39 | 1,80,000.00 | 70,145.61 | 0.64 |
| UHFSCar-11 | 1,09,854.39 | 1,80,000.00 | 70,145.61 | 0.64 |
| Bizet | 1,12,422.39 | 2,13,000.00 | 1,00,577.610 | 0.89 |
| Tempo | 1,11,936.39 | 2,07,000.00 | 95,063.61 | 0.85 |
| Raggio-de-Sole | 1,12,194.39 | 2,10,000.00 | 97,805.61 | 0.87 |

During the 2020-2021, the organic fertilization module observed that the genotypes ‘Bizet’ and ‘Raggio-de-Sole’ stood out as the most profitable among the carnation genotypes. They demonstrated the highest net returns and benefit cost ratios, indicating strong financial performance. ‘Bizet’ achieved the highest net return of Rs. 1,16,527.90 with a benefit cost ratio of 1.10, while ‘Raggio-de-Sole’ attained the second-highest net return of Rs. 1,08,211.90 and a benefit cost ratio of 1.03. Additionally, ‘Tempo’ and ‘UHFSCar-5’ showed relatively good profitability with net returns of around Rs. 1,02,667.90 and Rs. 94,411.90 and benefit cost ratios of 0.98 and 0.91, respectively. The remaining genotypes yielded lower net returns and benefit cost ratios, ranging from approximately Rs. 80,551.90 to Rs. 88,807.90 and 0.79 to 0.86, respectively.

**Table 4.19: Cost of cultivation of carnation and net returns on an area of 500 m$^2$ in organic fertilization module during 2020-2021 (1$^{st}$ year)**

| A. Input Cost | | | |
|---|---|---|---|
| **Particulars** | **Manday(s) required (No.)** | **Rate (Rs.)** | **Total cost (Rs.)** |
| **i) Labour** | | | |
| a. Bed preparation, mixing of farm yard manure and basal dose of fertilizer and planting | 4 | 350/manday | 1,400.00 |
| b. Irrigations | 20 | 350/manday | 7,000.00 |
| c. Pinching | 2 | 350/manday | 700.00 |
| d. Weeding and hoeing | 12 | 350/manday | 4,200.00 |
| e. Drenching and Spraying | 8 | 350/manday | 2,800.00 |
| f. Disbudding and deshooting | 8 | 350/manday | 2,800.00 |
| g. Staking | 2 | 350/manday | 700.00 |

| | | | |
|---|---|---|---|
| h. Harvesting of flowers, grading, packaging and loading for transportation | 12 | 350/manday | 4,200.00 |
| **Total** | **68** | | **23,800.00** |
| **ii) Planting material** | **Quantity required (No.)** | **Rate (Rs.)** | **Total cost (Rs.)** |
| Rooted cuttings considering total planting area as 375 $m^2$ and planting density of 24 plants/ $m^2$ | 24 x 375 = 9000 | 6/ plant | **54000.00** |
| **iii) Manures and fertilizers** | | | |
| a. Farm yard manure | 1875 kg | 1.50/kg | 2812.50 |
| b. Vermicompost | 375 kg | 5.00/kg | 1875.00 |
| c. Jeevamrit | 1080 litre | 2/l | 2160.00 |
| **Total** | | | **6847.50** |
| **iv) Plant protection chemicals** | | | |
| a. Agniastra (25 ml/l) | 4.46 litre | 35/l | 156.10 |
| b. Bhramastra (25 ml/l) | 4.46 litre | 25/l | 111.50 |
| **Total** | | | **267.60** |
| **v) Staking material** | | | |
| a. Iron poles (cost for 6 months considering total life for 15 years) | 200 poles | 150/pole | 1000.00 |
| b. Nets | | | |
| • 4x4 inch size of mesh, 2 bottom rows (cost for 6 months considering total life for 5 years) | 750 $m^2$ | 16.80/ $m^2$ | 1260.00 |
| • 5x5 inch size of mesh, 2 upper rows (cost for 6 months considering total life for 5 years) | 750 $m^2$ | 15.00/ $m^2$ | 1125.00 |
| **Total** | | | **3385.00** |
| **vi) Transportation and packaging cost** | | | |
| **a) Boxes required (Box size = 95 cm x 40 cm x 22 cm)** | | | |
| **Carnation genotypes** | **No.** | **Rate/Box (Rs.)** | **Total cost (Rs.)** |
| PM-1 | 37.20 | 80 | 2,976.00 |
| PM-2 | 38.40 | 80 | 3,072.00 |
| PM-3 | 38.40 | 80 | 3,072.00 |
| UHFSCar-1 | 38.40 | 80 | 3,072.00 |
| UHFSCar-2 | 37.80 | 80 | 3,024.00 |
| UHFSCar-3 | 36.60 | 80 | 2,928.00 |
| UHFSCar-4 | 39.00 | 80 | 3,120.00 |
| UHFSCar-5 | 39.60 | 80 | 3,168.00 |
| UHFSCar-6 | 37.80 | 80 | 3,024.00 |
| UHFSCar-7 | 36.60 | 80 | 2,928.00 |
| UHFSCar-11 | 37.80 | 80 | 3,024.00 |
| Bizet | 44.40 | 80 | 3,552.00 |
| Tempo | 41.40 | 80 | 3,312.00 |
| Raggio-de-Sole | 42.60 | 80 | 3,408.00 |
| **b) Cellophane paper required** | | | |
| **Carnation genotypes** | **Kilo gram** | **Rate (300 Rs/kg)** | **Total cost (Rs.)** |
| PM-1 | 0.8 | 300 | 240.00 |
| PM-2 | 1.0 | 300 | 300.00 |
| PM-3 | 1.0 | 300 | 300.00 |
| UHFSCar-1 | 0.8 | 300 | 240.00 |
| UHFSCar-2 | 0.8 | 300 | 240.00 |

| | | | |
|---|---|---|---|
| UHFSCar-3 | 0.8 | 300 | 240.00 |
| UHFSCar-4 | 0.8 | 300 | 240.00 |
| UHFSCar-5 | 0.8 | 300 | 240.00 |
| UHFSCar-6 | 0.8 | 300 | 240.00 |
| UHFSCar-7 | 0.8 | 300 | 240.00 |
| UHFSCar-11 | 0.8 | 300 | 240.00 |
| Bizet | 1.0 | 300 | 300.00 |
| Tempo | 1.0 | 300 | 300.00 |
| Raggio-de-Sole | 1.0 | 300 | 300.00 |
| **c) Vehicle charges up to Delhi flower market** | | | |
| **Carnation genotypes** | | | |
| PM-1 | 37.20 | 300 | 11,160.00 |
| PM-2 | 38.40 | 300 | 11,520.00 |
| PM-3 | 38.40 | 300 | 11,520.00 |
| UHFSCar-1 | 38.40 | 300 | 11,520.00 |
| UHFSCar-2 | 37.80 | 300 | 11,340.00 |
| UHFSCar-3 | 36.60 | 300 | 10,980.00 |
| UHFSCar-4 | 39.00 | 300 | 11,700.00 |
| UHFSCar-5 | 39.60 | 300 | 11,880.00 |
| UHFSCar-6 | 37.80 | 300 | 11,340.00 |
| UHFSCar-7 | 36.60 | 300 | 10,980.00 |
| UHFSCar-11 | 37.80 | 300 | 11,340.00 |
| Bizet | 44.40 | 300 | 13,320.00 |
| Tempo | 41.40 | 300 | 12,420.00 |
| Raggio-de-Sole | 42.60 | 300 | 12,780.00 |

**B. Returns**

| Carnation genotypes | Yield (no. of cut flowers) | Market price of cut stem during the flowering time (Rs.) | Gross returns (Rs.) |
|---|---|---|---|
| PM-1 | 37200 | 5 | 1,86,000.00 |
| PM-2 | 38400 | 5 | 1,92,000.00 |
| PM-3 | 38400 | 5 | 1,92,000.00 |
| UHFSCar-1 | 38400 | 5 | 1,92,000.00 |
| UHFSCar-2 | 37800 | 5 | 1,89,000.00 |
| UHFSCar-3 | 36600 | 5 | 1,83,000.00 |
| UHFSCar-4 | 39000 | 5 | 1,95,000.00 |
| UHFSCar-5 | 39600 | 5 | 1,98,000.00 |
| UHFSCar-6 | 37800 | 5 | 1,89,000.00 |
| UHFSCar-7 | 36600 | 5 | 1,83,000.00 |
| UHFSCar-11 | 37800 | 5 | 1,89,000.00 |
| Bizet | 44400 | 5 | 2,22,000.00 |
| Tempo | 41400 | 5 | 2,07,000.00 |
| Raggio-de-Sole | 42600 | 5 | 2,13,000.00 |

**C. Gross Returns (Rs.)**

| Input cost (A)(i)+(ii)+(iii)+(iv)+(v)+(vi)(a+b+c) | | Gross return (Rs.) | Net return (Rs.) | Benefit cost ratio |
|---|---|---|---|---|
| **Carnation genotypes** | | | | |
| PM-1 | 1,02,676.10 | 1,86,000.00 | 83,323.90 | 0.81 |
| PM-2 | 1,03,192.10 | 1,92,000.00 | 88,807.90 | 0.86 |
| PM-3 | 1,03,192.10 | 1,92,000.00 | 88,807.90 | 0.86 |
| UHFSCar-1 | 1,03,132.10 | 1,92,000.00 | 88,867.90 | 0.86 |
| UHFSCar-2 | 1,02,904.10 | 1,89,000.00 | 86,095.90 | 0.84 |

| | | | | |
|---|---|---|---|---|
| UHFSCar-3 | 1,02,448.10 | 1,83,000.00 | 80,551.90 | 0.79 |
| UHFSCar-4 | 1,03,360.10 | 1,95,000.00 | 91,639.90 | 0.89 |
| UHFSCar-5 | 1,03,588.10 | 1,98,000.00 | 94,411.90 | 0.91 |
| UHFSCar-6 | 1,02,904.10 | 1,89,000.00 | 86,095.90 | 0.84 |
| UHFSCar-7 | 1,02,448.10 | 1,83,000.00 | 80,551.90 | 0.79 |
| UHFSCar-11 | 1,02,904.10 | 1,89,000.00 | 86,095.90 | 0.84 |
| Bizet | 1,05,472.10 | 2,22,000.00 | 1,16,527.90 | 1.10 |
| Tempo | 1,04,332.10 | 2,07,000.00 | 1,02,667.90 | 0.98 |
| Raggio-de-Sole | 1,04,788.10 | 2,13,000.00 | 1,08,211.90 | 1.03 |

'Raggio-de-Sole' exhibited the highest profitability in inorganic fertilization module during 2021-2022. It demonstrated significant net returns of Rs. 2,59,384.63 and benefit cost ratio of 4.01. 'Bizet' also showed strong financial performance with a net return of Rs. 2,56,612.63 and a benefit cost ratio of 3.99. Similarly, 'Tempo', 'PM-1', 'PM-3' and 'UHFSCar-3' and displayed favorable profitability with net returns ranging from approximately Rs. 2,34,466.63 to Rs. 2,39,980.63 and benefit cost ratios between 3.75 and 3.81. The remaining genotypes had relatively lower net returns and benefit cost ratios, but still achieved values between 3.50 and 3.66.

**Table 4.20: Cost of cultivation of carnation and net returns on an area of 500 m$^2$ in inorganic fertilization module during 2021-2022 (2$^{nd}$ year)**

| **A. Input Cost** | | | |
|---|---|---|---|
| **Particulars** | **Manday(s) required (No.)** | **Rate (Rs.)** | **Total cost (Rs.)** |
| **i) Labour** | | | |
| a. Bed preparation, mixing of farm yard manure and basal dose of fertilizer and planting | - | - | - |
| b. Irrigations | 20 | 350/manday | 7,000.00 |
| c. Pinching | 2 | 350/manday | 700.00 |
| d. Weeding and hoeing | 12 | 350/manday | 4,200.00 |
| e. Fertigation / Drenching and Spraying | 20 | 350/manday | 7,000.00 |
| f. Disbudding and deshooting | 8 | 350/manday | 2,800.00 |
| g. Staking | 1 | 350/manday | 350.00 |
| h. Harvesting of flowers, grading, packaging and loading for transportation | 12 | 350/manday | 4,200.00 |
| **Total** | **75** | | **26,250.00** |
| **ii) Manures and fertilizers** | | | |
| a. Farm yard manure | 1875 kg | 1.50/kg | 2812.50 |
| b. Vermicompost | 375 kg | 5.00/kg | 1875.00 |
| c. Urea | 8.08 kg | 320/50 kg | 51.71 |
| d. Multi-K | 28.88 kg | 4750/50 kg | 2743.60 |
| e. Calcium nitrate | 11.98 kg | 1300/25 kg | 622.96 |
| **Total** | | | **8105.17** |

| | | | |
|---|---|---|---|
| **iii) Plant protection chemicals** | | | |
| a. Insecticides | | | |
| Cypermethrin (1ml/l) | 90 x 2 = 180 ml | 450/litre | 81.00 |
| Imidachloprid (0.5 ml/l) | 45 x 2 = 90 ml | 1500/litre | 135.00 |
| Simba (1 ml/l) | 90 x 2 = 180 ml | 890/litre | 160.20 |
| **Total** | | | **376.20** |
| b. Fungicides | | | |
| Dithane M-45 (2g/l, drenched thrice) | 1.5 kg | 360/kg | 540.00 |
| Bavistin (1g/l, drenched thrice) | 0.75 kg | 1180/kg | 885.00 |
| **Total** | | | **1425.00** |
| **iv) Staking material** | | | |
| a. Iron poles (cost for 6 months considering total life for 15 years) | 200 poles | 150/pole | 1000.00 |
| b. Nets | | | |
| • 4x4 inch size of mesh, 2 bottom rows (cost for 6 months considering total life for 5 years) | 750 $m^2$ | 16.80/ $m^2$ | 1260.00 |
| • 5x5 inch size of mesh, 2 upper rows (cost for 6 months considering total life for 5 years) | 750 $m^2$ | 15.00/ $m^2$ | 1125.00 |
| **Total** | | | **3385.00** |
| **v) Transportation and packaging cost** | | | |
| **a) Boxes required (Box size = 95 cm x 40 cm x 22 cm)** | | | |
| **Carnation genotypes** | **No.** | **Rate/Box (Rs.)** | **Total cost (Rs.)** |
| PM-1 | 60.00 | 80 | 4,800.00 |
| PM-2 | 57.60 | 80 | 4,608.00 |
| PM-3 | 60.60 | 80 | 4,848.00 |
| UHFSCar-1 | 57.00 | 80 | 4,560.00 |
| UHFSCar-2 | 54.60 | 80 | 4,368.00 |
| UHFSCar-3 | 60.60 | 80 | 4,848.00 |
| UHFSCar-4 | 56.40 | 80 | 4,512.00 |
| UHFSCar-5 | 56.40 | 80 | 4,512.00 |
| UHFSCar-6 | 55.80 | 80 | 4,464.00 |
| UHFSCar-7 | 55.80 | 80 | 4,464.00 |
| UHFSCar-11 | 56.40 | 80 | 4,512.00 |
| Bizet | 64.20 | 80 | 5,136.00 |
| Tempo | 59.40 | 80 | 4,752.00 |
| Raggio-de-Sole | 64.80 | 80 | 5,184.00 |
| **b) Cellophane paper required** | | | |
| **Carnation genotypes** | **Kilo gram** | **Rate (300 Rs/kg)** | **Total cost (Rs.)** |
| PM-1 | 1.4 | 300 | 420.00 |
| PM-2 | 1.2 | 300 | 360.00 |
| PM-3 | 1.5 | 300 | 450.00 |
| UHFSCar-1 | 1.2 | 300 | 360.00 |
| UHFSCar-2 | 1.2 | 300 | 360.00 |
| UHFSCar-3 | 1.5 | 300 | 450.00 |
| UHFSCar-4 | 1.1 | 300 | 330.00 |
| UHFSCar-5 | 1.2 | 300 | 360.00 |
| UHFSCar-6 | 1.2 | 300 | 360.00 |
| UHFSCar-7 | 1.1 | 300 | 330.00 |
| UHFSCar-11 | 1.2 | 300 | 360.00 |
| Bizet | 1.5 | 300 | 450.00 |
| Tempo | 1.4 | 300 | 420.00 |

| | | | |
|---|---|---|---|
| Raggio-de-Sole | 1.5 | 300 | 450.00 |
| **c) Vehicle charges up to Delhi flower market** | | | |
| **Carnation genotypes** | | | |
| PM-1 | 60.00 | 300 | 18,000.00 |
| PM-2 | 57.60 | 300 | 17,280.00 |
| PM-3 | 60.60 | 300 | 18,180.00 |
| UHFSCar-1 | 57.00 | 300 | 17,100.00 |
| UHFSCar-2 | 54.60 | 300 | 16,380.00 |
| UHFSCar-3 | 60.60 | 300 | 18,180.00 |
| UHFSCar-4 | 56.40 | 300 | 16,920.00 |
| UHFSCar-5 | 56.40 | 300 | 16,920.00 |
| UHFSCar-6 | 55.80 | 300 | 16,740.00 |
| UHFSCar-7 | 55.80 | 300 | 16,740.00 |
| UHFSCar-11 | 56.40 | 300 | 16,920.00 |
| Bizet | 64.20 | 300 | 19,260.00 |
| Tempo | 59.40 | 300 | 17,820.00 |
| Raggio-de-Sole | 64.80 | 300 | 19,440.00 |

**B. Returns**

| Carnation genotypes | Yield (no. of cut flowers) | Market price of cut stem during the flowering time (Rs.) | Gross returns (Rs.) |
|---|---|---|---|
| PM-1 | 60000 | 5 | 3,00,000.00 |
| PM-2 | 57600 | 5 | 2,88,000.00 |
| PM-3 | 60600 | 5 | 3,03,000.00 |
| UHFSCar-1 | 57000 | 5 | 2,85,000.00 |
| UHFSCar-2 | 54600 | 5 | 2,73,000.00 |
| UHFSCar-3 | 60600 | 5 | 3,03,000.00 |
| UHFSCar-4 | 56400 | 5 | 2,82,000.00 |
| UHFSCar-5 | 56400 | 5 | 2,82,000.00 |
| UHFSCar-6 | 55800 | 5 | 2,79,000.00 |
| UHFSCar-7 | 55800 | 5 | 2,79,000.00 |
| UHFSCar-11 | 56400 | 5 | 2,82,000.00 |
| Bizet | 64200 | 5 | 3,21,000.00 |
| Tempo | 59400 | 5 | 2,97,000.00 |
| Raggio-de-Sole | 64800 | 5 | 3,24,000.00 |

**C. Gross Returns (Rs.)**

| Input cost (A)(i)+(ii)+(iii)+(iv)+(v)(a+b+c) | | Gross return (Rs.) | Net return (Rs.) | Benefit cost ratio |
|---|---|---|---|---|
| **Carnation genotypes** | | | | |
| PM-1 | 62,761.37 | 3,00,000.00 | 2,37,238.63 | 3.78 |
| PM-2 | 61,789.37 | 2,88,000.00 | 2,26,210.63 | 3.66 |
| PM-3 | 63,019.37 | 3,03,000.00 | 2,39,980.63 | 3.81 |
| UHFSCar-1 | 61,561.37 | 2,85,000.00 | 2,23,438.63 | 3.63 |
| UHFSCar-2 | 60,649.37 | 2,73,000.00 | 2,12,350.63 | 3.50 |
| UHFSCar-3 | 63,019.37 | 3,03,000.00 | 2,39,980.63 | 3.81 |
| UHFSCar-4 | 61,303.37 | 2,82,000.00 | 2,20,696.63 | 3.60 |
| UHFSCar-5 | 61,333.37 | 2,82,000.00 | 2,20,666.63 | 3.60 |
| UHFSCar-6 | 61,105.37 | 2,79,000.00 | 2,17,894.63 | 3.57 |
| UHFSCar-7 | 61,075.37 | 2,79,000.00 | 2,17,924.63 | 3.57 |
| UHFSCar-11 | 61,333.37 | 2,82,000.00 | 2,20,666.63 | 3.60 |
| Bizet | 64,387.37 | 3,21,000.00 | 2,56,612.63 | 3.99 |
| Tempo | 62,533.37 | 2,97,000.00 | 2,34,466.63 | 3.75 |
| Raggio-de-Sole | 64,615.37 | 3,24,000.00 | 2,59,384.63 | 4.01 |

For organic fertilization module during 2021-2022, 'Bizet' had the highest net return of Rs. 2,72,069.90 and a benefit cost ratio of 4.70. Other genotypes, such as 'Tempo', 'UHFSCar-6', 'PM-1', 'PM-3', 'UHFSCar-5' and 'Raggio-de-Sole' also exhibited good profitability with net returns ranging from approximately Rs. 2,52,515.90 to Rs. 2,63,603.90 and benefit cost ratios around 4.47 and 4.59.

**Table 4.21: Cost of cultivation of carnation and net returns on an area of 500 m$^2$ in organic fertilization module during 2021-2022 (2$^{nd}$ year)**

| **A. Input Cost** | | | |
|---|---|---|---|
| **Particulars** | **Manday(s) required (No.)** | **Rate (Rs.)** | **Total cost (Rs.)** |
| **i) Labour** | | | |
| a. Bed preparation, mixing of farm yard manure and basal dose of fertilizer and planting | - | - | - |
| b. Irrigations | 20 | 350/manday | 7,000.00 |
| c. Pinching | 2 | 350/manday | 700.00 |
| d. Weeding and hoeing | 12 | 350/manday | 4,200.00 |
| e. Drenching and Spraying | 8 | 350/manday | 2,800.00 |
| f. Disbudding and deshooting | 8 | 350/manday | 2,800.00 |
| g. Staking | 1 | 350/manday | 350.00 |
| h. Harvesting of flowers, grading, packaging and loading for transportation | 12 | 350/manday | 4,200.00 |
| **Total** | **63** | | **22,050.00** |
| **ii) Manures and fertilizers** | | | |
| a. Farm yard manure | 1875 kg | 1.50/kg | 2812.50 |
| b. Vermicompost | 375 kg | 5.00/kg | 1875.00 |
| c. Jeevamrit | 1080 litre | 2/l | 2160.00 |
| **Total** | | | **6847.50** |
| **iii) Plant protection chemicals** | | | |
| a. Agniastra (25 ml/l) | 4.46 litre | 35/l | 156.10 |
| b. Bhramastra (25 ml/l) | 4.46 litre | 25/l | 111.50 |
| **Total** | | | **267.60** |
| **iv) Staking material** | | | |
| a. Iron poles (cost for 6 months considering total life for 15 years) | 200 poles | 150/pole | 1000.00 |
| b. Nets | | | |
| • 4x4 inch size of mesh, 2 bottom rows (cost for 6 months considering total life for 5 years) | 750 m$^2$ | 16.80/ m$^2$ | 1260.00 |
| • 5x5 inch size of mesh, 2 upper rows (cost for 6 months considering total life for 5 years) | 750 m$^2$ | 15.00/ m$^2$ | 1125.00 |
| **Total** | | | **3385.00** |
| **v) Transportation and packaging cost** | | | |
| **a) Boxes required (Box size = 95 cm x 40 cm x 22 cm)** | | | |
| **Carnation genotypes** | **No.** | **Rate/Box (Rs.)** | **Total cost (Rs.)** |
| PM-1 | 63.60 | 80 | 5,088.00 |
| PM-2 | 60.60 | 80 | 4,848.00 |

| | | | |
|---|---|---|---|
| PM-3 | 64.20 | 80 | 5,136.00 |
| UHFSCar-1 | 58.20 | 80 | 4,656.00 |
| UHFSCar-2 | 55.20 | 80 | 4,416.00 |
| UHFSCar-3 | 61.20 | 80 | 4,896.00 |
| UHFSCar-4 | 56.40 | 80 | 4,512.00 |
| UHFSCar-5 | 63.00 | 80 | 5,040.00 |
| UHFSCar-6 | 62.40 | 80 | 4,992.00 |
| UHFSCar-7 | 56.40 | 80 | 4,512.00 |
| UHFSCar-11 | 59.40 | 80 | 4,752.00 |
| Bizet | 66.00 | 80 | 5,280.00 |
| Tempo | 61.80 | 80 | 4,944.00 |
| Raggio-de-Sole | 64.20 | 80 | 5,136.00 |
| **b) Cellophane paper required** | | | |
| **Carnation genotypes** | **Kilo gram** | **Rate (300 Rs/kg)** | **Total cost (Rs.)** |
| PM-1 | 1.5 | 300 | 450.00 |
| PM-2 | 1.5 | 300 | 450.00 |
| PM-3 | 1.5 | 300 | 450.00 |
| UHFSCar-1 | 1.4 | 300 | 420.00 |
| UHFSCar-2 | 1.2 | 300 | 360.00 |
| UHFSCar-3 | 1.4 | 300 | 420.00 |
| UHFSCar-4 | 1.1 | 300 | 330.00 |
| UHFSCar-5 | 1.5 | 300 | 450.00 |
| UHFSCar-6 | 1.5 | 300 | 450.00 |
| UHFSCar-7 | 1.1 | 300 | 330.00 |
| UHFSCar-11 | 1.4 | 300 | 420.00 |
| Bizet | 1.0 | 300 | 300.00 |
| Tempo | 1.5 | 300 | 450.00 |
| Raggio-de-Sole | 1.5 | 300 | 450.00 |
| **c) Vehicle charges up to Delhi flower market** | | | |
| **Carnation genotypes** | | | |
| PM-1 | 63.60 | 300 | 19,080.00 |
| PM-2 | 60.60 | 300 | 18,180.00 |
| PM-3 | 64.20 | 300 | 19,260.00 |
| UHFSCar-1 | 58.20 | 300 | 17,460.00 |
| UHFSCar-2 | 55.20 | 300 | 16,560.00 |
| UHFSCar-3 | 61.20 | 300 | 18,360.00 |
| UHFSCar-4 | 56.40 | 300 | 16,920.00 |
| UHFSCar-5 | 63.00 | 300 | 18,900.00 |
| UHFSCar-6 | 62.40 | 300 | 18,720.00 |
| UHFSCar-7 | 56.40 | 300 | 16,920.00 |
| UHFSCar-11 | 59.40 | 300 | 17,820.00 |
| Bizet | 66.00 | 300 | 19,800.00 |
| Tempo | 61.80 | 300 | 18,540.00 |
| Raggio-de-Sole | 64.20 | 300 | 19,260.00 |
| **B. Returns** | | | |
| **Carnation genotypes** | **Yield (no. of cut flowers)** | **Market price of cut stem during the flowering time (Rs.)** | **Gross returns (Rs.)** |
| PM-1 | 63600 | 5 | 3,18,000.00 |
| PM-2 | 60600 | 5 | 3,03,000.00 |
| PM-3 | 64200 | 5 | 3,21,000.00 |
| UHFSCar-1 | 58200 | 5 | 2,91,000.00 |
| UHFSCar-2 | 55200 | 5 | 2,76,000.00 |

| | | | |
|---|---|---|---|
| UHFSCar-3 | 61200 | 5 | 3,06,000.00 |
| UHFSCar-4 | 56400 | 5 | 2,82,000.00 |
| UHFSCar-5 | 63000 | 5 | 3,15,000.00 |
| UHFSCar-6 | 62400 | 5 | 3,12,000.00 |
| UHFSCar-7 | 56400 | 5 | 2,82,000.00 |
| UHFSCar-11 | 59400 | 5 | 2,97,000.00 |
| Bizet | 66000 | 5 | 3,30,000.00 |
| Tempo | 61800 | 5 | 3,09,000.00 |
| Raggio-de-Sole | 64200 | 5 | 3,21,000.00 |

**C. Gross Returns (Rs.)**

| **Input cost (A)(i)+(ii)+(iii)+(iv)+(v) (a+b+c)** | | **Gross return (Rs.)** | **Net return (Rs.)** | **Benefit cost ratio** |
|---|---|---|---|---|
| **Carnation genotypes** | | | | |
| PM-1 | 57,168.10 | 3,18,000.00 | 2,60,831.90 | 4.56 |
| PM-2 | 56,028.10 | 3,03,000.00 | 2,46,971.90 | 4.41 |
| PM-3 | 57,396.10 | 3,21,000.00 | 2,63,603.90 | 4.59 |
| UHFSCar-1 | 55,086.10 | 2,91,000.00 | 2,35,913.90 | 4.28 |
| UHFSCar-2 | 53,886.10 | 2,76,000.00 | 2,22,113.90 | 4.12 |
| UHFSCar-3 | 56,226.10 | 3,06,000.00 | 2,49,773.90 | 4.44 |
| UHFSCar-4 | 54,312.10 | 2,82,000.00 | 2,27,687.90 | 4.19 |
| UHFSCar-5 | 56,940.10 | 3,15,000.00 | 2,58,059.90 | 4.53 |
| UHFSCar-6 | 56,712.10 | 3,12,000.00 | 2,55,287.90 | 4.50 |
| UHFSCar-7 | 54,312.10 | 2,82,000.00 | 2,27,687.90 | 4.19 |
| UHFSCar-11 | 55,542.10 | 2,97,000.00 | 2,41,457.90 | 4.35 |
| Bizet | 57,930.10 | 3,30,000.00 | 2,72,069.90 | 4.70 |
| Tempo | 56,484.10 | 3,09,000.00 | 2,52,515.90 | 4.47 |
| Raggio-de-Sole | 57,396.10 | 3,21,000.00 | 2,63,603.90 | 4.59 |

The profitability of various carnation genotypes for the cultivation of two years, 2020-2022 in inorganic fertilization module assessed based on their input cost, gross return, net return and benefit cost ratio showed that the genotypes ‘Bizet’ and ‘Raggio-de-Sole’ demonstrated the highest profitability among the carnation genotypes. They had the highest net returns and benefit cost ratios, indicating strong financial performance. Both the genotypes had a net return of Rs. 3,57,189.64 and a benefit cost ratio of 2.02. Other genotypes, such as ‘UHFSCar-5’, ‘PM-3’, ‘UHFSCar-3’ and ‘Tempo’ also exhibited good profitability with net returns ranging from approximately Rs. 3,10,215.64 to Rs 3,29,529.64 and benefit cost ratios around 1.80 and 1.89.

**Table 4.22: Cost of cultivation of carnation and net returns on an area of 500 m$^2$ in inorganic fertilization module during 2020-2022 (2 years)**

| **A. Input Cost** | | | |
|---|---|---|---|
| **Particulars** | **Manday(s) required (No.)** | **Rate (Rs.)** | **Total cost (Rs.)** |
| **i) Labour** | | | |
| a. Bed preparation, mixing of farm yard manure and basal dose of fertilizer and | 5 | 350/manday | 1,750.00 |

| | | | |
|---|---|---|---|
| planting | | | |
| c. Irrigations | 40 | 350/manday | 14,000.00 |
| d. Pinching | 4 | 350/manday | 1,400.00 |
| e. Weeding and hoeing | 24 | 350/manday | 8,400.00 |
| f. Fertigation/ Drenching and Spraying | 40 | 350/manday | 14,000.00 |
| g. Disbudding and deshooting | 16 | 350/manday | 5,600.00 |
| h. Staking | 3 | 350/manday | 1,050.00 |
| i. Harvesting of flowers, grading, packaging and loading for transportation | 24 | 350/manday | 8,400.00 |
| **Total** | **156** | | **54,600.00** |
| **ii) Planting material** | **Quantity required (No.)** | **Rate (Rs.)** | **Total cost (Rs.)** |
| Rooted cuttings considering total planting area as 375 $m^2$ and planting density of 24 plants/ $m^2$ | 24 x 375 = 9000 | 6/ plant | **54000.00** |
| **iii) Manures and fertilizers** | | | |
| a. Farm yard manure | 3750 kg | 1.50/kg | 5625.00 |
| b. Vermicompost | 750 kg | 5.00/kg | 3750.00 |
| c. Urea | 24.3 kg | 320/50 kg | 155.52 |
| d. Single Super Phosphate (SSP) | 23.44 kg | 300/50 kg | 140.64 |
| e. Muriate of Potash (MOP) | 6.23 kg | 800/50 kg | 99.68 |
| f. Multi-K | 57.76 kg | 4750/50 kg | 5487.20 |
| g. Calcium nitrate | 23.96 kg | 1300/25 kg | 1245.92 |
| **Total** | | | **16503.96** |
| **iv) Plant protection chemicals** | | | |
| a. Insecticides | | | |
| Cypermethrin (1ml/l) | 90 x 4 = 360 ml | 450/litre | 162.00 |
| Imidachloprid (0.5 ml/l) | 45 x 4 = 180 ml | 1500/litre | 270.00 |
| Simba (1 ml/l) | 90 x 4 = 360 ml | 890/litre | 320.40 |
| **Total** | | | **752.40** |
| b. Fungicides | | | |
| Dithane M-45 (2g/l, drenched thrice) | 3 kg | 360/kg | 1080.00 |
| Bavistin (1g/l, drenched thrice) | 1.5 kg | 1180/kg | 1770.00 |
| **Total** | | | **2850.00** |
| **v) Staking material** | | | |
| a. Iron poles (cost for 1 year considering total life for 15 years) | 200 poles | 150/pole | 2000.00 |
| b. Nets | | | |
| • 4x4 inch size of mesh, 2 bottom rows (cost for 1 year considering total life for 5 years) | 750 $m^2$ | 16.80/ $m^2$ | 2520.00 |
| • 5x5 inch size of mesh, 2 upper rows (cost for 1 year considering total life for 5 years) | 750 $m^2$ | 15.00/ $m^2$ | 2250.00 |
| **Total** | | | **6770.00** |
| **vi) Transportation and packaging cost** | | | |
| **a) Boxes required (Box size = 95 cm x 40 cm x 22 cm)** | | | |
| **Carnation genotypes** | **No.** | **Rate/Box (Rs.)** | **Total cost (Rs.)** |
| PM-1 | 96.60 | 80 | 7,728.00 |
| PM-2 | 95.40 | 80 | 7,632.00 |
| PM-3 | 97.20 | 80 | 7,776.00 |
| UHFSCar-1 | 95.01 | 80 | 7,600.80 |
| UHFSCar-2 | 93.60 | 80 | 7,488.00 |

| | | | |
|---|---|---|---|
| UHFSCar-3 | 97.20 | 80 | 7,776.00 |
| UHFSCar-4 | 94.20 | 80 | 7,536.00 |
| UHFSCar-5 | 96.60 | 80 | 7,728.00 |
| UHFSCar-6 | 92.40 | 80 | 7,392.00 |
| UHFSCar-7 | 91.80 | 80 | 7,344.00 |
| UHFSCar-11 | 92.40 | 80 | 7,392.00 |
| Bizet | 106.80 | 80 | 8,544.00 |
| Tempo | 100.80 | 80 | 8,064.00 |
| Raggio-de-Sole | 106.80 | 80 | 8,544.00 |
| **b) Cellophane paper required** | | | |
| **Carnation genotypes** | **Kilo gram** | **Rate (300 Rs/kg)** | **Total cost (Rs.)** |
| PM-1 | 2.20 | 300 | 660.00 |
| PM-2 | 2.10 | 300 | 630.00 |
| PM-3 | 2.30 | 300 | 690.00 |
| UHFSCar-1 | 2.00 | 300 | 600.00 |
| UHFSCar-2 | 2.00 | 300 | 600.00 |
| UHFSCar-3 | 2.30 | 300 | 690.00 |
| UHFSCar-4 | 1.90 | 300 | 570.00 |
| UHFSCar-5 | 2.00 | 300 | 600.00 |
| UHFSCar-6 | 2.00 | 300 | 600.00 |
| UHFSCar-7 | 1.90 | 300 | 570.00 |
| UHFSCar-11 | 2.00 | 300 | 600.00 |
| Bizet | 2.50 | 300 | 750.00 |
| Tempo | 2.30 | 300 | 690.00 |
| Raggio-de-Sole | 2.50 | 300 | 750.00 |
| **c) Vehicle charges up to Delhi flower market** | | | |
| **Carnation genotypes** | | | |
| PM-1 | 96.60 | 300 | 28,980.00 |
| PM-2 | 95.40 | 300 | 28,620.00 |
| PM-3 | 97.20 | 300 | 29,160.00 |
| UHFSCar-1 | 95.01 | 300 | 28,503.00 |
| UHFSCar-2 | 93.60 | 300 | 28,080.00 |
| UHFSCar-3 | 97.20 | 300 | 29,160.00 |
| UHFSCar-4 | 94.20 | 300 | 28,260.00 |
| UHFSCar-5 | 96.60 | 300 | 28,980.00 |
| UHFSCar-6 | 92.40 | 300 | 27,720.00 |
| UHFSCar-7 | 91.80 | 300 | 27,540.00 |
| UHFSCar-11 | 92.40 | 300 | 27,720.00 |
| Bizet | 106.80 | 300 | 32,040.00 |
| Tempo | 100.80 | 300 | 30,240.00 |
| Raggio-de-Sole | 106.80 | 300 | 32,040.00 |

**B. Returns**

| Carnation genotypes | Yield (no. of cut flowers) | Market price of cut stem during the flowering time (Rs.) | Gross returns (Rs.) |
|---|---|---|---|
| PM-1 | 96600 | 5 | 4,83,000.00 |
| PM-2 | 95400 | 5 | 4,77,000.00 |
| PM-3 | 97200 | 5 | 4,86,000.00 |
| UHFSCar-1 | 95010 | 5 | 4,75,050.00 |
| UHFSCar-2 | 93600 | 5 | 4,68,000.00 |
| UHFSCar-3 | 97200 | 5 | 4,86,000.00 |

| | | | |
|---|---|---|---|
| UHFSCar-4 | 94200 | 5 | 4,71,000.00 |
| UHFSCar-5 | 96600 | 5 | 4,83,000.00 |
| UHFSCar-6 | 92400 | 5 | 4,62,000.00 |
| UHFSCar-7 | 91800 | 5 | 4,59,000.00 |
| UHFSCar-11 | 92400 | 5 | 4,62,000.00 |
| Bizet | 106800 | 5 | 5,34,000.00 |
| Tempo | 100800 | 5 | 5,04,000.00 |
| Raggio-de-Sole | 106800 | 5 | 5,34,000.00 |

**C. Gross Returns (Rs.)**

| Carnation genotypes | Input cost (A)(i)+(ii)+(iii)+(iv)+(v)+(vi)(a+b+c) | Gross return (Rs.) | Net return (Rs.) | Benefit cost ratio |
|---|---|---|---|---|
| PM-1 | 1,72,844.36 | 4,83,000.00 | 3,10,155.64 | 1.79 |
| PM-2 | 1,72,358.36 | 4,77,000.00 | 3,04,641.64 | 1.77 |
| PM-3 | 1,73,102.36 | 4,86,000.00 | 3,12,897.64 | 1.81 |
| UHFSCar-1 | 1,72,180.16 | 4,75,050.00 | 3,02,869.84 | 1.76 |
| UHFSCar-2 | 1,71,644.36 | 4,68,000.00 | 2,96,355.64 | 1.73 |
| UHFSCar-3 | 1,73,102.36 | 4,86,000.00 | 3,12,897.64 | 1.81 |
| UHFSCar-4 | 1,71,842.36 | 4,71,000.00 | 2,99,157.64 | 1.74 |
| UHFSCar-5 | 1,72,784.36 | 4,83,000.00 | 3,10,215.64 | 1.80 |
| UHFSCar-6 | 1,71,188.36 | 4,62,000.00 | 2,90,811.64 | 1.70 |
| UHFSCar-7 | 1,70,930.36 | 4,59,000.00 | 2,88,069.64 | 1.69 |
| UHFSCar-11 | 1,71,188.36 | 4,62,000.00 | 2,90,811.64 | 1.70 |
| Bizet | 1,76,810.36 | 5,34,000.00 | 3,57,189.64 | 2.02 |
| Tempo | 1,74,470.36 | 5,04,000.00 | 3,29,529.64 | 1.89 |
| Raggio-de-Sole | 1,76,810.36 | 5,34,000.00 | 3,57,189.64 | 2.02 |

During the two-year period from 2020 to 2022, the cost of cultivation in the organic fertilization module revealed that the genotypes ‘Bizet’ and ‘Raggio-de-Sole’ consistently displayed the highest net returns and benefit cost ratios. These genotypes exhibited superior profitability compared to other variants, with net returns ranging from approximately Rs. 3,88,597.80 to Rs. 3,71,815.80 and benefit cost ratios ranging from 2.38 to 2.29. This indicates their strong financial performance in cultivation. Additionally, genotypes such as ‘PM-3’, ‘UHFSCar-5’ and ‘Tempo’ also demonstrated relatively high net returns and benefit cost ratios, suggesting favorable profitability. These genotypes showcased net returns ranging from approximately Rs. 3,52,411.80 to Rs. 3,55,183.80 and benefit cost ratios ranging from 2.19 to 2.21.

**Table 4.23: Cost of cultivation of carnation and net returns on an area of 500 m$^2$ in organic fertilization module during 2020-2022 (2 years)**

**A. Input Cost**

| Particulars | Manday(s) required (No.) | Rate (Rs.) | Total cost (Rs.) |
|---|---|---|---|
| **i) Labour** | | | |
| a. Bed preparation, mixing of farm yard manure and basal dose of fertilizer and | 4 | 350/manday | 1,400.00 |

| | | | |
|---|---|---|---|
| planting and planting | | | |
| b. Irrigations | 40 | 350/manday | 14,000.00 |
| c. Pinching | 4 | 350/manday | 1,400.00 |
| d. Weeding and hoeing | 24 | 350/manday | 8,400.00 |
| e. Drenching and Spraying | 16 | 350/manday | 5,600.00 |
| f. Disbudding and deshooting | 16 | 350/manday | 5,600.00 |
| g. Staking | 3 | 350/manday | 1,050.00 |
| h. Harvesting of flowers, grading, packaging and loading for transportation | 24 | 350/manday | 8,400.00 |
| **Total** | **131** | | **45,850.00** |
| **ii) Planting material** | **Quantity required (No.)** | **Rate (Rs.)** | **Total cost (Rs.)** |
| Rooted cuttings considering total planting area as 375 $m^2$ and planting density of 24 plants/ $m^2$ | 24 x 375 = 9000 | 6/ plant | **54000.00** |
| **iii) Manures and fertilizers** | | | |
| a. Farm yard manure | 3750 kg | 1.50/kg | 5625.00 |
| b. Vermicompost | 750kg | 5.00/kg | 3750.00 |
| c. Jeevamrit | 2160 litre | 2/l | 4320.00 |
| **Total** | | | **13695.00** |
| **iv) Plant protection chemicals** | | | |
| a. Agniastra (25 ml/l) | 8.92 litre | 35/l | 312.20 |
| b. Bhramastra (25 ml/l) | 8.92 litre | 25/l | 223.00 |
| **Total** | | | **535.20** |
| **v) Staking material** | | | |
| a. Iron poles (cost for 1 year considering total life for 15 years) | 200 poles | 150/pole | 2000.00 |
| b. Nets | | | |
| • 4x4 inch size of mesh, 2 bottom rows (cost for 1 year considering total life for 5 years) | 750 $m^2$ | 16.80/ $m^2$ | 2520.00 |
| • 5x5 inch size of mesh, 2 upper rows (cost for 1 year considering total life for 5 years) | 750 $m^2$ | 15.00/ $m^2$ | 2250.00 |
| **Total** | | | **6770.00** |
| **vi) Transportation and packaging cost** | | | |
| **a) Boxes required (Box size = 95 cm x 40 cm x 22 cm)** | | | |
| **Carnation genotypes** | **No.** | **Rate/Box (Rs.)** | **Total cost (Rs.)** |
| PM-1 | 100.80 | 80 | 8,064.00 |
| PM-2 | 99.00 | 80 | 7,920.00 |
| PM-3 | 102.60 | 80 | 8,208.00 |
| UHFSCar-1 | 96.60 | 80 | 7,728.00 |
| UHFSCar-2 | 93.00 | 80 | 7,440.00 |
| UHFSCar-3 | 97.80 | 80 | 7,824.00 |
| UHFSCar-4 | 95.40 | 80 | 7,632.00 |
| UHFSCar-5 | 102.60 | 80 | 8,208.00 |
| UHFSCar-6 | 100.20 | 80 | 8,016.00 |
| UHFSCar-7 | 93.00 | 80 | 7,440.00 |
| UHFSCar-11 | 97.20 | 80 | 7,776.00 |
| Bizet | 110.40 | 80 | 8,832.00 |
| Tempo | 103.20 | 80 | 8,256.00 |
| Raggio-de-Sole | 106.80 | 80 | 8,544.00 |

| b) Cellophane paper required | | | |
|---|---|---|---|
| **Carnation genotypes** | **Kilo gram** | **Rate (300 Rs/kg)** | **Total cost (Rs.)** |
| PM-1 | 2.30 | 300 | 690.00 |
| PM-2 | 2.50 | 300 | 750.00 |
| PM-3 | 2.50 | 300 | 750.00 |
| UHFSCar-1 | 2.20 | 300 | 660.00 |
| UHFSCar-2 | 2.00 | 300 | 600.00 |
| UHFSCar-3 | 2.20 | 300 | 660.00 |
| UHFSCar-4 | 1.90 | 300 | 570.00 |
| UHFSCar-5 | 2.30 | 300 | 690.00 |
| UHFSCar-6 | 2.30 | 300 | 690.00 |
| UHFSCar-7 | 1.90 | 300 | 570.00 |
| UHFSCar-11 | 2.20 | 300 | 660.00 |
| Bizet | 2.00 | 300 | 600.00 |
| Tempo | 2.50 | 300 | 750.00 |
| Raggio-de-Sole | 2.50 | 300 | 750.00 |
| **c) Vehicle charges up to Delhi flower market** | | | |
| **Carnation genotypes** | | | |
| PM-1 | 100.80 | 300 | 30,240.00 |
| PM-2 | 99.00 | 300 | 29,700.00 |
| PM-3 | 102.60 | 300 | 30,780.00 |
| UHFSCar-1 | 96.60 | 300 | 28,980.00 |
| UHFSCar-2 | 93.00 | 300 | 27,900.00 |
| UHFSCar-3 | 97.80 | 300 | 29,340.00 |
| UHFSCar-4 | 95.40 | 300 | 28,620.00 |
| UHFSCar-5 | 102.60 | 300 | 30,780.00 |
| UHFSCar-6 | 100.20 | 300 | 30,060.00 |
| UHFSCar-7 | 93.00 | 300 | 27,900.00 |
| UHFSCar-11 | 97.20 | 300 | 29,160.00 |
| Bizet | 110.40 | 300 | 33,120.00 |
| Tempo | 103.20 | 300 | 30,960.00 |
| Raggio-de-Sole | 106.80 | 300 | 32,040.00 |

**B. Returns**

| Carnation genotypes | Yield (no. of cut flowers) | Market price of cut stem during the flowering time (Rs.) | Gross returns (Rs.) |
|---|---|---|---|
| PM-1 | 100800 | 5 | 5,04,000.00 |
| PM-2 | 99000 | 5 | 4,95,000.00 |
| PM-3 | 102600 | 5 | 5,13,000.00 |
| UHFSCar-1 | 96600 | 5 | 4,83,000.00 |
| UHFSCar-2 | 93000 | 5 | 4,65,000.00 |
| UHFSCar-3 | 97800 | 5 | 4,89,000.00 |
| UHFSCar-4 | 95400 | 5 | 4,77,000.00 |
| UHFSCar-5 | 102600 | 5 | 5,13,000.00 |
| UHFSCar-6 | 100200 | 5 | 5,01,000.00 |
| UHFSCar-7 | 93000 | 5 | 4,65,000.00 |
| UHFSCar-11 | 97200 | 5 | 4,86,000.00 |
| Bizet | 110400 | 5 | 5,52,000.00 |
| Tempo | 103200 | 5 | 5,16,000.00 |
| Raggio-de-Sole | 106800 | 5 | 5,34,000.00 |

| C. Gross Returns (Rs.) | | | | |
|---|---|---|---|---|
| **Input cost (A)(i)+(ii)+(iii)+(iv)+(v)+(vi)(a+b+c)** | | **Gross return (Rs.)** | **Net return (Rs.)** | **Benefit cost ratio** |
| **Carnation genotypes** | | | | |
| PM-1 | 1,59,844.20 | 5,04,000.00 | 3,44,155.80 | 2.15 |
| PM-2 | 1,59,220.20 | 4,95,000.00 | 3,35,779.80 | 2.11 |
| PM-3 | 1,60,588.20 | 5,13,000.00 | 3,52,411.80 | 2.19 |
| UHFSCar-1 | 1,58,218.20 | 4,83,000.00 | 3,24,781.80 | 2.05 |
| UHFSCar-2 | 1,56,790.20 | 4,65,000.00 | 3,08,209.80 | 1.97 |
| UHFSCar-3 | 1,58,674.20 | 4,89,000.00 | 3,30,325.80 | 2.08 |
| UHFSCar-4 | 1,57,672.20 | 4,77,000.00 | 3,19,327.80 | 2.03 |
| UHFSCar-5 | 1,60,528.20 | 5,13,000.00 | 3,52,471.80 | 2.20 |
| UHFSCar-6 | 1,59,616.20 | 5,01,000.00 | 3,41,383.80 | 2.14 |
| UHFSCar-7 | 1,56,760.20 | 4,65,000.00 | 3,08,239.80 | 1.97 |
| UHFSCar-11 | 1,58,446.20 | 4,86,000.00 | 3,27,553.80 | 2.07 |
| Bizet | 1,63,402.20 | 5,52,000.00 | 3,88,597.80 | 2.38 |
| Tempo | 1,60,816.20 | 5,16,000.00 | 3,55,183.80 | 2.21 |
| Raggio-de-Sole | 1,62,184.20 | 5,34,000.00 | 3,71,815.80 | 2.29 |

# *Chapter-5*

# SUMMARY AND CONCLUSION

The present investigation on **"Evaluation of different genotypes of carnation (*Dianthus caryophyllus* L.) in response to organic and inorganic fertilization modules"** was carried out using 14 diverse genotypes of carnation to study the behaviour of different carnation genotypes for growth and flowering parameters using inorganic fertilization module following the recommended dose of fertilizers and organic fertilization module using jeevamrit and characterization and evaluation of these genotypes for horticultural traits to exploit in carnation improvement programme. The experiment was laid out at the experimental farm of the Department of Floriculture and Landscape Architecture of Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P.) during 2020-2022. The observation recorded on various growth and flowering parameters were subjected to analysis of variance (ANOVA) using Randomized Block Design (Factorial) with three replications.

**The results obtained from the present investigations have been summarized below:**

**1. Plant height (cm)**

During 2020-2021, 2021-2022 and pooled data of both the years, maximum plant height was shown by genotype 'Bizet' (96.38 cm, 102.90 cm and 99.64 cm, respectively). During 2021-2022, organic fertilization module (88.91 cm) recorded higher plant height over inorganic fertilization module (86.05 cm). In general, plant height during 2021-2022 (87.48 cm) was greater than during 2020-2021 (82.81 cm).

**2. Stem length (cm)**

During 2020-2021, maximum stem length among the genotypes was obtained in genotype 'PM-3' (81.90 cm) which was statistically at par with genotype 'Bizet' (81.40 cm) while during 2021-2022, maximum stem length among the genotypes was recorded in genotype 'Bizet' (88.50 cm) which was found to be at par with genotype 'PM-3' (86.33 cm) and organic fertilization module (77.94 cm) recorded greater stem length as compared to inorganic fertilization module (74.14 cm). The two years pooled data revealed that maximum stem length was recorded in genotype 'Bizet' (84.95 cm) which was statistically at par with genotype ‘PM-3’ (84.12 cm). In general, stem length during 2021-2022 (76.04 cm) was greater than during 2020-2021 (71.67 cm). As the stem length of all the genotypes were found to be above 55 cm, all the genotypes under study fall under ‘A’ grade.

### 3. Stem thickness (mm)

During 20220-2021, maximum stem thickness was obtained in genotypes ‘UHFSCar-1’ (5.95 mm) which was found to be statistically at par with genotypes ‘PM-1’ (5.55 mm), ‘UHFSCar-2’ (5.83 mm), ‘UHFSCar-3’ (5.77 mm), ‘UHFSCar-4’ (5.73 mm), ‘UHFSCar-5’ (5.89 mm), ‘UHFSCar-6’ (5.67 mm), ‘UHFSCar-7’ (5.78 mm), ‘Bizet’ (5.91 mm), ‘Tempo’ (5.77 mm) and ‘Raggio-de-Sole’ (5.71 mm). During 2021-2022 and pooled analysis of both the years, maximum stem thickness was recorded in the genotype ‘Bizet’ (5.91 mm) and between the fertilization modules, organic fertilization module (5.74 mm and 5.75 mm).

### 4. Strength of flower stem/sturdiness of stem (degree)

Stem strength was noted by measuring the level of sturdiness. To work out the sturdiness, angle of deviation of flower head below the horizontal plane with the natural curvature of the stem was recorded. Based upon the angle of deviation, stems were graded as falling under ‘A’, ‘B’ and ‘C’ grade stems. Lower the angle of deviation, sturdier is the stem and likewise ‘A’,‘B’and ‘C’ grades. All the cultivars fall under ‘A’ grade.

### 5. Number of days taken for bud formation

During 2020-2021, 2021-2022 and pooled data of both the years, genotype ‘PM-2’ (113.83 days, 113.83 days and 123.33 days, respectively) took minimum days for bud formation. Between the fertilization modules, organic fertilization module (135.45 days, 162.83 days and 137.74 days, respectively) took lesser number of days for bud formation as compared to inorganic fertilization module.

### 6. Bud width (mm)

During 2020-2021, 2021-2022 and the pooled data, maximum bud width was shown by genotype ‘Bizet’ (20.82 mm, 22.32 mm and 21.57 mm, respectively). The organic fertilization module (19.61 mm) attained greater bud width in both 2020-2021 and pooled data.

### 7. Flower size (cm)

During 2020-2021, 2021-2022 and the pooled data of two years, the genotype 'Raggio-de-Sole' (6.26 cm, 6.49 cm and 6.37 cm, respectively) recorded maximum flower size. Between the fertilization modules during 2021-2022, organic fertilization module (6.10 cm) recorded greater flower size in contrast to inorganic fertilization module (5.90 cm). In general, the flower size during 2021-2022 (6.00 cm) was greater than during 2020-2021 (5.80 cm).

### 8. Number of petals per flower

During 2020-2021, 20221-2022 and the pooled data of both the years, genotype 'Raggio-de-Sole' (77.77, 104.27 and 91.02, respectively) recorded maximum number of petals per flower.

### 9. Number of flowers per plant

During 2020-2021, 2021-2022 and the pooled data of both the years, genotype 'Bizet' (4.83, 7.23 and 6.03, respectively) recorded maximum number of flowers per plant. Between the fertilization modules during 2021-2022 and pooled data, organic fertilization module (6.77 and 5.55, respectively) recorded greater number of flowers per plant over inorganic fertilization module (6.51 and 5.38, respectively). In general, number of flowers per plant during 2021-2022 (6.64) was greater over during 2020-2021 (4.30).

### 10. Number of flowers per square metre

Number of flowers per square metre was maximum in genotype 'Bizet' (116.00, 173.60 and 144.80, respectively) during 2020-2021, 2021-2022 and the two years pooled data. Organic fertilization module (162.40 and 133.20, respectively) during 2021-2022 and the two years pooled data. In general, number of flowers per square metre during 2021-2022 (159.26) was greater over during 2020-2021 (103.17).

### 11. Number of days taken for harvesting of cut stem

During 2020-2021, 2021-2022 and both the years, genotype 'PM-2' (146.67 days, 166.17 days and 156.42 days, respectively) recorded minimum day taken for harvesting of cut stem. The organic fertilization module (163.07 days, 195.73 days and 179.43 days, respectively) took lesser days for harvesting of cut stem. In general, days taken for harvesting of cut stem were lesser during 2020-2021 (166.31 days) over during 2021-2022 (199.10 days).

### 12. Duration of flowering (days)

During 2020-2021, genotype 'PM-1' (83.83 days) recorded maximum duration of flowering which was found to be at par with genotypes 'PM-3' (79.00 days), 'UHFSCar-5' (79.33 days) and 'Bizet' (80.67 days). During 2021-2022, maximum duration of flowering was observed in genotype 'PM-2' (77.67 days) which was at par with genotypes 'PM-1' (71.67 days), 'PM-3' (71.50 days), 'UHFSCar-2' (68.50 days), 'Bizet' (75.33 days) and 'Tempo' (71.67 days). Pooled data of two years showed that genotype 'Bizet' (78.00 days) recorded maximum duration of flowering which was statistically at par with genotypes 'PM-1' (77.75 days), 'PM-2' (74.50 days), 'PM-3' (75.25 days) and 'Tempo' (71.75 days). During 2020-2021, 2021-2022 and both the years, organic fertilization module (75.38 days, 69.02 days and 72.20 days, respectively) recorded longer duration of flowering. In general, duration of flowering was more during 2020-2021 (72.76 days) over during 2021-2022 (65.90 days).

### 13. Vase life (Days)

During 2020-2021, genotype 'Tempo' (9.00 days) recorded maximum days of vase life which was statistically at par with genotypes 'UHFSCar-5' (8.63 days), 'UHFSCar-6' (8.30 days) and 'Bizet' (8.50 days). During 2021-2022, maximum vase life was attained by genotype 'Bizet' (7.70 days) which was found to be at par with genotypes 'PM-1' (6.93 days), 'PM-3' (6.90 days), 'UHFSCar-1' (7.13 days), 'UHFSCar-3' (7.03 days) and 'UHFSCar-5' (7.30 days). The two years pooled data of vase life revealed that maximum vase life was recorded in genotype 'Bizet' (8.10 days) which was statistically at par with genotypes 'UHFSCar-1' (7.62 days), 'UHFSCar-5' (7.97 days) and 'Tempo' (7.72 days) whereas it was recorded minimum in genotype 'Raggio-de-Sole' (5.87 days). In general, during 2020-2021 (7.81 days) the vase life was recorded longer over during 2021-2022 (6.74 days).

### 14. Cost of cultivation

During the two-year period from 2020-2022, inorganic fertilization module assessed based showed that the genotypes 'Bizet' and 'Raggio-de-Sole' demonstrated the highest profitability among the carnation genotypes with net return of Rs. 3,57,189.64 and benefit cost ratio of 2.02. Other genotypes, such as 'UHFSCar-5', 'PM-3', 'UHFSCar-3' and 'Tempo' also exhibited good profitability with net returns ranging from approximately Rs. 3,10,215.64 to Rs 3,29,529.64 and benefit cost ratios around 1.80 and 1.89. The cost of cultivation in the organic fertilization module revealed that the genotypes 'Bizet' and 'Raggio-de-Sole' consistently displayed the highest net returns and benefit cost ratios of Rs. 3,88,597.80 to Rs. 3,71,815.80 and benefit cost ratios ranging from 2.38 to 2.29. Genotypes such as 'PM-3', 'UHFSCar-5' and 'Tempo' also demonstrated relatively high net returns and benefit cost ratios, suggesting favorable profitability. These genotypes showcased net returns ranging from approximately Rs. 3,52,411.80 to Rs. 3,55,183.80 and benefit cost ratios ranging from 2.19 to 2.21.

**CONCLUSION:**

- Carnations performed well in both the fertilization modules however, the organic fertilization module performed better in multiple characteristics, including stem thickness, number of days taken for bud formation, bud width, number of flowers per plant and per square metre, number of days taken for harvesting of cut stem, duration of flowering and profitability. The organic fertilization module increased the bacterial count at $10^7$ dilution from the initial value of 97.67 cfu $g^{-1}$ to 122.33 cfu $g^{-1}$. The actinomycetes count at $10^2$ dilution also increased from the initial value of 37.67 cfu $g^{-1}$ to 57.67 cfu $g^{-1}$. The initial fungal count at $10^2$ dilution was 26.33 cfu $g^{-1}$ which increased to 28.33 cfu $g^{-1}$. This suggests that organic fertilization module (Jeevamrit @ 20 ml/plant as drenching at 30 days interval) can act as an alternative for chemical fertilizers in consideration to the low input cost along with improving soil health and have the potential to contribute to better financial outcomes.
- Among the different genotypes tested, 'Bizet' performed the best under organic fertilization module with highest b:c ratio of 2.38. However, under inorganic fertilization module, 'Bizet' and 'Raggio-de-Sole' (b:c ratio of 2.02) performed better over the rest of the genotypes.

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## APPENDIX- I

**Mean monthly meteorological data of Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) for the year 2020-22 (*w.e.f.* December, 2020 to September, 2022)**

| Months | Temperature (°C) | | | Relative Humidity (%) (Mean) | Rainfall (mm) |
|---|---|---|---|---|---|
| | Maximum | Minimum | Mean | | |
| **December, 2020** | 21.90 | 2.50 | 12.20 | 55 | 23.80 |
| **January, 2021** | 20.50 | 2.34 | 11.42 | 58 | 21.30 |
| **February, 2021** | 23.00 | 4.80 | 13.90 | 62 | 59.70 |
| **March, 2021** | 27.30 | 9.00 | 18.15 | 43 | 14.80 |
| **April, 2021** | 25.40 | 10.80 | 20.10 | 55 | 65.90 |
| **May, 2021** | 29.40 | 14.30 | 21.85 | 59 | 148.90 |
| **June, 2021** | 30.40 | 17.90 | 24.15 | 63 | 99.50 |
| **July, 2021** | 29.50 | 20.30 | 24.9 | 75 | 265.80 |
| **August, 2021** | 29.40 | 19.80 | 24.6 | 78 | 93.90 |
| **September, 2021** | 28.20 | 18.90 | 23.55 | 79 | 218.30 |
| **October, 2021** | 27.10 | 11.80 | 19.45 | 66 | 52.60 |
| **November, 2021** | 23.90 | 4.80 | 14.35 | 54 | - |
| **December, 2021** | 18.60 | 2.30 | 10.45 | 64 | 14.30 |
| **January, 2022** | 16.10 | 3.20 | 9.65 | 58 | 26.10 |
| **February, 2022** | 18.80 | 2.70 | 10.75 | 55 | 82.70 |
| **March, 2022** | 27.60 | 9.40 | 18.50 | 44 | - |
| **April, 2022** | 33.20 | 13.3 | 23.25 | 37 | 1.00 |
| **May, 2022** | 32.00 | 16.10 | 24.05 | 52 | 84.80 |
| **June, 2022** | 32.10 | 17.70 | 24.90 | 49 | 85.60 |
| **July, 2022** | 28.50 | 20.50 | 24.50 | 81 | 195.40 |
| **August, 2022** | 29.00 | 19.90 | 24.45 | 78 | 219.50 |
| **September, 2022** | 27.80 | 17.80 | 22.80 | 77 | 233.50 |

**Source**: Meteorological Observatory, Department of Environmental Science, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (HP) 173230

# APPENDIX- II

**ANOVA for various growth and flowering parameters of carnation genotypes in response to fertilization modules for 2020-2021**

| Source of variation | df | Mean Sum of Squares | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Plant height | Stem length | Stem thickness | Stem sturdiness | Bud width | Bud length | Days taken for bud formation |
| Replications | 2 | 0.21 | 15.93 | 0.08 | 11.18 | 4.92 | 0.85 | 143.17 |
| Fertilization modules | 1 | 0.06 | 66.04 | 0.68 | 4.03 | 8.69 | 1.76 | 438.86 |
| Genotypes | 13 | 3745.29 | 2607.93 | 4.61 | 109.94 | 36.18 | 49.49 | 9003.57 |
| Fertilization modules x Genotypes | 13 | 105.27 | 170.37 | 0.93 | 54.37 | 17.30 | 15.27 | 1262.48 |
| Error | 54 | 539.87 | 878.02 | 6.43 | 170.13 | 26.56 | 105.64 | 5300.17 |

| Source of variation | df | Mean Sum of Squares | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Flower size | No. of petals/ flower | No. of flowers/plant | No. of flowers/ $m^2$ | Days taken for flower harvest | Duration of flowering | Vase life |
| Replications | 2 | 0.05 | 85.34 | 0.03 | 14.31 | 315.45 | 201.52 | 1.27 |
| Fertilization modules | 1 | 0.16 | 102.17 | 0.10 | 58.16 | 880.76 | 576.19 | 0.10 |
| Genotypes | 13 | 2.27 | 10169.97 | 4.88 | 2809.16 | 5717.95 | 2,619.24 | 48.54 |
| Fertilization modules x Genotypes | 13 | 0.62 | 786.84 | 0.19 | 112.40 | 1469.91 | 1,491.81 | 3.66 |
| Error | 54 | 2.17 | 1620.87 | 7.44 | 4287.62 | 3897.88 | 3,000.48 | 21.55 |

**ANOVA for various growth and flowering parameters of carnation genotypes in response to fertilization modules for 2021-2022**

| Source of variation | df | Mean Sum of Squares | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Plant height | Stem length | Stem thickness | Stem sturdiness | Bud width | Bud length | Days taken for bud formation |
| **Replications** | 2 | 20.28 | 28.78 | 0.45 | 2.34 | 5.18 | 27.60 | 1,212.50 |
| **Fertilization modules** | 1 | 170.73 | 302.87 | 0.50 | 0.19 | 0.49 | 0.04 | 1,508.76 |
| **Genotypes** | 13 | 4771.23 | 3437.60 | 1.82 | 135.59 | 85.15 | 40.90 | 15,771.57 |
| **Fertilization modules x Genotypes** | 13 | 95.53 | 174.49 | 0.92 | 55.41 | 23.15 | 11.56 | 1,067.91 |
| **Error** | 54 | 1053.16 | 756.14 | 3.50 | 160.08 | 67.22 | 217.16 | 5,146.83 |

| Source of variation | df | Mean Sum of Squares | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Flower size | No. of petals/ flower | No. of flowers/plant | No. of flowers/$m^2$ | Days taken for flower harvest | Duration of flowering | Vase life |
| **Replications** | 2 | 0.00 | 11.61 | 1.42 | 816.59 | 412.17 | 0.04 | 0.04 |
| **Fertilization modules** | 1 | 0.88 | 4.36 | 1.44 | 830.03 | 867.86 | 0.09 | 0.09 |
| **Genotypes** | 13 | 6.21 | 13366.30 | 8.99 | 5180.03 | 3591.29 | 19.05 | 19.05 |
| **Fertilization modules x Genotypes** | 13 | 1.42 | 302.87 | 1.21 | 694.44 | 1305.14 | 5.83 | 5.83 |
| **Error** | 54 | 3.23 | 406.85 | 4.08 | 2347.58 | 4416.50 | 26.50 | 26.50 |

**ANOVA for various growth and flowering parameters of carnation genotypes in response to fertilization modules for pooled data of two years (2020-2022)**

| Source of variation | df | Mean Sum of Squares | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Plant height | Stem length | Stem thickness | Stem sturdiness | Bud width | Bud length | Days taken for bud formation |
| Replications | 2 | 10.65 | 44.30 | 0.07 | 7.78 | 0.10 | 3.06 | 901.58 |
| Years | 1 | 74.06 | 804.94 | 0.01 | 7.29 | 2.41 | 11.65 | 36138.67 |
| Fertilization modules | 1 | 20.24 | 43.69 | 1.17 | 2.99 | 6.62 | 0.78 | 1787.52 |
| Years x Fertilization modules | 1 | 193.54 | 325.29 | 0.01 | 1.23 | 2.55 | 0.98 | 160.10 |
| Genotypes | 13 | 8375.19 | 5803.45 | 3.85 | 184.30 | 108.10 | 70.00 | 18793.64 |
| Years x Genotypes | 13 | 308.56 | 242.16 | 2.57 | 61.24 | 13.22 | 20.43 | 5981.50 |
| Fertilization modules x Genotypes | 13 | 128.96 | 100.46 | 0.61 | 24.94 | 10.18 | 12.85 | 874.98 |
| Years Fertilization modules x Genotypes | 13 | 184.24 | 244.32 | 1.22 | 84.84 | 30.29 | 13.94 | 1455.41 |
| Error | 110 | 1707.95 | 1634.56 | 10.37 | 335.94 | 103.78 | 348.19 | 10901.08 |

| Source of variation | df | | Mean Sum of Squares | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Flower size | No. of petals/ flower | No. of flowers/ plant | No. of flowers/ $m^2$ | Days taken for flower harvest | Duration of flowering | Vase life |
| Replications | 2 | 0.03 | 33.75 | 0.56 | 320.11 | 872.37 | 539.04 | 0.45 |
| Years | 1 | 0.36 | 1.71 | 229.44 | 132155.69 | 45145.93 | 2030.10 | 47.90 |
| Fertilization modules | 1 | 0.15 | 32.14 | 1.16 | 665.04 | 1800.60 | 1429.17 | 0.00 |
| Years x Fertilization modules | 1 | 0.89 | 74.45 | 0.39 | 223.44 | 0.21 | 14.88 | 0.18 |
| Genotypes | 13 | 6.69 | 18716.66 | 10.84 | 6243.17 | 13966.79 | 4613.45 | 46.64 |
| Years x Genotypes | 13 | 1.78 | 4819.67 | 3.03 | 1746.31 | 4323.07 | 1597.07 | 20.94 |
| Fertilization modules x Genotypes | 13 | 1.16 | 585.52 | 0.74 | 425.53 | 1269.41 | 1619.67 | 2.59 |
| Years Fertilization modules x Genotypes | 13 | 0.88 | 504.12 | 0.66 | 381.02 | 1330.45 | 1177.29 | 6.91 |
| Error | 110 | 5.41 | 2090.93 | 12.41 | 7145.98 | 8528.30 | 7491.63 | 48.91 |

# APPENDIX- III

**Interpretation of physico-chemical and available NPK (kg/ha) content of soil**

| **Interpretation of pH** | | | |
|---|---|---|---|
| Below 6.5 | | Acidic | |
| 6.5-8.7 | | Neutral | |
| Above 8.7 | | Alkaline | |
| **Interpretation of electrical conductivity (dS/m)** | | | |
| Below 0.8 | | Normal- Suitable for all crops | |
| 0.8-1.6 | | Critical for salt sensitive crops | |
| 1.6-2.5 | | Critical for salt tolerant crops | |
| Above 2.5 | | Injurious to all crops | |
| **Interpretation of organic carbon (%)** | | | |
| Below 0.25 | | Very low | |
| 0.25-0.50 | | Low | |
| 0.50-1.00 | | Medium | |
| 1.00-1.50 | | High | |
| Above 1.50 | | Very High | |
| **Interpretation of available N, P and K (kg/ha)** | | | |
| **Nutrient** | **Low** | **Medium** | **High** |
| Nitrogen | < 272 | 272-544 | >544 |
| Phosphorus | < 12.4 | 12.4-22.4 | > 22.4 |
| Potassium | < 137 | 137-337 | >337 |

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| | | |
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| **No. of words in Abstract** | : | 366 |

**ABSTRACT**

The present investigation entitled, **"Evaluation of different genotypes of carnation (*Dianthus caryophyllus* L.) in response to organic and inorganic fertilization modules"** was carried out at the experimental farm of Department of Floriculture and Landscape Architecture, Dr YS Parmar University of Horticulture and Forestry, Nauni, Solan (H.P) during 2020-2022 under polyhouse with the objectives to find out the possibility of organic cultivation of carnation and to identify suitable genotype(s) for organic and inorganic cultivation. The experiment comprised of fourteen genotypes of carnation and two treatments: inorganic fertilization module (Recommended Dose of Fertilizers) and organic fertilization module (Jeevamrit @ 20 ml/plant as drenching at 30 days interval). The experiment was laid out in Randomized Block Design (Factorial) with three replications. The results revealed that carnations performed well in both the fertilization modules, the organic fertilization module however performed better in multiple characteristics, including stem thickness (5.75 cm), lesser number of days taken for bud formation (149.14 days), bud width (19.61 mm), number of flowers per plant and per square metre (5.55 cut flowers per plant and 133.20 cut flowers per $m^2$), lesser number of days taken for harvesting of cut stem (179.43 days), longer duration of flowering (72.20 days) and profitability. Even though, quality parameters such as stem length and stem sturdiness were non-significant, yield showed significant results. The organic fertilization module increased the bacterial count at $10^7$ dilution from the initial value of 97.67 cfu $g^{-1}$ to 122.33 cfu $g^{-1}$. The actinomycetes count at $10^2$ dilution also increased from the initial value of 37.67 cfu $g^{-1}$ to 57.67 cfu $g^{-1}$. The initial fungal count at $10^2$ dilution was 26.33 cfu $g^{-1}$ which increased to 28.33 cfu $g^{-1}$. This suggests that organic fertilization module (jeevamrit @ 20 ml/plant as drenching at 30 days interval) can act as an alternative for chemical fertilizers in consideration to the low input cost along with improving soil health and have the potential to contribute to better financial outcomes. It can also be concluded that among the different genotypes tested, 'Bizet' performed best under organic fertilization module with highest b:c ratio of 2.38. However, under inorganic fertilization module, 'Bizet' and 'Raggio-de-Sole' (b:c ratio of 2.02) performed better over the rest of the genotypes.

| | |
|---|---|
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