EVALUATION OF CARNATION (*Dianthus caryophyllus* L.) VARIETIES UNDER SHADE NET CONDITION OF EASTERN U.P.

Thesis
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By

Naveen Kumar Yadav
Id. No. H-14755/23

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

Master of Science (Horticulture)

FLORICULTURE AND LANDSCAPING

JULY, 2025

CERTIFICATE – I

This is to certify that the thesis entitled **"Evaluation of Carnation (*Dianthus caryophyllus* L.) varieties under shade net condition of Eastern U.P."** submitted in partial fulfilment of the requirement for the degree of **Master of Science (Horticulture)** with major in **Floriculture and Landscaping** of the **College of Horticulture and Forestry.** Post Graduate Studies, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya is a recorded *bonafide* research carried out by **Mr. Naveen Kumar Yadav,** Id. No. **H-14755/23** under my supervision and no part of the thesis has been submitted for any other degree or diploma.

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

Kumarganj, Ayodhya **(Sunil Kumar)**

25 July, 2025 **Chairman Advisory Committee**

CERTIFICATE – II

We, the undersigned, members of the advisory committee of **Mr. Naveen Kumar Yadav, Id. No. H-14755/23** a candidate for the degree of **Master of Science (Horticulture)** with major in **Floriculture and Landscaping** agree that the thesis entitled **"Evaluation of Carnation (*Dianthus caryophyllus* L.) varieties under shade net condition of Eastern U.P."** may be submitted in partial fulfilment of the requirements for the degree.

(Sunil Kumar)

Chairman

(Sanjay Kumar)

External Examiner

(S. K. Verma)

Major Member

(Bhanu Pratap)

Minor Member

Head of department

Deptt. of Floriculture & Landscaping
College of Horticulture & Foresty
A.N.D.U.A. & T., Kumarganj, Ayodhya

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DECLARATION FOR ANTI-PLAGIARISM

I, **Naveen Kumar Yadav, Id. No. H-14755/23** certifies that the thesis entitled **"Evaluation of carnation (*Dianthus caryophyllus* L.) varieties under shade net condition of Eastern U.P."** submitted in partial fulfilment of the degree of **Master of Science** in **(Horticulture) Floriculture and Landscaping** to the College of Horticulture and Forestry, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) is original work and has similarities with published work not more than minor similarities as per the UGC (Promotion of Academic Integrity & Prevention of Plagiarism in Higher Education Institutions) Regulations, 2018, adopted by the university.

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Place: Kumarganj, Ayodhya

Date: 25 July 2025

Naveen Kumar

Signature of the candidate

CERTIFICATE FROM THE MAJOR ADVISOR

This is to certify that be above statement made by the candidate is correct to the best of my knowledge.

25/07/2025

(Major Advisor)
Dr. Sunil Kumar
Assistant Professor
Deptt. of Floriculture & Landscaping
N.D.U.A.T.,Kumarganj,Ayodhya

25/7/25

Head of Department
Deptt. of Floriculture & Landscaping
College of Horticulture & Foresty
A.N.D.U.A. & T., Kumarganj, Ayodhya

(Bhagwan Deen)
Dean
Post Graduate Studies

Dean, PGS

25/7/25

Dean, CHF
DEAN
College of Horticulture & Foresty
ANDUAT Kumarganj-Ayodhya

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Kumarganj, Ayodhya **Naveen Kumar Yadav**

25 July, 2025

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LIST OF ABBREVIATIONS

%	Percentage
Kg	Kilogram
g	Gram
˚C	Degree Celsius
ppm	Parts Per Million
U.P.	Uttar Pradesh
Cm	Centimeter
Viz.	Namely
/	Per
PSB	Phosphate Soluble Bacteria
FYM	Farm Yard Manure
mm	Meli meter
&	And
M^2	Meter square
VC	Vermi compost
N	North
E	East
ANDUAT	Acharya Narendra Deva University of Agriculture and Technology
NPK	Nitrogen Phosphorous Potassium
N	Nitrogen
P_2O	Phosphorous Oxide
K_2O	Potassium Oxide
ml	Mili Liter
@	At the rate
DAP	Days After Planting
et al.	And others
Fig.	Figure
CD	Critical Difference
SE(m)±	Standard error mean
ANOVA	Analysis of variance
RH	Relative Humidity
m	Meter
cm^2	Centimeter square

INTRODUCTION

Carnation (*Dianthus caryophyllus* L.) is one of the most important cut flowers of the world. It belongs to the family Caryophyllaceae having a diploid chromosome number 2n=30. The generic word Dianthus is from the word Dios which means divine, and Anthos means flower. So, it is also known as divine flowers. Flowers are most appealing form of human expression as they devote beauty, purity, honesty, and divinity. Flowers were referred extensively in ancient Sanskrit classics like Rig-Veda, Ramayana, Mahabharata, etc. where, beauty and divinity are described (Medeo *et al.* 2019).

It is grown in several parts of the world and is believed to be the native of Mediterranean region. As a cut flower due to its excellent keeping quality, wide array of colour and forms, also ability to withstand long distance transportation and remarkable ability to rehydrate after continuous shipping. Carnations are preferred to roses and chrysanthemums, in several exporting countries as cut flower can also become useful in gardening for bedding, edging, borders, pots, and rock gardens and commercially utilized for extraction of perfume in France and the Netherlands (Samatha, 2016). The volatile oil of carnation contains 40% benzyl benzoate, 30 % eugenol, 7% phenylethyl alcohol, 5% benzyl salicylate and 1% methyl salicylate. About 100g of oil is obtained from 500 Kg of flowers. The flower heads are dried and used in pot-pourri, scented sachets and cosmetic products. The plant is quite rich in saponins (Hosure, 2015).

It is popular as cut flower on account of its exquisite shape, wide range of colours, good vase life and light in weight which makes it ideal for distant market. Carnation plants are half-hardy herbaceous perennial, solitary, terminally formed, the petals are broad with frilled margins and the calyx cylindrical with bracts at the base. The hybrids involving many Dianthus species are of perpetual flowering types. The florist's carnations are grouped into two major classes such as ‘Standard’ and ‘Spray’ (Samatha, 2016). The standard type produces larger blooms on longer flower stalks. On the other hand, the spray type produces many flowers of smaller sizes with weaker stems. Each stem forms terminal flowers which are bisexual or occasionally unisexual. The hybrids have remarkably long flowering period which produces bloom continuously in mild weather. The crop grown in open field is

exposed to aberration of environmental conditions and attack by different pest and diseases, resulting in poor quality flowers.

Standard Carnation performs well under cool climate, whereas spray type grows better at higher temperature. Growth and flowering of Carnations are influenced by several factors. Carnation is long day plant. It forms flowers faster during long day than in short day. It requires more than 21.5 Klux light intensity, cyclic lighting or continuous lighting from dusk to dawn hastens flowering. Temperature plays an important role in Carnation growing. Temperature fluctuations result in reduction of flower yield, stem strength, increased calyx splitting and shorter keeping quality. The optimum range of temperature during winter and spring is 10-12.7^{0}C and during summer 13.0-15.4^{0}C, respectively. Polyhouse fitted with fan and pad system can bring down the temperature by 8-100C. However, top ridge and side ventilation also gives good fresh air exchange and lowers the temperature. High humidity results into several fungal diseases. The crop must be protected from rain by covering the plants with polyethylene sheets. Carbon dioxide level affects both growth and quality. Low level of CO_2 100-150 ppm in greenhouse during the day inhibit the growth. The greenhouse CO_2 level should be maintained at 300-500 ppm on cloudy days and 750- 1500 ppm on sunny days (Pralhad, 2009).

A carnation variety varies with region, season, genotypes and growing environment. The major Carnation growing countries are Italy, Spain, Columbia, Kenya, Srilanka, Canary Islands, France, Holland, USA and Germany. While the major importers of carnation are France, United Kingdom, Holland, Israel, Italy, Spain, Peru, Greece, Mexico and Equador. In India the major production regions are located around The Nilgiris, Hosur, Bengaluru, Kolkata, Pune, Delhi, Solan, Shimla, Ludhiana and Hyderabad. According to the Ministry of Agriculture and Farmer Walfare, Government of India (2022-23) the total area covers under carnation cultivation is 2.38 thousand hectare and cut flower production is 10.68 thousand tonnes.

The demand for Carnation cut flower is gaining momentum with increasing aesthetic sense and higher socio-economic standard of the people. In India, it is common practice to have the plants growing in greenhouses for the cut flower production resulting in increased crop production. On the other hand, when the plants are grown in open condition especially plants in northern India, the planting after April has to pass through a great stress due to prevailing high temperature. Though such low temperature conditions exist in India during

winter months but the shortage of light during winter months is the main barrier for its reduced and delayed flower production owing to its long day requirement. In addition to its long day, other operations are also known to affect its flowering, but so far, there is no systematic report from India on its growth and flower regulation.

Protected cultivation of carnation involves growing the crops under controlled environments such as polyhouses or shade nets to optimize growth and flower quality. It provides a stable microclimate, shielding plants from temperature extremes, wind, rain, and pests. Carnations grown under protected conditions exhibit enhanced stem strength, reduced calyx splitting, improved vase life, and uniform flowering. The controlled light, temperature, humidity, and CO_2 levels promote better vegetative and reproductive growth. Standard types thrive in cooler climates, while spray types perform better at higher temperatures. Polyhouses with fan-pad systems or natural ventilation help maintain ideal conditions. Protected cultivation also enables off-season production and higher market returns. It is especially beneficial in regions like Eastern U.P., where open-field cultivation faces climatic challenges.

Superiority of Carnation as a cut flower is judged based on its quality which plays a vital role in the international cut flower trade. Therefore, testing the available varieties for suitability and adaptability with respect to flowering, flower quality, and yield parameters are of prime importance. Hence, the present investigation is going to be carried out under shade net conditions to know the performance of different varieties of carnations. In carnation, there are lots of varieties having variable characters and variable qualities. Quality of flowers has great value in case of marketing of cut flowers, so varietal performances have gotten value for deciding the planting of single variety. A systematic study of vegetative characters would facilities the breeders to select suitable genotypes for planned breeding programme. Further there is need for suitable varieties and production technologies which are suitable for Eastern Uttar Pradesh conditions and a selection of proper variety for producing the desired quantity and quality of flowers for domestic as well as international market is of greater importance. Since carnation is new to Ayodhya region of Uttar Pradesh there is a need to evaluate and introduce this crop to farmers fields. Considering the importance of the flower crops, an experiment has been conducted to evaluate 09 carnation varieties for their yield and quality attributes under greenhouse condition at Technology Park, Horticulture Block, Floriculture Unit, Acharya Narendra Deva University of

Agriculture and Technology, Kumarganj Ayodhya. Keeping this point of view, therefore the present investigation on "Evaluation of Carnation (*Dianthus caryophyllus* L.) varieties under shade net condition of Eastern U.P." was carried out with the following objectives:

1. To study the performance of different carnation varieties under shade net conditions
2. To calculate the benefit-cost ratio.

Problem statement and Justification of the study

Carnation (*Dianthus caryophyllus* L.) is a leading cut flower worldwide, it is valued for its wide color range, long vase life, and high demand in domestic and international market. However, the performance of carnation varieties is greatly influenced by climatic and management conditions. In Eastern Uttar Pradesh, the scientific evaluation of carnation varieties under protected structures is negligible or very limited. Due to this knowledge gap, growers often fail to select suitable varieties, resulting the poor flower yield, inferior quality, and reduced profitability. Hence, there is a need to assess different carnation varieties systematically for their adaptability and performance under the protected environment.

Carnation has tremendous commercial potential in India, and its cultivation under protected structures like shade net can provide year-round quality flowers. In Eastern Uttar Pradesh, where climatic conditions differ from other carnation-growing regions, identifying the best-performing varieties is crucial for enhancing productivity and market value. The study will provide region-specific recommendations, enabling farmers to select the best varieties for higher yield and quality flowers. Moreover, the results will contribute valuable scientific information for floriculture researchers and strengthen the floriculture-based economy of the region.

Hypothesis

- **Null Hypothesis (H_0):** There is no significant difference between different varieties and benefit-cost ratio of carnation evaluated under shade net conditions in Ayodhya, district of Eastern U. P.
- **Alternative Hypothesis (H_1):** There is significant difference between different varieties and benefit-cost ratio of carnation evaluated under shade net conditions in Ayodhya, district of Eastern U. P.

REVIEW OF LITERATURE

These days, carnations are a very profitable and important flower, especially when grown in polyhouses for their cut flowers. Some types are also used in gardens, pots, and window boxes. Both standard and spray carnations are popular for home decorations. Growing high-quality carnations year-round outdoors is tough, but greenhouses allow cultivation even in the off-season. Different carnation varieties vary greatly in how much they yield, their quality, and how long they last in a vase.

In this chapter, the review of past literature pertaining to the performance of carnations and the other related flowers under protected conditions has been compiled to enable better understanding of the varieties and suitable growth conditions in flowering plants.

2.1 Vegetative parameters

2.1.1 Plant Height

Kumar *et al.* (2015) evaluated 11 chrysanthemum varieties in Chhattisgarh plains and reported that maximum plant height (60.90 cm) was recorded in Decorative White and was found on par with Golden incurved (60.70 cm), Pompon Rosy Pink (58.20 cm). While minimum plant height was obtained in Decorative Reddish Yellow (46.20 cm).

Maitra and Roychowdhury (2014) reported that Enfont De Nice was the tallest plant producing variety (73.84 cm) which was statistically at par with the effects of Chabaud Super Mix (73.68 cm) and Chabaud Extra Mix (72.73 cm). The minimum plant height was obtained from the plants of the variety Lilipot Mix (47.38 cm). Among the 50 cultivars of carnation, cultivar Don Pedro (95.61 cm) was recorded maximum plant height, and the next superior cultivars were Hermes (94.70 cm) and Snow Storm (94.24 cm) however, minimum plant height (50.41 cm) was observed in cultivar EC-5 (Chauhan *et al.* 2014).

Mehmood *et al.* (2014) reported that plant height among the different cultivars of carnation differed significantly. The range was from 64.96 cm to 78.66 cm. Cultivar Grand Salam (78.66 cm) recorded highest plant height and the cultivar Tempo was shortest (64.96 cm) under lath house condition. Among eight carnation varieties *viz*. Diana, Aurturo, White

Dona, Pink Dona, Soto, Red King, Tuareg and Dona evaluated under naturally ventilated greenhouse, the maximum plant height was recorded in the cultivar Red King (75 cm) as compared to all other verities (Singh *et al.* 2013).

Gharge *et al.* (2011) revealed that plant height was maximum (134.0 cm) in the variety Yellow Firato. The next superior varieties were Firato (126.4 cm) and Diana (125.8 cm), and both were at par. And shortest (99.14 cm) plant height was observed in the variety Viking.

Ryagi *et al.* (2007) studied the effect of pinching on growth, yield and quality of flowers of carnation varieties viz., Dover, Cherry Solar, Yellow Solar and Domingo under polyhouse The maximum plant height was recorded in variety Solar (78.55 cm) which was on par with variety Domingo (78.12 cm) and the minimum plant height was recorded in variety Dover (68.52 cm) grown under polyhouse.

Kumar and Singh (2003) studied carnation cultivar Red Corso under screen house for three planting seasons *viz*. early, mid and late and two-day length conditions, viz., short and long days in all possible combinations. Plant height was maximum (86.65 cm) in the autumn season. In the interaction effect, the autumn season and long day condition showed the maximum plant height of 93.36 cm.

2.1.2 Number of shoots

Uddin *et al.* (2015) reported that the maximum number of branches was recorded from Rose Pink (19.7/plant) while the minimum was from Samsan (2.5/plant) at 50 DAT of chrysanthemum cultivars.

Maitra and Roychowdhury (2014) reported that carnation variety Chabaud Extra Mix as the highest side-shoot producer (18.12) followed by Enfont De Nice (14.21). The other varieties showed statistically at par less effective results including Chabaud Super Mix produced the minimum number of side-shoots plant-1 (12.41) when grown under open field condition in plains of West Bengal, India.

Mehmood *et al.* (2014) evaluated carnation cultivars under lath house and revealed that cultivars Tempo (6.3) and Nelson (6.2) recorded a greater number of shoots as compared to Cinderella (5.4) and Grand Salam (4.6). Least number of shoots was counted in cultivars Kaly.

In the carnation cultivar Soto, the number of branches (8.13) is maximum with the combined application of Azospirillum, PSB, vermicompost and FYM at 75% RDF (T_{11}) (Dalawai and Naik 2014).

Tarannum *et al.* (2014) stated that number of shoots production in carnation is greatly influenced by apical dominance. It was registered maximum (6.80) in Cv. Soto followed by White Dona (6.07), Big Mama (5.87), Dona (5.73) and Harish (5.60) which exhibited lesser apical dominance as compared to Cv. Big Net (4.60). Among eight varieties of carnations studied maximum number of branches per plant were recorded with variety Red King (8.0) which was at par with variety Soto (7.3) (Singh *et al.* 2013).

Patil (2001) noted that, the carnation variety Madame Collette recorded maximum number of branches (4.52), followed by Desio (4.35) and Alma (4.22), whereas variation Leon recorded minimum number of branches (2.85) at 180 days after plantation.

2.1.3 Stem Girth

Mehmood *et al.* (2014) stated that carnation cultivar Nelson had thicker and stronger stems (6.21 mm), while Grand Salam had weaker stems (3.63 mm). On the other hand, Tempo, Kaly and Cinderella had stems of moderate thickness (5.61, 5.44 and 4.48 mm respectively).

Kadam *et al.* (2014) reported that gladiolus variety Fidelio (19.25) having maximum stem girth followed by Amsterdam (17.84) and Yellow Stone (17.82). While variety Flavo Laguna (9.08) has least.

Gharge *et al.* (2009) revealed that, among different Carnation varieties evaluated cv. Pink Shiva had the maximum stalk girth (5.07 mm) and proved to be superior over others. When the carnation plants grown in Sand + Soil + Compost combination the plants exhibited thicker stem girth of 5.42 mm (Tejaswini and Murgod 2005).

Among the nine carnation varieties *viz*., Alma, Aicardi, Candy, Desio, Madame Collette, Pirandello, Sorisso, Sugar Baby and West Pretty grown under protected conditions, cultivar Sugar Baby, Madame Collette, Alma and West Pretty had thicker and strong stem (7.14, 6.88, 5.98 & 5.16 mm, respectively) while cultivar Sorisso had weak stem of 3.53 millimeter (Shiragur *et al.* 2004).

2.1.4 Number of leaf pairs per plant

Kumar *et al.* (2015) studied the performance of eleven chrysanthemum cultivars and reported that the number of leaves per plant is higher in taller cultivars than the shorter cultivars. Maximum number of leaves per plant (44) was found in Decorative white whereas, Nagpur White as control had least number of leaves.

Maximum number of leaves (202.30) were observed in the plants receiving Azospirillum, PSB, vermicompost and FYM at 75% RDF whereas, minimum was with 100% RDF (Dalawai and Naik, 2014).

Among the eight carnation cultivars evaluated under polyhouse condition, cultivar Soto (149.73) recorded maximum number of leaves followed by Dona (110.00), White Dona (105.20) and Harish (104.00) however; minimum was recorded in Big Net (79.07) (Tarannum *et al.* 2014).

Among the eight carnation varieties evaluated under naturally ventilated greenhouse in mid hills of Kumaon Himalaya cultivar Tuareg (11.00) recorded maximum leaf pair per stem followed by Dona (10.60) and Pink Dona (10.30). Whereas minimum was recorded in White Dona (8.00) (Singh *et. al.* 2013)

Sugapriya *et al.* (2012) evaluated Dendrobium orchids for growth and yield under greenhouse conditions and reported that cultivar Medame Uraiwan produced higher (18.33) leaves followed by Manel (17) and Burana fancy (17) however, the minimum (9) production was observed for Sripratum.

Gharge *et al.* (2011) reported that the number of leaves were maximum in variety Yellow Firato (214.4) followed by Firato (209.7) and Aicardi (207.5) whereas minimum was in cultivar Alibaba (172.8).

2.1.5 Leaf length

Sugapriya *et al.* (2012) evaluated the performance of nine dendrobium orchid varieties under partially environment-controlled greenhouse and reported that leaf length was maximum in the varieties Burana fancy (16.5 cm), Emma white (16.0 cm), Somark white (15.9 cm) and Manel (15.5 cm) whereas minimum was in Medame uraiwan (11.2 cm).

Gharge *et al.* (2011) revealed that leaf length was maximum in carnation variety Buemonde (12.48 cm) followed by Dali (12.09 cm), Pink Shiva (12.03) Gaudina (11.83 cm) and Diana (11.71 cm). Variety Firato (8.74 cm) had minimum leaf length (8.74 cm) when grown under naturally ventilated polyhouse (NVPH) conditions. Among the ten varieties grown under low-cost poly house longest leaves were produced in cultivar Madame Collette (11.27 cm), followed by Alma (9.85 cm) and Denton (9.71 cm), whereas leaves produced were shortest (6.03 cm) in cultivar Leon (Reddy *et al.* 2004).

Shiragur *et al.* (2004) studied the performance of standard carnation varieties under protected cultivation and reported that leaf length was maximum in varieties Madame Collette, Pirandello, West Pretty and Aicardi (10.88, 10.30, 10.04 and 8.78 cm, respectively) while cultivar Sorisso recorded the minimum leaf length of 6.03cm.

2.1.6 Number of internodes per stem

Carnation cultivar Nelson possessed the maximum number of internodes per stem (12.66), followed by Kaly (11.33) and Grand Salam (11.00). Tempo produced the minimum number of internodes per stem (7.33) (Mehmood *et al.* 2014).

Gharge *et al.* (2011) reported that carnation variety Yellow Firato (22.80) produced maximum number of internodes per branch followed by Firato (20.29) and Diana (19.91) which were on par with each other. The minimum internodes per branch were recorded in variety Dali (15.47) followed by Viking (16.16).

Ryagi *et al.* (2007) evaluated carnation varieties for vegetative growth parameters. Significant variation was recorded in the number of internodes among the studied cultivars. The maximum number of internodes was observed in Cherry Solar with 17.78, followed by Solar with 17.33. In contrast, the minimum number of internodes was recorded in Dover with 15.57. These results indicate genotypic differences in vegetative growth behaviour.

2.1.7 Internodal length

Dalawai and Naik (2014) reported that carnation cultivar Soto had maximum internodal length (7.64 cm) with the combined application of Azospirillum, PSB, vermicompost and FYM at 75% RDF. However, application of 100% RDF alone recorded the minimum internodal length.

Gharge *et al.* (2011) investigated variation in internodal length among carnation varieties. The study revealed significant differences in vegetative growth parameters. The maximum internodal length was recorded in Aicardi with 7.52 cm. In contrast, the minimum internodal length of 4.37 cm was observed in Viking. These findings highlight the influence of varietal differences on stem morphology.

Patil *et al.* (2001) evaluated different carnation cultivars for vegetative growth attributes. The study revealed considerable variation in internodal length among the varieties tested. Pirandello recorded the maximum internodal length of 6.89 cm. In contrast, Desio exhibited the minimum internodal length of 4.65 cm. These observations indicate genotypic influence on stem elongation in carnation.

2.1.8 *Per cent* mortality of plants

Dalawai and Naik (2014) studied the integrated nutrient management studies in carnation cultivar Soto under naturally ventilated polyhouse and reported that the minimum per cent mortality due to insect (1.87%) and disease (3.41%) was observed in the treatment combination of Azospirillum (60 g/m2) + PSB (60 g/m2) + FYM (2 kg/m2) + vermicompost (500 g/ m2) and 75% RDF whereas, maximum mortality was observed in control (100% RDF) (3.41 and 4.40).

Gharge *et al.* (2009) reported that, minimum per cent mortality was observed in carnation variety Diana (8.27%), followed by Buemonde (8.33%) and Firato (8.58%) whereas, it was maximum in Alibaba (25.04) which significantly differed to other varieties.

Shiragur (2002) stated that the mortality of plants due to fusarium wilt was minimum (9.6%) in cultivar Madame Collette, followed by varieties Pirandello (10.44%), Alma (10.73%) and Aicardi (11.22%), whereas it was maximum (25.98%) in cultivar Sorisso.

2.2 Flower quality and yield parameters

2.2.1 Days taken to first flower bud initiation

Kumar *et al.* (2015) evaluated 11 chrysanthemum varieties for loose flower production and reported that earlier first bud appearance was observed in Pompon Rosy Pink (43 days) followed by Decorative Reddish Yellow (47 days) and Anemone silver (47 days).

Among the eight genotypes of carnation evaluated by Tarannum *et al.* (2014), cultivar Soto was the first to show its visible flower bud by taking 95.16 days after planting, followed by Golem whereas Big Mama (135.34 days) and Big Net (130.01 days) were very late to initiate variable buds.

Chauhan *et al.* (2014) reported that carnation cultivar EC-9 was the first to show its visible flower bud, taking 128.00 days after planting, followed by Arka Flame and EC-17 (136.00 days) whereas cultivars EC-2 (160.33 days), Gaudina (156.27 days), EC-15 (155.60 days) and EC-18 (153.80 days) were very late to initiate buds.

Maitra and Roychowdhury (2014) studied the performance of six spray carnation cultivars and reported that cultivar Lilipot Mix reached the flower bud initiation stage earliest (54.37 days), followed by Chabaud Super Mix (76.74 days), Chabaud Finest Mix (78.63 days), Chabaud Mix (79.59 days) and Enfont De Nice (81.38 days). The most delayed effect was observed in the cultivar Chabaud Extra Mix (89.54 days).

In an integrated nutrient management studies conducted by Dalawai and Naik (2014) among the different treatment combinations, minimum days taken for flower bud initiation (114.88) was observed with the application of Azospirillum (60 g/m2) + PSB (60 g/m2) + FYM (2 kg/m2) + VC (500 g/m2) + 75% RDF.

Kumar and Singh (2003) reported that the maximum number of days (102.94) for flower bud emergence was taken by autumn planting whereas further delay in planting led to early emergence of flower bud the earliest bud emergence (85.65 days) was observed in the late winter season. The plants exposed to long day conditions took the least number of days for their bud emergence (78.5%). In case of the interaction effect, the earliest bud emergence (71.61 days) was observed in the late winter season with long days.

2.2.2 Days taken to first flower bud opening

Maitra and Roychowdhury (2014) studied the suitability of 6 spray carnation cultivars and reported that cultivar Chabaud Finest Mix required the shortest time period from FFBI to colour showing stage (34.75 days) followed by Lilipot Mix (35.77 days) and Chabaud Mix (37.02 days). Whereas cultivars Chabaud Super Mix (38.50 days) and Enfont De Nice (40.75 days) took maximum days.

Dalawai and Naik (2014) studied the integrated nutrient management in carnation cultivar Soto, and reported that the combined application of Azospirillum, PSB, vermicompost and FYM at 75% RDF (T11) took the minimum days for flower bud development (20.37).

Chauhan *et al.* (2014) evaluated the performance of fifty carnation cultivars with respect to flowering behavior. The study revealed significant variation in the number of days taken for first flowering. Cultivar EC-9 was the earliest to flower, taking only 141.40 days. In contrast, the maximum duration for first flowering was observed in EC-1 with 178.80 days.

Sugapriya *et al.* (2012) evaluated performance of nine dendrobium orchid varieties under partially environment-controlled greenhouse and reported that variety Sonia-17 (31.43 days) exhibited minimum time interval from flower bud initiation to first flower opening while the varieties Sripratum red (48.63 days), Emma white (46.73 days) and Manel (46. 20 days) have taken maximum number of days for flower bud development.

2.2.3 Bud length (cm)

Medeo *et al.* (2019) recorded maximum bud length in variety Cindrella (3.17 cm) among 9 carnation cultivars and minimum was reported in Kitaro (2.63 cm).

Jose *et al.* (2019) evaluated 9 carnation varieties and reported that maximum bud length (4.10 cm) was observed in variety Manuela, whereas minimum stalk length was observed in Gaudina (2.57 cm).

Maitra and Roychowdhury, (2013) reported maximum bud length in variety Tashman Pink (3.81 cm) among 10 carnation cultivars and minimum was reported in C. Rimo (3.64 cm).

2.2.4 Bud diameter

Patil (2001) studied that the carnation cv. Madame Collette recorded maximum bud diameter (2.29 cm) and was found on par with Alma (2.16 cm) and Desio (2.11 cm) whereas, Leon recorded minimum bud diameter (1.50 cm).

The flower bud of carnation cv. IAHS-23 was larger (2.13 cm diameter) when compared to IAHS-7, which recorded 1.38 cm in diameter (Sathisha, 1997).

2.2.5 Length of flower stalk

Maitra and Roychowdhury (2014) reported that cultivar Chabaud Super Mix produced the longest stalks (35.43 cm) which was statistically at par with the cultivar Chabaud Extra mix (34.21 cm). The shortest flower stalks (5.00 cm) were obtained from cultivar Lilipot Mix.

Dalawai and Naik (2014) stated that maximum stalk length (93.76 cm) was observed in the treatment Azospirillum, PSB, vermicompost and FYM at 75% RDF.

Among the eight carnation cultivars evaluated by Tarannum *et al.* (2014) Maximum flower stalk length was observed in cultivar Soto (93.57) followed by Big Mama (88.33) and Dona (84.50) however, Liber (51.37) had shorter stalk.

Verma *et al.* (2012) evaluated 15 carnation varieties and reported that maximum flower stalk length (50.5 cm) was observed in variety New Tempo followed by Yellow Candy (46.5 cm), Tikar (43.7 cm), Master (41.9 cm) and Tasman (40.3 cm), whereas minimum stalk length was observed in Firato (27.5 cm).

Dalal *et al.* (2009) found that, in carnation maximum stalk length was recorded in cv. Domingo (86.05 cm), followed by Master (85.60 cm), whereas minimum stalk length was recorded in Yellow Solar (75.82 cm).

Among the carnation varieties studied, Gharge *et al.* (2009) revealed that, stalk length was maximum in variety Yellow Firato (97.94 cm) followed by Diana (89.84 cm) whereas, Viking recorded minimum stalk length (76.70 cm) and was on par with Alibaba (79.64 cm).

2.2.6 Girth of flower stalk

Dalawai and Naik (2014) studied the integrated nutrient management in carnation cultivar Soto and reported that maximum stalk girth (0.45 cm) was observed with the application of Azospirillum (60 g/m2) + PSB (60 g/m2) + FYM (2 kg/m2) + VC (500 g/m2) + 75% RDF.

Tarannum *et al.*, (2014) observed that carnation cultivar White Dona (5.70), Soto (4.99), Dona (4.60) and Harish (4.23) had better and strong flower stalks whereas Big Mama (3.67) had weak flower stalks by having lesser stalk girth.

Islam *et al.* (2013) studied five anthurium varieties and revealed that Variety Triticaca had maximum flower stalk diameter (5.1 mm) while minimum diameter (3.0 mm) was recorded in Caesar.

Gharge *et al.* (2009) observed Stalk girth was maximum in carnation variety Pink Shiva (5.07 mm) which was superior over rest of the varieties. Flower stalk girth was minimum in variety Yellow Firato (3.66 mm) followed by Aicardi (4.14 mm), Dali (4.25 mm) and Alibaba (4.32 mm).

Ryagi *et al.* (2007) studied the effect of pinching on growth, yield and quality of carnation varieties under greenhouse. The study revealed that maximum stalk girth (5.12 cm) was observed in Domingo, whereas it was minimum in cultivar Dover (3.73 mm).

2.2.7 Flower diameter

Kumar *et al.* (2015) evaluated 11 chrysanthemum varieties for loose flower production and reported that maximum flower diameter (7.60 cm) recorded for cv. Suneel whereas, minimum was recorded in Pompon Rosy Pink.

In an integrated nutrient management study conducted by Dalawai and Naik (2014) the maximum flower diameter (6.95 cm) was recorded when the plants supplied with (*Azospirillum* (60 g/m2) + PSB (60 g/m2) + FYM (2 kg/m2) + VC (500 g/m2) + 75% RDF).

Flower diameter of carnation was found superior in cultivars Soto (5.86), Big Mama (5.69), Harish (5.69) and White Dona (5.70) whereas, cultivar Liber (4.36) produced small sized flowers (Chauhan *et al.* 2014)

Maitra and Roychowdhury (2014) stated that Chabaud Super Mix as the best performer regarding flower diameter (5.91 cm) followed by Chabaud Extra Mix (5.64 cm), Chabaud Finest Mix (4.97 cm), Chabaud Mix (4.86 cm) and Enfont De Nice (4.85 cm). Cv Lilipot Mix produced flowers with minimum diameter (4.56 cm). Singh *et al.* (2013) studied the carnation varieties under naturally ventilated polyhouse and observed that cultivar Red King had maximum flower diameter (7.83 cm)

Dalal *et al.* (2009) found that flower diameter was maximum in carnation cv. Master and Paolo (5.21 cm) whereas, it was minimum in Domingo (4.90 cm).

Singh *et al.* (2006) reported that maximum flower diameter (6.61cm) with 4-hour additional light, whereas it was minimum (5.76 cm) under natural day length.

The maximum carnation flower diameter (5.7 cm) was obtained in single pinching and was least (5.2 cm) in double pinching, whereas in case of interaction it was maximum in (5.8 cm) in single pinching with 200 ppm nitrogen and single pinching with 500 ppm nitrogen (Singh and Singh 2005).

2.2.8 Number of petals per flower

Kumar *et al.* (2015) evaluated eleven chrysanthemum cultivars for their floral performance. The study revealed considerable variation in the number of florets per flower among the tested varieties. The maximum florets per flower were recorded in Decorative Reddish Yellow with 860 florets. This indicates the superior floral density of this cultivar compared to others.

Tarannum *et al.* (2014) studied the genotypic and phenotypic correlation between vegetative and flower yield parameters in carnation and concluded that number of petals per flower exhibited positive and highly significant association with flower length and flower weight at genotypic level. Whereas, it had positive and significant association with flower length and flower weight at phenotypic level.

Gharge *et al.* (2009) observed maximum number of petals per flower in carnation variety Gaudina (74.18) followed by Aicardi (70.53) and Alibaba (70.19) whereas, it was minimum in variety Yellow Firato (46.36).

Patil (2001) evaluated 10 carnation cultivars under low-cost polyhouse and reported that maximum number of petals per flower were recorded in cultivar Madame Collette (68.33), followed by cultivar Desio (60.67) whereas cultivar Leon recorded minimum (38 33) number of petals per flower.

Naveen *et al.* (1999) noted that carnation cultivar Carbaret had maximum number of petals per flower (85.5) under polyhouse condition as compared to 49.00 under open condition.

2.2.9 Fresh weight of flower

Kumar *et al.* (2015) evaluated 11 chrysanthemum varieties and reported that the maximum average flower weight (8.50 g) and average 100 flower weight (320 g) were observed in cv. Pompon Rosy Pink.

Maitra and Roychowdhury (2014) revealed that cv. Enfont De Nice was the best performer regarding the fresh weight of flowers (254.88 g), which was statistically at par with the fresh weights of flowers of Chabaud Extra Mix (251.18 g) and Chabaud Super Mix (242.04 g). Chabaud Mix (225.42 g) and Chabaud Finest Mix (214.53 g) performed moderately well. Lilipot Mix produced the flowers having minimum fresh weight (191.32 g).

Tarannum *et al.* (2014) evaluated different carnation cultivars for flower weight. The study exhibited significant variation among the tested varieties. Cultivar Soto was found superior, recording the maximum flower weight of 53.37 g. It was closely followed by White Dona with 52.12 g. In contrast, the minimum flower weight of 26.44 g was observed in Liber.

Gharge *et al.* (2009) reported that, carnation variety Pink Shiva had highest fresh weight of flower stalk (35.08 g) followed by Gaudina (30.57 g) and Viking (29.34 g) and found on par. On the other hand, minimum flower weight was noticed in Buemonde (21.81 g) followed by Dali (23.36 g) and Aicardi (23.83 g).

According to Tejaswini and Murgod (2005) fresh weight of carnation flower was significantly higher (14.45 g) with Sawdust: Soil: Compost (1:2:10 + 3 liter/m^2/day irrigation + water soluble fertilizers. Fresh weight was recorde least with (Sand: Soil: Compost (1:2:1) + 6 liter/m^2/day irrigation + water soluble fertilizers).

Singh *et al.* (2013) studied eight varieties of carnation to evaluate flower fresh and dry weight. The results indicated significant variation among the tested cultivars. Red King recorded the highest fresh weight of 8.30 g and dry weight of 2.66 g. It was followed by Turang, which also showed comparatively higher flower weight. These findings emphasize the role of varietal differences in influencing biomass accumulation in flowers.

2.2.10 Vase life

Maitra and Roychowdhury (2014) studied six spray carnation cultivars and reported that vase-life was maximum in the cultivar Lilipot Mix (4.63 days) followed by Chabaud Super Mix (4 days), which was statistically at par with Chabaud Mix (3.88 days), Chabaud Finest Mix (3.75 days) and Chabaud Extra Mix (3.63 days). The minimum post-harvest longevity was obtained from Enfont De Nice (3.38 days).

Mehmood *et al.* (2014) evaluated five carnation cultivars and revealed that Shelf life was highest in cultivar Tempo (8.2 days). The next superior cultivar was Nelson (6.3 days) and Grand Salam (5.2 days). The cultivar Kaly and Cinderella (4.0 days) were on par to each other.

Dalawai and Naik, (2014) studied the integrated nutrient management studies in carnation cultivar Soto under naturally ventilated polyhouse and reported that the maximum vase life (12.52 days) was observed with the application of (Azospirillum (60 g/m^2) + PSB (60 g/m^2) + FYM (2 kg/m^2) + VC (500 g/m^2) + 75% RDF).

Tarannum *et al.* (2014) stated that carnation cultivars Soto (10.00 days), Dona (9.50 days) and White Dona (9.33 days) recorded higher vase life however, Big Mama registered minimum (6.17 days). Among eight carnation varieties evaluated under naturally ventilated greenhouse cultivar Red King recorded maximum vase life (29.33 days) (Singh et al, 2013).

Dalal *et al.* (2009) revealed that, highest vase life of carnation cut flower was recorded in cv. Master (8.23 days c) and Paolo (8.19 days) whereas, it was lowest (7.93 days) in Yellow Solar and Domingo (7.99 days).

Among the carnation varieties studied, Gharge *et al.* (2009) reported that shelf life was maximum in variety Pink Shiva (15.18days) and Aicardi (14.83 days). However, variety Yellow Firato (4.85 days) recorded minimum shelf life, followed by Firato (4.96 days), Buemonde (5.15 days) and Dali (6.35 days).

Singh *et al.* (2007) studied the effect of vase and pulsing solutions on keeping quality of standard carnation cut flowers and reported that the vase life of cut flowers was maximum (11.45 days) in solution containing sucrose (5%) + aluminum sulphate (200 ppm). Among different combinations comprising sucrose, biocides and ethylene antagonists, the maximum vase life (13.44 days) was observed when the stems were pre-treated with STS, under cool

conditions for 24 hours, followed by placing the stems in vase solution containing sucrose (5%) + aluminum sulphate (200 ppm). Among the pulsing treatments, maximum vase life (11.89 day) was obtained with solution containing sucrose (10%) + aluminum sulphate (200 ppm) + STS.

According to Tejaswini and Murgod (2005) the vase life was found to be highest (8.89) in case of flowers produced in module M4 (Sand: Soil:Compost (1:2:1) + 6 lit./m^2/day irrigation regimes + Straight fertilizers) and was least (7.33 days) in M1 (Sand: soil: compost 1:2:1 + 6 liter /m^2/day irrigation + water soluble fertilizers) in carnation cultivar Sunrise.

2.2.11 Calyx splitting (%)

Among the eight genotypes of carnation evaluated by Tarannum *et al.* (2014) per cent calyx splitting was low in variety Soto (0.00 %) & Big Net (0.00 %) followed by White Dona (1.00 %), Big Mama (1.33 %), Harish (1.33 %) and Dona (1.67 %), whereas maximum calyx splitting was recorded in the variety Liber (2.67 %) and Golem (2.33).

Among the ten carnation cultivars evaluated under naturally ventilated polyhouse (NVPH) conditions per cent calyx splitting was low in variety Alibaba (0.09%), followed by Yellow Firato (0.51%) and Firato (0.94%), whereas it was maximum in variety Viking (23 .09%) (Gharge *et al.* 2009).

Singh *et al*. (2006) noted that calyx splitting was not observed in any of the treatment. This was apparently due to prevailing warmer temperature conditions in March-April when bud development took place.

Shiragur (2002) reported that the calyx splitting varied among the carnation varieties. It was minimum in variety West Pretty, (0.09%), followed by Sugar Baby (0.25%), Desio (0.44%), Madame Collette (0.98 %) and it was maximum in cultivar Pirandello (13.46%).

2.2.12 Number of flowers per plant/year

Among five Carnation cultivars, flower yield per plant was maximum in cv. Master (4.57) followed by Domingo (4.18) and Paolo (4.17), whereas it was lowest (3.21) in Yellow Solar (Dalal *et al.* 2009).

Gharge *et al.* (2009) reported that, highest number of flowers per plant was recorded in Carnation variety Yellow Firato (7.64) followed by Firato (7.58). Variety Viking (5.33) produced minimum number of flowers per plant.

Singh and Singh (2005) reported number of flowers per plant was maximum (5.80) in Double pinching method, while in case of interaction effect of pinching method and nitrogen application, the maximum number of flowers per plant was recorded under double pinching and 500 ppm nitrogen (7.40 flowers).

Number of flowers per plant was maximum (6.3) in Carnation cv. Red Corso whereas, it was recorded minimum in New Espana (4.3) reported by Dwivedi and Kareem (2004).

Among ten Carnation cultivars studied, cv. Madame Collette recorded maximum flower yield (4.56 per plant), followed by Alma and Sugar Baby (4.18 and 4.12 per plant, respectively) however, Leon recorded minimum (2.82) number of flowers per plant (Reddy *et al.* 2004).

Shahakar *et al.* (2004) investigated the performance of six standard varieties of Carnations under polyhouse and reported that, yield of flowers per plant (5.80) was maximum in cv. Cobra which was at par with Guadiana. Next in order were Super Green (5.20), Niva (5.13), Salsa (4.46) and Montezuma (4.25). Under low-cost polyhouse Patil (2001) evaluated 10 varieties of Carnation and recorded maximum number of flowers in cv. Madame Collette (4.29), followed by Desio (4.13), while minimum number of flowers was recorded in Leon (2.71).

2.2.13 Number of flowers/m^2/year

Carnation cv. Master produced the highest (164.52) yield of flowers per square meter followed by Domingo (150.48) and Paolo (150.12) whereas, it was lowest (115.56) in Yellow Solar (Dalal *et al.* 2009).

Gharge *et al.* (2009) reported that, maximum number of flowers per square meter was recorded in Carnation variety Yellow Firato (254.6) which was on par with Firato (252.6) and Dali (241.0). However, variety Viking (117.68) produced minimum number of flowers per plant.

Ryagi *et al.* (2007) reported that among varieties studied, significantly higher number of total flowers were recorded in Domingo (112.54 per m^2), followed by Dover (75.23 per m^2) and minimum flower yield was recorded in variety Cherry Solar (44.89 per m^2).

An experiment was conducted by Ryagi *et al.* (2007) to study the effect of pinching on different varieties of Carnation grown under polyhouse and study revealed that among varieties the significantly more number of total flowers were recorded in variety Domingo (112.54 per m^2), followed by Dover (75.23 per m^2) and minimum flower yield was recorded in variety Cherry Solar (44.89 per m^2). In case of interaction effect of cultivar and pinching method the maximum flowers per m^2 was recorded in cultivar Domingo with single pinching method (117.05 per m^2).

Shahakar *et al.* (2004) investigated the performance of six standard Carnation varieties under polyhouse condition and revealed that highest yield of flowers per m^2 (171.80) was recorded in cultivar Cobra which was at par with Gaudina. Next in order were Sugar Baby (162.40), Niva (143.64), Salsa (124.88) and Montezuma (119.00).

Shiragur *et al.* (2004) evaluated nine standard Carnation varieties and reported that maximum flowers per square meter were found in cultivar West Pretty (346.93 flowers), followed by Desio, Aicardi and Madame Collette (3.17, 309.75 and 297.45 flowers, respectively) while cultivar Sugar Baby produced the lowest number of flowers per square meter (233.31).

MATERIALS AND METHODS

The present investigation was carried out to evaluate the carnation (*Dianthus caryophyllus* L.) varieties under shade net condition of Eastern Uttar Pradesh. The experiment includes nine standard carnation varieties *viz*., Purple Sky, Master, Kiro, Baltico, Vanity, Dorian, Domingo, Star, Carvantes. During the experimental period, plants received uniform cultural treatment. Detailed information of the materials used, experimental procedures followed, and techniques adopted are described in this chapter.

3.1 Location of experimental site

The present investigation was conducted at the Technology Park, Horticulture Block, Floriculture unit, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, 224229 during September 2024 to April 2025. Kumarganj is situated at a latitude of approximately 26.5356° N (or 26° 32' 8.16" N), longitude approximately 81.8352° E (or 81° 50' 6.72" E) and altitude (Elevation above Mean Sea Level) approximately 113 meters (371 feet).

3.2 Climatic condition and meteorological data

The weather in the Kumarganj District of Ayodhya is categorized as semi-arid, with three different seasons: summer, winter, and rainy. The meteorological data are illustrated in ANNEXURE-I.

3.3 Experimental material

3.3.1 Source of Planting Material

The rooted stem cutting grown in jiffy bags was purchased and collected from Rise n' Shine Biotech Pvt. Ltd., located at 301-Metro House, Mangaldas Road, Pune 411001, Maharashtra, India.

3.3.2 Technical program

Crop	:	Carnation
Year of planting	:	2024-25
Date of planting	:	October, 2024
Growing structure	:	Shade net house
Planting method	:	Raised bed (four-row planting system)
Bed size	:	8m×0.6m×0.15m
Spacing	:	15cm×15cm
Layout design	:	Completely Randomized Design
Number of treatments	:	09 (varieties)
Number of replications	:	3
Experimental site	:	Technology Park, Horticulture Block, Floriculture unit, ANDUAT, Kumarganj, Ayodhya, UP, 224229

Purple Sky

Master

Kiro

Baltico

Vanity

Star

Plate 3.1 (a) Carnation varieties taken for experimental purpose

Domingo

Dorian

Carventas

Plate 3.1 (b) Carnation varieties taken for experimental purpose

3.3.3 Treatment Details

Sl. No.	Treatments	Varieties
1.	T_1	Purple Sky
2.	T_2	Master
3.	T_3	Kiro
4.	T_4	Baltico
5.	T_5	Vanity
6.	T_6	Dorian
7.	T_7	Domingo
8.	T_8	Star
9.	T_9	Carvantes

3.3.4 Structure of shade net

The shade net house area approximately 1000 m^2 was oriented in East-West direction. Its frame was made up of galvanized iron pipe and covered shade net. Two sides are covered with insect proof net of 60 meshes for natural ventilation and protection against entry of insect pests.

3.4 Cultural Operations

3.4.1 Preparation of bed

Land inside the shade net house was ploughed thoroughly and dug to a depth of 30 cm, one month before planting of crop. Weeds, stones, stubbles etc. were fully removed and the soil media was brought to fine tilth. The raised beds of 8.0 m length, 75 cm width and 0.15 cm height were prepared with walkway distance of 50 cm between beds according to the layout plan. Beds were incorporated with well decomposed FYM, sand, neem cake and coir pith at a ratio of 2:1:1:1.

3.4.2 Sterilization of beds

The beds were sterilized thoroughly with Formalin (Formaldehyde 37–40%) @ 3 liters per 100 liters of water per 10 m^2 area then cover with plastic black polyethylene for 4 days. Thereafter, the polyethylene sheet was removed, and the beds were aerated for 36 hours. Later, the sterilized field was thoroughly irrigated thrice to drain out the chemical residues.

a. Preparation of beds for planting of carnation

b. Sterilized beds are ready for transplantation of carnation

c. Rooted stem cutting of carnation

d. Individual carnation rooted stem cutting grown in giffy bag

e. Transplanting of carnation rooted cutting in beds

f. Irrigation the cation after planting with the help of rose cane

Plate 3.2. Beds preparation and transplanting of carnation rooted stem cutting in shade net structure

3.4.3 Transplanting

Healthy carnation plants with 6-7 leaves were planted on raised beds. Four row system of planting was followed with the spacing of 15 cm between row to row and 15cm between plant to plant and irrigation was given immediately after transplanting.

3.4.4 Irrigation

The plots were irrigated with drip irrigation system by providing two laterals per bed. The drippers of 2 lph were fixed at 30 cm apart on 16 mm lateral. The beds were irrigated regularly to keep the soil moderately moist by giving 4-5 liters of water per square meter per day before noon or late in the evening to keep the soil moderately moist.

3.4.4.1 Misting

Misting was carried out by overhead 4-way foggers in summer months to bring the temperature and humidity to an optimum level.

3.4.5 Fertilizer

A water-soluble balanced fertilizer, NPK (19:19:19), was applied as a foliar spray at regular intervals to ensure optimal nutrient availability during the vegetative and flowering stages. The fertilizer contains 19% nitrogen (N), 19% phosphorus (P_2O_2), and 19% potassium (K_2O).

3.4.6 Weeding and plant protection measures

Hand weeding was followed to keep the entire polyhouse free from weeds. Pests like Thrips (*Thrips tabaci*), Red mites (*Tetranychus urticae*) and Bud borer (*Helicoverpa armigera*) were controlled by spray of Imidacloprid @ 0.5 ml per lit (Confidor 0.05%), or Ekalux (Quinolphos) 1 ml per liter, Vertimac @ 0.03% (Abamectin @ 0.1%)) and Methomyl 40 SP (Lannate 0.2%) 1 ml per liter respectively. Fusarium wilt, a severe disease of Carnation was controlled by drenching the beds with Carbendazim (0.2%) regularly as precautionary measures.

3.4.7 Supporting

It is an important operation to get flowers with long, firm and straight stalks. Supporting carnation plants were provided through Galvanized iron (GI) nets.

3.4.8 Pinching

This is an important cultural operation to break the apical dominance, which will lead to bottom break and ultimately enhance branching and increase yield and quality. Pinching was done by removing the growing tips on 25th Nov (30 DAP), leaving 5-6 pairs of leaves from the base. Single pinching method was adopted.

3.4.9 Disbudding

Standard Carnation varieties must be disbudded. The side buds were removed as soon as possible without damaging the leaves and the stems to promote the growth of terminal flower buds, which produce quality flowers.

3.4.10 Harvesting

Harvesting of the standard Carnation was done when the petals have started to elongate outside the calyx (paint brush stage or cross bud stage). Flowers were harvested by cutting them with a sharp knife or pruning secateurs at the base of stalk, leaving 2-3 nodes on the main stem, to encourage side shoots to grow. The flowers were placed in buckets with clean water for 4-5 hours.

3.5 Collection of Experimental Data

The data were collected on various parameters of vegetative, flowering, flower quality, yield and environmental factors. Five plants were selected at random and tagged in each treatment and replication. The mean value of the data observed was taken to represent a particular genotype with respect to character.

3.5.1 Vegetative parameters

3.5.1.1 Plant height (cm)

The plant height of the tagged plants was recorded by measuring the plant from the base to tip of the plant at monthly interval. The average plant height was worked out and expressed in centimeter.

3.5.1.2 Number of shoots per plant

The total number of lateral shoots produced per plant after pinching was recorded from tagged plants at monthly interval and average was worked out.

3.5.1.3 Stem girth (mm)

The girth of stem from all the tagged plants was recorded with the help of digital vernier calipers at a point just above the ground at grand growth period. The average stem girth was worked out and expressed in millimeters.

3.5.1.4 Number of internodes per stem

By counting the number of internodes produced from the three tagged plant shoots at monthly interval average was worked out.

3.5.1.5 Internodal length (cm)

Length of internode from shoots of tagged plants at monthly intervals was measured and the average was worked out and expressed in centimeter.

3.5.1.6 Number of leaf pairs per plant

Number of leaves produced per plant was recorded from the tagged plants by counting the number at monthly interval starting from one month after pinching and the average was worked out.

3.5.1.7 Leaf length (cm)

The length of randomly selected ten leaves from each tagged plant was recorded and average was worked out and expressed in centimeters.

3.5.1.8 *Per cent* mortality of plant

The number of plants died due to fusarium wilt was recorded during entire experimental period and expressed in percentage. The diseased samples were examined to pathological tests, and it was noticed that the death of plants occur due to fusarium wilt.

3.5.2 Flower quality and yield parameters

3.5.2.1 Days taken to first flower bud initiation

Number of days taken to appearance of visible bud from the day of planting from all tagged plants was recorded and average was worked out.

3.5.2.2 Days taken to first flower bud opening

The number of days taken for flower bud opening were recorded by counting the days from bud initiation to flower bud opening. Unfolding of one or two outer petals was considered as bud opening.

a. Measuring plant height of carnation at different interval of growing period

b. Performing pinching in carnation

c. Measuring internodal length of carnation

d. Measuring leaf length of carnation

e. Paint brush stage of carnation (ready to harvest)

Plate 3.3 Measurement and recording different growth stages parameters of carnation

3.5.2.3 Bud length(cm)

To determine the bud length, manual vernier calipers were used for measurement. The average bud length was subsequently derived from five flowers cut during their peak flowering stage, with results reported in centimeters.

3.5.2.4 Bud diameter (cm)

The diameter of bud at its maximum width was recorded with the help of manual vernier calipers. Average bud diameter was worked out from the 5 cut flowers harvested at peak flowering and expressed in centimeters.

3.5.2.5 Length of flower stalk (cm)

From the point just below the bud to the point of origin of branch on the main stem at grand growth stage was measured and average was worked out from ten stems from each treatment and expressed in centimeter.

3.5.2.6 Girth of flower stalk (mm)

Girth of flower stalk was recorded with the help of digital vernier calipers at middle of flower stalk. Average of the ten randomly selected flower stalks' girth was expressed in millimeters.

3.5.2.7 Flower diameter (cm)

The diameter of flowers was measured at the full bloom stage. Five cut flowers were randomly selected during peak flowering. Each flower was harvested carefully for uniformity. The diameter was measured across the widest part of the bloom. Measurements were taken using a centimeter scale. The average diameter was calculated and expressed in centimeters.

3.5.2.8 Number of petals per flower

Destructive sampling was carried out for petal count analysis. Five flowers were randomly selected from each treatment. The selected flowers were carefully dissected. Individual petals were manually counted for each flower. The total number of petals per flower was recorded. An average was calculated and expressed as number of petals per flower.

3.5.2.9 Fresh weight of flower (g)

Flowers were collected from previously tagged plants. Five flowers were randomly selected for weight measurement. Each flower weighed individually using a digital balance. The total weight of five flowers was summed up, and average was expressed in grams.

3.5.2.10 Vase life (days)

The flower stems were harvested when buds were at paint brush stage during early morning hours. Immediately the flowers were kept in fresh water for 2-3 hours to remove the field heat. Later, these cut flower stalks were cut again to have a uniform stem length of 30 cm. After that, the flowers were kept in conical flasks containing 500 ml tap water. Flowers were monitored daily until they were found unfit for containing in vase. Fading of outer row petals was considered as end of vase life of flowers and vase life is expressed in days.

3.5.2.11 Calyx splitting (%)

The number of flowers whose sepals were split open was recorded from each treatment and expressed in percentage. For statistical analysis data were transformed by using transformation Y= (X + 0.5) 1/2 since there was zero value in data.

3.5.2.12 Number of flowers/plant/year

Number of flowers harvested from the labeled plants was recorded, average was worked out and expressed in number.

3.5.2.13 Number of flowers/m^2/year

The number of flowers harvested from each plant was recorded as the yield per plant. Based on the yield per plant, yield per sq. m was calculated for the period of 6 months from the commencement of flowering up to the end of the period of investigation.

3.6 Benefit-cost ratio analysis

The economics of gerbera cultivation in poly house (560 m^2) was worked out for one year using standard method suggested by NCPA (National Council for use of Plastic in Agriculture), (Anon, 1995). The details of the economics are presented in ANNEXURE-III.

3.6.1 Gross return

The gross income was worked out based on the prevailing market price (Rs. 4/- per flower) and expressed in rupees per 560 m^2 per year.

$$\text{Gross return} = \text{Total Production (Quantity)} \times \text{Value (Rs.)}$$

3.6.2 Net return

The net income per 560 m^2 per year was calculated by subtracting the cost of cultivation from the gross income and expressing it in rupees per 560 m^2 per year.

$$\text{Net return} = \text{Gross return - Cost of cultivation}$$

3.6.3 Benefit cost ratio

The benefit-cost ratio was worked out by using the following formula.

$$\text{Benefit : Cost ratio (B: C)} = \frac{\text{Net Return (Rs./m}^2\text{)}}{\text{Cost of Cultivation (Rs./m}^2\text{)}}$$

3.7 Environmental parameters

The data of various environmental parameters like temperature, relative humidity, precipitation, etc. were collected from the Department of Agricultural Meteorology, College of Agriculture, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya and illustrated in ANNEXTURE-I.

3.8 Statistical analysis

3.8.1 Analysis of variance

Variance is the measure of variability and is defined as the average of the square deviation from the mean. It helps in working out the variance due to different source and also provides the basis for test of significant (Singh and Choudhary 1979).

Analysis of variance was carried out as per the procedure given by Panse and Sukhatme (1967) using the mean values of random plants in each replication from all treatments to find out the significance of treatment effect.

Source of Variation	d.f.	Sum of Squares	Mean Sum of Squares	F value
Treatments	(t-1)	TrSS	TrMS = TrSS/(t-1)	TrMS/EMS
Error	t(r- 1)	ESS	EMS = ESS/t(r - 1)	
Total	(rt - 1)	TSS		

Where,

TrSS = Treatment Sum of Squares
ESS = Error Sum of Squares
EMS = Error Mean Sum of Squares
TrMS = Treatment Mean Sum of Squares
TSS (Total) = Total Sum of Squares
t = treatment
r = number of replications

3.8.2 Critical difference

In order to compare the means of entries, the critical difference (CD) was calculated by using the following formula.

CD = SE × 't' value at error degrees of freedom.

Where SE = $\sqrt{\frac{2 \times \text{Error MS}}{\text{r}}}$

t = Tabulated 't' value at 5 *per cent* level.

RESULTS AND DISCUSSION

The experimental results of the present study on "Evaluation of carnation (*Dianthus caryophyllus* L.) varieties under shade net condition of Eastern U.P." were undertaken during the year 2024-25 at Technology Park, Horticulture block, Floriculture unit, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya are furnished in this chapter under the following subheadings.

4.1 Vegetative parameters

4.2 Flower quality and Yield parameters

4.1 Vegetative parameters

4.1.1 Plant height (cm)

The data regarding the plant height at different stages of crop growth viz., 30,60,90,120,150 and 180 days after in different carnation varieties are presented in Table 4.1 and Fig. 4.1.

Monthly variation in plant height was significant throughout the growth period among the different carnation varieties. The variety Kiro was found to be superior compared to rest of the varieties. Plant height at 30 DAP varied significantly among different varieties ranging from 15.33 cm to 19.01 cm. The variety Baltico recorded the highest plant height (19.01 cm) and was superior to all. It was followed by Dorian (18.91cm) and Kiro (18.33 cm) whereas, the least plant height was noticed in the variety Purple Sky (15.33 cm).

Similarly at 60 DAP plant height ranged between 27.45 cm to 32.32 cm. The variety Kiro (32.32 cm) recorded highest plant height, it was at par with Dorian (32.28cm) and Master (32.14 cm), respectively while, lowest was recorded in the Purple Sky (27.45 cm).

Plant height ranged between 33.07 cm and 48.78 cm at 90 DAP. Significantly the highest plant height was recorded in the variety Kiro (48.78 cm) whereas, Master (47.21cm) and Baltico (46.37cm) respectively, was found at par with respect to their plant height. The lowest plant height was recorded in Cervantes (33.07 cm).

At 120 DAP the variety Kiro showed continued the highest plant height (74.00 cm) which was significantly at par with Baltico (72.53cm) and Master (72.20cm), respectively. The lowest plant height was noticed in Variety Cervantes (44.47cm). At 150 DAP the variety Kiro showed continued the highest plant height (91.40 cm) which was significantly at par with Master (90.07cm) and Baltico (88.40cm), respectively. The least plant height was found in Variety Cervantes (62.80cm). Similarly, at 180 DAP the variety Master showed the highest plant height (101.53 cm) which was statistically at par with Kiro and Baltico (100.07 and 96.20cm, respectively), whereas shortest plant height was observed in Variety Cervantes (79.40cm).

Variations with respect to plant height among the genotypes could be attributed mainly to the genetic make-up of the genotype as well as influence of the growing environmental conditions, production technology and cultural practices. This is in accordance with the reports of Chauhan *et al*. (2014) in carnation. Anand *et al.* (2021) found a range of 81.89 (Gioele) cm to 100.50 cm (Happy Golem) and Tarannam *et al.* (2014) found a range of 56.96 cm to 111.13 cm 8 genotypes of carnation. This variability in plant height among the carnation cultivars is mainly due to genetic nature, growing environmental conditions, production technology and cultural practices.

4.1.2 Number of leaf pairs per plant

The data regarding the Number of leaf pairs per plant at different stages of crop growth viz., 30,60,90,120,150 and 180 days after in different carnation varieties are presented in Table 4.2 and Fig. 4.2. which varied significantly within the varieties.

The variety Master registered the maximum number of leaf pair per plant (36.50, 51.26, 55.63, 63.22 and 76.85 respectively) throughout the growing period *viz*., 30, 60, 90, 120 and 150 DAP, respectively and was superior to other varieties and which was statistically at par with variety Kiro (35.00, 49.83, 53.10,61.65 and 73.82, respectively) at 30, 60, 90, 120 and 150 DAP and Purple Sky (40.61, 48.88, 52.85 and 65.80) at 60,90,120 and 150 DAP, respectively. The minimum number of leaf pair per plant was recorded in the variety Cervantes (21.80, 23.78, 33.99, 38.09 and 39.89) at following (30, 60, 90, 120 and 150 DAP, respectively).

Similarly, at 180 DAP the variety Kiro showed the highest number of leaf pair per plant (88.99) which was statistically at par with Master and Vanity (80.69 and 70.10, respectively), whereas lowest number of leaf pairs per plant was observed in Variety Cervantes (42.31).

Similar results were obtained Medeo *et al.* (2019) recorded maximum 82.83 leaf pairs per plant in carnation cultivar Kino and also, Jose *et al.* (2017) found range of 64.74 to 84.73 number of leaf pairs per plant. This might be due to taller plant, increased number of secondary shoots, number of nodes and the congenial microclimate that prevailed inside the polyhouse, favouring increased growth rate of plants.

4.1.3 Number of shoots per plant

The data on number of shoots produced per plant after pinching in different varieties of carnation were recorded at different stages of plant growth are presented in Table 4.3 and Fig. 4.3.

Number of shoots per plant recorded at 30 days after planting varied least significantly among different varieties. The number of shoots per plant was maximum in variety Kiro (5.66), Vanity (5.64) and Purple Sky (5.35) whereas, it was minimum in Cervantes (3.15) and Dorian (4.50) which were found on par with each other.

Numbers of shoots per plant was recorded at 60 DAP, variety Kiro which recorded maximum number of shoots per plant (5.99) and was followed by Master (5.89) and Purple Sky (5.82). The minimum number of shoots per plant was registered in Cervantes (4.00).

At 90, 120, 150 and 180 DAP significant and maximum number of shoots per plant (6.15,6.41, 7.08 and 7.2, respectively) was registered in the Kiro followed by Master 6.30 and 6.82 respectively), Purple Sky (6.21 and 6.51, respectively) at 120 and 150 DAP and were found at par with each other whereas, minimum was recorded in Cervantes (4.47,4.72, 5.20 and 5.50, respectively).

These results are similar to those of the findings of Maitra and Roychowdhury (2014), Chauhan *et al*. (2014), Tarannum and Naik (2014), in carnation. Gharge *et al.* (2011) recorded a maximum 7.64 shoots in carnation cultivar Yello Firato. Mehmood *et al*. (2014) recorded a range of 3.7 to 6.3 shoots in carnation cultivars grown under lath house. Similar

reports were quoted by Tarannum *et al.* (2014) 6.80 (Soto) and Anand *et al.* (2021) 7.98 (Gioele) in different carnation cultivars.

Table 4.1 Plant height of different carnation varieties grown in shade net conditions at monthly interval

Growth stages / Varieties	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
Purple Sky	15.33	27.45	41.18	69.47	81.13	95.80
Master	17.66	32.14	47.21	72.20	90.07	101.53
Kiro	18.33	32.32	48.78	74.00	91.40	100.07
Baltico	19.01	30.63	46.37	72.53	88.40	96.20
Vanity	17.25	30.49	41.93	71.40	86.40	94.07
Dorian	18.91	32.28	41.80	52.73	71.67	85.87
Domingo	18.17	30.85	36.00	51.67	63.87	80.40
Star	17.09	30.10	34.07	54.80	67.40	78.33
Cervantes	18.14	30.92	33.07	44.47	62.80	79.40
CD @ 5%	0.5	0.5	2.4	1.0	1.7	1.6
SE(m)±	0.2	0.2	0.8	0.3	0.6	0.5

Table 4.2 Number of leaf pairs per plant of different carnation varieties grown in shade net conditions at monthly interval

Growth Stages / Varieties	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
Purple Sky	28.10	40.61	48.88	52.85	65.80	69.85
Master	36.50	51.26	55.63	63.22	76.85	80.69
Kiro	35.00	49.83	53.10	61.65	73.82	80.99
Baltico	27.60	31.80	37.89	43.36	49.52	54.89
Vanity	29.40	39.70	47.39	44.90	67.28	70.10
Dorian	26.10	29.80	35.20	43.01	47.29	55.20
Domingo	24.60	32.58	34.55	42.41	48.25	46.89
Star	25.10	33.00	36.41	41.25	44.25	51.36
Cervantes	21.80	23.78	33.99	38.09	39.89	42.31
CD @ 5%	1.6	1.6	2.6	2.4	2.4	2.5
SE(m)±	0.5	0.5	0.9	0.8	0.8	0.9

Table 4.3 Number of shoots per plant of different carnation varieties grown in shade net conditions at monthly interval

Growth stages / Varieties	30 DAP	60 DAP	90 DAP	120 DAP	150 DAP	180 DAP
Purple Sky	5.35	5.82	6.01	6.21	6.51	6.89
Master	4.98	5.89	6.00	6.30	6.82	7.10
Kiro	5.66	5.99	6.15	6.41	7.08	7.21
Baltico	4.99	5.36	5.32	6.11	6.45	7.00
Vanity	5.64	5.78	5.68	6.00	6.37	6.74
Dorian	4.50	5.20	5.45	5.89	6.40	6.52
Domingo	5.00	5.60	5.89	6.12	6.20	6.91
Star	5.03	5.00	5.32	5.23	5.90	6.22
Cervantes	3.15	4.00	4.47	4.72	5.20	5.50
CD @ 5%	0.3	0.3	0.2	0.3	0.3	0.3
SE(m)±	0.1	0.1	0.1	0.1	0.1	0.1

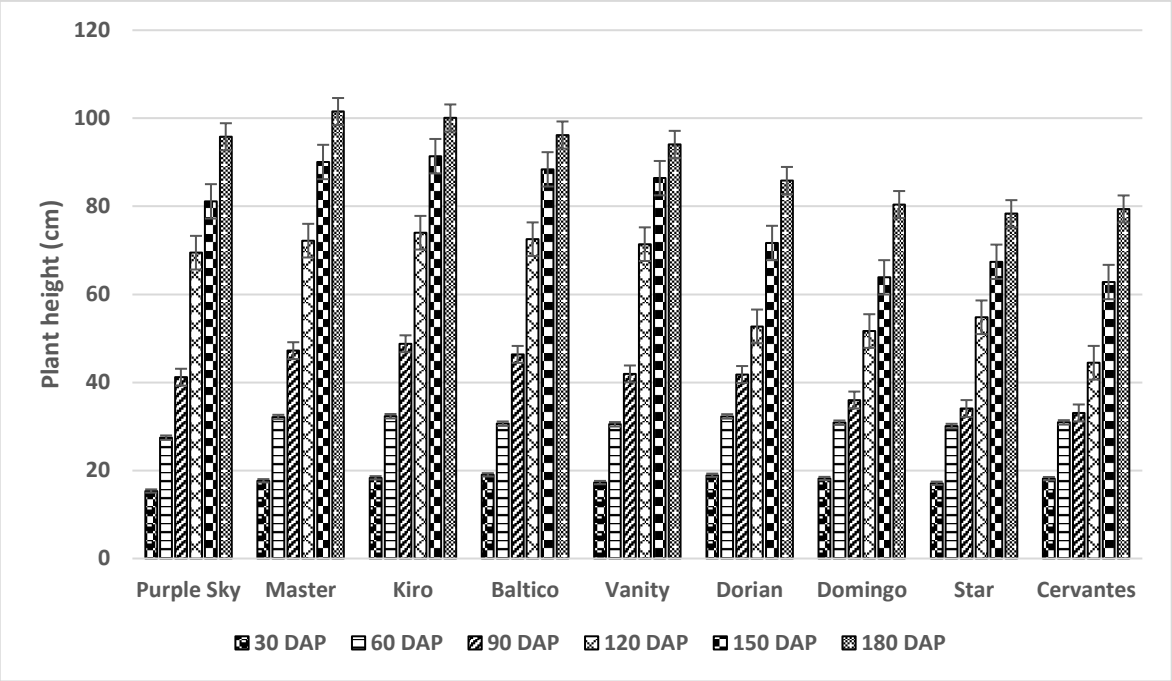

Fig. 4.1 Plant height of different carnation varieties grown in shade net conditions at monthly interval

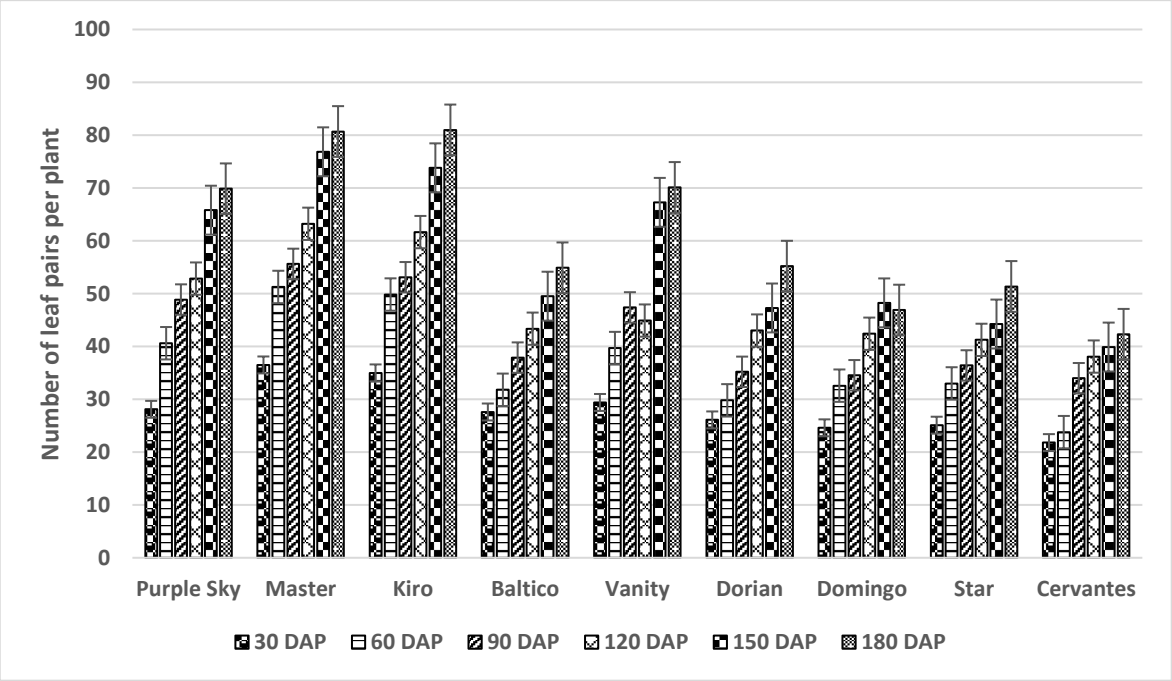

Fig. 4.2 Number of leaf pairs per plant of different carnation varieties grown in shade net conditions at monthly interval

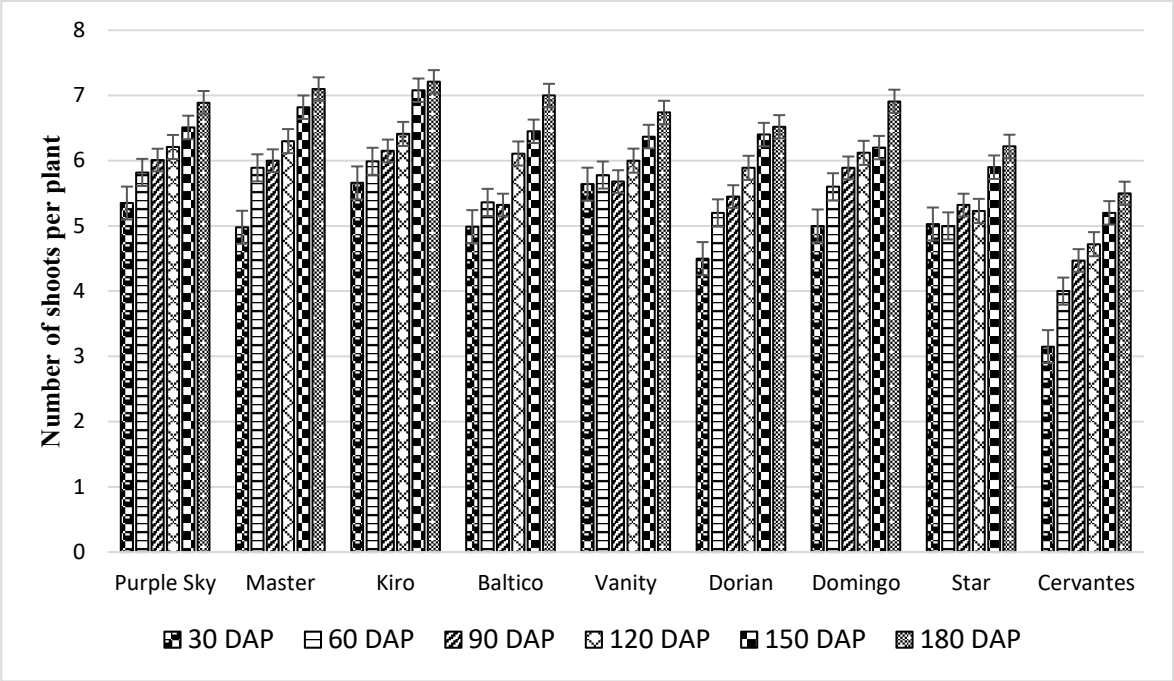

Fig. 4.3 Number of shoots per plant of different carnation varieties grown in shade net conditions at monthly interval

4.1.4 Stem girth (mm)

At a glance of the results of stem girth is presented in Table 4.4 and Fig. 4.4, the varieties showed significant differences with respect to the stem girth. Maximum (7.39mm) stem girth was recorded by Purple Sky which is statistically at par with Vanity (6.97mm) and Baltico (6.91 mm) whereas, the minimum stem girth was showed by Star (6.09mm).

The results are in accordance with the earlier findings of Mehmood *et al.* (2014) found a range of 3.63 mm to 6.21 mm of stem girth of different carnation cultivars grown under lath house. These findings are in line with results obtained previously in different carnation cultivars by Roni *et al.* (2014) Red Carpet (5.0), Shiragur (2002), Gharge *et al.* (2009) and Tarannum *et al*. (2014). Thicker stems indicated that these cultivars have higher capacity of storing reserve food material.

4.1.5 Number of internodes per stem

The data regarding the number of internodes per stem is presented in Table 4.4 and Fig. 4.5.

Significant differences were observed with respect to number of internodes per stem which ranged from 12.93 to 14.27. The variety Dorian was recorded maximum (14.27) number of internodes per stem which statistically at par with Domingo (14.10) and Cervantes (14.07). Whereas, Kiro showed least number of internodes per stem (12.93).

These findings are in line with the results obtained previously by Mehmood *et al.* (2014) recorded as same maximum number of internodes (12.66) in carnation cultivar Nelson. Similar variations in number of internodes have been recorded earlier in carnation as reported by Patil (2001) and Tarannum *et al.* (2014). These differences in number of internodes per stem may be due to varietal characters.

4.1.6 Internodal length (cm)

The data regarding the internodal length is presented in Table 4.5 and Fig. 4.6. Significant variation was found among the varieties with respect to internodal length. It was ranged from minimum (4.58cm) in Kiro to maximum (6.64) in Cerventes followed by Vanity (5.94cm) and Dorian (5.59).

These findings are in line with the results obtained previously by Jose *et al.* (2017), Patil (2001), Gharge *et al.* (2009) and Tarannum *et al.* (2014) in carnation. Kumar and Singh (2003) recorded smallest length of internodes in double pinched carnation plants and longer internodal length in no pinched plants and he concluded that internodal length is inversely related to the number of pinching and method of pinching.

Table 4.4 Stem girth and number of internodes of different carnation varieties grown in shade net conditions

Parameters / Varieties	Stem Girth	No. of Internode
Purple Sky	7.39	13.67
Master	6.40	13.80
Kiro	6.55	12.93
Baltico	6.91	13.20
Vanity	6.97	13.67
Dorian	6.69	14.27
Domingo	6.71	14.10
Star	6.09	13.73
Cervantes	6.87	14.07
CD @ 5%	0.7	0.6
SE(m)±	0.2	0.2

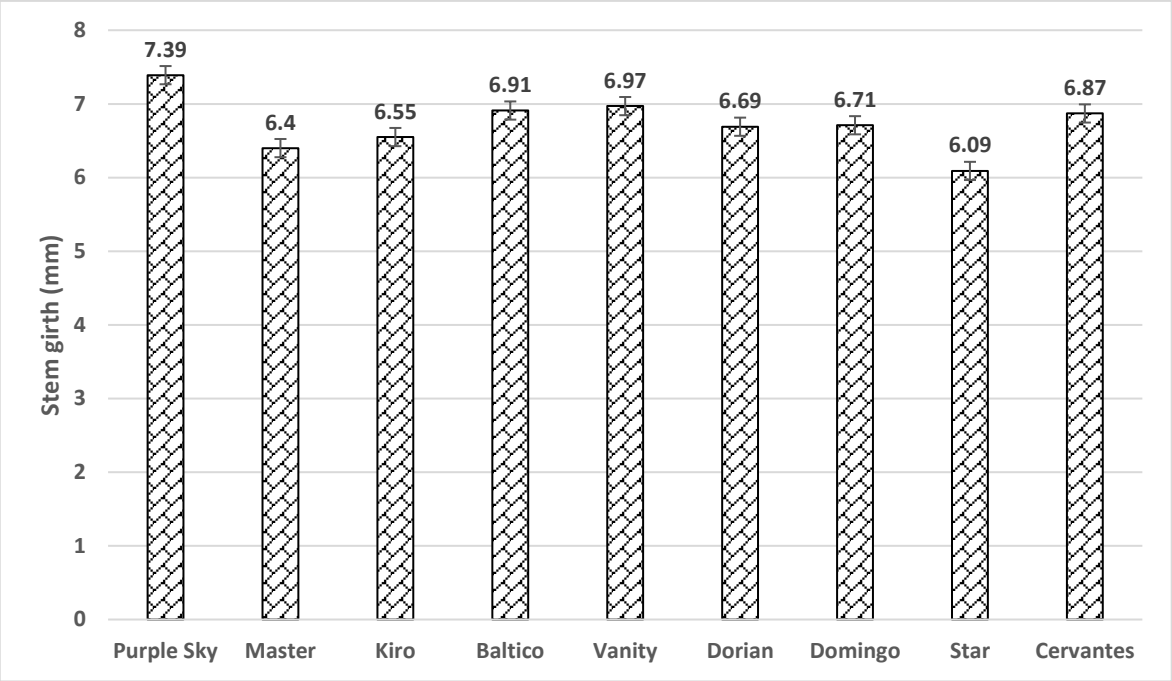

Fig. 4.4 Stem girth of different carnation varieties grown in shade net conditions

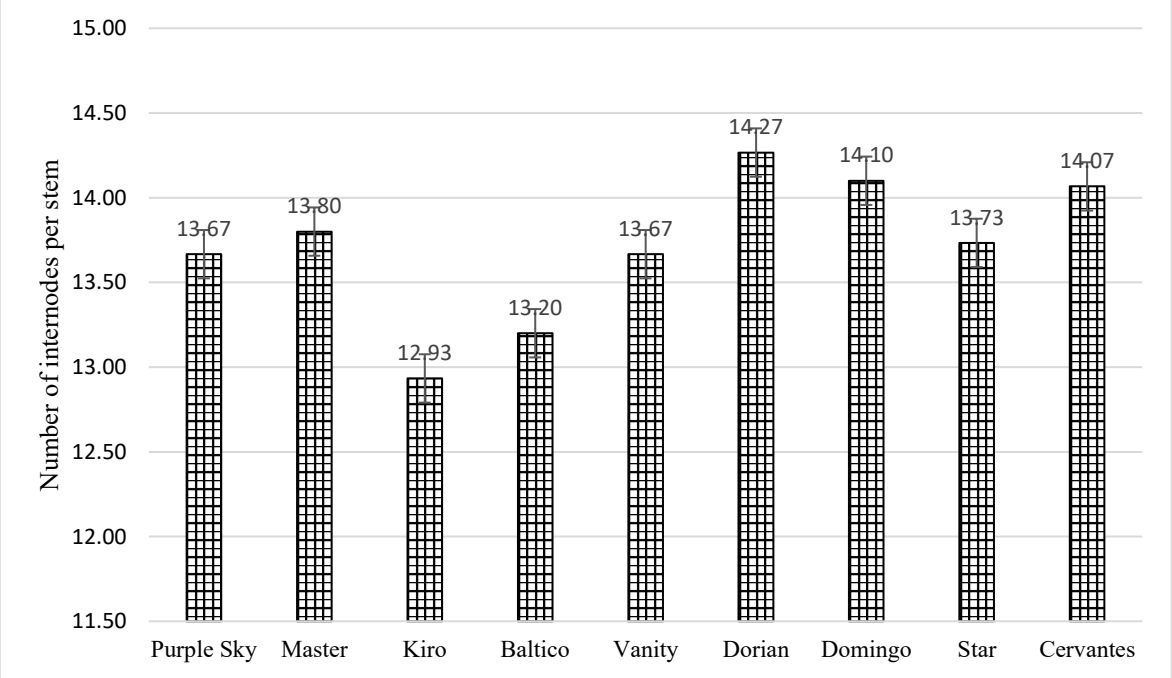

Fig. 4.5 Number of internodes per stem of different carnation varieties grown in shade net conditions

4.1.7 Leaf length (cm)

The data regarding the leaf length is presented in Table 4.5 and Fig. 4.7. The varieties showed significant differences with respect to leaf length. The range was obtained from 10.51cm to 13.55cm. Vanity showed minimum (10.51cm) while Domingo showed maximum (13.55cm) followed by Dorian (13.01cm).

This was in line with the results reported by Maitra and Roychowdhury (2013), Patil (2001), Gharge *et al.* (2009) and Tarannum *et al.* (2014). The results are in agreement with the findings of Kumar and Singh (2003).

4.1.8 *Per cent* mortality of plants

The data regarding the per cent mortality of plants is presented in Table 4.5 and Fig. 4.8. A wide significant difference in per cent mortality of plants was noticed among the varieties. It was ranged from minimum 0 in Kiro, Vanity and Star to maximum 48 in Domingo.

Mortality of the plants due to fusarium wilt was observed and variation in mortality among cultivars might be attributed to variation in response of cultivar to pathogen. Similar variation among the varieties has been reported previously in Carnation by Ben Yephet *et al.* (1993), Patil (2001), Sathisha (1997), Shiragur (2002) and Gharge *et al.* (2009).

Table 4.5 Internodal length, leaf length and *per cent* mortality of plants of different carnation varieties grown in shade net conditions

Parameters / Varieties	Internodal Length	Leaf length	*Per cent* mortality of plants
Purple Sky	5.25	12.31	4
Master	5.17	12.50	12
Kiro	4.58	11.10	0
Baltico	5.08	12.08	18
Vanity	5.94	10.51	0
Dorian	5.59	13.01	24
Domingo	5.19	13.55	48
Star	5.47	11.34	0
Cervantes	6.64	14.6	46
CD @ 5%	0.9	0.34	1.0
SE(m)±	0.3	0.11	0.3

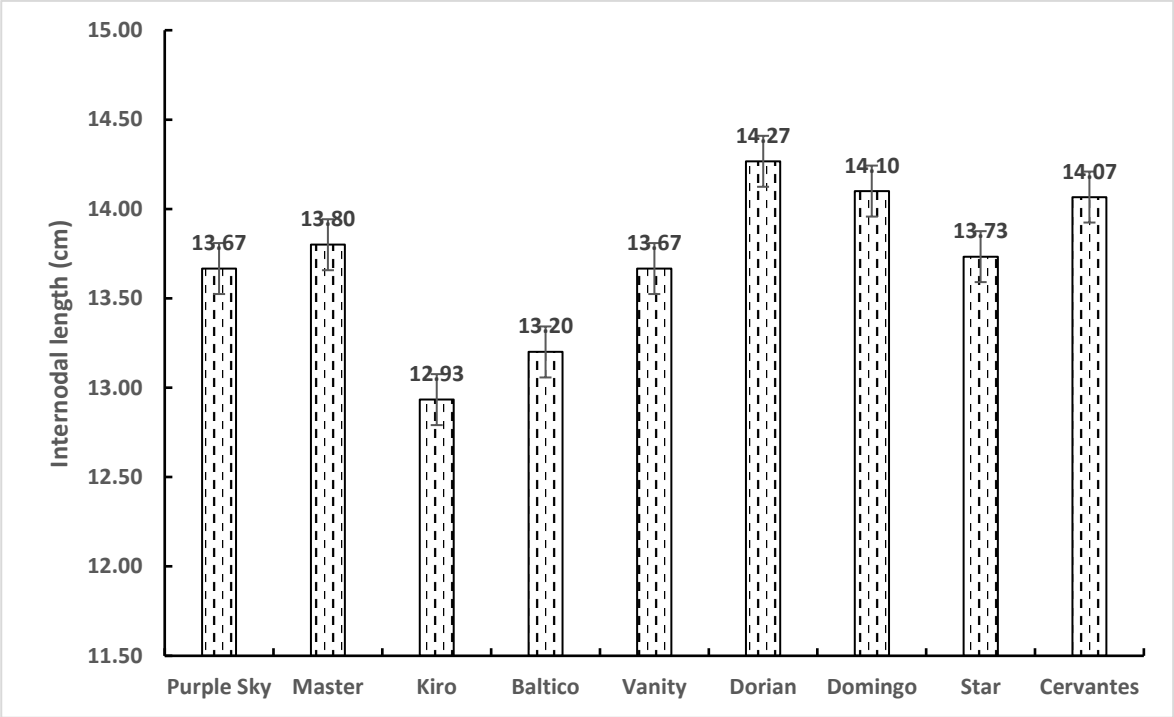

Fig. 4.6 Internodal length of different carnation varieties grown in shade net conditions

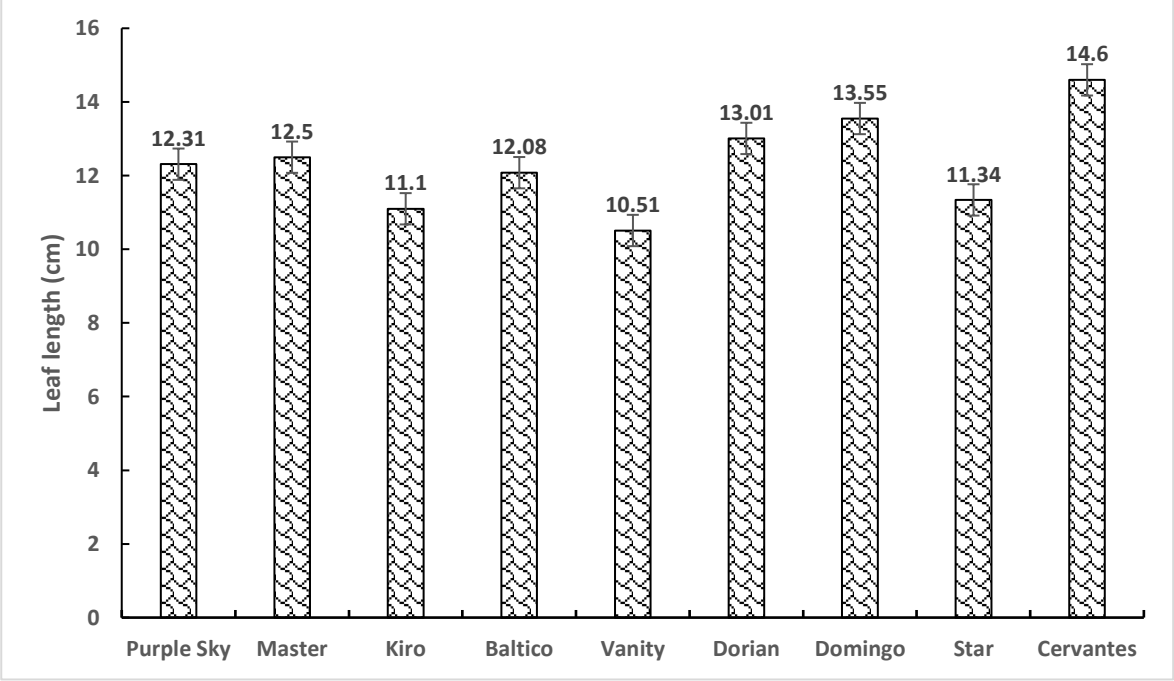

Fig. 4.7 Leaf length of plants of different carnation varieties grown in shade net conditions

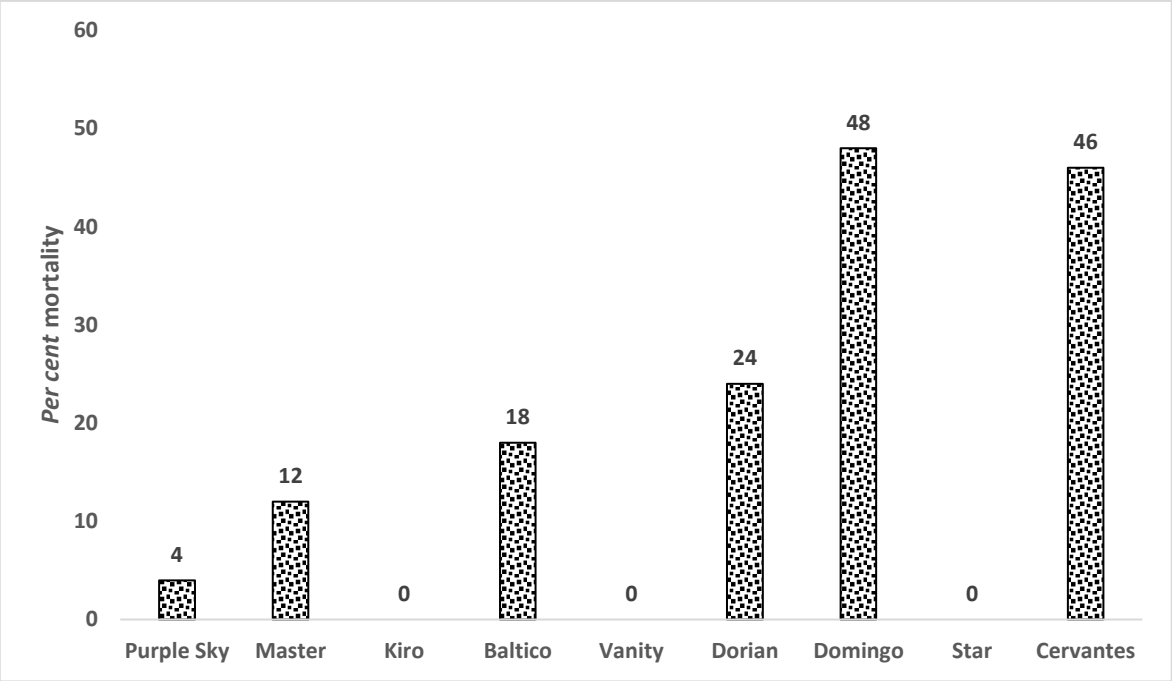

Fig. 4.8 *Per cent* mortality of plants of different carnation varieties grown in shade net conditions

4.2 Flower Quality and Yield Parameters

4.2.1 Days taken to first flower bud initiation

The data regarding the days taken to first flower bud initiation is presented in Table 4.6 and Fig. 4.9. Significant differences were observed with respect to days taken to first flower bud initiation which ranged from 98.33 days to 120.29 days.

The variety Cervantes was the first to show its visible flower bud by taking (98.33 days) which was on par with Domingo (100.10 days) after pinching and significantly differed over other cultivars. The variety Baltico (120.29 days) was last to initiate flower buds which statistically at par with Master (118.25 days) and Vanity (116.67 days), respectively.

Similar variations due to cultivars were also observed by Medeo *et al.* (2019), Patil (2001), Shiragur *et al.* (2004), Dalal *et al.* (2009), Gharge *et al.* (2009), Chauhan *et al.* (2014) and Tarannum *et al.* (2014).

4.2.2 Days taken to first flower bud opening

The data regarding the days taken to first flower bud opening is presented in Table 4.6 and Fig. 4.10.

Significant differences were observed with respect to days taken to first flower bud opening which ranged from 124.81 days to 142.08 days. The variety Cervantes was the earliest to open its flower buds by taking (124.81 days) which was at par with by Domingo (129.84 days) whereas, Baltico (142.08 days), Master (139.10 days) and Vanity (138.18 days) were late for flower bud opening. However, variety Purple Sky (134.89 days) and Dorian (132.08 days) were medium in their time to show the opened flower buds.

The result is in accordance with the findings by Medeo *et al.* (2019), Patil (2001) and Shiragur *et al.* (2002). These variations might be attributed to genetical makeup and physiological differences among the genotypes as reported by Gharge *et al.* (2009) and Tarannum *et al.* (2014).

4.2.3 Bud length (cm)

The data regarding the bud length is presented in Table 4.6 and Fig. 4.11. **S**ignificant differences were seen among varieties for bud length which is ranged from 2.07 cm to 2.84 cm. The maximum bud length (2.84 cm) was recorded in Cervantes followed by Star (2.77 cm). Whereas, Purple Sky showed minimum bud length (2.07 cm).

The present investigations are in line with the findings of Medeo *et al.* (2019), Maitra and Roychowdhury (2013) and Roni *et al.* (2014).

Table 4.6 Days taken to first flower bud initiation, days taken to first flower bud opening, bud length and bud diameter of different carnation varieties grown in shade net conditions

Parameters / Varieties	Days taken to first flower bud initiation	Days taken to first flower bud opening	Bud length	Bud diameter
Purple Sky	112.29	134.89	2.07	1.61
Master	118.25	139.10	2.21	1.73
Kiro	115.33	135.59	2.52	1.87
Baltico	120.29	142.08	2.65	1.71
Vanity	116.67	138.18	2.35	1.86
Dorian	111.80	132.05	2.20	1.83
Domingo	100.10	129.84	2.38	2.05
Star	113.67	135.81	2.77	2.01
Cervantes	98.33	124.81	2.84	1.84
CD @ 5%	2.1	1.8	0.3	0.2
SE(m)±	0.7	0.6	0.1	0.1

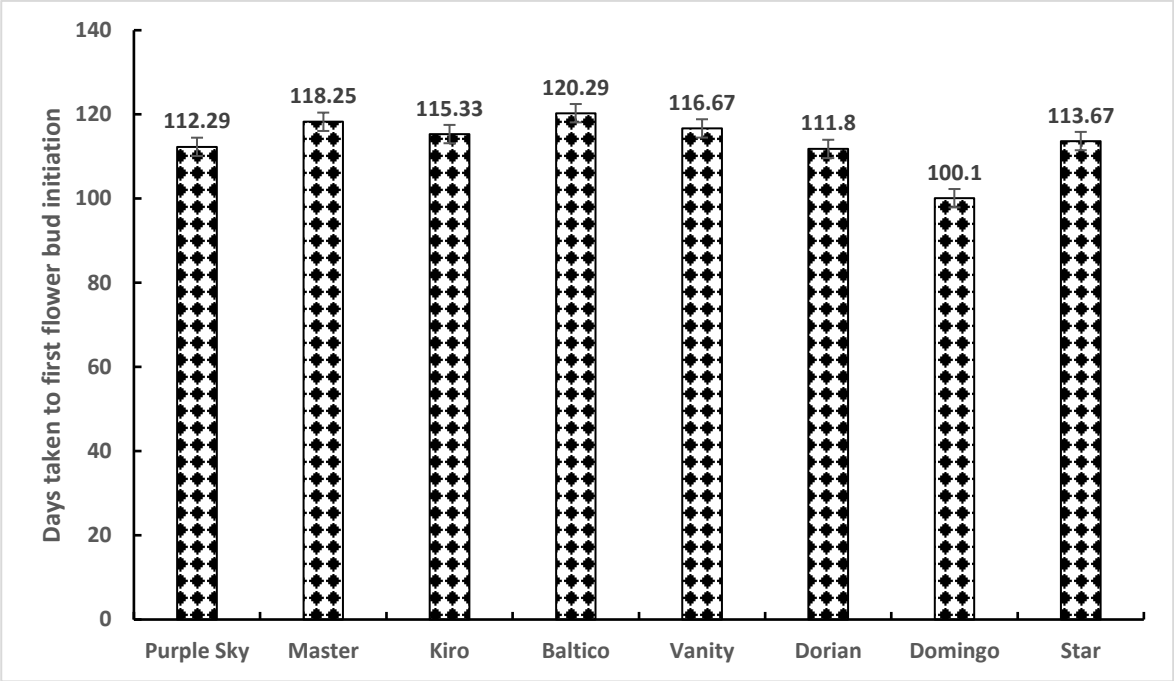

Fig. 4.9 Days taken to first flower bud initiation of different carnation varieties grown in shade net conditions

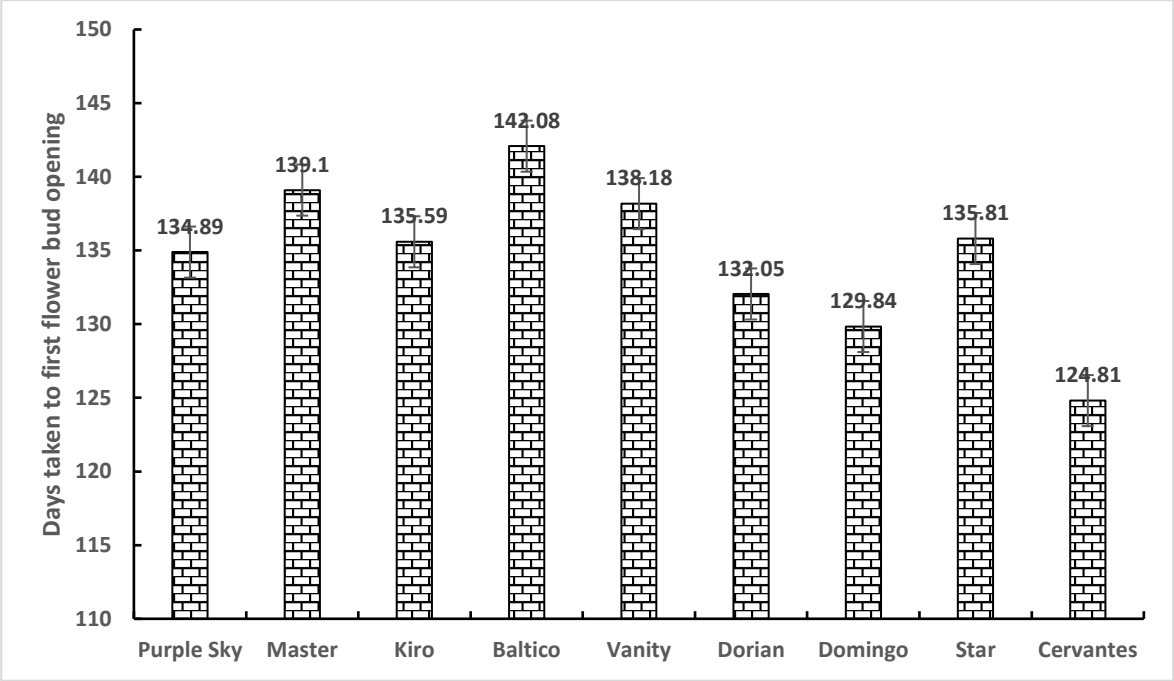

Fig. 4.10 Days taken to first flower bud opening of different carnation varieties grown in shade net conditions

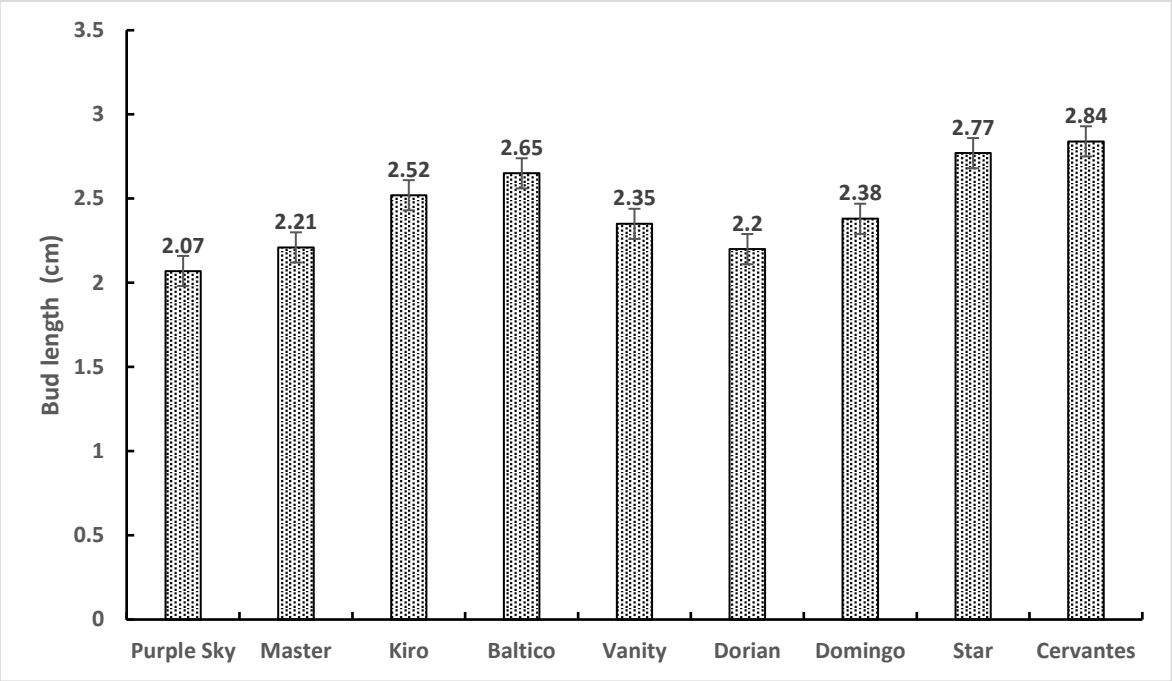

Fig. 4.11 Bud length of different carnation varieties grown in shade net conditions

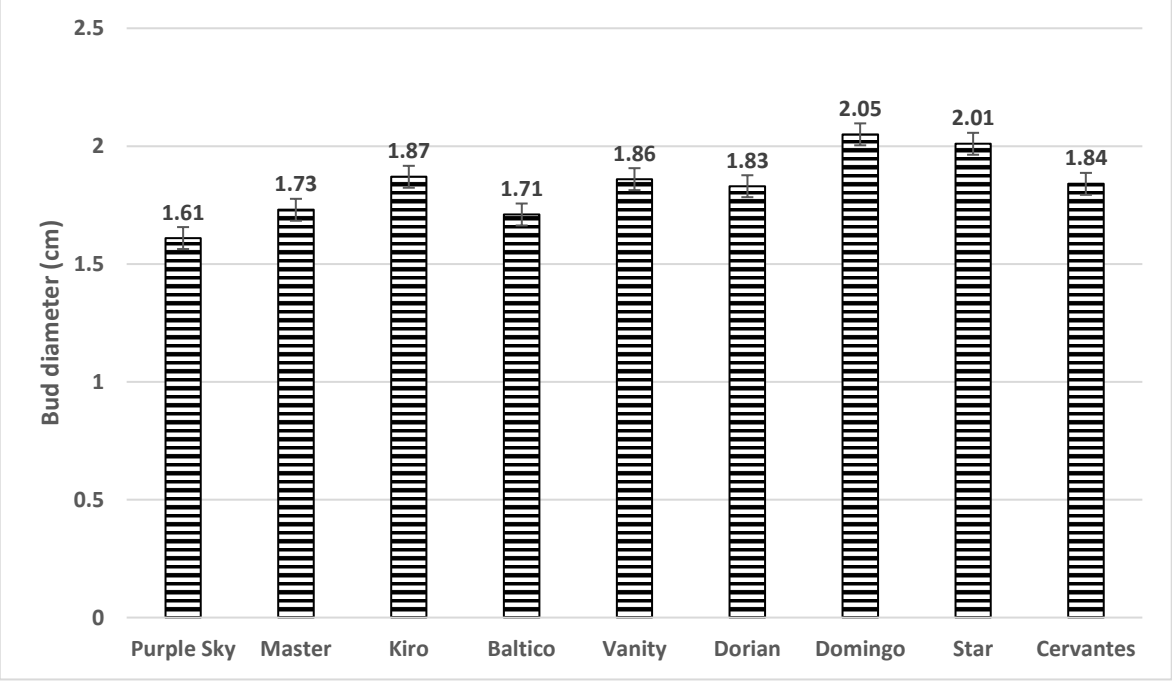

Fig. 4.12 Bud diameter of different carnation varieties grown in shade net conditions

4.2.4 Bud diameter (cm)

The data regarding the bud diameter is presented in Table 4.6 and Fig. 4.12. Significant differences were noticed among the varieties for bud diameter which ranged from 1.61 cm to 2.05 cm. It was maximum in variety Domingo (2.05cm) and was followed by variety Star (2.01cm). The variety Purple Sky observed minimum bud diameter (1.61cm).

Similar variations in bud and flower diameter among the genotypes have been reported previously by Singh *et al*. (2013), Maitra and Roychowdhury (2014), Tarannum and Naik (2014) in carnation. Jose *et al.* (2017) and Medeo *et al.* (2019) also recorded the same finding as presented in the investigation.

4.2.5 Length of flower stalk (cm)

The data regarding the length of flower stalk is presented and furnished in Table 4.7 and Fig. 4.13. Varying amount of differences was recorded among the different carnation varieties for length of flower stalk. It was maximum in the variety Master (89.23 cm) which was on par with Kiro (88.04 cm). While Cervantes showed minimum length of flower stalk 59.83 cm.

The difference in stalk length among the cultivars may be due attributed to the inherent genetic character associated with the cultivars and also due to the growing environmental conditions as reported by Jose *et al.* (2017), Anand *et al.* (2021) and Tarannum *et al.* (2014).

4.2.6 Girth of flower stalk (mm)

Stalk girth varied significantly among the different carnation varieties. The data regarding the girth of flower stalk is presented in Table 4.7 and Fig. 4.14. It was maximum in the variety Domingo (5.67mm) followed by Cervantes (5.13 mm) and Purple Sky (5.10 mm) and were at par with each other. While Master noticed minimum girth of flower stalk 4.23 mm.

Girth of flower stalk also plays a vital role in making the flower suitable for export standards. Flower stalks as evidence from the stalk girth which might be due to the genetical constitution of the cultivars. Similar variation in stalk girth among cultivars was also

reported previously in carnation by Anand (2021), Tarannum *et al.* (2014) and Mehmood *et al*. (2014).

4.2.7 Flower diameter (cm)

Significant differences were noticed among the varieties for flower diameter which ranged from 5.81 cm to 7.12 cm. The data regarding the flower diameter is presented in Table 4.7 and Fig. 4.15. Baltico had maximum (7.12 cm) flower diameter followed by Vanity (7.11 cm) and Domingo (6.55 cm) whereas, it was minimum in Purple Sky (5.81 cm). However, the variety Cervantes (6.18 cm), Dorian (6.17 cm) and Kiro (5.95 cm) were found on par with each other. Similarly, variations in flower diameter among the carnation cultivars have been reported previously by Singh *et al.* (2014), Sarkar and Sharma (2016), Maitra and Roychowdhury (2013) and Medeo *et al.* (2019).

4.2.8 Number of petals per flower

Significant variation was noticed among the varieties with respect to number of petals per flower which ranged from 47.03 to 73.35. The data regarding the number of petals per flower is presented in Table 4.7 and Fig. 4.16. The maximum number of petals per flower was recorded in variety Domingo (73.35) which was followed by Purple Sky (72.52) and Vanity (71.56). Whereas, Star had minimum (47.03) petals per flower, it was at par with Baltico (49.23) and Dorian (51.06), whereas Cervantes (67.83) produced moderate number of petals per flower.

Being a genetically controlled character, and the ability to take nutrients efficiently may had significant role in producing number of petals per flower in different genotypes. Similar variations have also been recorded previously in carnation by Shamanth (2016), Pralhad (2009), Gharge *et al.* (2009) and Tarannum *et al.* (2014).

Table 4.7 Length of flower stalk, girth of flower stalk, flower diameter and number of petals per flower of different carnation varieties grown in shade net conditions

Parameters / Varieties	Length of flower stalk (cm)	Girth of flower stalk (mm)	Flower diameter (cm)	No. of petals
Purple Sky	80.95	5.10	5.81	72.52
Master	89.23	4.23	5.83	55.68
Kiro	88.04	5.04	5.95	52.52
Baltico	80.51	4.28	7.12	49.23
Vanity	82.06	4.43	7.11	71.56
Dorian	70.22	4.79	6.17	51.06
Domingo	62.52	5.67	6.55	73.35
Star	63.14	4.40	6.54	47.03
Cervantes	59.83	5.13	6.18	67.83
CD @ 5%	1.4	0.8	0.6	1.9
SE(m)±	0.5	0.3	0.2	0.6

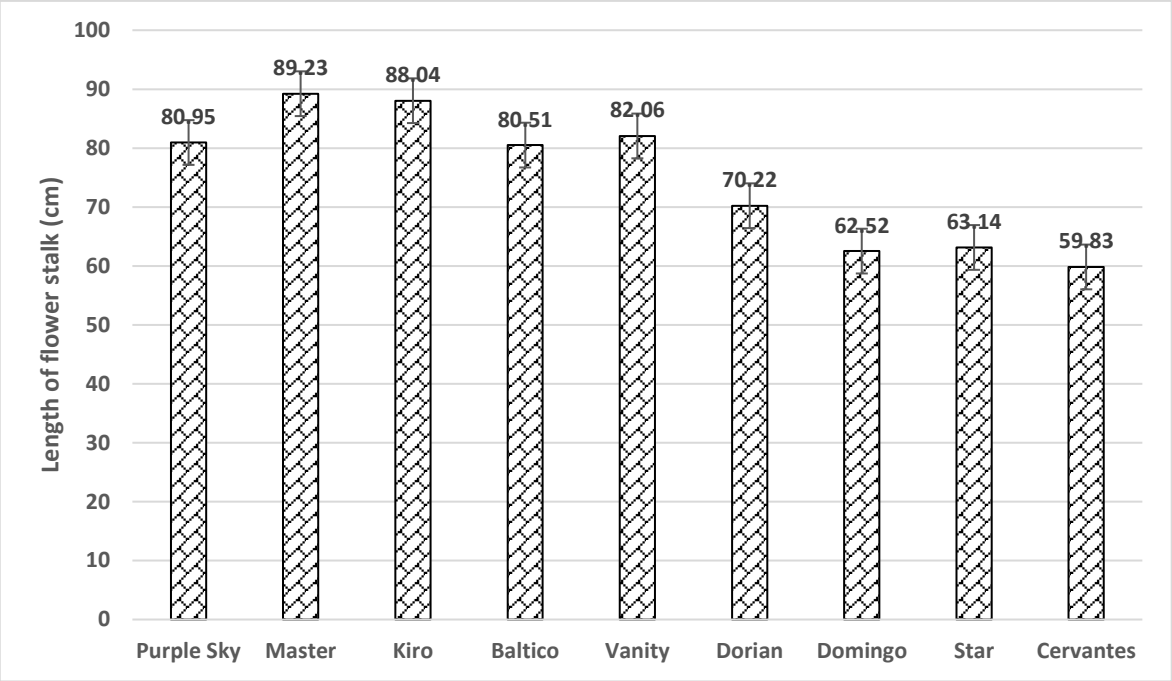

Fig. 4.13 Length of flower stalk of different carnation varieties grown in shade net conditions

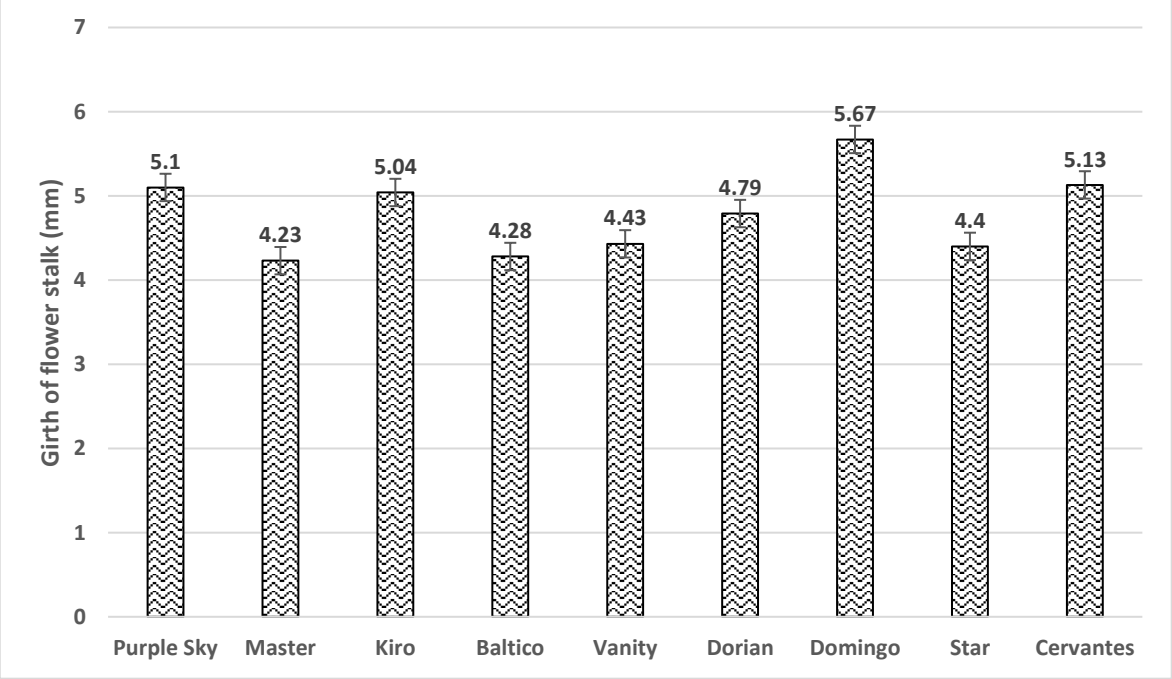

Fig. 4.14 Girth of flower stalk of different carnation varieties grown in shade net conditions

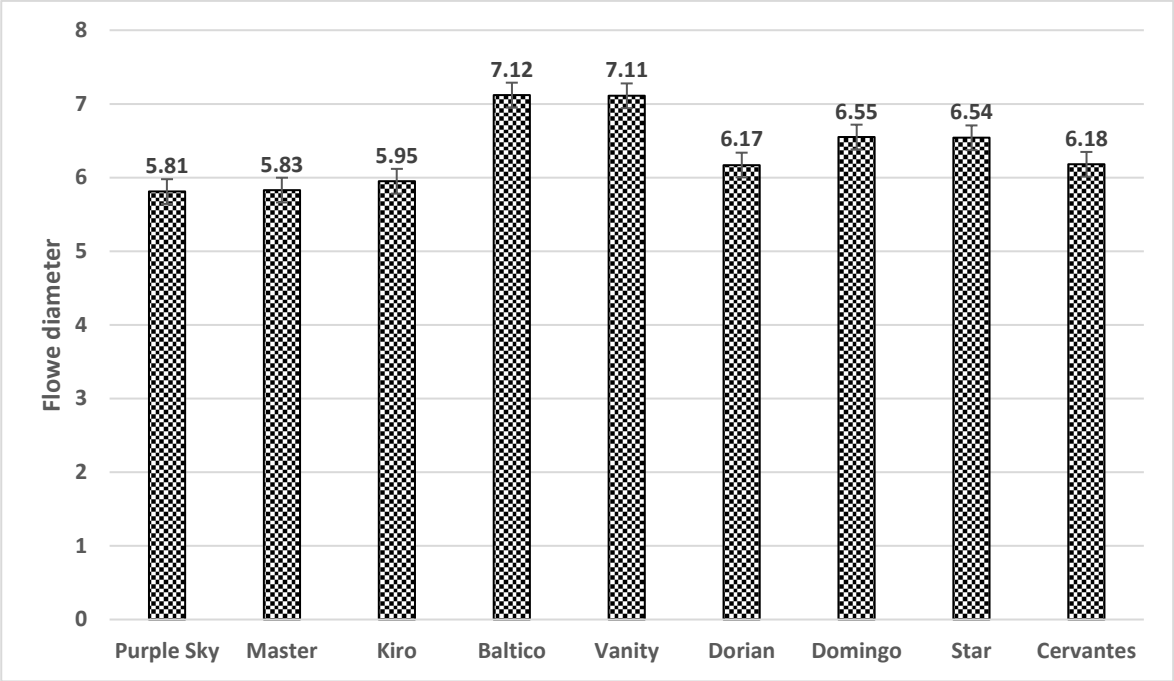

Fig. 4.15 Flower diameter of different carnation varieties grown in shade net conditions

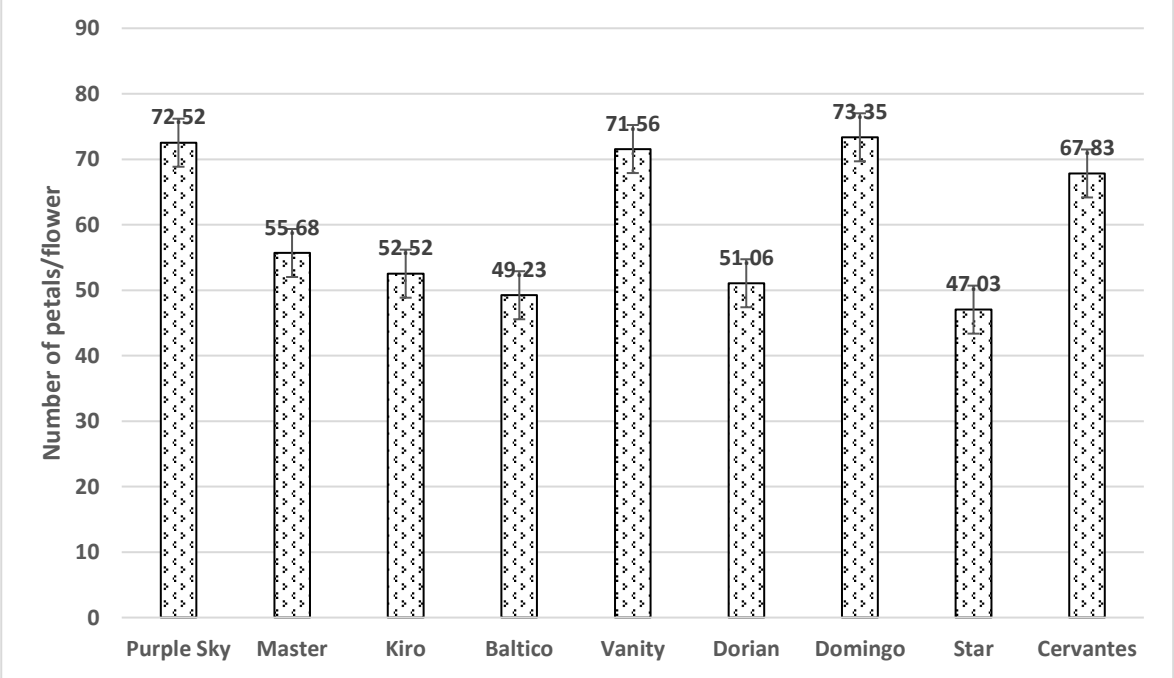

Fig. 4.16 Number of petals per flower of different carnation varieties grown in shade net conditions

4.2.9 Fresh weight of cut stalk (g)

Significant differences were obtained in varieties for fresh weight of cut stalk which ranged from 25.00 g to 54.40 g. The data regarding the fresh weight of cut stalk is presented in Table 4.8 and Fig. 4.17. Maximum was found in Master (54.40 g) which was statistically on par with Dorian (45.60 g) and Vanity (36.80 g) whereas, minimum was noticed in Baltico (25.00 g). The variety Purple Sky (35.20 g), Star (35.07 g) and Kiro (33.53 g) were on with each other.

Variation in flower weight could be expected among the cultivars as the attribute is generally a genetic character. Such variations in weight of flower among the cultivars were also observed by earlier workers in Carnation by Tarannum *et al.* (2014) and Singh and Sangama (2003).

4.2.10 Vase life (days)

Significant differences were seen in among the different varieties of carnation for vase life. The data regarding the vase life is presented in Table 4.8 and Fig.4.18. The variety Star extended its vase life up to maximum of 13.80 days which were found statistically at par with Baltico (13.05 days) and Domingo (12.72 days). However, the least vase life was noticed in variety Dorian (9.07 days).

This variation in vase life among the cultivars might be attributed to the increased accumulation of carbohydrates. Variation in vase life could also be attributed to, the variation in ability to produce ethylene and sensitivity to it among the different cultivars. Similar variation for vase life were also observed previously in carnation by Jose *et al.* (2017), Anand *et al.* (2021) and Shamanth (2016).

Plate 4.1 Recording vase life of carnation

4.2.11 Calyx splitting (%)

Throughout the experimental period, no incidence of calyx splitting was observed in any of the evaluated carnation varieties under shade net conditions. This suggests that the environmental conditions and varietal responses were conducive to maintaining calyx integrity.

4.2.12 Number of flowers per plant/year

The perusal data presented in in Table 4.8 and Fig. 4.19 revealed that, the significant differences were noticed among the varieties with respect to number of flowers per plant per year which ranged from 5.51 to 8.76. Significantly the highest number of flowers recorded in variety Domingo (8.76) and was superior compared to all other varieties studied. The next superior strains Baltico (8.12) and Star (7.49) were statistically at par with each other. Whereas Purple Sky was recorded minimum (5.51) flowers per plant which was at par with Master (5.90).

Carnation flower number ranged from 6.33 to 11.67 per plant (Tarannum *et al.* 2014) and 5.33 to 7.64 per plant (Gharge *et al.* 2011). Cultivar Tempo (6.4) recorded highest number of carnation flowers per plant whereas, cultivar Kaly (2.66) produced minimum number of flowers per plant when grown under lath house condition. Similar variation in carnation with respect to flower yield was also observed by Jose *et al.* 2017, Anand *et al.* (2021), Mahmood *et al.* (2013) and Shamanth (2016).

4.2.13 Number of flowers/m^2/year

The data regarding the number of flowers/m^2/year is furnished in Table 4.8 and Fig.4.20. Significant differences were noticed among the varieties with respect to number of flowers/m^2/year which ranged from 244.57 to 389.06. The variety Domingo recorded maximum number of flowers per square meter (389.06), which was significantly superior over other varieties. The variety Baltico (360.64) which was statistically at par with Star (332.50) with respect to number of flowers/m^2/year. However, Purple Sky and Master registered minimum (244.57 and 262.04), respectively.

The numbers of flowers per sq.m observed under the present investigation has been inline with Shivamurty (2015) and slightly lower than the findings of Hosure (2015).

Plate 4.2 Field view of experimental field

Table 4.8 Fresh weight of flowers, vase life, number of flowers/plant/year and number of flowers/m^2/year of different carnation varieties grown in shade net conditions

Parameters / Varieties	Fresh weight of flowers (g)	Vase life (days)	No. of flowers/plant	No. of flowers/m^2
Purple Sky	35.20	9.15	5.51	244.57
Master	54.40	9.83	5.90	262.04
Kiro	33.53	11.38	6.30	279.95
Baltico	25.00	13.05	8.12	360.64
Vanity	36.80	9.20	6.45	286.47
Dorian	45.60	9.07	7.06	313.56
Domingo	27.67	12.72	8.76	389.06
Star	35.07	13.80	7.49	332.50
Cervantes	30.20	10.38	7.23	321.11
CD @ 5%	4.3	1.2	0.4	16.0
SE(m)±	1.5	0.4	0.1	5.4

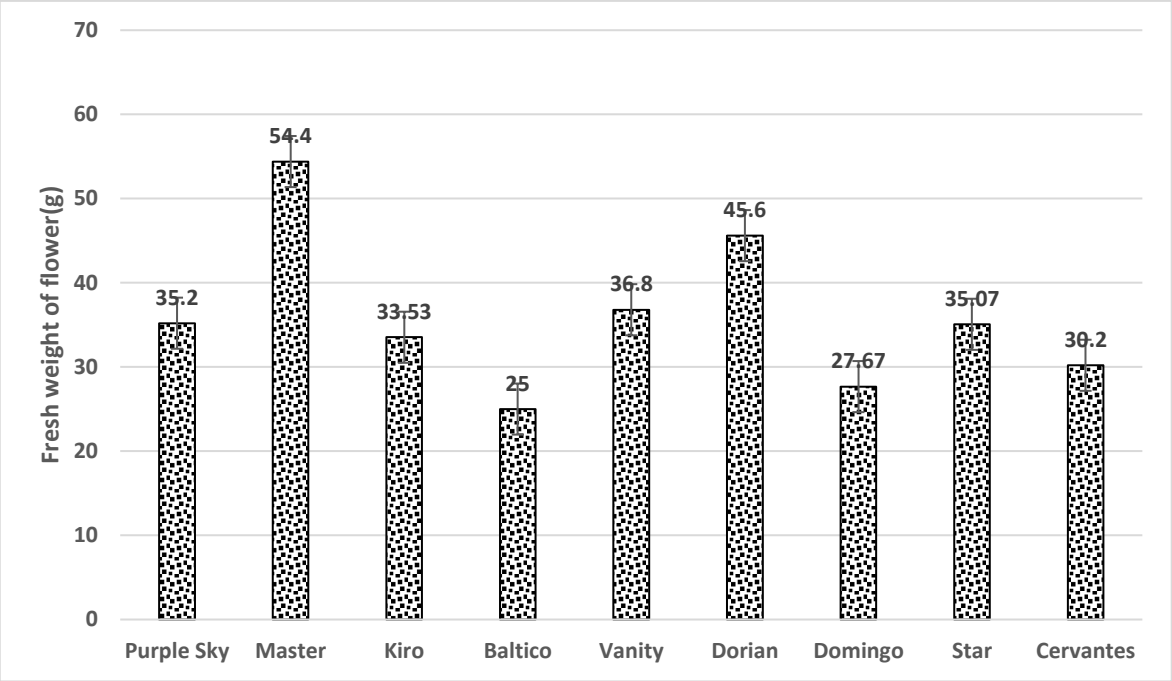

Fig. 4.17 Fresh weight of flower of different carnation varieties grown in shade net conditions

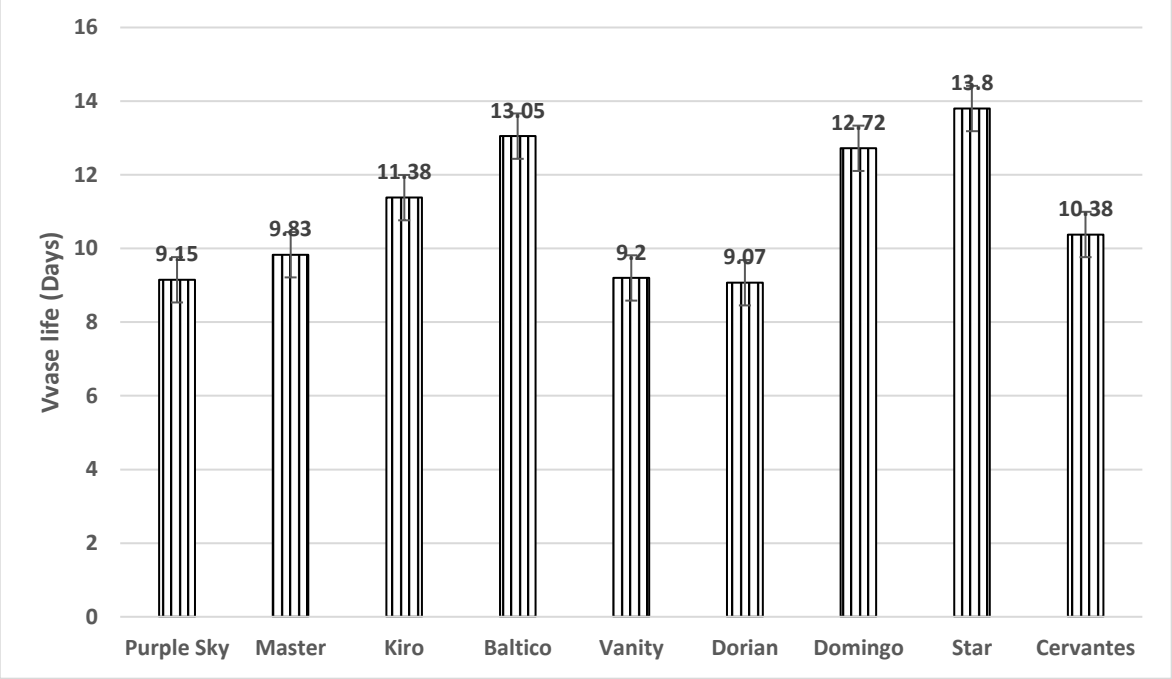

Fig. 4.18 Vase life of different carnation varieties grown in shade net conditions

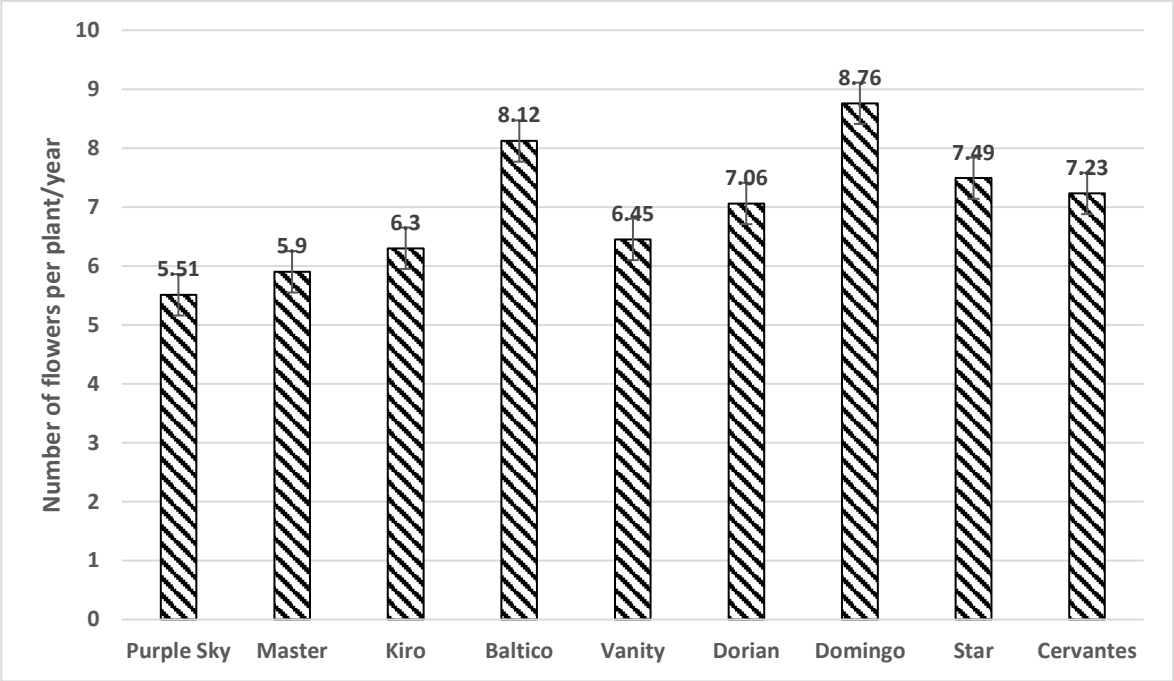

Fig. 4.19 Number of flowers per plant/year of different carnation varieties grown in shade net conditions

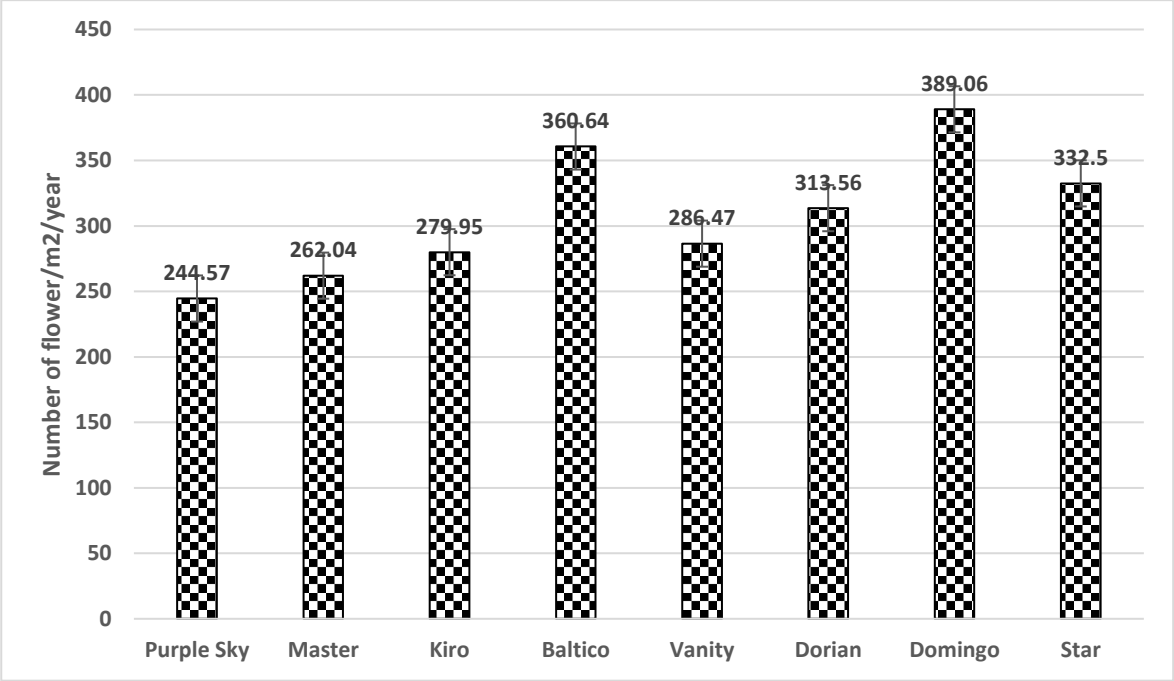

Fig. 4.20 Number of flowers/m^2/year of different carnation varieties grown in shade net conditions

4.3 Benefit cost ratio

The economics of cultivation of carnation for an area of 560 m^2 under shade net conditions was worked out for one year and presented in Table: 4.9 and depicted in Appendix-II. The economic analysis revealed that the variety Domingo obtained maximum gross returns (Rs. 783458.4/560m^2), followed by Baltico (Rs. 719797.6/560 m^2) by sale of cut flowers. The cultivars Domingo (Rs. 871494.4/560m^2) and Baltico (Rs. 807833.6/560 m^2) were also obtained maximum net returns with a cost benefit ratio of 9.90:1 and 9.18:1, respectively under shade net conditions.

The cost-benefit ratio observed under the present investigation was higher than the findings of Medeo *et al.* 2019 which is due to the market price of individual cut flower stalk.

Table 4.9 Benefit cost ratio of different carnation varieties grown in shade net conditions

Varieties	Cut flower stalks yield/m^2	Cut flower stalks yield/560 m^2	Total cost of cultivation (Rs.)	Gross return (Rs.)	Net return (Rs.)	B:C ratio
Purple Sky	5.51	244.57	88,036	4,59,801	547836.8	6.22:1
Master	5.90	262.04	88,036	498933.6	586969.6	6.67:1
Kiro	6.30	279.95	88,036	539052	627088	7.12:1
Baltico	8.12	360.64	88,036	719797.6	807833.6	9.18:1
Vanity	6.45	286.47	88,036	553656.8	641692.8	7.29:1
Dorian	7.06	313.56	88,036	614338.4	702374.4	7.98:1
Domingo	8.76	389.06	88,036	783458.4	871494.4	9.90:1
Star	7.49	332.50	88,036	656764	744800	8.46:1
Cervantes	7.23	321.11	88,036	631250.4	719286.4	8.17:1

*@Rs. 4/-flower

SUMMARY AND CONCLUSIONS

The present investigation on evaluation of carnations was carried out during the 2024-25 at the Technology Park, Horticulture block, Floriculture unit, Department of Floriculture and Landscaping, College of Horticulture and Forestry, Kumarganj, Ayodhya. For the study, nine varieties were taken, and twenty-one parameters were studied. The experimental data for different components of vegetative, flower quality and yield parameters were subjected to statistical analysis.

A wide range of differences among the varieties was observed for many characters like plant height, number of shoots per plant, stem girth, number of internodes per stem, internodal length, number of leaf pairs per plant, leaf length, per cent mortality of plant, days taken to first flower bud initiation, days taken to first flower bud opening, bud length, bud diameter, length of flower stalk, girth of flower stalk, flower diameter, number of petals per flower, fresh weight of flower, vase life, calyx splitting, number of flowers per plant/ year, number of flowers/m^2/year. There was a sufficient difference among the accessions for all the parameters studied.

5.1 Mean Performance of Genotypes

- At all stages of crop growth, different varieties recorded different plant heights. Baltico reported maximum plant height at 30 DAP (19.01 cm), Kiro recorded maximum plant height at 60 DAP (32.32 cm), 90 DAP (48.78 cm), 120 DAP (74.00 cm), 150 DAP (91.40 cm) and Master at 180 DAP (101.53 cm), while Purple Sky recorded minimum plant height at 30 DAP (15.33 cm) and 60 DAP (27.45 cm). Cervantes recorded minimum plant height at 90 DAP (33.07 cm), 120 DAP (44.47 cm), 150 DAP (62.80 cm), and 180 DAP (79.40 cm).
- At all the stages of crop growth, the maximum number of leaf pairs/ per plant was recorded in Master i.e. 36.50, 51.26, 55.63, 63.22 and 76.85 at 30, 60, 90, 120 and 150 DAP, respectively, Kiro at 180 DAP recorded maximum number of leaf pair/plant (88.99). Minimum number of leaf pairs/plant was recorded in Cervantes i.e. 21.80, 23.78, 33.99, 38.09, 39.89 and 42.31 at 30, 60, 90, 120, 150 and 180 DAP respectively.

- At all the stages of crop growth, the maximum number of shoots per plant was recorded in Kiro i.e. 5.66, 5.99, 6.15, 6.41, 7.08 and 7.21 at 30, 60, 90, 120, 150 and 180 DAP, respectively. Minimum number of shoots per plant was recorded in Cervantes i.e. 3.15, 4.00, 4.47, 4.72, 5.20 and 5.50 at 30, 60, 90, 120, 150 and 180 DAP respectively.
- Among the different cultivars studied, purple Sky was found superior with respect to stem girth (7.39 mm), and Star found the minimum (6.09 mm) stem girth throughout the crop growth period.
- Number of internodes per stem differed significantly among the varieties and maximum was recorded in Dorian (14.27) and minimum was 12.93 in Kiro.
- Significant differences were observed among different varieties with regard to internodal length. It was maximum in Cervantes (6.64 cm) and minimum in Kiro (4.58 cm).
- With regard to per cent mortality of plants, the Domingo reported with maximum per cent mortality (48) as compared to the other varieties, whereas the minimum (0) was reported in Kiro, Vanity and Star.

5.1.1 Flower quality and yield parameters

- Among the varieties studied, Cervantes took minimum number of days for first flower bud initiation (98.33 days) compared to other varieties and was significantly superior over rest of the cultivars, while Baltico took a greater number of days (120.29 days) for first bud initiation.
- The variety Cervantes took minimum days for first flower bud opening (124.81 days). Whereas variety Baltico took maximum number of days to first flower bud opening (142.08 days) among the varieties studied.
- In the case of bud length, variety Cervantes recorded maximum (2.84 cm), while minimum bud length (2.07 cm) was reported in variety Purple Sky.
- Maximum bud diameter was recorded in Domimgo (2.05 cm). However, minimum bud diameter was recorded in Purple Sky (1.61 cm).
- Maximum length of flower stalk was recorded in variety Master (89.23 cm). However, the minimum length of flower stalk was recorded in Cervantes (59.83 cm).

- Data showed significant difference for the girth of flower stalk and recorded maximum (5.67mm) in Domingo and was minimum in Master (4.28 mm) among all varieties.
- The variety had found maximum flower diameter (7.12 cm) in Baltico, and the minimum (5.81 cm) was recorded in Purple Sky.
- The maximum number of petals per flower was reported in Domingo (73.35) and it was superior over all the treatments. The minimum number of petals per flower was recorded in Star (47.03).
- Among the various varieties, Master recorded the fresh weight of flower (54.40 g) per plant per month, the minimum fresh weight of flower (25.00 g) was observed in Baltico.
- Maximum number of flowers per plant / year was recorded from the variety Domingo (8.76), which was significantly superior to the rest of the treatments. While the minimum was reported in Purple Sky (5.51).
- The variety Domingo (389.06) recorded significantly highest and exhibited its superiority over other varieties for the number of flowers/m^2/year and the minimum was observed in variety Purple Sky (244.57).
- Highest (13.80 days) vase life of flowers was noticed in Star, and the lowest vase life (9.07 days) was observed in the variety Dorian.
- Results for calyx splitting were not recorded in all the varieties throughout the trail.
- Highest B:C ratio was recorded in Domingo (9.90) among all varieties, while lowest B:C ratio was recorded in Purple Sky (6.22).

5.2 Conclusions

From the overall picture that emerged from these results, while assessing the nine varieties under study for the vegetative and flowering quality and yield parameters following conclusions can be drawn.

- In vegetative parameters Master had shown good performance with respect to number of leaf pairs/plant (76.85), plant height(101.53cm) 180 DAP. Kiro shown best performance for plant height (100.07cm), number of leaf pairs/plant (80.99), number of shoots per plant (7.21), per cent mortality of plant (0).

- In flower quality and yield parameters Master for length of flower stalk (89.23cm), fresh weight of flower (54.40g), Domingo for bud diameter (2.05cm), girth of flower stalk (5.67mm), number of petals per flower (73.35), number of flowers per plant/year (8.76), number of flowers/year (389.06).
- Domingo recorded the highest B:C ratio of 9.90:1 among all the varieties.
- Based on these results, Domingo shows strong potential for successful cultivation under Eastern U.P. conditions and may be recommended as a leading variety for commercial floriculture.

5.3 Suggestions for Future Work

- Future research should focus on evaluating additional carnation varieties under diverse agro-climatic conditions to validate adaptability and performance.
- Emphasis should be placed on breeding for traits such as enhanced flower longevity, resistance to pests and diseases, and improved vase life.
- Integration of modern biotechnological tools can aid in faster selection and genetic improvement.
- Studies on optimized nutrient and irrigation management, along with sustainable cultivation practices, will further enhance yield and quality.
- Additionally, post-harvest handling, value addition, and market linkage strategies should be explored to increase profitability and ensure the commercial viability of carnation cultivation on a broader scale.

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ANEXTURE-I

Meteorological data

Week	Period	Temp. ^{0}C (Min.)	Temp. ^{0}C (Max.)	Rainfall (mm)	Rainy days	Sunshine Hours	RH (Avg.)
44	29-10-24 to 04-11-24	18	32.2	0	0	7.5	69
45	05-11-24 to 11-11-24	17.2	30	0	0	6.7	67.1
46	12-11-24 to 18-11-24	14.3	28.8	0	0	6.7	67.6
47	19-11-24 to 25-11-24	10.5	26.4	0	0	6.1	51.45
48	26-11-24 to 02-12-24	9.2	26.1	0	0	8	62.1
49	03-12-24 to 09-12-24	7.7	26.7	0	0	8.7	62.6
50	10-12-24 to 16-12-24	4	23.1	0	0	8.1	63.45
51	17-12-24 to 23-12-24	6.2	24.6	0	0	7.8	62.85
52	24-12-24 to 31-12-24	11	20.8	0	0	3	70.8
1	01-01-25 to 07-01-25	7.1	15.5	0	0	0.5	80.45
2	08-01-25 to 14-01-25	6.7	19.1	2	0	4.2	73.2
3	15-01-25 to 21-01-25	8.8	20.2	0	0	5.3	70.8
4	22-01-25 to 28-01-25	7	22.6	0	0	7.1	69.4
5	29-01-25 to 04-02-25	7.5	23.7	0	0	8.2	64.65
6	05-02-25 to 11-02-25	7.6	25.3	0	0	9.3	58.7

7	12-02-25 to 18-02-25	9.4	26.7	0	0	9.7	54.9
8	19-02-25 to 25-02-25	10.7	27.1	0	0	9.7	53.75
9	26-02-25 to 04-03-25	12.5	27.6	0	0	8.7	59.8
10	05-03-25 to 11-03-25	12	28.9	0	0	9.6	63.4
11	12-03-25 to 18-03-25	14.5	35	0	0	9	68.3
12	19-03-25 to 25-03-25	15	34.9	0	0	9.3	64.05
13	26-03-25 to 01-04-25	14.8	35.5	0	0	9.5	63.6
14	02-04-25 to 08-04-25	16.7	37.9	0	0	8.7	64.5
15	09-04-25 to 15-04-25	21.2	34.1	0	0	8	67.75
16	16-04-25 to 22-04-25	22.7	37.1	0	0	10	60.5
17	23-04-25 to 29-04-25	20.6	39.6	0	0	9.4	57.9
18	30-04-25 to 06-05-25	30.2	35.8	0	0	10.5	69
19	07-05-25 to 13-05-25	32.7	39.6	0	0	10.8	67.1
20	14-05-25 to 20-05-25	33.2	39.4	0	0	11.0	67.6
21	21-05-25 to 27-05-25	32.9	39.3	0	0	11.2	51.45
22	28-05-25 to 30-05-25	33.9	39.3	0	0	11.3	62.1

Source: Department of Agro-meteorology, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.)

ANEXTURE-II

Economics of carnation cultivation under shade net condition (560 m^2) for one year

S. No.	Particulars	Cost per year (Rs.)
A	**Fixed Cost**	
1.	Establishment cost of polyhouse structure with Drip Irrigation system, including foggers @ Rs. 250 per m^2 for a period of one year out of 1,40,000/- for 10 years (Rs. 250 X 560 m^2)	14,000
2.	Land and bed preparation (Levelling, FYM, and Coco peat mixing of bed materials and bed making) for one year out of Rs. 11760/- for 3 years	3920
3.	Plant material (24889 plants/ 560 m^2 @ Rs.7 per plant = 24889 X 7 = Rs. 1,74,223/-)	58,075
4.	Soil sterilization cost for one year out of Rs. 2800/- for 3 years	934
5.	Supporting material for carnation plants (net) @ Rs. 22 per m^2 for a period of one year out of 12,320/- for three years (Rs. 22 x 560 m^2)	4107
B	**Variable Cost**	
1.	Labor cost	3000
2.	Insecticides and pesticides	500
3.	Manures and fertilizers	1000
4.	Shade net maintenance, including electricity	2000
5.	Miscellaneous costs (packing, transportation, etc.)	500
	Total cost (A+B)	**88,036**

APPENDICES

ANALYSIS OF VARIANCE TABLE FOR DIFFERENT VARIETIES OF CARNATION GROWN UNDER SHADE NET CONDITIONS

Appendix-I: Plant height of different carnation varieties grown in shade net conditions at 30 DAP

Source of Variation	DF	SS	MSS	F Cal	Significant
Treatment	8	30.51	3.81	38.77	S
Error	18	1.77	0.10		
Total	26.00	32.28			

***Level of Significant at 5%**

Appendix-II: Plant height of different carnation varieties grown in shade net conditions at 60 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	54.52	6.82	69.03	S
Error	18	1.78	0.10		
Total	26.00	56.30			

***Level of Significant at 5%**

Appendix-III: Plant height of different carnation varieties grown in shade net conditions at 90 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	795.56	99.45	52.64	S
Error	18	34.01	1.89		
Total	26.00	829.57			

***Level of Significant at 5%**

Appendix-IV: Plant height of different carnation varieties grown in shade net conditions at 120 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	3155.78	394.47	1142.79	S
Error	18	6.21	0.35		
Total	26.00	3161.99			

***Level of Significant at 5%**

Appendix-V: Plant height of different carnation varieties grown in shade net conditions at 150 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	3290.47	411.31	427.79	S
Error	18	17.31	0.96		
Total	26.00	3307.77			

***Level of Significant at 5%**

Appendix-VI: Plant height of different carnation varieties grown in shade net conditions at 180 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	2041.14	255.14	302.67	S
Error	18	15.17	0.84		
Total	26.00	2056.31			

***Level of Significant at 5%**

Appendix-VII: Number of leaf pairs per plant of different carnation varieties grown in shade net conditions at 30 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	554.59	69.32	81.22	S
Error	18	15.36	0.85		
Total	26.00	569.95			

***Level of Significant at 5%**

Appendix-VIII: Number of leaf pairs per plant of different carnation varieties grown in shade net conditions at 60 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	2032.25	254.03	304.33	S
Error	18	15.02	0.83		
Total	26.00	2047.28			

***Level of Significant at 5%**

Appendix-IX: Number of leaf pairs per plant of different carnation varieties grown in shade net conditions at 90 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	1789.78	223.72	100.24	S
Error	18	40.17	2.23		
Total	26.00	1829.96			

***Level of Significant at 5%**

Appendix-X: Number of leaf pairs per plant of different carnation varieties grown in shade net conditions at 120 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	2017.13	252.14	133.58	S
Error	18	33.98	1.89		
Total	26.00	2051.10			

***Level of Significant at 5%**

Appendix-XI: Number of leaf pairs per plant of different carnation varieties grown in shade net conditions at 150 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	4626.49	578.31	306.81	S
Error	18	33.93	1.88		
Total	26.00	4660.42			

***Level of Significant at 5%**

Appendix-XII: Number of leaf pairs per plant of different carnation varieties grown in shade net conditions at 180 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	4978.63	622.33	286.55	S
Error	18	39.09	2.17		
Total	26.00	5017.72			

***Level of Significant at 5%**

Appendix-XIII: Number of shoots per plant of different carnation varieties grown in shade net conditions at 30 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	13.76	1.72	73.22	S
Error	18	0.42	0.02		
Total	26.00	14.18			

***Level of Significant at 5%**

Appendix-XIV: Number of shoots per plant of different carnation varieties grown in shade net conditions at 60 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	9.33	1.17	42.02	S
Error	18	0.50	0.03		
Total	26.00	9.83			

***Level of Significant at 5%**

Appendix-XV: Number of shoots per plant of different carnation varieties grown in shade net conditions at 90 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	6.53	0.82	57.12	S
Error	18	0.26	0.01		
Total	26.00	6.78			

***Level of Significant at 5%**

Appendix-XVI: Number of shoots per plant of different carnation varieties grown in shade net conditions at 120 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	7.38	0.92	37.27	S
Error	18	0.45	0.02		
Total	26.00	7.82			

***Level of Significant at 5%**

Appendix-XVII: Number of leaf pairs per plant of different carnation varieties grown in shade net conditions at 150 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	7.00	0.88	41.14	S
Error	18	0.38	0.02		
Total	26.00	7.39			

***Level of Significant at 5%**

Appendix-XVIII: Number of shoots per plant of different carnation varieties grown in shade net conditions at 180 DAP

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	6.87	0.86	35.75	S
Error	18	0.43	0.02		
Total	26.00	7.30			

***Level of Significant at 5%**

Appendix-XIX: Stem girth of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	3.29	0.41	2.65	S
Error	18	2.79	0.16		
Total	26.00	6.09			

***Level of Significant at 5%**

Appendix-XX: Internodal length of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	8.26	1.03	4.00	S
Error	18	4.64	0.26		
Total	26.00	12.91			

***Level of Significant at 5%**

Appendix-XXI: Leaf length of plants of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	39.00	4.88	123.59	S
Error	18	0.71	0.04		
Total	26.00	39.71			

***Level of Significant at 5%**

Appendix-XXII: *Per cent* mortality of plants of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	7,384.51	923.07	5,454.11	S
Error	18	3.05	0.17		
Total	26	7,387.55			

***Level of Significant at 5%**

Appendix-XXIII: Number of internodes per stem of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	4.39	0.55	4.02	S
Error	18	2.46	0.14		
Total	26.00	6.85			

***Level of Significant at 5%**

Appendix-XXIV: Days taken to first flower bud initiation of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	1415.73	176.97	118.17	S
Error	18	26.96	1.50		
Total	26.00	1442.69			

***Level of Significant at 5%**

Appendix-XXV: Days taken to first flower bud opening of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	649.18	81.15	74.02	S
Error	18	19.73	1.10		
Total	26.00	668.91			

***Level of Significant at 5%**

Appendix-XXVI: Bud length of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	1.74	0.22	9.41	S
Error	18	0.42	0.02		
Total	26.00	2.15			

***Level of Significant at 5%**

Appendix-XXVII: Bud diameter of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	0.46	0.06	3.94	S
Error	18	0.26	0.01		
Total	26.00	0.73			

***Level of Significant at 5%**

Appendix-XXVIII: Length of flower stalk of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	3112.45	389.06	619.38	S
Error	18	11.31	0.63		
Total	26.00	3123.76			

***Level of Significant at 5%**

Appendix-XXIX: Girth of flower stalk of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	5.72	0.72	3.51	S
Error	18	3.67	0.20		
Total	26.00	9.39			

***Level of Significant at 5%**

Appendix-XXX: Flower diameter of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	6.05	0.76	7.10	S
Error	18	1.92	0.11		
Total	26.00	7.97			

***Level of Significant at 5%**

Appendix-XXXI: Number of petals per flower of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	2906.27	363.28	299.57	S
Error	18	21.83	1.21		
Total	26.00	2928.10			

***Level of Significant at 5%**

Appendix-XXXII: Fresh weight of flower of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	1989.03	248.63	39.04	S
Error	18	114.64	6.37		
Total	26.00	2103.67			

***Level of Significant at 5%**

Appendix-XXXIII: Vase life of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	81.90	10.24	19.33	S
Error	18	9.53	0.53		
Total	26.00	91.43			

***Level of Significant at 5%**

Appendix-XXXIV: Number of flowers per plant/year of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	26.61	3.33	74.33	S
Error	18	0.81	0.04		
Total	26.00	27.41			

***Level of Significant at 5%**

Appendix-XXXV: Number of flowers/m^2/year of different carnation varieties grown in shade net conditions

Source of Variation	DF	SS	MSS	F Cal	Significance
Treatment	8	52484.29	6560.54	75.18	S
Error	18	1570.86	87.27		
Total	26.00	54055.15			

***Level of Significant at 5%**

BIO-DATA

Name	:	**Naveen Kumar Yadav**
Father's Name	:	Mr. Salilesh Kumar Yadav
Mother's Name	:	Mrs. Rajkumari
Date of Birth	:	21/07/2000
Marital Status	:	Unmarried
Nationality	:	Indian
Languages Known	:	Hindi, English
Corresponding Address	:	Village and Post Kadanpur Pure Netani, Milkipur, Ayodhya, U.P., 224228
Permanent Address	:	Village and Post Kadanpur Pure Netani, Milkipur, Ayodhya, U.P., 224228
E-mail	:	naveenfz1999@gmail.com
Mobile No.	:	+919598800424

Academic Credentials

Class	Board / University	Subject	Year	Division	CGPA/ Percentage
High School	U.P Board	Science	2015	First	85.66
Intermediate	U.P Board	Science	2017	First	78.00
B.Sc. (Hons.) Hort.	SVPUAT, Meerut (U.P.)	Horticulture	2023	First	07.77
M.Sc. (Hort.)	ANDUAT, Kumarganj, Ayodhya (U.P.)	Floriculture and Landscaping	Pursuing	-	-

DECLARATION

I hereby declare that the information furnished above is true to the best of my knowledge & belief; documentary evidences will support them as and when required

Naveen Kumar

(Naveen Kumar Yadav)

Place : Kumarganj, Ayodhya

Date : 25 July 2025

Department of Floriculture and Landscaping
College of Horticulture and Forestry
Acharya Narendra Deva University of Agriculture and Technology,
Kumarganj, Ayodhya 224229 (U.P.) India

Name	: Naveen Kumar Yadav	**Id. No.**	: H-14755/23
Semester	: IV	**Degree**	: M.Sc. (Hort.) Floriculture and Landscaping
Year of Admission	: 2023		
Major	: Floriculture and Landscaping	**Department**	: Floriculture and Landscaping
		Minor	: Fruit Science
Thesis Title	: Evaluation of carnation (*Dianthus caryophyllus* L.) varieties under shade net condition of Eastern U.P.		
Advisor	: Dr. Sunil Kumar		

ABSTRACT

The present investigation was conducted during 2024–25 at the Technology Park, Horticulture Block, Floriculture Unit, College of Horticulture and Forestry, Kumarganj, Ayodhya, to evaluate the performance of nine carnation (*Dianthus caryophyllus* L.) varieties under shade net conditions in Eastern Uttar Pradesh. The study aimed to assess vegetative growth, flower quality, yield parameters, and economic viability using a Completely Randomized Design (CRD) across twenty-one traits. Significant varietal differences were observed in vegetative traits such as plant height, number of shoots per plant, stem girth, internodal length, leaf pair count, and plant mortality. Master exhibited superior vegetative growth with the highest plant height (101.53 cm at 180 DAP) and leaf pair count (76.85), while Kiro excelled in shoot production (7.21) and showed zero mortality, indicating strong adaptability. Flower quality and yield parameters also varied notably among cultivars. Cervantes initiated flowering earliest (98.33 days), while Master produced the longest flower stalks (89.23 cm) and heaviest blooms (54.40 g). Domingo stood out with the highest bud diameter (2.05 cm), flower stalk girth (5.67 mm), petal count (73.35), and flower yield both per plant/year (8.76) and per square meter/year (389.06). Star recorded the longest vase life (13.80 days), enhancing its post-harvest appeal. Economic analysis revealed Domingo as the most profitable variety, achieving the highest benefit-cost (B:C) ratio of 9.90:1, followed by Master and Kiro. However, these findings suggest that Domingo is the most promising cultivar for commercial carnation cultivation under shade net conditions in Eastern U.P., offering optimal growth, superior floral traits, and high economic returns.

(Sunil Kumar)
Major Advisor and Chairman

Naveen Kumar
(Naveen Kumar Yadav)
Author

पुष्प एवं भू-दृश्य विभाग
उद्यान एवं वानिकी महाविद्यालय
आचार्य नरेंद्र देव कृषि एवं प्रौद्योगिक विश्वविद्यालय,
कुमारगंज, अयोध्या- २२४२२९, (उ.प्र.) भारत

नाम	: नवीन कुमार यादव	**पहचान क्रमांक**	: एच्-१४७५५/२३
सेमेस्टर	: चतुर्थ	**डिग्री**	: स्नातकोत्तर (उधान) पुष्प एवं भू-दृश्य
प्रवेश का वर्ष	: २०२३	**विभाग**	: पुष्प एवं भू-दृश्य
प्रमुख अनुशासन	: पुष्प एवं भू-दृश्य	**गौण अनुशासन**	: फल विज्ञान
शोध का शीर्षक	: पूर्वी उत्तर प्रदेश की छायादार शुद्ध स्थिति के तहत कार्नेशन (*डायनथस कैरियोफिलस* एल०) किस्मों का मूल्यांकन		
सलाहकार	: डॉ० सुनील कुमार		

सारांश

वर्तमान जांच 2024-25 के दौरान प्रौद्योगिकी पार्क, बागवानी ब्लॉक, फूलों की खेती इकाई, उद्यान एवम् वानिकी महाविद्यालय, आचार्य नरेन्द्र देव कृषि एवम् प्रौद्योगिक विश्वविद्यालय, कुमारगंज, अयोध्या में पूर्वी उत्तर प्रदेश में छायादार शुद्ध स्थितियों के तहत नौ कार्नेशन (*डायनथस कैरियोफिलस* एल०) किस्मों के प्रदर्शन का मूल्यांकन करने के लिए की गई। अध्ययन का उद्देश्य इक्कीस लक्षणों में पूरी तरह से यादृच्छिक डिजाइन (सीआरडी) का उपयोग करके वानस्पतिक विकास, फूलों की गुणवत्ता, उपज मापदंडों और आर्थिक व्यवहार्यता का आकलन करना है। पौधे की ऊंचाई, प्रति पौधे की टहनियों की संख्या, तने का घेरा, अंतरनोडल लंबाई, पत्ती जोड़ी की गिनती और पौधे की मृत्यु दर जैसे वानस्पतिक लक्षणों में महत्वपूर्ण विविधता अंतर देखा गया। मास्टर ने उच्चतम पौधे की ऊंचाई (180 डीएपी पर 101.53 सेमी) और पत्ती जोड़ी गिनती (76.85) के साथ बेहतर वनस्पति विकास का प्रदर्शन किया, जबकि किरो ने शूट उत्पादन (7.21) में उत्कृष्ट प्रदर्शन किया और मजबूत अनुकूलन क्षमता का संकेत देते हुए शून्य मृत्यु दर दिखाई। फूलों की गुणवत्ता और उपज के पैरामीटर भी किस्मों के बीच विशेष रूप से भिन्न होते हैं। ग्रीवांस ने सबसे पहले फूल (98.33 दिन) शुरू किए, जबकि मास्टर ने सबसे लंबे फूल डंठल (89.23 सेमी) और सबसे भारी खिलने (54.40 ग्राम) का उत्पादन किया। डोमिंगो उच्चतम कली व्यास (2.05 सेमी), फूल डंठल परिधि (5.67 मिमी), पंखुड़ी गिनती (73.35), और फूल उपज दोनों प्रति पौधे / वर्ष (8.76) और प्रति वर्ग मीटर / वर्ष (389.06) के साथ बाहर खड़ा था। स्टार ने सबसे लंबे फूलदान जीवन (13.80 दिन) दर्ज किए, जिससे इसकी फसल के बाद की अपील बढ़ गई। आर्थिक विश्लेषण ने डोमिंगो को सबसे अधिक लाभदायक किस्म के रूप में प्रकट किया, जिसने 9.90:1 के उच्चतम लाभ-लागत (बी: सी) अनुपात को प्राप्त किया, इसके बाद मास्टर और किरो का स्थान रहा। इन निष्कर्षों से पता चलता है कि डोमिंगो पूर्वी यूपी में छाया शुद्ध परिस्थितियों में वाणिज्यिक कार्नेशन खेती के लिए सबसे आशाजनक खेती हैं, जो इष्टतम विकास, बेहतर पुष्प लक्षण और उच्च आर्थिक रिटर्न प्रदान करती हैं।

(सुनील कुमार)
प्रमुख सलाहकार और अध्यक्ष

Naveen Kumar
(नवीन कुमार यादव)
लेखक