EVALUATION OF CARNATION (*Dianthus caryophyllus* L.) VARIETIES UNDER GREENHOUSE CONDITION

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CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

LIST OF APPENDICES

1. INTRODUCTION

Carnation (*Dianthus caryophyllus* L.) belongs to the family *Caryophyllaceae* having diploid chromosome number 2n=30. It is grown in several parts of the world and is believed to be the native of Mediterranean region. The generic name *Dianthus* comes from the writings of Theophratus who lived about 300 B.C.; *dios*, devine; *anthos*, flower; the flower of the Gods. Linnaeus chose the species name, *caryophyllus,* after the genus of Clove, as the fragrance from Carnation is reminiscent of clove. The common name, Carnation, is likely derived from '*coronation'*, as the Greeks wove Dianthus flowers into crowns for their athletes. It is genetically a quantitative long day plant (Blake, 1955).

The variety William Sim produced in 1938-39 by William Sim of North Berwick, Marine was the greatest contribution to the present Carnation industry. From that one red flowering plant, there have been mutations to white, pink, orange and several variegated forms. Today the Sim Carnation strains are grown throughout the world. Years ago Carnations were grown in local greenhouses near population centers. Increased production per unit of greenhouse area, along with high flower quality, could be achieved during winter months in the area of high light intensity namely, in Colorado and California. The advent of plastic film also made it possible for southern California growers to produce Carnations in simple structures without winter heating.

Carnation is an important flower crop having great commercial value as a cut flower due to its excellent keeping quality, wide array of colour and forms. Carnation, apart from producing cut flowers can also become useful in gardening for bedding, edging, borders, pots, and rock gardens. From medicinal point of view, the Carnation flowers are considered to be cardiotonic, diaphoretic and alexiteric (Shiragur *et al*., 2004b).

In the world, area of 'natural climates' for Carnations, are generally occurs near 30^{o} N or S latitude and on the Western edges of the continents. The area under Carnation has more than doubled within one year from 2001-2002 to 2002-2003 from a mere 6 ha to over 19 ha with a total estimated production of over 338 lakh stems in Bangalore (Rural and Urban districts) itself (Anon.,2003). A similar trend is also seen in Pune region of Maharashtra. India has been identified as one of the major forces in the world floriculture scenario. With liberalization of Indian economy, floriculture has become a new rising industry in agribusiness. Karnataka has a prominent position on floriculture map of India. Carnations are grown commercially in India in places having mild climate in Solan, Shimla, Kalimpong, Kodaikanal, Mandi, Kullu, Srinagar, Ooty and Yercaud. In Pune and Bangalore, it is grown under controlled condition. In Karnataka apart from Bangalore, the entire part of transitional belt seems to be very ideal for cultivation of flowers on account of favourable climate, soil and other factors (Shiragur, 2004b).

Carnation plants are half hardy herbaceous perennial. The flowers are 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'. The standard type produces larger blooms on longer flower stalks. On the other hand the spray type produces many flowers of smaller size with weaker stem. The commercial Carnation plant is capable of producing 10-20 flowers per year. Each flowering stem originates from a 'break' or shoot that emerges from one side of flower stem node. A typical flowering stem develops 15-18 nodes with two opposite leaves at each node. A long time goal of Carnation breeder is to develop varieties of standard Carnations which will not produce shoots at the upper nodes. Such varieties would make it possible to eliminate 'disbudding,' the most costly labour operation in Carnation culture.

Standard Carnation performs well under cool climate, whereas spray type grow better at higher temperature. Growth and flowering of Carnations are influenced by several factors. Carnation is long day plant. It forms flowers fasters 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 8-10^{0}C. 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.

Carnations require sufficient amount of light and proper ventilation to produce high quality flowers and therefore design and orientation of greenhouse are of greater importance. The Carnation flowers are sold as cut flowers round the year throughout the world and it is one the top three cut flowers traded in the international market. The flower quality is maintained in the long distance transport as they have ability to rehydrate after transportation. Though there are different types of greenhouses, naturally ventilated polyhouses are preferred in mild climate in which temperature is reduced by ventilation (Ryagi *et al*., 2007). Cut flowers of Carnations are sensitive to ethylene and senescence is accomplished by sequential rise in ethylene production by different flower parts (Nichols *et al.,* 1983). Silver Thiosulphate (STS) an inhibitor of ethylene action is known to increase vase life of Carnation and other ethylene sensitive flowers (Veen, 1983; Singh *et al.,* 2003). Since, STS contains Silver which is considered to be an environmental pollutant, its use has been restricted for treating the ethylene sensitive flowers (Serek and Reid, 1993). Maintenance of turgidity is an important factor in prolonging vase life of many flowers.

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.

The performance of Carnation varieties varies with region, season, genotypes and growing environment. In India, there is a wide fluctuation in temperature, light intensity and humidity which not only affect the yield and quality of flowers but also limit their availability for a particular period of a year. It is necessary to grow Carnation under polyhouse condition for obtaining good quality flowers. Testing of the available varieties for suitability and adaptability with respect to flowering, flower quality, and yield parameters are of prime importance. Many varieties are grown in the world, however only few varieties are under commercial cultivation in India. A systematic study of vegetative characters would facilitate the breeders to select suitable genotypes for planned breeding programme. Further there is need of suitable varieties and production technologies suitable to our conditions. Selection of proper variety for producing the desired quantity and quality of flowers for domestic as well as export market is of greater importance. Hence the present study is undertaken with following objectives.

Objectives:

- To study the performance of different Carnation varieties under greenhouse condition
- To find out the most suitable Carnation varieties for cultivation under northern transitional tract of Karnataka
- To workout the cost economics of Carnation cultivation under naturally ventilated polyhouse condition

2. REVIEW OF LITERATURE

Carnation in the modern times has become one of the most important and highly remunerative flower crops grown under polyhouse, mainly for its cut flowers. Some of its varieties are used for bedding, pots, rock gardens, window boxes and edging too. Now a days, not only standard Carnations, even spray type Carnations are popular in flower arrangements for decoration of homes. It is difficult to obtain higher yields of good quality flowers throughout the year under open conditions. However, the cultivation of Carnation is possible even during the off season under greenhouse condition. The varieties differ significantly in their performance with respect to yield, quality and vase life.

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

2.1 Varietal evaluation

The new varieties of the Bulgarian Carnation race developed in recent years excel Sim varieties in decorative and commercial characteristics. They produce larger and fuller flowers with bigger and heavily serrated petals, improved shape, wider colour range and stronger fragrance combined with higher stability against calyx splitting and longer vase life (Boikov, 1983).

The important characters for Carnation evaluation are keeping quality of the flowers, Fusarium tolerance and production, as reported by Gelder (1987).

Atanassova (1988) recommended Carnation varieties *viz.,* Salmony, Mirna, Silvery Pink and White Lilliann for commercial cultivation under Bulgarian conditions for combined yield and quality.

New Bulgarian Carnation varieties with a complex of most importation decorative and commercial advantages have been developed. Entirety new characters significantly improving the competitiveness and commercial efficiency of this culture have been attained, such as flower size over 12 cm in diameter, strong fragrance, development of stem branches from the adventitious buds at the root neck, tolerance to virus diseases, combined with high Fusarium resistance (Boikov, 1992).

Among the different types of Carnations perpetual flowering types are the hybrids involving many *Dianthus* species. It flowers all the year round. The florist's Carnations are grouped into two major classes "Standard" and "Spray". The standard types produce larger blooms on longer flower stalks. The spray on the other hand produces many flowers of smaller size with weaker stem (Bhatt, 1993). The cultivar William Sim produced during 1938 and 1939 by William Sim of the USA is the greatest contribution to the present Carnation industry. From this red flowering variety, there have been mutation to white, pink, orange and several variegated forms.

The study on performance of ten varieties *viz.,* Arthur Sim, William Sim, White Sim, Scania, Laddie, Can Can, Shocking Pink, Tangerine, Harvest Moon and Clear Yellow grown under the open field conditions of sub-tropical environments of Punjab revealed that Sim Carnation can be successfully grown as a single crop and was not possible to extend upto second year. The yield of high quality flowers was obtained 328/ m^2 from the plants established in the beds in the month of September. The varieties like Arthur Sim, Can Can and Clear Yellow exhibited high tolerance (Gill *et al.,* 1988).

Lal *et al.* (1998) studied the performance of fourteen varieties of Carnation; five standard varieties *viz.,* Scania, Dusty, White Sim, Shocking Pink and Arthur Sim found to be having performed better in terms of their flower production and tolerance to various fungal diseases.

Sahakar and Sable (2003) investigated the performance of six varieties of Carnation grown in Naturally Ventilated greenhouse and reported that, all performed well with respect to growth, cut flower yield and post harvest life. Among them, cultivar Cobra, Gaudina and Super green were found to produce maximum number of flowers.

2.2 Growth Parameters

2.2.1 Plant Height

Khanna *et al*. (1981) reported that 15 x15 cm spacing was found to produce significantly taller plants than wider spacing that is 30 x 30 cm. He also recorded plant height of 62.0 cm in cultivar Marguerite Scarlet.

Singh *et al*. (1994) studied the effect of summer shading on the plant growth and flower production on standard Carnation cultivar Espana under different shading treatment *viz.,* 0, 25 and 50 per cent shading. The maximum (54.47cm) plant height was recorded in 25 per cent shade treatment. The minimum (49.42) plant height was recorded in 0 per cent shade treatment.

Kaicker (1998) reported, plant height of important cultivars for spray type Chaubad Giants and Enfant de Nice were 50 cm tall, Carnation Fantasie was 50-60 cm tall, Carnation Dwarf Frangrance about 30 cm tall while plant height of Malmaison Giant was 40 cm.

Lal *et al.* (1998) reported that the variety Scania attained maximum plant height (59.46 cm), followed by Shocking Pink (59.51 cm). The varieties Tangerine (52.67 cm), Harvest Moon (53.06 cm) and Yellow Dusty (53.3 cm) had smaller plants among the standard types.

The maximum plant height (62.10cm) was recorded under unpinched and the least (39.27cm) when the plants were pinched twice (Pathania *et al.,* 2000).

Patil (2001) observed maximum plant height in cultivar Alma (116.86 cm), followed by cultivar Sugar Baby (116.18 cm). It was minimum (76.76 cm) in cultivar Leon under low cost polyhouse.

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

Among the six standard Carnation cultivar viz., Cobra, Gaudina , Montezuma, Niva, Salsa and Super green under polyhouse condition, cultivar Gaudina recorded maximum plant height (85.72 cm), followed by Montezuma , Super green, Salsa, Niva and Cobra. Minimum plant height of 64.60 centimeter was recorded in Cobra (Shahakar and Sable 2003).

Dwivedi and Kareem (2004) evaluated 15 varieties of Carnation under cold arid region of India and revealed that average plant height varied from 47.65 cm and 57.66 cm in new Espana and Arthur Sim, respectively.

Under partially modified greenhouse condition Gurav *et al*. (2004) standardized the package of practices for Carnation cultivar Sunrise and recorded maximum plant height (60.16 cm) at first harvest in treatment M_7 (soil + compost + sand at ratio 2:1:1 substrate and 40 KPa irrigation regime, basal dose @ 200:200:100 NPK Kg/ha/year + 100 and 200 kg N and K /ha/year through fertigation.

According to Reddy *et al*. (2004), cultivar Alma recorded maximum plant height (110.55cm), followed by Sugar Baby (110.32 cm), Pirandello (107.16 cm) and Candy (102.50 cm), whereas cultivar Leon recorded minimum plant height of 83.74 cm. Height of plant was medium in varieties Denton, Desio and Madame Collette (98.83, 96.91 and 94.15 cm, respectively) grown under low cost polyhouse conditions.

Shiragur *et al*. (2004b) reported that out of nine varieties viz., Alma, Aicardi, Candy, Desio, Madame Collette, Pirandello, Sorisso, Sugar Baby and West Pretty cultivated under protected conditions for evaluating vegetative characters. Varieties Madame Collette, Candy and West Pretty were vigorous in their growth throughout the growing period in terms of plant height (115.86, 115.67 and 105.66 cm respectively) but finally Pirandello recorded maximum plant height (118.22 cm), whereas cultivar Desio, Sorisso, Aicardi and Sugar Baby were moderate in terms of plant height (106.64, 105.38,102.62 and 101.67 cm, respectively).

Singh and Singh (2005) observed maximum (58.50 cm) plant height in single pinching. In interaction effect the maximum plant height of 69.10 cm was found in single pinching with 500 ppm nitrogen.

Maximum plant height (90.67 cm) was observed when plants were treated with common basal dose + Vermicompost (500g / m2 twice a year) + 3% Manchurian mushroom tea + 3% Panchagavya, whereas plants treated with 50% required dose of fertilizers resulted in minimum plant height of 78.49 cm (Bhalla *et al*., 2006).

Studies were conducted on the effect of supplementing the day length on growth and flower production in Carnation cultivar Tasman. The study revealed that, plants under 6 hour additional light exhibited the maximum plant height (76.0 cm), followed by exposure to 4 hour additional light of 73.9 cm (Singh *et al*., 2006).

Eighteen standard Chrysanthemum varieties were evaluated to study their performance under polyhouse cum rain-shelter and open conditions. Among them, cultivar Temptation was found tallest (85.67 cm) under polyhouse cum rain shelter. However, under open condition, cultivar Snow Ball exhibited maximum plant height of 84.00 cm. (Talukdar *et al*., 2006).

Bhalla *et al*. (2007) reported that, the maximum plant height (69.84 cm) was observed in cultivar Raggio - de - Sole as compared to cultivar Murcia (67.95 cm). Amongst different treatment combinations, maximum plant height (72.47 cm) was observed in treatment T_6 (Sand + Soil + Vermicompost at ratio 1:1:1 + Inorganic water soluble fertilizers + biofertilizers), whereas minimum plant height (64.93 cm) was observed in treatment T_3 that is sand + soil + FYM (Control). Interaction data revealed that maximum plant height (73.20 cm) was observed in cultivar Raggio – de- Sole when grown in media containing sand + soil + Vermicompost at ratio 1:1:1 + inorganic fertilizers + biofertilizers.

Ryagi *et al*. (2007) studied the effect of pinching on growth, yield and quality of flowers of Carnation varieties viz., Dover, Cherry Solar, 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.

2.2.2 Stem girth

Atanassova and Batchvrova (1998) observed maximum stem girth at base (6.0 mm) in cultivar Yanita, followed by cultivar Krassina (5.6 mm) and cultivar Red Barbara had minimum girth and stem of 4.5 mm.

Maximum stem girth (5.99 mm) found in cultivar Madame Collette, whereas minimum stem girth (3.83 mm) was recorded in cultivar Leon (Patil, 2001).

Among the varieties evaluated under polyhouse condition, 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.,* 2004b).

Tejaswini and Murgod (2005) reported that stem thickness was significantly higher (5.42 mm) in module M_5 (Sand + Soil + Compost).

2.2.3 Number of nodes and internodal length

Hanzel *et al.* (1954) observed the number of internodes in Carnation. The variety Northland had 24.2 stems originating from base, 23.2 in stems originating from middle portion and 17.2 in case of stems originating from top portion at the time of flowering.

Cultivar improved White Sim had 17.8 nodes on primary shoots at the time of flowering under normal day length condition (Heins *et al.,* 1979).

Bhautkar (1994) reported variation in nodes ranging from 12 in cultivar White Sim to 23 in cultivar Eveline grown under greenhouse.

Mahesh (1996) studied the performance of 10 Carnation varieties and revealed that internodal length ranged from 6.32 to 8.85 cm. The cultivar Starlight DOP (spray) showed

minimum internodal length, whereas Cultivar Dusty Pink (standard) showed maximum (8.85 cm) internodal length.

Sawwan and Samawi (2000) observed that double pinch after six weeks of planting significantly reduced number of nodes per flowering stem.

Maximum number of internodes per branch recorded in cultivar Desio (18.86) and the minimum in cultivar Leon (13.45). The internodal length was maximum in cultivar Pirandello (6.89 cm) and was minimum (4.65 cm) in cultivar Desio (Patil *et al.,* 2001).

Shiragur *et al.* (2004b) reported that number of internodes per stem was maximum in cultivar Madame Collette, Alma, Sugar Baby and Desio, (20.38, 19.54, 19.28 and 18.48, respectively). However, it was minimum (15.69) in cultivar West Pretty. Cultivar Sorisso, Madame Collette, Pirandello and Aicardi had maximum internodal length (5.71, 5.69, 5.4 and 5.18 cm, respectively) while it was minimum in cultivar West Pretty (4.75 cm).

Ryagi *et al.* (2007) recorded maximum number internodes in variety Cherry solar (17.78), followed by Solar (17.33) and it was minimum in variety Dover (15.57).

Among the pinching methods, more number of internodes recorded in double pinched plants and minimum was recorded in single and half pinched plants. Whereas, interaction effect were found significant with maximum number of internodes recorded in Cherry Solar variety with single pinching (18.80).

2.2.4 Number of shoots:

The performance of Bulgarian varieties was good with respect to number of branches per plant than Sim varieties (Boikov, 1983).

There was variation in average numbers of shoots from 4.3 in traditional group of varieties to 5.9 in *Dianthus* x *Doris* group of varieties (Sparnaaij *et al.,* 1990 a).

Sparnaaij *et al.* (1990 b) reported number of shoots per plant varied from 3.3 to 6.7 in Carnation genotypes.

Sparnaaij and Putten (1990) studied the performance of different progenies of Carnation. The number of shoots varied from 3.0 in progenies of *Dianthus superbus* to 5.4 in progenies of cross between *Dianthus Knappi X Dianthus Caryophyllus.*

Bhautkar (1994) reported variation in number of branches ranging from 10 in varieties Lena, Scania and Arthur Sim to 18 in cultivar Eveline under greenhouse.

Singh *et al.* (1994) noted that number of shoots produced by the plant under shade was more than unshaded plants and there was no significant difference with two shading treatments (25% and 50% shading).

Mahesh (1996) conducted study and revealed that variety Starlight DOP (Spray) had maximum no. of branches (4.20), whereas variation white with Red Edge (Standard) had least number of branches (1.87)

Sathisha (1997) conducted trail in a greenhouse and revealed that variation IAHS-7 had a highest number of branches (13.75), followed by variation IAHS- 27 (10.25) whereas, variation IAHS-5 had minimum number branches (6.70).

The number of branches per plant varied from 7.5 cm in cultivar Cabaret to 8.0 in cultivar Red Corso under polyhouse condition (Naveenkumar *et al.,* 1999b).

Patil (2001) noted that the variation 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.

Ramesh Kumar and Kartar Singh (2003) reported relatively higher number of branches (8.58) in autumn planting in Carnation

Maximum number of shoots (9.33) per plant were recorded in treatment M_1 (Soil + Compost + Sand (2:1:1) substrate, 20 KPa irrigation regime, basal dose @ 200:200:100 NPK kg/ha/year + 100 and 200 kg N & K/ha/year through fertigation, followed by (9.17) in treatment M_4 (Same as M_1, except fertigation through straight fertilizers (Gurav *et al.,* 2004).

Under low cost polyhouse cultivar Madame Collette recorded maximum number of branches (4.80) per plant followed by Sugar Baby (4.73), Pirandello (4.40) and Alma (4.100 whereas, minimum number of branches (2.97) were recorded in cultivar Leon (Reddy *et al.,* 2004).

Shahakar *et al.* (2004) studied the growth, flower quality and yield a of Carnation varieties under polyhouse condition and revealed that Cobra recorded significantly superior result in respect of number of shoots per plant (5.80) and it was followed by Gaudina, Super Green Niva and Salsa. Minimum number of shoot was observed in Montezuma (4.25).

In a greenhouse trial on Carnation conducted by Shiragur *et al.* (2004b), varieties West Pretty (7.81), Desio (7.14), Aicardi (6.96) and Candy (6.64) exhibited production of more number of shoots. However cultivar Sugar Baby (5.25) had exhibited less number of shoots per plant.

Singh and Singh (2005) reported that, the maximum number of branches (9.5) were observed in Double pinching and 500 ppm nitrogen, followed by (9.1) in Double pinching and 200 ppm nitrogen.

Singh *et al.* (2006) reported 7.4 side shorts per plant under natural day length, whereas, in 4 hours and 6 hours additional light the number of side shoots were 7.3 and 7.0 respectively.

Ryagi *et al.* (2007) reported that the number of branches was found maximum in variety Domingo (5.85) and minimum in Cherry Solar (2.26).

2.2.5 Length of shoot

The maximum shoot length was observed in cultivar Alma (114.45 cm), followed by cultivar Sugar Baby (111.65 cm) and minimum shoot length was observed in Leon (70.87 cm) at 180 days after planting under low cost polyhouse condition (Patil, 2001).

Singh *et al.* (2006) reported that the long days enhanced internodal length shoots and hence, produced longer flowering stems. The extended photoperiod resulted in longer flowering stem (69.9 cm and 67.8 cm under 4 hr. and 6 hr. additional light, respectively.) over the control (50.2 cm).

2.2.6 Number of leaves

Sparnaaij *et al.* (1990a) noted that number of leaf pair per branch in Carnation ranged from 17.7 and 27.3.

Kanamadi and Patil (1993) studied the performance of chrysanthemum varieties in the transitional tract of Karnataka and reported that the maximum number of leaves was observed in cultivar Red Gold (168.23) and minimum in the cultivar Co-1 (58.00).

Naveenkumar *et al.* (1999b) studied the effect of growing environment on flowers of Carnation and the study revealed that cultivar Red Corso and Cabaret under polyhouse recorded 27 and 23 leaf pairs at flowering, respectively.

Leaf production varied significantly in gladiolus varieties at 60 days after planting and it ranged from 9.13 in cultivar Magic to 21.27 in cultivar Vedanapali (Kamble, 2001).

Patil (2001) reported that the number of leaves produced per plant was maximum in cultivar Madame Collette (204.80), followed varieties Alma (194.82) and Candy (184.67), and was minimum in cultivar Leon (129.54) at 180 days after planting plants under low cost polyhouse.

Ramesh Kumar and Kartar Singh (2003) reported relatively higher number of leaves (209.47) was observed in autumn planting. Plant grown under short days at winter recorded 215.03 leaves. However, in case of interaction effect, the maximum number of leaves (224.71) was recorded under autumn planting season with short day length.

Under low cost polyhouse condition, cultivar Madame Collette produced maximum number of leaves per plant (184.10), followed by Candy (180.74) and Alma (172.28), whereas minimum was recorded in cultivar Leon (110.29) (Reddy *et al.,* 2004).

Among the six Carnation varieties evaluated under polyhouse, maximum number of leaves was recorded in cultivar Gaudina (93.76), whereas minimum was recorded in cultivar Niva (67.10) (Shahakar *et al.,* (2004).

Shiragur *et al.* (2004b) studied the performance of standard Carnation varieties under protected cultivation and study revealed that the number of leaves produced per plant was maximum in cultivar Madame Collette (208.97), Aicardi (204.03), Candy (203.87) and Alma (198.73), while Sorisso produced lesser number 4 leaves (165.47).

Talukdar *et al.* (2006) recorded maximum number of leaves in chrysanthemum cultivar Cavelia (128.33) under open condition while in polyhouse cum-rain shelter condition it was 64.67 in cultivar Stanly Gosling.

2.2.7 Length of leaf

Lindgren and Uhlinger (1981) noted that the cultivar Smoky Carnation had 5 cm long leaves. In another study Uhlinger and Lindgren (1984) noted leaves of 11 cm length in cultivar N-74133.

Kamble (2001) observed the cultivar Trust had recorded maximum leaf length (53.31cm), while cultivar Melody recorded minimum (42.67 cm) at 60 days after planting.

The cultivar Madame Collette recorded maximum leaf length (13.12cm), whereas cultivar Leon recorded minimum leaf-length (7.29cm) grown under low cost poly house (Patil, 2001).

Ramesh Kumar and Kartar Singh (2003) reported that the leaf length was lowest (15.18 cm) when the cuttings were planted in late winter. The maximum leaf length (17.84) was recorded in the plants grown under short days of winter. In case of interaction effect, the maximum leaf length was recorded in autumn planting season of short days.

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.* (2004b) 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.

2.2.8 Per cent Mortality

According to Blanc (1983) varieties Pallas and Elsy were found very resistant to mortality (0.5%) and varieties Tanga, Lonseva, Vanessa and Danillo were fairly tolerant with 30 to 60 per cent mortality and cultivar Scania was highly susceptible that is 100% death of plants.

Boikov (1983) noted that some of the Bulgarian varieties had higher resistance to Fusarium wilt (*Fusarium oxysporum F. Sp. dianthi)*, race 20 than Sim varieties. The percentage of symptomless plants in the trial under conditions of artificial infection in the cultivar Plam was 92.5%, while in the Scania (control) cultivar it was 17.5 per cent.

Garibaldi (1983) reported that for all the pathotypes of *Fusarium oxysporum* f. sp. *dianthi* cultivar Duca was resistant.

Tramier *et al.* (1983) evaluated 27 Carnation varieties to study the Fusarium wilt incidence and noted that varieties Diano (0.3%), Elsy (1%), Duca (3%), Lanakino (3%), Clair (4%) and Pallas (8%) were resistant and varieties Embed (86%), Lonzelou (84%), Vanessa (68%) and Tangra (57%) were susceptible ones.

Tramier *et al.* (1987) found varieties Elsy and Pallas were tolerant with 14 and 17 per cent of diseased plants, respectively and varieties Aril Diana and Sacha as moderately tolerant but cultivar Ember was highly susceptible (100% diseased plants).

Boikov (1992) stated the advantages of Bulgarian complex Carnation varieties and noted that over 80% of the Bulgarian varieties showed high Fusarium resistance, both in laboratory and in commercial condition. About 15% of them registered moderate were medium resistance to this disease and 5% were tolerant to it.

Schoffelmeer *et al.* (1992) evaluated the Carnation varieties against Fusarium wilt resistance and stated that cultivar Novada was most resistant (95%) and varieties Lena and Early Sam were most susceptible (100%).

Ben-Yephet *et al.* (1993) studied the comparison of the effect of inoculation in the

greenhouse and at field in the Fusarium wilt development in six Carnation varieties. The study revealed that varieties Galit, Pallas and Eveline were free from disease, whereas cultivar Fantasia recorded maximum disease incidence (100%) in 1st and 3rd year followed by Raggio-di-sole 95% in 1st year and 100% in 3rd year. In another study of 11 varieties evaluated, the study revealed that varieties Aviv, Golden Queen, Mark Queen and Pink Tween were free (0%) from any disease symptoms under greenhouse, whereas varieties, Libnatl, Alpinia, Orili and Spring Tween recorded 100% disease incidence under greenhouse.

Atanassova and Batchvarova (1995) observed that varieties Regina, Nicki, Krassina, Yanita and Biliana were high yielding than Red Barbara and were highly resistant to *Fusarium oxysporum f. sp. dianthi* race (95% resistantance) whereas varieties Red Barbara was found tolerant (31.9% resistantnce).

Ben-yephet *et al*. (1996) evaluated five Carnation varieties to study Fusarium wilt resistance and reported that cultivar Galit, Eveline and Candy had no disease incidence, whereas cultivar Hermon showed 40 per cent disease incidence.

In Carnation varieties, IAHS-27 had minimum mortality (13.57%) whereas cultivar IAHS- 7 had the highest mortality of 25 % (Sathisha, 1997).

Lal *et al.* (1998) studied the performance of fourteen Carnation varieties for their susceptibility to various fungal diseases and reported that the varieties Scania, Dusty, White sim, Shocking Pink, Arthur sim and Sam's Pride were moderately to highly susceptible. While, the varieties, Alec's Red, William Sim, Harvest Moon, Lena, Yellow Dusty, Tangerine, Laddie and Scarlet Elegance were highly susceptible. Patil *et al.* (2001) studied the performance of Carnation varieties against Fusarium wilt resistance and found that varieties Sugar Baby and Aicardi recorded minimum plant mortality (5.86%) due to Fusarium wilt, whereas cultivar Leon recorded maximum mortality (16.67%).

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.

2.3 Flowering Parameters

2.3.1 Number of days taken to bud initiation

Naveenkumar *et al.* (1990b) observed that cultivar Red Corso was early in flowering (138 days) when compared to Cabaret (162 days).

Bhautkar (1994) studied the performance of 10 varieties under greenhouse and reported that cultivar Barbara was the earliest to initiate (following 10th days after planting). However, cultivar Eveline was late which required 119 days for the bud initiation. In another study, cultivar Sterile DOP (spray) was earliest (122.06 days), whereas cultivar Pink (Standard) was late (166.77 days) in flowering (Mahesh, 1996).

Satisha (1997) reported that early flower bud initiate was recorded in cultivar, IAHS - 22 (95.75 days), followed by cultivar IAHS – 23 (96.30 days).

Patil (2001) studied 10 Carnation varieties under low cost polyhouse and reported that cultivar Leon was earliest to initiate flowering (55 days), whereas cultivar Aicardi was too late which took 128.67 days for flower bud initiation.

Ramesh Kumar and Kartar 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 condition took the least number of days for their bud emergence (78.5%). In case of interaction effect the earliest bud emergence (71.61 cays) was observed in late winter season with long days.

Among six cultivar evaluated under Naturally Ventilated Greenhouse, cultivar Salsa was earliest to initiate flowers (74.8 days after planting), whereas cultivar Cobra was late which took 87.55 days for flower bud initiation (Sahakar and Sable 2003).

An experiment was carried out to study the performance of 10 Carnation varieties by Reddy *et al.* (2004). According to them, the flower bud initiation was earlier in cultivar Leon (55 days), followed by Sorisso (71 days) and Desio (72 days). Late flowers were observed in varieties Aicardi, Pirandello and Candy (128, 120.67, 114.66 days respectively).

Sahakar *et al*. (2004) studied the growth, flower quality and yield of six Carnation varieties under polyhouse and reported that cultivar Salsa recorded the shortest period (99.55 days) for flower bud initiation while cultivar Gaudina recorded maximum (122.20) days for bud initiation.

Sarkar *et al.* (2004) studied the performance and gerbera under protected condition and reported that Gerbera varieties under study took 109.72 to 141.12 days to visibility of flower bud.

Among the nine Carnation varieties evaluated under law cost ploy house, cultivar Desio was earliest to initiate bud (63.83 days), followed by cultivar Sorrisso (67.50 days), while cultivar Pirandello was late which took 119.50 days for flower bud initiation (Shiragur *et al.* 2004a).

2.3.2 Number of days taken for flower bud opening

Cultivar Espana took 82 days to reach stage of harvesting from planting (Sing *et al.* 1994). Sparnaaij *et al.* (1990a) reported the first flowering ranged from 103 days from pinching in *Dianthus* X *Doris* hybrid (80910-4) to 17 days in *Dianthus knappi* hybrid (79127-2).

Varieties differed significantly for number of days taken for bud opening under low cost greenhouse. Cultivar Master took maximum number of days (6.38) for bud opening, while cultivar Vienna took minimum number of days (6.06) for bud opening (Krishnappa *et al.,* 2000).

Under low cost polyhouse Patil (2001) evaluated 10 varieties. Among them Leon was earliest for flower bud opening (84.67 days), followed by cultivar Sorisso (97.33 days), whereas cultivar Aicardi was late in flower bud opening (151.67 days).

Shiragur *et al.* (2004a) evaluated the 10 standard Carnation varieties under protected cultivation and reported that the cultivar Sorisso and Desio showed early flower bud opening (91.50 and 93.33 days, respectively), whereas in cultivar Aicardi flower bud initiation was late hence, there was delay in flower bud opening (137 days).

Sarkar and Ghimiray (2004) studied the performance of gerbera under protected condition and reported that, gerbera varieties Red Explosion and Kalimpong Red required 118.43 and 15.18 days to flower bud opening, respectively.

Among the varieties studied under polyhouse condition by Sahakar *et al.* (2004), cultivar Salsa recorded the minimum number of days (20.60 days) for flower opening, while cultivar Super green recorded maximum days for flower opening.

Tejaswini and Murgod (2005) reported that module M_4 (Sand: Soil: Compost + 6 liter irrigation regime per m^2 per day + straight fertilization) exhibited slow opening (5.33 days), followed by those from module M_3 (Saw dust: Soil: Compost + 6 liter irrigation regime per m^2 per day + water soluble fertilizers (94.67 days). On the contrary, flower from M_7 (Saw dust: Soil: compost + Irrigation regime 3 liter per day + water soluble fertilization) opened quickly 93.45 days).

2.3.3 Number of days taken for flower development

Mahesh (1996) reported the cultivar Pink (Standard) took very less time for flower bud development (26.20 days), whereas cultivar Sterile DOP (Spray) took more time for flowering (41.06 days) in Carnation.

The time taken for bud development from flower initiation was very less in case of cultivar IAHS-22 (20.35 days) as compared to cultivar IAHS-7 (36.3 days) under low cost greenhouse (Sathisha, 1997).

Patil (2001) evaluated 10 varieties under low cost polyhouse and reported that cultivar Alma took very less time for bud development (18.00 days), whereas cultivar Sorisso took more time (26.33 days) for development of flower bud.

Shiragur *et al.* (2004a) observed that cultivar West Pretty took less time for bud development (17.67 days), followed by Sugar Baby (18.00 days), whereas cultivar Sorisso was late in bud development (29.33 days) when cultivars were evaluated under low cost polyhouse.

Singh and Singh (2005) reported that earliest flowering (170.90 days) was observed in single pinching and 500 ppm Nitrogen while double pinching and 200 ppm Nitrogen combination took maximum days (196.93) for flowering.

2.3.4 Duration of Flowering

Gill and Arora (1988) reported the duration of flowering in cultivar Scania was 33.81 days.

Lal *et al.* (1998) studied the performance of different variation of Carnation and noted that the longest duration of flowering (31.5 days) was observed in the variety Sims pride which is a spray type, followed by the standard type Scania (31.03 days).

The duration of flower was maximum (48.77 cm) when no pinching was performed and minimum (21.10 cm) was with double pinched plants (Pathania *et al.,* 2000).

Patil (2001) reported that the flowering period was maximum in cultivar Desio (188.67 days) and was minimum in cultivar Aicardi (143.33 days).

Dwivedi and Kareem (2004) evaluated the fifteen Carnation varieties and noted that the longest duration (34.3 days) was observed in variety Flair, followed by 33.0 days in Etora. Red Carnation variety had shortest duration of flowering (26.65 days).

Shiragur *et al.* (2004a) evaluated the standard Carnation cultivar under protected cultivation and reported that as far as flower duration is concerned, cultivar Aicardi (235.0) recorded maximum duration, followed the Alma (229.67), West Pretty (222.67), Candy (222.0) and Sugar Baby (218.67), whereas varieties Pirandello (184.67), Desio (184.67), Sorisso (193.33) recorded minimum duration.

2.4 Flower Quality Parameters

2.4.1 Length of flower Stalk

Boikov (1983) observed that the average flower stalk length of Bulgarian Carnation varieties was higher (101.11 cm) than sim Carnation varieties (89.0cm). Gill and Arora (1988) observed the average flower stalk length ranged from 44.8 cm in cultivar Scania and 48.5 cm in cultivar Can Can.

Bhautkar (1994) revealed that flower stalk length ranged from 65-87 cm. cultivar Lena recorded maximum flower stalk length (87 cm), whereas cultivar White Sim recorded minimum (65 cm).

Singh *et al.* (1994) observed that stem length (59.05 cm) was found higher under 25% shading treat, whereas it was minimum (58.78) under 0% shade for second flush in Carnation crop.

Mahesh (1996) evaluated Carnation varieties under low cost polyhouse and found that flower stalk length varied from 99.35 to 115.10 cm in varieties Arthur sim and starlight DOP, respectively.

Cultivar IAHS-23 had the longest flower stalk length (80 cm) at harvest, followed by cultivar IAHS-22 (79.40 cm), whereas varieties IAHS – 7 had the shortest flower stalk length of 66.75 cm. (Sathisha, 1997).

Lal *et al.* (1998) studied the performance of different varieties of Carnation in U.P. hills and noted that longest flowering stalk (28.85 cm) was found in the variety Scania, followed by Shocking Pink (27.28 cm). The minimum flowers stalk length was found in variety Scarlet Elegance (20.05 cm).

The maximum flower stem length (54.08 cm) was observed in cultivar Red Corso under polyhouse as compared to open (42.00 cm) in cultivar Cabaret it was 38.00 cm under polyhouse condition (Naveenkumar *et al.,* 1999b).

Pathania *et al.* (2000) noted that the stem length was maximum (48.77 cm) when no pinching was followed. The stem length was minimum (21.10 cm) when double pinching was followed. The stem length of 34.50 cm recorded in pinch and half for second flush.

Patil (2001) studied the 10 Carnation varieties under low cost polyhouse and revealed that cultivar Sugar Baby recorded maximum stalk length (106.77 cm), followed by cultivar Alma (103.83 cm), whereas minimum stalk length was recorded in cultivar Leon (67.04 cm).

Ramesh Kumar and Kartar Singh (2003) observed that stem length was maximum

(37.41 cm) in autumn season. In case of interaction effect, autumn season with long day condition showed maximum stem length (39.86 cm).

Singh and Sangama (2003) noticed that significant variation was observed in flower stalk length at different Carnation varieties ground under than and pad cooling system greenhouse condition. Cultivar Navajo had longest stalk length of 70.06 cm, followed by cultivar Sunrise (67.63 cm). The minimum stalk length of 39.26 cm was recorded in cultivar Isaq.

Among the fifteen varieties of Carnation, cultivar Dusty Pink showed maximum flower stalk length of 27.00 cm whereas it was more in cultivar Cabaret (19.65 cm) (Dwivedi and Kareem, 2004).

An experiment was carried out by Reddy *et al.* (2004) to study the vegetative growth, flower yield and quality of ten standard Carnation varieties under law cost polyhouse condition. The study revealed that the length of flower stalk was longest in varieties Alma, Sugar Baby, Aicardi and Pirandello (95.92, 93.63, 89.85 and 89.15 cm. respectively). Moderate flower stalk length was recorded in varieties Desio, Candy and Madame Collette (88.68, 87.54 and 85.76 cm, respectively), whereas shortest stalk length was recorded in cultivar Leon (67.70 cm).

Six Carnation varieties were evaluated under polyhouse by Sahakar *et al.* (2004). The study revealed that maximum stem length was observed in cultivar Gaudina (93.94 cm) and it was minimum in cultivar Niva (68.26 cm).

Study conducted under low cost polyhouse by Shiragur *et al.* (2004a) found that, maximum stalk length was recorded in cultivar Pirandello (91.02 cm), followed by cultivar Candy (87.74 cm), whereas minimum stalk length was recorded in cultivar Desio (67.88 cm).

The maximum flower stem length (52.10cm) was found under single pinching and minimum (39.5cm) under double pinching. In case of interaction effect the maximum flower stalk length (58.4) was recorded in single pinching and 500 ppm nitrogen (Singh *et al.,* 2005).

Singh *et al.* (2006) noted that the extended photoperiods resulted in longer flower stem (69.9 cm and 67.8 cm under 4 hour and 6 hour additional light, respectively) over the control (50.2 cm).

Maximum stem length (64.38 cm) was observed in cultivar Raggio-de-sole as compared to cultivar Murcia. Amongst different treatment combinations, maximum stem length (67.47 cm) was recorded under treat T_6 (Sand + Soil + Vermicompost (1:1:1) + Inorganic water soluble fertilizers + Bio fertilizers) and minimum under T_1 (Control) (Bhalla *et al.,* 2007).

Ryagi *et al.* (2007) studied the effect of pinching on growth, yield and quality of Carnation varieties under greenhouse and the study revealed that maximum stem girth was recorded in cultivar Yellow solar (88.6 cm), whereas it was minimum in cultivar Domingo (86.3 cm) . In case of interaction effect between cultivar and pinching method, the maximum stalk length was observed in cultivar Cherry Solar with single pinching (93.2 cm), whereas it was lowest in cultivar Domingo with double pinching.

2.4.2 Girth of Flower Stalk

Girth of flower stalk of Bulgarian varieties was higher (3.8 mm) when compared to Sim varieties (3.7 mm), stem thickness at third mode was highest in case of genotype Pink (0.31 cm) and was lowest (0.20 cm) in case of genotype Deep Pink (Mahesh, 1996).

The maximum girth of flow stalk was observed in cultivar IAHS-5 (0.49 cm), whereas the lowest flower stalk girth (0.36 mm) was recorded in cultivar IAHS-7 grown under low cost poly house (Satisha, 1997).

Patil (2001) observed maximum girth of flower stalk 15.60 mm) in cultivar Madame Collette, followed by cultivar Sugar Baby (5.60 mm) and minimum flower stalk girth was recorded in cultivar Leon (3.50 mm) grown under low cost polyhouse.

An experiment was carried out by Reddy *et al.* (2004) to study the vegetative growth, flower yield and quality of 10 standard Carnation varieties under low cost polyhouse condition. The study revealed that girth of flower stalk was maximum in cultivar Madame Collette (0.56 cm), Sugar Baby (0.55 cm) and Alma (0.53 cm), whereas cultivar Leon recorded minimum.

Six Carnation varieties were evaluated under polyhouse by Shahakar *et al.* (2004). The study revealed that the maximum girth of stem was recorded in cultivar Super green

(0.49 cm), followed by cultivar Niva (0.48 cm), cultivar Cobra (0.45 cm), and Cultivar Gaudina (0.43cm).

Under low cost polyhouse, maximum girth of flower stalk (6.94 mm) was recorded in cultivar Sugar Baby, followed by cultivar Madame Collette (6.70 mm), whereas minimum (3.27 mm) girth of flower stalk was recorded in cultivar Sorisso (Shiragur *et al.,* 2004a).

According to Tejaswini and Murgod (2005), the stem thickness was significantly higher (5.42 mm) in cultivar Sunrise in Molecule M_5 (Sand: Soil: Compost (1:2:1) + 3 lit./m^2/day irrigation regimes + water soluble fertilizers).

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 cultivar Domingo, whereas it was minimum in cultivar Dover (3.73 mm). In case of interaction effect between variety and pinching methods the maximum stalk girth was recorded in cultivar Domingo with double pinching (5.35 mm). It was recorded minimum (3.54 cm) in varieties Dover with single pinching and cherry solar with single and half pinching.

2.4.3 Flower Diameter

Flower diameter of Bulgarian race was found significantly higher (8.9 cm) compared to flower diameter of Sim Carnations (7.7 cm) at peak flowering (Boikov 1983).

Pawliczuk and Orlikowski (1987) noted that cultivar Kmic had maximum flower diameter (7.9 cm), whereas cultivar Pallas had minimum (6.8 cm).

Singh *et al.* (1994) observed maximum bloom size (8.4 cm) in cultivar Scania, whereas it was minimum 96.7 cm0 in cultivar Can Can.

According to Atanassova and Batchvarova (1995) the diameter of flower was maximum in cultivar Biliand and red Barbariz (4.5 cm), whereas it was minimum (4.3) in cultivar Yanita.

Naveenkumar *et al.* (1999a) reported that flower diameter ranged between 6.83 cm in cultivar Red Corso to 5.40 cm in cultivar Cabaret.

The maximum flower diameter (7.20 cm) was noted in cultivar Cabaret under polyhouse as compared to open condition (4.80 cm) (Naveenkumar *et al.,* 1999b).

Mahesh (1996) studied the Carnation varieties under low cost polyhouse and observed that diameter varied from 4.66 cm in cultivar White to 7.11 cm in cultivar Arthur sim. In another study conducted by Satisha (1997), it was found that, cultivar IAHS – 23 had larger sized flower (7.58 cm diameter) when compared with IAHS –7 (5.10 cm diameter).

Patil (2001) noticed that cultivar Madame Collette had maximum flower diameter (6.63 cm), followed by cultivar Alma (6.31 cm), whereas cultivar Leon had minimum flower diameter of 4.13 cm.

Flower diameter was maximum (6.98 cm) in no pinched plants. However, it was minimum 5.60 cm in case of double pinched plants (Pathania *et al.,* 2000).

Singh and Sangama (2003) noted that there was significant variation among the varieties evaluated. The maximum flower diameter of 6.08 cm was recorded in cultivar Aicardi, followed by cultivar Sunrise (5.61 cm). The flower diameter was minimum in cultivar Lilac Torres (4.25 cm).

Dwivedi and Kareem (2004) reported that diameter of flower showed no significant variation and it ranged from 5.0 cm in cultivar White candy to 5.9 cm in varieties Shocking pink, Atora and Carpalmor.

Gurav *et al.* (2004) reported that the maximum flower diameter (6.98 cm) was recorded in modulus M_1 (Soil + compost + Sand (2:1:1) substrate,20 kPa irrigation regime, basal dose @ 200:200:100 NPK kg/ha/year + 100 and 20 kg N and K /ha/year) through fertigation, whereas it was minimum of 5.47 cm in modulus M_9(same as M_1, except rationing after one year).

An experiment was carried out by Reddy *et al.* (2004) to study the ten standard Carnation varieties under low cost polyhouse condition. The study revealed that the cultivar Madame Collette recorded maximum flower diameter (6.65 cm), followed by Desio (5.44 cm), whereas diameter of flower bud was minimum in cultivar Leon (4.66 cm).

Six Carnations cultivars were evaluated under polyhouse by Shahakar *et al.* (2004). The results revealed that the maximum flower diameter (7.45 cm) was in cultivar Gaudina, whereas it was minimum (6.00 cm) in variety Salsa.

Among nine varieties grown under low cost polyhouse, cultivar Candy recorded maximum flower diameter (6.63 cm), followed by cultivar Madame Collette (6.41 cm), whereas cultivar Sorisso recorded minimum flower diameter of 5.63 cm (Shiragur *et al.,* 2004a).

The maximum flower diameter (5.7 cm) was obtained in single pinching and was least (5.2 cm) in double pinching, whereas in case of interaction effect 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).

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

2.4.4 Length of Flower

Bhautkar (1994) reported that the maximum length of flower (7 cm) was recorded in varieties White Sim, Lena, and Arthur sim, whereas minimum (4.5 cm) was recorded in cultivar Starlight under glasshouse.

Gurav *et al.* (2004) evaluated Carnation cultivar Sunrise under partially modified greenhouse and revealed that the flower length was found to be maximum (5.36 cm) in treatment M_4 (Soil + compost + Sand (2:1:1) substrate, 20 KPa irrigation fertigation + basal dose @ 200: 200:100 NPK kg/ha/yr + fertigation through straight fertilizers), whereas it was recorded minimum of 4.45 cm.

2.4.5 Number of Petals

Halliday and Watson (1953) reported that variety Northland had more number of petals per flower (57.5) as compared to variety William Sim (47.7).

Boikov (1983) noticed that mean number of petals in Bulgarian Carnation varieties was significantly higher (66.1) when compared with mean number of petals in sim Carnation varieties 63.8.

Boikov (1992) noted that in new Bulgarian Carnation varieties, number of petals per flower ranged between 100 and 200, which was much more than that of Mediterranean and Sim varieties. Lindgren and Uhlinger (1996) observed 29 petals per flower in cultivar Prairie Pink.

Atanassova and Batchvarova (1995) recorded maximum number of petals in varieties Regina and Krassina (48.5 and 97.5 respectively), whereas variety Nicki had minimum of 29.6 petals.

According to Mahesh (1996) number of petals ranged from 44.88 in cultivar Pink to 66.75 in cultivar Arthur sim.

Naveenkumar *et al.* (1999b) noted that cultivar Cabaret had maximum number of petals per flower (87), whereas cultivar Red Corso had minimum of 42.

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

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.

Evaluation of Carnation varieties under protected cultivation revealed that number of petals ranged from 42.32 in cultivar Sugar Baby to 69.16 in cultivar Alma (Shiragur *et al.,* 2004a).

2.4.6 Flower Weight

The fresh weight of Bulgarian race (10.60 gm) was higher than Sim varieties (8.24 gm) as reported by Boikov (1983).

Singh *et al.* (1994) observed no significant difference in final cut flower weight. It was maximum (28.82 gm) in 0% shade whereas minimum (28.02 gm) in 50% shade treatment for second flush.

Krishnappa *et al.* (2000) reported significant differences in cumulative fresh weight of flowers. Significantly highest cumulative fresh weight (148.28 gm) was recorded in cultivar Aleda, whereas minimum cumulative fresh weight of flower was recorded in cultivar Vienna (104.96 gm).

Singh *et al.* (2001) studied different varieties and noticed that cultivar Forca recorded higher fresh weight (28.73 gm), followed by Tasman (20.16 gm) and Aicardi (19.53 gm) and lowest weight was observed in Lillac Torres (10.10gm).

Cultivar Pentara and Sunrise recorded better fresh weight with the incorporation of silver nitrate + Sucrose + 8- Hydroxyquinoline as reported by Chikkasubbanna and Sharada (2002).

Shiragur (2002) studied the performance of Carnation varieties under polyhouse condition and reported that the varieties, Madame Collette, Sugar Baby, Aicardi, Alma and Pirandello recorded higher flower weight (16.42, 15.83, 13.92, 13.43, and 13.83 gm respectively), while cultivar Sorisso recorded minimum flower weight of 8.42 gm.

Singh and Sangama (2003) reported that cultivar Forca had highest fresh weight of flower stalk (28.13 gm) followed by cultivar Tasman (18.33 gm). The minimum fresh weight of 11.96 gm was obtained in cultivar Lilac Torres.

Among the difference Carnation varieties studied, Cultivar Madame Collette recorded higher fresh weight (16.42 gm), followed by cultivar Sugar Baby (15.83 gm) and Aicardi (13.92 gm) and lowest (8.42 gm) in cultivar Sorisso (Shiragur *et al.,* 2004a).

According to Tejaswini and Murgod (2005) fresh weight of flower was significantly higher (14.45 gm) in molecule M_7 (Sawdust: Soil: Compost (1:2:10 + 3 liter /m^2/day irrigation + water soluble fertilizers. Fresh weight was recorded least in molecule M_1 (Sand: Soil: Compost (1:2:1) + 6 liter/M_2/day irrigation + water soluble fertilizers).

2.4.7 Calyx Splitting

Halliday and Watson (1953) noticed that calyx splitting varied from 1.04 per cent in cultivar Northland to 3.97 per cent in cultivar Millers yellow grown under greenhouse.

Boikov (1983) observed less incidence of calyx splitting in Bulgarian varieties (0.9%) when compared to Sim varieties (14.3%).

Skalska, (1983) Studied the influence of fertilization on flower calyx splitting in pink Carnation variety Lena and noticed that the number of flowers with split calyx per m^2 was not influence significantly by the fertilization of the plants to the required level of nutrients in soil. He further reported that, the greatest number of flower with split calyx was obtained in spring, in the period from 16 February to 15 May.

Mitteau (1987) observed no calyx splitting in varieties Vanya and Carola. The maximum calyx splitting was recorded in cultivar Ember (27%) whereas it was minimum (1%) in varieties Tanga and Virginie.

Varieties Srebrina and Cana were free from calyx splitting (Anon., 1990).

Bulgarian Carnation varieties were considerably free from calyx splitting, which ranged between 0.1 and 0.5 per cent according to Boikov (1992).

Cultivar IAHS- 27 had minimum calyx splitting (3.64%), followed by cultivar IAHS–7 (5.37%), whereas maximum calyx splitting (10.24%) was observed in cultivar IAHS-5 (Satisha, 1997).

Calyx splitting was found minimum in cultivar Clear Yellow (10.30%) where it was maximum (15.7%) in cultivar Scania (Gill and Arora, 1998).

Lal *et al.* (1998) recorded the lowest calyx splitting percentage (27.7) in the variety Alec's Red, followed by Yellow Dusty (28.76%) among the standard Carnations.

Pathania *et al.* (2000) reported that when no pinching was followed, the percentage of calyx splitting was minimum (38.07) because of more vigour in petals, whereas it was minimum (19) in double pinched plants having 16 laterals.

Among varieties studied, Patil (2001) noted no calyx splitting in varieties Sugar Baby

and Desio and low calyx splitting in cultivar Madame Collette (0.83%) whereas, cultivar Leon recorded maximum calyx splitting (12.50%).

Shiragur (2002) reported that the calyx splitting varied among the 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%).

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.

2.4.8 Vase Life

Among ten varieties evaluated by Bhautkar (1994), varieties Thalassa and Bianca recorded maximum vase life (8 day each). However, cultivar Arthur sim recorded minimum vase life of 3 days.

Singh *et al.* (1994) observed longer vase life under unshaded plants for second flush.

Mahesh, (1996) reported that cultivar Deep Pink and Dusty Pink had maximum flower longevity of 16.00 days and 15.53 days, respectively, whereas cultivar White Sim with red edge had minimum (10.45 days) longevity.

Satisha, (1997) reported that cultivar IAHS –7 had maximum vase life of 11.48 days, followed by cultivar IAHS-27 (10.80 days) and IAHS -23 (10.10 days), whereas minimum vase life (7.50 days) was recorded in cultivar IAHS–5.

Naveenkumar *et al.* (1999a) observed maximum vase life (10.0) in cultivar Cabaret, whereas it was minimum (8.67 days) in cultivar Red Corso under polyhouse when treated with 8- HQC 200 ppm.

The maximum vase life of 11.0 days was recorded in cultivar Master, followed by cultivar Kristina (10.63 days), whereas cultivar Vienna recorded significantly shortest (9.74 days) vase life (Krishnappa *et al.,* 2000).

Pathania *et al.* (2000) reported that the keeping quality of cut Carnations was higher (13.13 days) in case of unpinched plants because of better availability of nutrition and accumulation of carbohydrates.

Patil (2001) evaluated 10 Carnation varieties under polyhouse and noted significant difference in vase life. The maximum vase life was recorded in cultivar Sugar Baby (12.33 days) and it was minimum in cultivar Leon (5.33 days).

Chikkasubbanna and Sharada (2002) observed that maximum vase life of 10.80 days was recorded in cultivar Pentara in 0.4 Mm STS + 6.1% Sucrose + 400 ppm 8-Hydroxyquinoline as against the control (4.80 days). In case of different combinations of chemicals vase life was maximum in cultivar Sunrise (15.80 days) in 100 ppm silver nitrate + 4% sucrose + 200 ppm 8-HQ compared to 7.40 days in control.

According to Sumanbhatia *et al.* (2002) the maximum vase life was recorded in cultivar Impala (13.5 days) and Purple Choppin (9.67 days) with holding solution of 100 ppm STS + 2 per cent sucrose.

Ramesh Kumar and Kartar Singh (2003) observed that durability of flower was maximum (9.15 days) in autumn planting season, whereas maximum vase life was observed in long day condition (8.33 days). In case of interaction effect, the maximum durability of flower was recorded in autumn season with long day condition (10.93 days).

Among the 10 varieties of Carnation evaluated for post harvest quality under greenhouse, by Singh and Sangama (2003), cultivar Sunrise recorded Maximum variation life of 12.60 days, followed by variety Forca (12.40 days). Cultivar Lilac Torres had shortest vase life of 8.40 days.

According to Shiragur *et al.* (2004a), cultivar Alma recorded maximum vase life of 16.33 days, followed by Desio (16.17 days), Sugar Baby (15 days), West Pretty (15 Days), whereas cultivar Sorisso had recorded minimum vase life of 6.67 days.

Six Carnation varieties were evaluated under polyhouse by Shahakar *et al.* (2004). The study revealed that the maximum vase life was observed in cultivar Super green (9.50 days), followed by Niva (9.00days), Salsa (8.00 days), Montezuma (7.00 days), Cobra (6.00 days) and Gaudina (5.80 days). Singh *et al.* (2006) noted that additional lighting did not affect vase life of the flowers.

Ryagi *et al.* (2007) studied the effect at pinching on growth, yield and quality of Carnation varieties under greenhouse and the study revealed that maximum vase life of 8.52 days was recorded in cultivar Yellow solar whereas it was minimum in cultivar Dover (7.97 days). In case of interaction effect between cultivar and pinching method, the maximum vase life of 8.81 days was in cultivar Yellow Solar with single pinching whereas it was minimum in cultivar Dover with single pinching (7.53 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 of sucrose, biocides and ethylene antagonists, the maximum vase life (13.44 days) was observed when the stems were pre–treated with STS, 1mM 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 (0.2 mM).

According to Tejaswini and Murgod (2005) the vase life was found to be highest (8.89) in case of flowers produced in molecule M_4 (Sand: Soil: Compost (1:2:1) + 6 lit./m^2/day irrigation regimes + Straight fertilizers) and was least (7.33 days) in M_1 (Sand: soil: compost 1:2:1 + 6 liter /m^2/ day irrigation + water soluble fertilizers) in Carnation cultivar Sunrise.

2.5 Yield Parameters

2.5.1 Number of flower per plant

Khanna *et al.* (1981) reported that production of flowers per plant was significantly more (14.2 flowers) in widest spacing of 30 x 30 cm^2. Pinching the plants either twice or thrice enhanced the number of flowers per plant significantly over control.

Most productive varieties of Bulgarian type had 70-80 per cent higher yield than the Sim varieties and 30-40 per cent than Mediterranean type (Boikov, 1992).

Bhautkar (1994) observed maximum number of flowers in cultivar Eveline (18) followed by cultivar Furore (17) and Cultivar Starligtht (16), whereas minimum number of flowers was recorded in cultivar Lena (10).

Singh *et al.* (1994) noted that better flower yield was observed during the second flush that is in winter months. The maximum number of flowers per plant was harvested from 25 % shade treatment (13.27 flowers).

Atanassova and Batchvarova (1995) observed maximum number of flower per plant in cultivar Nicki (6.2), followed by cultivar Yanita (6.0) and minimum in cultivar Red Barbara.

Gill and Arora (1998) recorded maximum number of flowers per plant in cultivar Can Can (6.7 flowers).

Lal *et al.* (1998) studied the performance of fourteen varieties of Carnation and reported that higher number of flowers per plant were observed in spray variety Sam's Pride (11.2). However, among the standard varieties maximum number of flowers (5.1) were produced by the variety Scania, followed by Arthur Sim (4.97) and White Sim (4.7). The Variety Tangerine (4.13) produced lesser number of flowers per plant.

Naveenkumar *et al.* (1999b) recorded highest number of flowers per plant (7.75) in cultivar Red Corso under polyhouse as compared to lesser (4.5) flowers per plant under open cultivation. Cultivar Cabaret recorded 6.25 flowers per plant under polyhouse as compared to 3.00 flowers per plant under open condition.

Under low cost polyhouse Patil (2001) evaluated 10 varieties of Carnation and recorded maximum number of flowers in cultivar Madame Collette (4.29), followed by Cultivar Desio (4.13), while minimum number of flowers was recorded in cultivar Leon (2.71).

Ramesh Kumar and Singh (2003) observed maximum number of flowers per plant in autumn season of planting, whereas in case of interaction of effect of planting season and day length, the maximum number of flowers per plant were observed in autumn season of planting with long day length.

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

Gurav *et al.* (2004) standardized the package of practices for Carnation under partially modified greenhouse and reported that, treatment M_4 (Soil + Compost + Sand (2:1:1) 20 KPa irrigation + basal dose @ 200: 200: 100 NPK kg/ha/yr + 100 and 200 kg N and K/ha/yr fertilization (Straight fertilizers) was found to be superior in producing maximum number of 'A' grade flower (Stem length = 55 cm and above) (154.20), flowers/plant year (5.88). The treatment M_7 (Soil + Compost + Sawdust 2:1:1) + 40 KPa irrigation + basal dose @ 200: 100: 100 NPK kg/ha/year + 100 and 200 kg N and K/ha/yr through Fertigation (Water Soluble fertilizers) recorded minimum number of flowers per plant (3.59).

An experiment was carried out by Reddy *et al.* (2004) to evaluate the 10 Carnation varieties and the study revealed that cultivar Madame Collette recorded maximum yield (4.56 flowers per plant), followed by Alma and Sugar Baby (4.18 and 4.12 flower per plant, respectively). Varieties Pirandello, Desio and Aicardi recorded moderate flower yield, however cultivar Leon recorded minimum flower yield, of 2.82 flowers per plant.

Shiragur *et al.* (2004a) evaluated nine standard Carnation varieties under protected cultivation and reported that yield of flower in terms of number of flowers per plant was highest in varieties West Pretty (7.81 flowers), followed by Desio, Aicardi and Madame Collette (7.14, 6.97 and 6.69 respectively) while, cultivar Sugar Baby produced the lowest number of flowers per plant (5.25 flowers).

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 cultivar Cobra which was at par with Gaudina. Next in order were Super green (5.20), Niva (5.13), Salsa (4.46) and Montezuma (4.25).

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).

The treatment combinations T_6 (sand + soil + vermicompost (1:1:1) + inorganic water soluble fertilizers + bio-fertilizers) produced maximum number of flowers per plant (5.66), while minimum number of flowers per plant. (4.53) were observed in control (sand + Soil + FYM, @ 1: 1:1) (Bhalla *et al.*, 2007).

2.5.2 Number of flowers per square meter

Naveenkumar *et al.* (1999) reported that maximum number of flowers per plant (8.0 and 6.7 in Red Corso and Cabaret varieties, respectively) were obtained in treatment T5 (6-7 leaf pair and 15 days).

Pathania *et al.* (2000) observed that double pinched plants with 16 laterals yielded the maximum number of flowers per m^2 (177.77) of poor quality. However, pinch and a half method staggered the flowers production in two flushes, yielding about 66.66 flowers per M_2 of good quality.

Gurav *et al.* (2004) standardized the package of practices for Carnation under partially modified greenhouse and reported that treatment M_4 (Soil + Compost + Sand (2: 1:1) + 20 KPa irrigation + Basal dose @ 200: 200: 100 NPK kg/ha/yr +100 and 200 kg N and K/ha/yr. through fertigation (Straight fertilizer) was found to be superior in producing maximum number of flowers per m^2 per year (168.00). The same treatment i.e. M_4 produced maximum number of 'A' grade flowers (Stem length = 55 cm and above) (154.20). The treatment M_7 (Soil +compost + Sawdust (2: 1:1) + 40 KPa irrigation + Basal dose @ 200:200:100 NPK kg/ha/yr +100 and 200 kg N and K /ha/yr through fertigation (water soluble) recorded minimum number of flowers per m^2 (102.24).

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*. (2004a) 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).

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).

2.6 Economics

Totth (1984) reported that, cultivation of Carnation for cut flowers is no longer profitable due to enormous increase in production costs. However, profitability can be improved by adopting improved cultural methods and also by the introduction of highly productive good quality varieties.

Subramanyam (1986) studied the economics of production and marketing of Chrysanthemum flowers in Karnataka. He concluded that labour cost accounted for the major portion of input and there was a huge difference in returns when the cut flowers were sold through channel I (sale through commission) and channel II (sale to pre-harvest contractors).

In rose cultivation, the major item of input cost was planting and plant material. The investment in roses was found to be economically viable as it gave a benefit-cost ratio of 1.7 to 1.8 with hardly 2 to 3 years payback period depending upon the channel of sale (Subramanyan, 1989).

In an economic analysis made at Taiwan production in Gypsophilla, Carnation, Gerbera and lilies under protected structure indicated that although the production costs were higher for lilies, the returns were also higher. The revenues obtained from Gypsophylla although were lower, production costs were also low and thereby the profit margin was higher in Gypsophylla as compared to Carnation and lilies. However, gerbera production costs and revenues were similar (Lin and Chin, 1990).

Zawaneberg (1990) compared the cost and returns of the five major greenhouse cut flower crops viz., Carnation, Chrysanthemum, Freesia, Gerbera and Roses in Netherlands over a period of ten years. According to him Chrysanthemum production has showed lowest increase in labour cost. Rapid growing cycle and closer planting resulted in higher productivity.

Ferretto and Bendetto (1994) studied the economics of Carnation cut flower production during winter by promoting supplementary light and concluded that the utilization of supplementary light can increase yields. They were of the opinion that for positive economics 30 per cent increase in the yield and prices are essential.

Ambad *et al*. (2001) reported that Gerbera has become a crop of choice in polyhouse cultivation. Construction of polyhouse needs high investments. MPKV, Rahuri has developed handy wooden structure affordable to all categories of growers with reasonably low cost

Mysore *et al*. (2005) studied the economic feasibility and profitability of Carnation cultivation under polyhouse condition in Pune and Bangalore and indicated it to be highly profitable and economically viable in both the regions. Use of cost effective methods appear to cut down the erection cost by 50 % in Bangalore in comparison to that in Pune. Similarly cut in cost was seen in other items such as the inner net, drip irrigation system and bed preparation in Bangalore, thereby reducing the overall cost of establishment by 27% at Rs. 3,08,155/500m^2 polyhouse as against Rs.4,22,585/500m^2 in Pune.

3. MATERIAL AND METHODS

The present investigation was carried out to study the performance of Carnation (*Dianthus caryophyllus* L.) varieties under naturally ventilated polyhouse during February, 2008 to August, 2008 for second flush. The experiment includes ten standard Carnation varieties of which five varieties *viz.,* Gaudina, Viking, Buemonde, Firato and Yellow Firato were from KF Bio plant Pune, while remaining five varieties *viz.,* Diana, Pink Shiva, Aicardi, Alibaba and Dali were from SPA Flora, Bangalore. The experiment was carried out at the Hi-Tech Horticulture Unit, Saidapur farm, Main Agricultural Research Station, University of Agricultural Sciences, Dharwad.

3.1. Geographical location of experimental site

The site is situated in Northern Transitional Zone (zone 8) of Karnataka at 15° 26' North latitude and 75°07' East longitude with an altitude of 678 m above the mean sea level.

3.2. Climate

Dharwad is considered to be mild tropical rainy region. The mean rainfall of this area is about 825 mm distributed over a period of seven to eight months (April to November) with two prominent peak periods during July and October. March, April and May are the hottest months with mean maximum temperature in the range of 33 to 37°C. The mean maximum temperatures rarely go beyond 37°C and mean minimum temperature below 11°C. Relative humidity generally fluctuates between 45 and 85 per cent. The meteorological data for the year 2008-09 as recorded in the Meteorological Observatory of the Agricultural College, Dharwad is presented in Appendix II. Also the weather data regarding environmental parameters like temperature and relative humidity under greenhouse is presented in Appendix III.

3.3 Experimental details

Crop	: Carnation (Standard type)
Experimental design	: RBD
Number of replications	: Three
Polyhouse size	: 560 m^2 (28 x 20m)
Spacing	: 20 X 15 cm^2
Treatments details	: Ten varieties

Treatments	Colour of petals
T_1: Gaudina	Red
T_2: Viking	White
T_3: Buemonde	Pink
T_4: Yellow Firato	Yellow
T_5: Firato	Orange
T_6: Diana	Yellow
T_7: Pink Shiva	Pink
T_8: Aicardi	Red
T_9:Alibaba	White
T_{10}: Dali	Orange (Saffron)

3.4 Experimental procedure

3.4.1 Details of greenhouse

The experiment was conducted under naturally ventilated polyhouse with misting facility. The polyhouse is made up with a galvanized iron pipe frame covered with polythene film of 800 gauge (200 micron) both side and top ventilation is provided and were covered with insect proof net of 60 meshes for natural ventilation and protection against entry of insect pests. A rollable flap of polythene sheet was also provided outside of insect net of side ventilation to regulate the requirement of temperature and humidity depending upon the season and weather condition. The shade with 50 per cent shading was also laid out above the head space inside the polyhouse to reduce the light intensity and temperature as well. The devices like thermometer and hygrometer were fixed to record the temperature and

Plate1. An outside view of naturally ventilated

Plate 2. General view of crop at flowering under greenhouse

humidity, respectively throughout the growing season of crop. In night time rollable film was taken upside/down for trapping the CO_2 released by plants during night respiration and also increases the night temperature. Carnation varieties harvested for the second season during year 2007 were allowed to grow for subsequent season in a naturally ventilated greenhouse, oriented East West direction.

3.4.2 Maintenance of second flush

The Carnation plants planted on raised beds of size 30 cm height X 100 cm width X 25 m length with walkway distance of 50 cm between beds. The crop was maintained for the second flush by following package of practices.

3.4.3 Pruning and cleaning of past season crop

All the dead and unproductive shoots were cut back by leaving 10-15 cm stem from the soil surface. Harvesting of first season crop by leaving 3-4 basal internodes was itself pruning for maintenance of second flush.

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.

3.4.5 Fertilizer application

Recommended fertilizer dose was applied through fertigation system using commonly available water soluble fertilizers of different grades with the help of automatic computerized fertigation system. The micronutrients were applied as and when required.

3.4.6 Misting

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

3.4.7 Weeding and plant protection measures

Hand weeding was followed to keep the entire polyhouse free from weeds. Fusarium wilt, a severe disease of Carnation was controlled by drenching the beds with Carbendazim (0.2%) regularly as precautionary measures.

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.

3.4.8 Netting

The support was provided by iron rods at 3 m distance to both side of the bed and wire of 15 cm X 15cm mesh supported by stacks at the corner of beds. The three layers of mesh were laid together on the soil surface. When the plants are growing, the nets were lifted accordingly. The bottom net of 7.5 x 7.5 cm was laid then one net each of 10 x 10 cm and 12.5 x 12.5 cm and the upper net of 12.5 x 12.5 cm were laid. Usually, 33 plants m^2 were planted.

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.

3.4.9 Mainteinance of plants

There were some weak and disfigured plants, leaves and flower during the growing period and these were removed regularly as and when noticed.

3.4.10 Greenhouse management

The optimum temperature range of 28^{0}C during day time and 10-18 ^{0}C during night time were maintained for vigorous growth and quality flower production of standard Carnation. In the beginning, 80-85 per cent relative humidity was maintained and at full growth stage it was maintained 60-65 per cent. Whenever the temperature in the polyhouse rose, the rollable polythene flap was made to roll up. Sufficient irrigation was given and misters were turn on to bring down the temperature. Sometimes the spray of cold water applied to bring down the temperature. Under low temperature condition the rollable polyethylene flap was made to roll down to conserve the heat inside the polyhouse. The light inside the polyhouse was controlled by either rolling or spreading the shade nets provided over the plants inside the greenhouse structure.

3.4.11 Harvesting and marketing

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. The flowers were packed first in card board sleeves (20 numbers per sleeve) and then finally in card board boxes of size 120 cm length, 60 cm width and 30 cm height and sold to local florist as well as sent to Belgaum and Davangere flower merchants.

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.

The observations on vegetative parameters were recorded at 30, 60,120,150 and 180 days after first flush (DAF).

3.5.1 Vegetative parameters

3.5.1.1 Plant height

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

3.5.1.2 Number of shoots

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 Length of shoot

Length of shoot was recorded from the point of origin of each shoot to the tip of the plants from all tagged plants at monthly interval and the average length of branch was worked out and expressed in centimeter.

3.5.1.4 Stem girth

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

3.5.1.5 Number of internodes per stem

It was recorded by counting the number of internodes produced from three shoots from all tagged plants at monthly interval and average was worked out.

3.5.1.6 Internodal length

It was recorded from the selected three shoots of tagged plants at monthly intervals and the average was worked out and expressed in centimeter.

3.5.1.7 Number of leaves

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

3.5.1.8 Leaf length

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

3.5.1.9 Per cent mortality of plants

The number of plants died due to Fusarium wilt was recorded at the time of flowering season and expressed in percentage. The diseased samples were examined for pathological tests and it was noticed that the death of plants occur due to Fusarium wilt.

3.5.2 Flowering parameters

3.5.2.1 Number of days to flower initiation

Number of days taken for appearance of visible bud from the day of last harvest of flowers of first season from all tagged plants was recorded and average was worked out.

3.5.2.2 Number of days to flower bud opening

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

3.5.2.3 Number of days to development of flower bud

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

3.5.2.4 Duration of flowering

Duration of flowering was recorded by counting the days from first flower bud opening to the harvesting of last flower in the second flush.

3.5.3 Flower quality parameters

3.5.3.1 Length of flower stalk

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

3.5.3.2 Girth of flower stalk

Girth of flower stalk was recorded with the help of vernier calipers at middle of flower stalk. It was recorded from ten cut flowers harvested at peak flowering and average was worked out and expressed in millimeter.

3.5.3.3 Flower length

Flower length was recorded from the point just below the calyx to the upper point of the flower. It was recorded from ten flowers harvested at peak flowering from each treatment and average was worked out and expressed in centimeter.

3.5.3.4 Flower diameter

Diameter of flower was recorded at its full bloom stage from ten randomly selected cut flowers harvested at peak flowering and average was worked out and expressed in centimeter.

3.5.3.5 Number of petals per flower

It was recorded by counting petals from ten flowers selected at random in each treatment and average was worked out.

3.5.3.6 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 were zero value in data.

3.5.3.7 Weight of flower

Weight of flower was recorded by ten freshly harvested flowers with stalk per treatment on weighing balance and average individual flower weight was calculated and represented in gram.

3.5.3.8 Vase life

The flower stems were harvested when buds were at paint brush stage. Immediately after harvest the flower were kept in fresh water for 2 hours to remove the field heat. After that, the flowers were kept in conical flasks containing distilled water. Fading of outer raw petals was considered as end of vase life of flowers and vase life is expressed in days.

3.5.4 Yield parameters

3.5.4.1 Number of flower per plant

Number of flowers harvested from the labeled plants was recorded and average was worked out.

3.5.4.2 Number of flowers per square meter

Number of flowers per square meter was worked out by totaling the number of flowers harvested from one square meter area of net plant area for the period of six months.

3.5.5 Environmental parameters

The temperature and relative humidity were recorded at weekly interval by instrument called Digital Thermo-hygrometer and expressed as mean monthly data.

3.6 Economics

Economics of standard Carnation production under naturally ventilated polyhouse was worked out by considering the present price of inputs and produce.

Net returns (Rs/ha) = Gross returns (Rs/ha) – cost of cultivation (Rs/ha)

$$\text{Benefit: cost ratio} = \frac{\text{Net returns (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

3.7 Statistical analysis

The data pertaining to biometric parameters *viz.,* vegetative, flowering, flower quality and yield parameters recorded during the experimental period were tabulated treatment and replication wise and these were subjected to computerized statistical analysis as per the method suggested by Panse and Sukhatme (1967). The test of significance (F-test) and critical difference (CD) were made at five per cent probability, wherever F- test was found significant. For comparison of means of two treatments, Duncan's Multiple Range Test (DMRT) was adopted for ranking the treatments.

4. EXPERIMENTAL RESULTS

The experimental results of the studies on "Evaluation of Carnation (*Dianthus caryophyllus* L) varieties under greenhouse condition" conducted during February to August, 2008 in the naturally ventilated polyhouse in the Hi-tech Horticulture Unit, Saidapur farm, Main Agriculture Research Station, University of Agricultural Sciences, Dharwad are furnished in this chapter under the following sub-headings.

4.1 Vegetative parameters
4.2 Flowering characters
4.3 Flower quality parameters
4.4 Yield parameters
4.5 Calyx splitting
4.6 Per cent mortality
4.7 Economics

4.1 Vegetative parameters

Vegetative parameters like plant height, stem girth, number of nodes per branch, internodal length, number of shoots per plant, length of shoot, number of leaves, leaf length were measured at different stages of plant growth from 30 days after the final harvest of the first crop to 180 days at monthly interval. These parameters were analyzed and presented below.

4.1.1 Plant height (cm)

The data pertaining to plant height at different stages of growth in different Carnation varieties are depicted in Table 1 and illustrated through Fig. 1.

4.1.1.1 Plant height at 30 days after the first flush

The plant height among the different varieties differed significantly. The range was from 27.19 cm to 57.53 cm. Variety Yellow Firato recorded highest plant height (27.19 cm). Viking (32.85 cm), Alibaba (34.02 cm), Diana (34.36 cm), Aicardi (34.70 cm), and Gaudina (35.21 cm) varieties were shortest types. However varieties Firato (42.40 cm), Buemonde (36.53cm), Pink Shiva (38.65 cm) were on par and were medium in their height.

4.1.1.2 Plant height at 60 days after the first flush

The plant height measured at 60 days after the final harvest of first crop varied from 38.48 cm to 64.73 cm. The variety Yellow Firato (67.73 cm) recorded maximum plant height, followed by Firato (53.69 cm) and Pink Shiva (49.93 cm). Buemonde (47.82 cm), Gaudina (47.45 cm), Aicardi (45.99 cm), Diana (45.64 cm), Alibaba (45.31 cm) and Viking (44.13 cm) varieties recorded medium plant height and were on par. The minimum plant height was recorded in variety Dali (38.48 cm).

4.1.1.3 Plant height at 90 days after the first flush

Plant height ranged between 76.22 cm and 89.26 cm. The highest plant height was recorded in variety Yellow Firato (89.26 cm) which was closely followed by Firato (88.69 cm), Diana (86.42 cm) and Aicardi (84.56 cm). All these varieties were on par and significantly superior over the rest of the varieties. The lowest plant height was recorded in variety Alibaba (76.72 cm) followed by Buemonde (76.22 cm) and Dali (77.65 cm) and were on par. Variety Pink Shiva (82.43 cm), Gaudina (81.54 cm) and Viking (81.29 cm) recorded medium plant height and were on par.

4.1.1.4 Plant height at 120 days after the first flush

Variety Firato recorded maximum plant height (109.9cm) which was closely followed by Yellow Firato (107.4 cm). Both the varieties were on par and significantly superior over the rest of the varieties. The next superior types were Diana (97.31 cm), Aicardi (47.18 cm) and Alibaba (94.59 cm) and were on par. Variety Viking recorded shortest plant height of 89.62 cm followed by Buemonde (84.27 cm) and Dali (86.57 cm) and were on par. Gaudina (89. 00 cm) and Pink Shiva (86.90) recorded medium height and both were on par to each other.

Table 1. Plant height (cm) at different stages of growth in Carnation varieties grown under greenhouse

Treatments	Plant height (cm) at different days after first flush (DAF)					
	30	60	90	120	150	180
T_1: Gaudina	35.21	47.45	81.54	89.02	101.39	119.78
T_2: Viking	32.85	44.13	81.29	83.62	90.81	99.14
T_3: Buemonde	36.53	47.82	76.72	84.27	99.68	112.66
T_4: Yellow Firato	57.59	67.73	89.26	107.38	127.34	133.97
T_5: Firato	42.40	53.69	88.69	109.92	120.79	126.37
T_6: Diana	34.36	45.64	86.42	97.31	116.69	125.84
T_7: Pink Shiva	38.65	49.93	82.43	86.90	108.20	119.75
T_8: Aicardi	34.70	45.99	84.56	97.18	106.41	114.57
T_9: Alibaba	34.02	45.31	76.22	94.59	99.18	104.22
T_{10}: Dali	27.19	38.48	77.65	86.57	91.30	108.00
Mean	37.35	48.62	82.48	93.68	106.18	116.43
S. Em±	2.00	1.76	1.67	1.05	0.94	0.90
C.D at 5%	5.94	5.23	4.98	3.11	2.80	2.69

4.1.1.5 Plant height at 150 days after the first flush

The highest plant height was recorded at 90 days after the final harvest of the first crop in variety Yellow Firato (127.3cm) which was significantly superior over the rest of the varieties. Varieties Firato, Diana, Pink Shiva and Aicardi recorded 120.79 cm, 116.7 cm, 108.2 cm and 106.4 cm plant heights respectively. Varieties Gaudina (101.4 cm), Buemonde (99.68 cm) and Alibaba (99.18 cm) did not differed significantly. Viking (90.81 cm) and Dali (91.30 cm) were on par and recorded comparatively lower plant height.

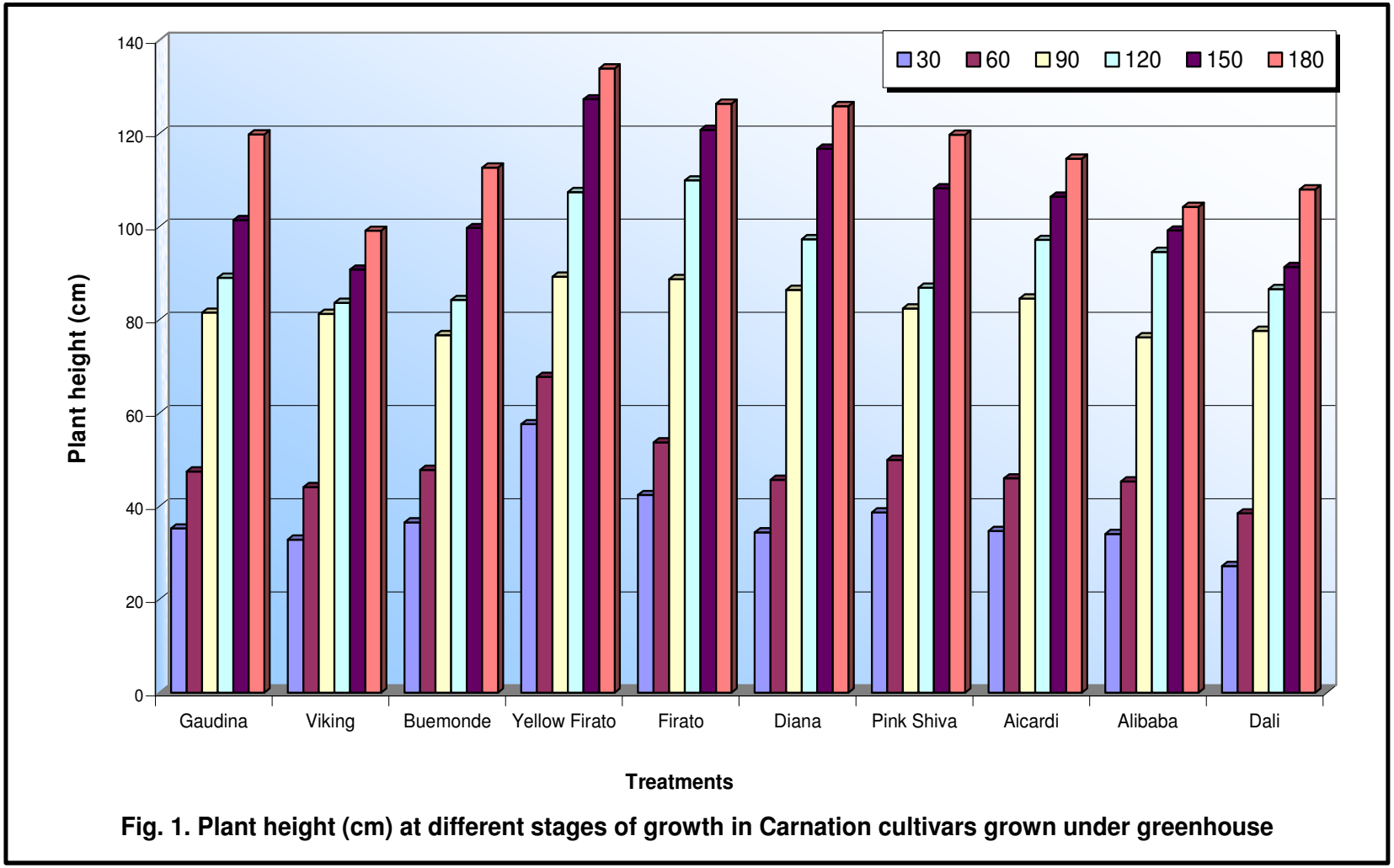

Fig. 1. Plant height (cm) at different stages of growth in Carnation cultivars grown under greenhouse

Fig. 1. Plant height (cm) at different stages of growth in Carnation cultivars grown under greenhouse

4.1.1.6 Plant height at 180 days after the first flush

The plant height of Carnation varieties at 180 days after the final harvest of the first crop differed significantly. Plant height was maximum (134.0 cm) in variety Yellow Firato. The next superior varieties were Firato (126.4cm) and Diana (125.8 cm) and both were on par. The varieties Gaudina (119.8 cm), Pink Shiva (119.8 cm), Aicardi (114.6 cm), Buemonde (112.7 cm), Dali (108.0 cm) and Alibaba (104.2 cm) recorded medium plant height and were significantly different to each other. The shortest (99.14 cm) plant height was observed in variety Viking.

4.1.2 Number of shoots per plant

The data on number of shoots per plant recorded at different stages of growth are compiled in Table 2 and illustrated with Fig. 2.

4.1.2.1 Number of shoots per plant at 30 days after first flush

Number of shoots recorded on 30 days after the first flush, did not differ significantly among Carnation varieties. Number of Shoots per plant was maximum in variety Yellow Firato (5.52), whereas it was recorded minimum (4.46) in variety Viking.

4.1.2.2 Number of shoots at 60 days after first flush

Significant differences were observed for production of shoots among the different varieties of Carnation. Variety Pink Shiva (6.14) recorded maximum number of shoots, followed by 6.12 in Diana. The minimum number of shoots was registered in variety Viking (4.55). Rest of the varieties were on par to each other.

4.1.2.3 Number of shoots at 90 days after first flush

Number of shoots produced among the varieties at 90 day after first flush ranged between 4.92 and 6.48. Variety Diana recorded maximum number of shoots (6.48) which was on par with Yellow Firato (6.43), Dali (6.41), Firato (6.34), Pink Shiva (6.22) Aicardi (6.12), Buemonde (6.11) and Gaudina (5.86). The minimum number of shoots were recorded in variety Viking (4.92), followed by Alibaba (5.49).

4.1.2.4 Number of shoots at 120 days after first flush

Differences were significant among the Carnation varieties for number of shoots per plant at 120 days after first flush. Variety Yellow Firato produced maximum number of shoots (6.80) and was on par with varieties Dali (6.67), Diana (6.57), Aicardi (6.51), Firato (6.49), Buemonde (6.43), Pink Shiva (6.29) and Gaudina (6.16). The minimum number of shoots were observed in Viking (5.18), followed by Alibaba (5.54).

4.1.2.5 Number of shoots at 150 days after first flush

At 150 days after the first flush, number of shoots varied significantly among the varieties which ranged from a minimum of 5.22 to maximum of 7.15. It was maximum in variety Yellow Firato (5.22), however it was on par with the varieties Firato (6.94), Dali (6.84), Diana (6.67), Aicardi (6.63), Gaudina (6.54) and Buemonde (6.54). However, variety Viking produced minimum (5.22) number of shoots.

4.1.2.6 Number of shoot at 180 days after the first flush

Carnation varieties varied significantly for number of shoots per plant at 180 days after first flush. It was maximum in variety Yellow Firato (7.64), which was closely followed by Firato (7.58) and Dali (7.23). The minimum numbers of shoots were recorded in variety Viking (5.33). The varieties Aicardi (6.78), Buemonde (6.60), Gaudina (6.56), Pink Shiva (6.32) and Alibaba (6.19) produced moderate number of shoots.

4.1.3. Length of shoots

A glance of the result presented in the Table 3 and illustrated in the Fig. 3 revealed that length of shoots of various Carnation varieties differed significantly.

4.1.3.1 Length of shoots at 30 days after first flush

Significant differences were observed among the Carnation varieties for length of shoots. It was maximum in variety Yellow Firato (42.20 cm), whereas it was minimum in

Table 2. Number of shoots at different stages of growth in Carnation varieties grown under greenhouse

Treatments	Number of shoots at different days after first flush (DAF)					
	30	60	90	120	150	180
T_1: Gaudina	5.29	5.70	5.86	6.16	6.54	6.56
T_2: Viking	4.46	4.55	4.92	5.18	5.22	5.33
T_3: Buemonde	5.22	5.66	6.11	6.43	6.54	6.60
T_4: Yellow Firato	5.52	6.00	6.43	6.80	7.15	7.64
T_5: Firato	5.47	5.78	6.34	6.49	6.94	7.58
T_6: Diana	5.39	6.12	6.48	6.57	6.67	6.87
T_7: Pink Shiva	5.15	6.14	6.22	6.29	6.31	6.32
T_8: Aicardi	5.36	5.50	6.12	6.51	6.63	6.78
T_9: Alibaba	5.19	5.38	5.49	5.54	6.10	6.19
T_{10}: Dali	5.28	5.84	6.41	6.67	6.84	7.23
Mean	5.23	5.67	6.04	6.26	6.49	6.71
S. Em±	0.25	0.22	0.21	0.22	0.20	0.20
C.D at 5%	NS	0.65	0.63	0.66	0.59	0.59

variety Alibaba (15.64 cm), followed by Viking (16.73 cm) and Dali (18.10) and found on par with each other. The variety Firato (34.63), Gaudina (32.88 cm), Diana (31.47 cm) and Buemonde (31.44 cm) were found on par to each other and produced medium length shoots.

4.1.3.2 Length of shoots at 60 days after first flush

Length of shoots varied significantly among the different varieties of Carnation studied. Variety Yellow Firato (54.88 cm) recorded maximum length of shoots, followed by Firato (54.48) which was found on par to Yellow Firato. The minimum length of shoot recorded in variety Alibaba (23.37), followed by Aicardi (24.38) and Dali (26.20) and the

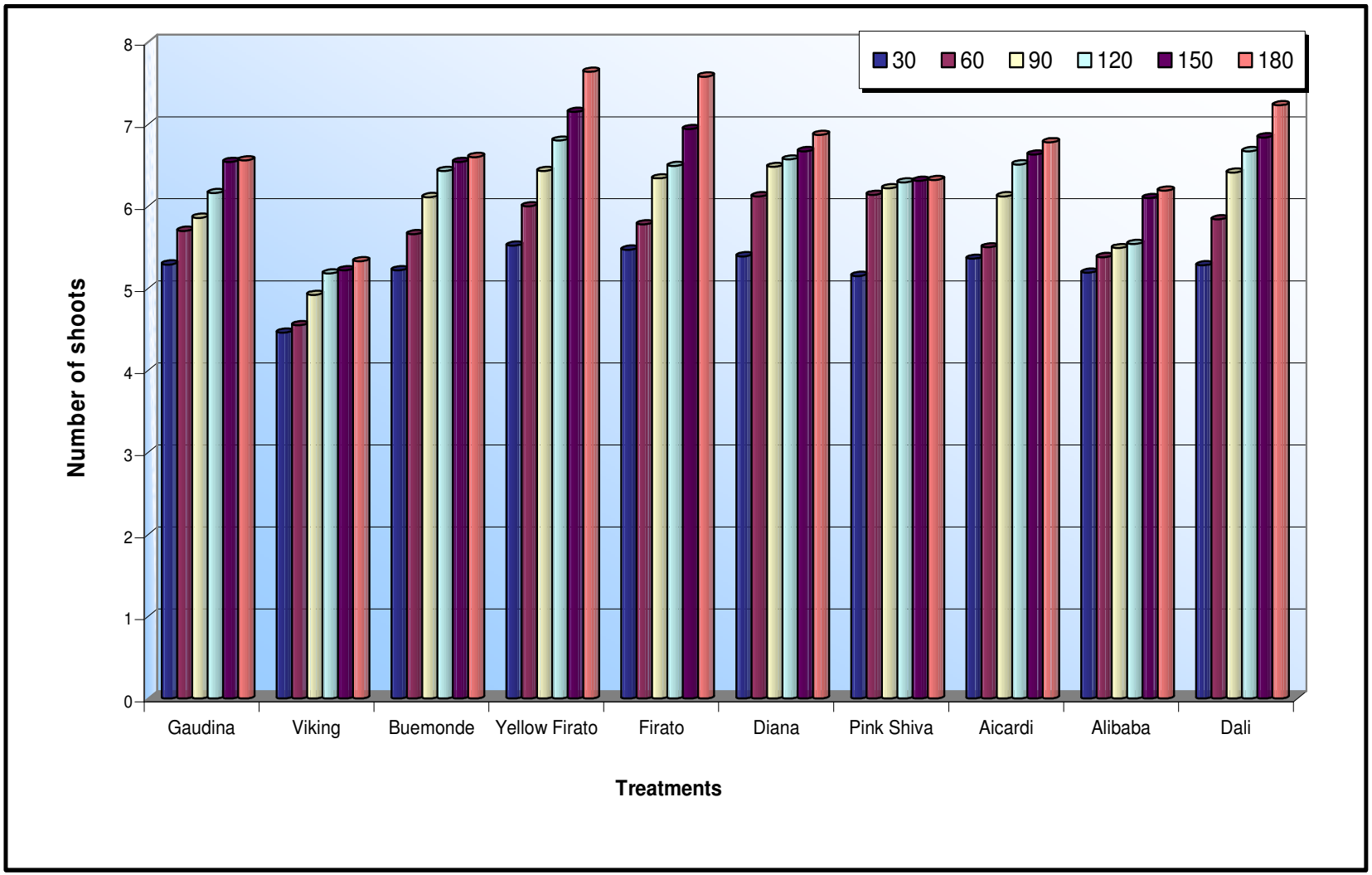

Fig. 2. Number of shoots at different stages of growth in Carnation cultivars grown under greenhouse

Table 3. Length of shoot (cm) at different stages of growth in Carnation varieties grown under greenhouse

Treatments	Length of shoots (cm) at different days after first flush (DAF)					
	30	60	90	120	150	180
T_1: Gaudina	32.88	38.47	44.29	89.23	98.74	100.31
T_2: Viking	16.73	48.79	56.84	64.70	77.96	81.89
T_3: Buemonde	31.44	37.36	42.13	80.33	85.45	94.72
T_4: Yellow Firato	42.20	54.88	65.69	89.32	101.51	107.44
T_5: Firato	34.63	54.48	63.26	85.16	92.50	98.90
T_6: Diana	31.47	38.49	47.58	76.86	81.78	94.92
T_7: Pink Shiva	21.63	43.35	62.51	71.63	79.25	88.74
T_8: Aicardi	19.42	24.38	56.37	72.33	76.98	84.43
T_9: Alibaba	15.64	23.37	47.56	65.82	71.74	81.34
T_{10}: Dali	18.10	26.20	55.72	68.08	74.96	83.47
Mean	26.42	38.98	54.20	76.35	84.09	91.62
S. Em±	1.10	1.09	1.08	1.02	0.94	0.89
C.D at 5%	3.27	3.25	3.22	3.03	2.78	2.66

results did not differ significantly. Varieties Diana (38.49 cm), Gaudina (38.47 cm) and Buemonde (37.36) were found on par with each other.

4.1.3.3 Length of shoots at 90 days after the first flush

Length of shoots varied significantly among the different Carnation varieties at 150 days after the first flush. It was maximum in variety Yellow Firato (65.26 cm) and Pink Shiva (62.51) and both were on par. The length of shoots were found minimum in variety Buemonde (42.3 cm), followed by Gaudina (44.29 cm) and it was found medium in varieties Viking (56.84 cm), Aicardi (56.37 cm) and Diana (47.58 cm).

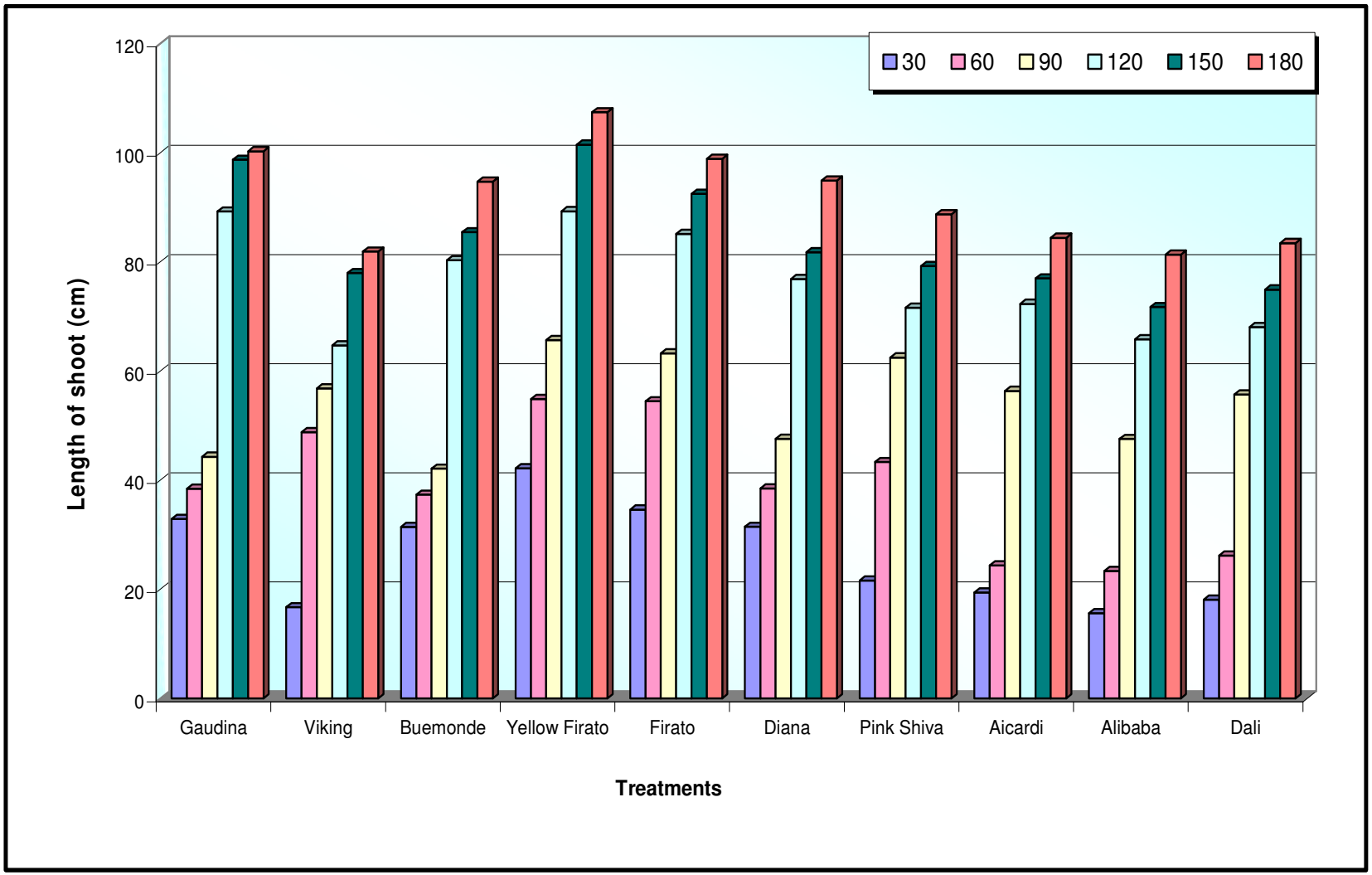

Fig. 3. Length of shoot (cm) at different stages of growth in Carnation cultivars grown under greenhouse

4.1.3.4 Length of shoots at 120 days after first flush

Carnation varieties varied significantly for length of shoots at 120 days after first flush. Length of shoots was maximum in variety Yellow Firato (89.32 cm) which was closely followed by Gaudina (89.23 cm) and Firato (85.16 cm) and found on par to each other. The varieties Firato (85.16 cm), Buemonde (80.33cm) Diana (76.86 cm), Aicardi (72.33 cm) and Dali (68.08 cm) recorded medium length of shoots and differed significantly with each other.

4.1.3.5. Length of shoots at 150 days after the first flush

The maximum length of shoots was recorded in variety Yellow Firato (101. 5 cm), followed by Gaudina (98.74 cm), While it was minimum in variety Alibaba (71.74 cm). The varieties Firato (92.50 cm), Buemonde (85.45 cm) Diana (81.78 cm), Viking (77.96 cm) and Aicardi (76.98 cm) differed significantly with each other.

4.1.3.6 Length of shoots at 180 days after the first flush

Length of shoots varied significantly among different Carnation varieties at 180 days after first flush. It was maximum in variety Yellow Firato measuring a length of 107.4 cm and was superior to rest of the varieties, however minimum shoot length was recorded in variety Alibaba (81.34 cm) followed by Viking (81.89 cm) and Dali (83.47 cm). The varieties Gaudina (100. 3 cm) and Firato (98.90 cm) were on par. Similarly varieties Diana (94.92 cm) and Buemonde (94.72 cm) were also on par. Variety Pink Shiva (88.74 cm) and Aicardi (84.43 cm) differed significantly with respect to length of shoot.

4.1.4. Stem girth

A glance of the results in Table 4 revealed that varieties varied significantly for stem girth, which ranged from 3.17 to 7.77 mm. The variety Pink Shiva recorded maximum stem girth (7.77 mm) which was superior over rest of the varieties. The variety Firato was having thin stems (3.17 mm), followed by Viking (3.20 mm), Buemonde (3.26 mm) and Yellow Firato (3.31 mm). These varieties were on par to one another. Varieties Dali (4.44 mm), Aicardi (4.40 mm) and Gaudina had stems of medium thickness, which were not differing statistically. Varieties Alibaba (6.33 mm) and Diana (5.81 mm) were also on par with each other.

4.1.5 Number of internodes per branch

The data pertaining to number of internodes per branch at varying stages of plant growth are presented in Table 4 and illustrated in the Fig. 4

4.1.5.1 Number of internodes per branch at 30 days after first flush

Number of internodes per branch differed significantly among the different Carnation varieties. Firato (5.53) produced maximum number of internodes per branch, closely followed by Pink Shiva (5.36). These varieties were at par and significantly superior over rest of the varieties. Variety Yellow Firato (4.91) and Aicardi (4.25) had average number of internodes, which did not differ significantly. The varieties Buemonde (3.50), Gaudina (3.48), Alibaba (3.40), Diana (3.38) and Dali (3.06) produced less number of internodes per branch, and were on par and number of internodes per branch was lowest in Viking (2.78).

4.1.5.2 Number of internodes per branch at 60 days after first flush

Number of internodes per branch recorded at 60 days after the final harvest at the first crop varied significantly among the different varieties of Carnation. Maximum number of internodes per branch (9.53) was recorded in variety Firato, followed by Aicardi (9.39) and were on par. Diana recorded minimum number of internodes per branch (6.22). Varieties Yellow Firato (8.73), Buemonde (8.62), Alibaba (8.20) differed significantly and found on par to one another. Varieties Dali (7.35), Gaudina (6.89) and Viking (6.74) were also on par.

4.1.5.3 Number of internodes per branch at 90 days after the first flush

The number of internodes at 90 day after the last harvest of the first crop varied from 13.15 in variety Dali to 16.99 in Yellow Firato. Varieties Firato (16.60), Diana (16.17) and Buemonde (15.99) were on par with respect to number of internodes per branch. Varieties Gaudina (15.02), Aicardi (14.99) and Alibaba (14.42) were on par to each other.

Table 4. Stem girth (cm) at peak growth and number of internodes per branch at different stages of growth in Carnation varieties grown under greenhouse

Treatments	Number of internodes per branch at different days after first flush (DAF)						Main stem girth (mm)
	30	60	90	120	150	180	
T_1: Gaudina	3.48	6.89	15.02	16.16	19.82	18.99	4.36
T_2: Viking	2.78	6.74	15.41	15.58	15.94	16.16	3.20
T_3: Buemonde	3.50	8.62	15.99	15.20	16.20	16.59	3.26
T_4: Yellow Firato	4.91	8.73	16.99	18.89	20.91	22.80	3.31
T_5: Firato	5.53	9.53	16.60	18.72	20.15	20.29	3.17
T_6: Diana	3.38	6.22	16.17	18.06	19.58	19.91	5.81
T_7: Pink Shiva	5.36	7.94	14.03	16.09	19.62	18.77	7.77
T_8: Aicardi	4.25	9.39	14.99	16.71	18.29	18.39	4.40
T_9: Alibaba	3.40	8.20	14.42	14.84	16.26	17.11	6.33
T_{10}: Dali	3.06	7.35	13.15	13.61	15.37	15.47	4.44
Mean	3.97	7.96	15.28	16.38	18.21	18.45	4.61
S. Em ±	0.17	0.20	0.22	0.30	0.36	0.29	0.23
C.D at 5%	0.52	0.60	0.65	0.88	1.08	0.85	0.69

4.1.5.4 Number of internodes per branch at 120 days after the first flush

Significant differences were observed for number of internodes per branch among the different varieties at 120 days after the final harvest of the first crop. The maximum number of internodes was recorded in Yellow Firato (18.89), followed by Firato (18.72) and Diana (18.06), which were found on par. The number of internodes produced per branch was minimum in variety Dali (13.61). Varieties Aicardi (16.71), Gaudina (16.16) and Pink Shiva (16.09) were moderate in production of internodes per branch and they were on par. The varieties Gaudina, Pink Shiva and Viking (15.58) were also on par.

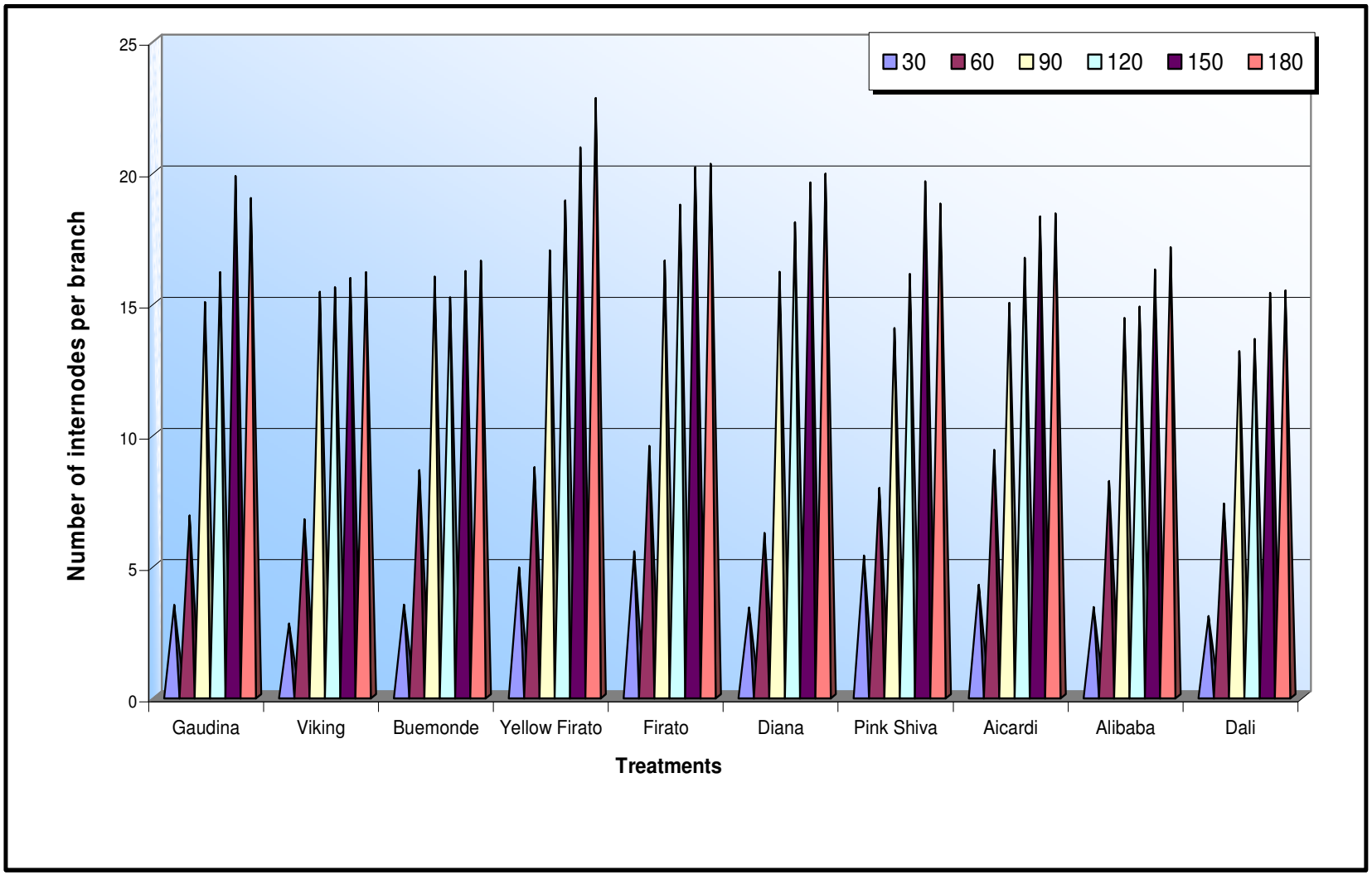

Fig. 4. Number of internodes per branch at different stages of growth in Carnation cultivars grown under greenhouse

4.1.5.5 Number of internodes per branch at 150 day after the first flush

Number of internodes per branch differed significantly at 150 days after the last harvest of the first crop. Yellow Firato (20.91) produced maximum number of internodes per branch followed by Firato (20.15) and Gaudina (19.82) and these were found on par to each other. Variety Dali produced minimum number of internodes (15.37), followed by Viking (15.94), Buemonde (16.20) and Alibaba (16.26) and all these were on par. Variety Aicardi (18.29) differed significantly among the different Carnation varieties. Variety Firato (20.15) Gaudina (19.82), Pink Shiva (19.62) and Diana (19.58) were also on par to each other.

4.1.5.6 Number of internodes per branch at 180 days after the first flush

Significant differences were observed for the production of number of internodes per branch among the different varieties of Carnation at 180 days after the first crop. Variety Yellow Firato (22.80) produced maximum number of internodes per branch which was superior to rest of the varieties. The next superior types were Firato (20.29) and Diana (19.91) which were on par to each other. Varieties Gaudina (18.99), Pink Shiva (18.77) and Aicardi (18.39) recorded average number of internodes per branch. The varieties Alibaba (17.11) and Buemonde (16.59) were on par to each other. The minimum internodes per branch was recorded in variety Dali (15.47), followed by Viking (16.16).

4.1.6 Internodal length

The data related to internodal length at varying stages of plant growth are furnished in Table 5 and illustrated in the Fig. 5.

4.1.6.1 Internodal length at 30 days after the first flush

Maximum internodal length was observed in variety Aicardi (3.40 cm) followed by Alibaba (3.31 cm) which were superior to rest of the varieties and were on par. The varieties Diana (2.85 cm) Firato (2.71 cm), Yellow Firato (2.71 cm) and Gaudina (2.53 cm) produced medium internodal length and were on par to each other. The varieties Firato, Yellow Firato, Gaudina, Viking (2.43 cm) and pink Shiva (2.42) were also found on par to each other. The minimum internodal length was found in Dali (2.27 cm) followed by Buemonde (2.27) and which were having same internodal length.

4.1.6.2 Internodal length at 60 days after the first flush

Variety Diana recorded maximum internodal length (4.39 cm) which was significantly superior over rest of other varieties. The minimum internodal length was observed in variety Viking (2.73 cm). The varieties Yellow Firato (3.81 cm), Aicardi (3.70 cm), Dali (3.61 cm), (3.61 cm), Alibaba (3.57 cm), Pink Shiva (3.43 cm), Gaudina (3.39) and Firato (3.37) did not differ significantly.

4.1.6.3 Internodal length at 90 days after the first flush

Among the varieties studied, internodal length varied from 3.40 cm to 5.80 cm at 90 days after the first crop. The internodal length was maximum in variety Aicardi (5.80 cm) and on par with Alibaba (5.51 cm) and Diana (5.34 cm). Internodal length was minimum in variety Viking (3.40 cm) which significantly differed to rest of the varieties. The variety Yellow Firato (4.66 cm), Pink Shiva (4.64 cm), Dali (4.48 cm) and Buemonde (4.31 cm) were medium in their internodal length. The varieties Dali, Buemonde, Gaudina (4.03 cm) and Firato (4.00 cm) were on par to each other.

4.1.6.4 Internodal length at 120 days after the first flush

At 120 days after the final harvest of the first crop, internodal length was in the range of 4.181 cm to 7.15 cm. Variety Aicardi (7.15 cm) had recorded maximum internodal length, however it was superior over rest of the varieties. The next superior one was Alibaba (5.99 cm) which significantly differed in comparison with all the varieties. The varieties Dali (5.41 cm) Yellow Firato (5.21 cm), Firato (4.42 cm) and Pink Shiva (4.88 cm) recorded medium internodal length and were on par to each other. The minimum internodal length was recorded in variety Viking (4.18 cm), followed by Buemonde (4.42 cm), Dali (4.54 cm) and Gaudina (4.54 cm) and were statistically on par to each other.

Table 5. Internodal length (cm) at different stages of growth in Carnation varieties grown under greenhouse

Treatments	Internodal length (cm) at different days after first flush (DAF)					
	30	60	90	120	150	180
T_1: Gaudina	2.53	3.39	4.03	4.54	5.07	5.22
T_2: Viking	2.43	2.73	3.40	4.18	4.21	4.37
T_3: Buemonde	2.27	3.60	4.31	4.42	4.93	5.21
T_4: Yellow Firato	2.56	3.81	4.66	5.21	5.28	5.52
T_5: Firato	2.71	3.37	4.00	4.92	5.77	5.86
T_6: Diana	2.85	4.39	5.34	5.41	5.62	5.83
T_7: Pink Shiva	2.42	3.43	4.64	4.88	5.10	5.63
T_8: Aicardi	3.40	3.70	5.80	7.15	7.47	7.52
T_9: Alibaba	3.31	3.57	5.51	5.99	6.03	6.44
T_{10}: Dali	2.27	3.61	4.48	4.54	4.83	4.94
Mean	2.67	3.56	4.62	5.12	5.43	5.65
S. Em±	0.13	0.18	0.18	0.18	0.19	0.24
C.D at 5%	0.38	0.53	0.53	0.55	0.56	0.71

4.1.6.5 Internodal length after 150 day after first flush

Carnation varieties differ significantly with respect to internodal length at 150 days after the first flush. Internodal length was maximum in variety Aicardi (7.47 cm) and significantly superior over rest of the varieties. The next superior ones were Alibaba (6.03 cm), Firato (5.77 cm) and Diana (5.62 cm) and were on par. The lowest internodal length was observed in Viking (4.21 cm). The varieties Diana (5.62 cm), Yellow Firato (5.28 cm), Pink Shiva (5.10 cm) and Gaudina were on par to each other.

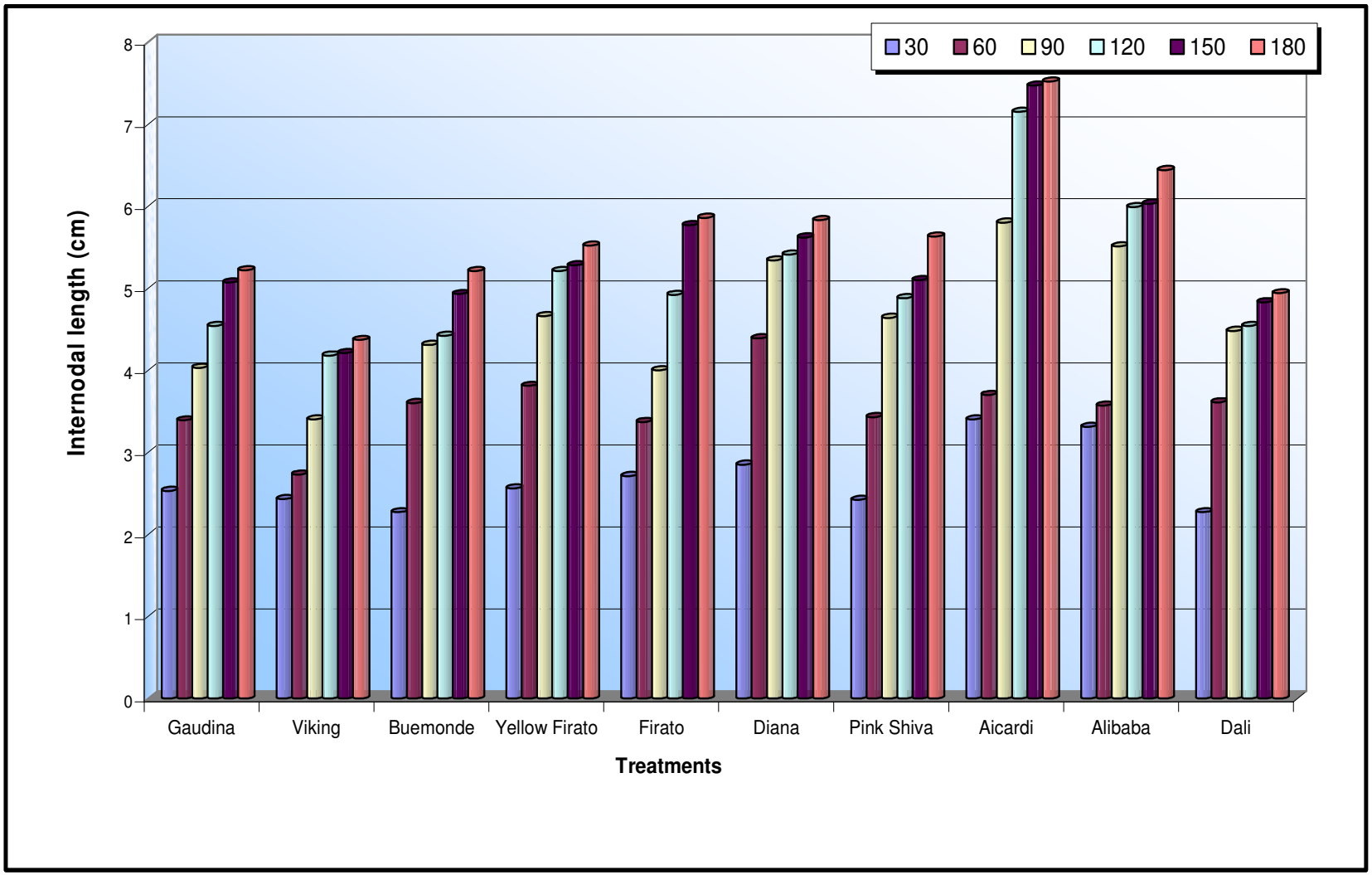

Fig. 5. Internodal length at different stages of growth in Carnation cultivars grown under greenhouse

Table 6. Number of leaves per plant at different stages of growth in Carnation varieties grown under greenhouse

Treatments	Number of leaves at different days after first flush (DAF)					
	30	60	90	120	150	180
T_1: Gaudina	50.34	92.14	98.63	136.56	167.70	192.95
T_2: Viking	38.13	71.72	107.30	143.26	154.85	185.88
T_3: Buemonde	42.16	115.16	125.71	157.45	177.02	179.23
T_4: Yellow Firato	72.32	137.33	166.57	195.02	202.57	214.43
T_5: Firato	62.75	87.58	132.24	167.35	192.84	209.65
T_6: Diana	48.51	128.41	146.77	174.45	181.72	197.52
T_7: Pink Shiva	40.47	65.34	112.74	145.00	163.65	182.32
T_8: Aicardi	52.37	68.71	128.78	158.72	187.85	207.49
T_9: Alibaba	35.08	64.42	109.96	118.09	137.97	172.83
T_{10}: Dali	58.63	78.02	124.64	140.65	178.74	200.48
Mean	50.07	90.88	125.33	153.65	174.49	194.28
S. Em±	0.80	0.89	1.06	1.31	1.17	1.32
C.D at 5%	2.39	2.65	3.15	3.90	3.47	3.93

4.1.6.6 Internodal length after 180 days after first flush

Carnation varieties differed significantly for internodal length for 150 days after first flush. Internodal length was maximum in variety Aicardi (7.52) which was superior to rest of the varieties. Variety Viking registered minimum (4.37 cm) internodal length, followed by Dali (4.94 cm) and were on par to each other. The varieties Alibaba (6.44 cm), Firato (5.86 cm) and Diana (5.83 cm) recorded medium internodal length however there was no statistical significance.

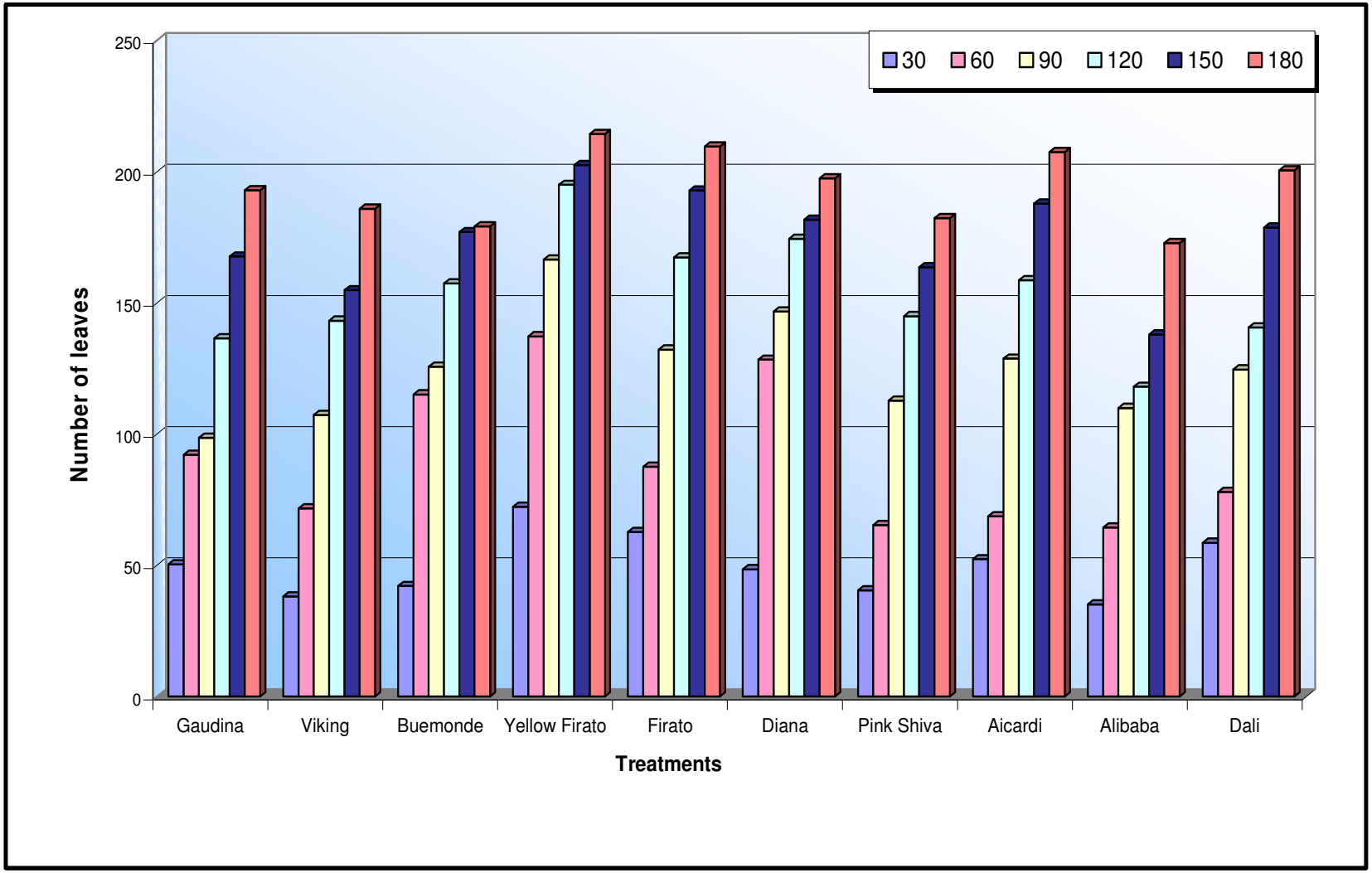

Fig. 6. Number of leaves at different stages of growth in Carnation cultivars grown under greenhouse

4.1.7 Number of leaves per plant

The data on number of leaves per plant at the different stages of growth are presented in the Table 6 and Fig. 6. There was significant difference among the Carnation varieties.

4.1.7.1 Number of leaves per plant at 30 days after first flush

Carnation varieties varied significantly for number of leaves per plant at 30 days after the first flush. Number of leaves per plant was maximum in variety Yellow Firato (72.32). This was superior over rest of the varieties. The next superior varieties were Firato (62.75), Dali (58.63) and Aicardi (50.37) and found significantly differing to each other. The minimum number of leaves per plant was recorded in variety Alibaba (35.08).

4.1.7.2 Number of leaves per plant at 60 days after first flush

Carnation varieties varied significantly for number of leaves per plant at 60 days after first flush. The numbers of leaves were maximum in variety Yellow Firato (137.3) which was superior over rest of the varieties. The minimum number of leaves were recorded in variety Alibaba (64.42) followed by Pink Shiva (65.34). Varieties Diana (128.4), Buemonde (115.2), Gaudina (92.14), Firato, (87.58), Dali (78.02), Viking (71.72) and Aicardi (68.71) were differing significantly with respect to number of leaves.

4.1.7.3 Number of leaves per plant at 90 days after first flush

Significant differences were observed among Carnation varieties for leaf length at 90 days after the first flush. The number of leaves per plant was highest in variety Yellow Firato (116.6), Followed by Diana (146.8), Firato (132.2) and Aicardi (128.8) and differ each other significantly. The minimum number of leaves were observed in variety Gaudina (98.63).

4.1.7.4 Number of leaves per plant at 120 days after first flush

Differences were observed among the different Carnation varieties for number of leaves at 120 days after first flush. The variety Yellow Firato produced maximum number of leaves per plant (195.6), whereas the lowest number of leaves per plant was noticed in variety Alibaba (118.1). The varieties Diana (174.5), Firato (167.4), Aicardi (158.7) Pink Shiva (145.0) and Dali (140.7) were significantly differing to each other.

4.1.7.5 Number of leaves per plant at 150 days after first flush

Number of leaves varied significantly among the varieties at 150 days. Variety Yellow Firato continued maximum number of leaves (202.6) and found superior over the rest of the varieties. While variety Alibaba (138.0) was continued to record minimum leaves per plant (138.0), whereas rest of the varieties were significantly differing to each other with respect to number of leaves per plant except Diana (181.7) and Dali (178.7). The varieties Dali and Buemonde also differed significantly.

4.1.7.6 Number of leaves per plant at 180 days after the first flush

Carnation varieties varied significantly for number of leaves per plant at 180 days after the first flush. Number of leaves was maximum in variety Yellow Firato (214.4) the next superior varieties were Firato (209.7) and Aicardi (207.5) which were found on par. The number of leaves was minimum in variety Alibaba (172.8). Varieties Dali (200.5), Gaudina (193.0) and Viking (185.9) were found significantly differing to one another. Varieties Pink Shiva (182.3) and Buemonde (179.2) were found on par. Similarly Dali (200.5) and Diana (197.5) were also found on par.

4.1.8 Leaf length (cm)

The results from Table 7 and Fig. 7 revealed that leaf length significantly differed among the varieties.

4.1.8.1 Leaf length (cm) at 30 days after first flush

Carnation varieties showed significant differences with respect to leaf length at 30 days after first flush. Leaf length was maximum in variety Buemonde (10.23 cm) which was closely followed by Dali (9.49 cm). It was recorded minimum in variety Aicardi (6.77 cm), followed by Firato (6.88 cm) and Viking (7.48 cm). The leaf length was moderate in varieties

Table 7. Leaf length (cm) at different stages of growth in Carnation varieties grown under greenhouse

Treatments	Leaf length (cm) at different days after first flush (DAF)					
	30	60	90	120	150	180
T_1: Gaudina	8.52	9.43	10.23	10.29	11.30	11.83
T_2: Viking	7.48	8.44	8.61	8.76	9.43	10.31
T_3: Buemonde	10.23	10.51	10.85	11.81	11.86	12.48
T_4: Yellow Firato	9.25	9.37	9.64	10.39	10.59	10.88
T_5: Firato	6.88	7.50	7.58	8.23	8.59	8.74
T_6: Diana	8.78	9.39	10.21	10.51	10.56	11.71
T_7: Pink Shiva	9.21	9.71	10.52	11.40	11.56	12.03
T_8: Aicardi	6.77	7.19	7.78	8.68	9.90	10.22
T_9: Alibaba	8.76	9.31	9.84	10.25	10.42	10.95
T_{10}: Dali	9.49	9.27	10.75	11.66	11.94	12.09
Mean	8.56	9.01	9.57	10.24	10.62	11.12
S. Em±	0.25	0.26	0.22	0.22	0.25	0.27
C.D at 5%	0.75	0.76	0.64	0.67	0.75	0.79

Yellow Firato (9.25 cm), Pink Shiva (9.21 cm), Diana (8.78cm), Alibaba (8.76 cm) and Gaudina (8.52 cm).

4.1.8.2 Leaf length at 60 days after first flush

Among the varieties studied, leaf length varied from 7.19 cm to 10.51 cm at 60 days after the first flush. The leaf length was maximum in variety Buemonde (10.51 cm) and was superior over rest of all varieties. Leaf length was minimum in variety Aicardi (7.19 cm) and Viking (8.44 cm) and was found on par with each other.

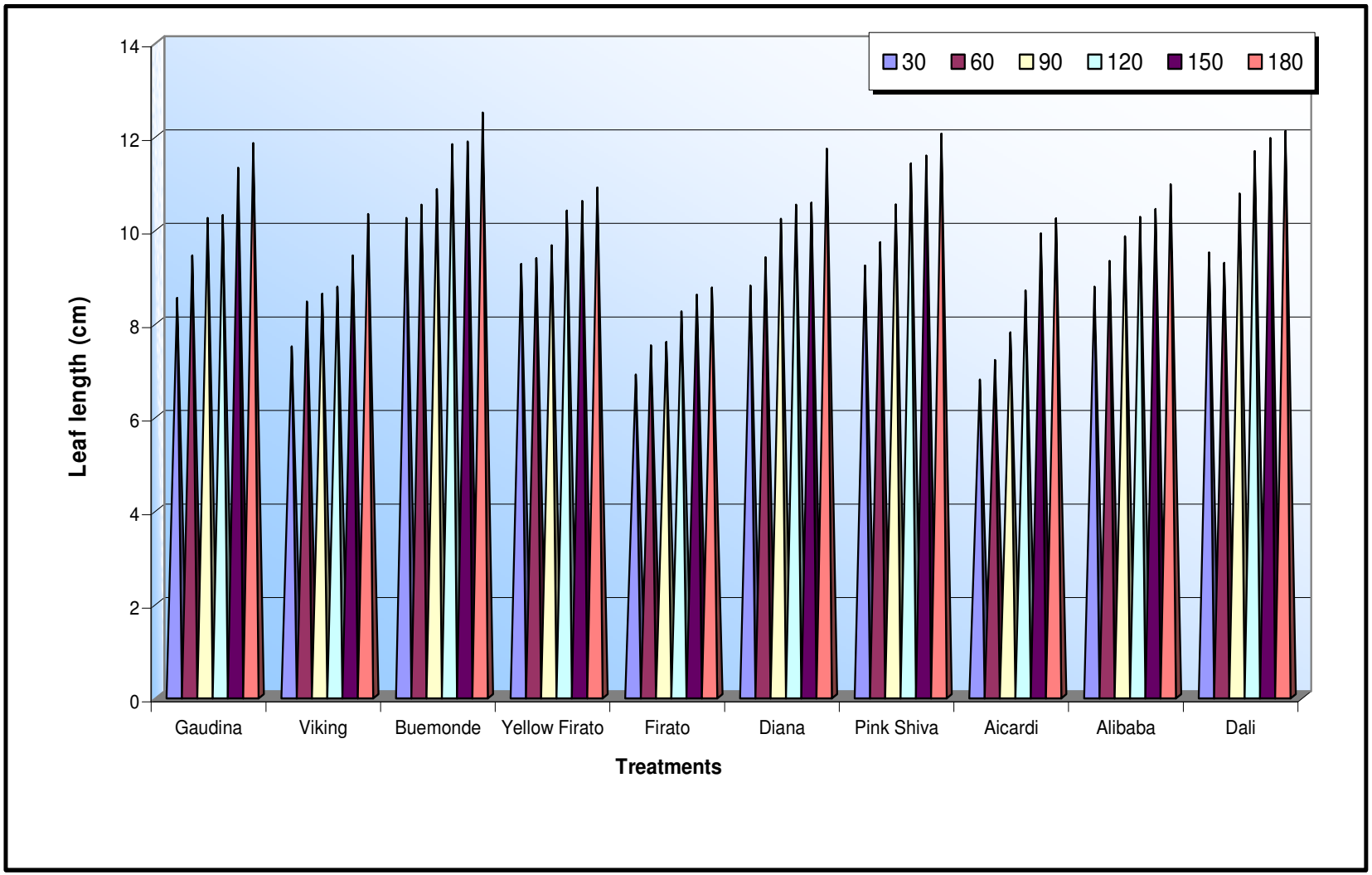

Fig.7. Leaf length (cm) at different stages of growth in Carnation cultivars grown under greenhouse

4.1.8.3 Leaf length at 90 days after the first flush

Significant differences were observed among the Carnation varieties for leaf length at 90 days after first flush. The leaf length was maximum in variety Buemonde (10.85 cm) which was closely followed by Dali (10.75 cm), Pink Shiva (10.52 cm), Gaudina (10.23 cm) and Diana (10.21 cm) and was on par with each other. Variety Firato (7.58 cm) recorded minimum leaf length, followed by Aicardi (7.78 cm). Variety Alibaba (9.84 cm), Yellow Firato (9.64) and Viking were moderate in their leaf length.

4.1.8.4 Leaf length at 120 days after the first flush

At 120 days after the first flush, leaf length was in the range of 8.23 cm to 11.81 cm. Variety Buemonde (11.81 cm) had recorded maximum leaf length followed by Dali (11.66 cm) and Pink Shiva (11.40 cm); however the results were on par. Leaf length was minimum in variety Firato (8.23 cm) followed by Aicardi (8.68 cm) and Viking (8.76 cm). Varieties Diana (10.51 cm), Yellow Firato (10.39 cm), Gaudina (10.29 cm) and Alibaba (10.25 cm) were moderate in their leaf length; however, there was no statistical difference.

4.1.8.5 Leaf length at 150 days after the first flush

Leaf length at 150 days after the first flush in different Carnation varieties varied significantly from a minimum of 8.59 cm to a maximum of 11.94 cm. Leaf length was maximum in variety Dali, which was on par with varieties Buemonde (11.86 cm), Pink Shiva (11.56 cm) and Gaudina (11.30 cm). Leaf length was minimum in variety Firato (8.59 cm) while leaf length was moderate in varieties Yellow Firato (10.59 cm), Diana (10.56 cm), Alibaba (10.42 cm) and Aicardi (9.90 cm) were moderate in leaf length, however the results were on par.

4.1.8.6 Leaf length at 180 days after the first flush

Carnation varieties showed significant differences with respect to leaf length at 180 days after the first flush. Leaf length was maximum in 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) recorded minimum leaf length (8.74 cm). The varieties Alibaba (10.95 cm), Yellow Firato (10.88 cm) Viking (10.34cm) and Aicardi (10.22 cm) were moderate in leaf length which was on par with each other.

4.2 Flowering characters

Data related to flowering characters like days taken for flower bud initiation, days taken to bud opening, days taken for flower bud development and duration of flowering are furnished in Table 8 and illustrated in the Fig. 8.

4.2.1 Days taken for flower bud initiation

Significant differences were observed between the different Carnation varieties with respect to flower bud initiation.

The number of days for flower bud initiation was recorded minimum in variety Diana (67.58 days) and significantly differed over other varieties, whereas variety Firato (96.72 days) was last to initiate variable buds, followed by Gaudina (91.47 days) and Buemonde (89.59 days). Varieties Dali (88.21 days), Pink Shiva (87.38 days), Viking (85.43 days) and Alibaba (85.42 days) were midlate in flower bud initiation.

4.2.2 Days taken for bud opening

The number of days required for flower bud opening in different Carnation varieties grown under greenhouse was recorded and presented in Table 8. The data revealed that number of days taken for flower bud opening was significant. The variety Diana (88.54 days) was the earliest to open its buds, followed by Yellow Firato (94.55 days) and Viking (99.52 days), whereas varieties Firato (114.6 days) and Gaudina (113.6 days) were very late for flower bud opening. Varieties Buemonde (109.6 days), Alibaba (108.5 days), Aicardi (105.5 days) and Pink Shiva (105.1 days) were medium duration types with respect to days taken for bud opening. Varieties Aicardi and Pink Shiva were on par to each other.


Gaudina


Viking


Buemonde


Yellow Firato


Firato

Diana


Pink Shiva


Aicardi


Alibaba

Dali

Plate 3. Crop stand of individual varieties

Table 8. Number of days required for different reproductive growth in different varieties of Carnation grown under greenhouse

Treatments	Days to flower bud initiation	Days to bud opening	Days to bud development	Duration of flowering (days)
T_1: Gaudina	91.47	113.56	22.06	156.17
T_2: Viking	85.43	99.52	14.24	162.59
T_3: Buemonde	89.59	109.58	20.27	158.85
T_4: Yellow Firato	79.42	94.55	15.06	166.65
T_5: Firato	96.72	114.63	18.07	151.84
T_6: Diana	67.58	88.54	21.24	180.12
T_7: Pink Shiva	87.38	105.12	18.08	159.54
T_8: Aicardi	80.51	105.51	25.09	166.50
T_9: Alibaba	85.42	108.46	23.07	161.72
T_{10}: Dali	88.21	112.22	24.05	159.08
Mean	85.17	105.17	20.12	162.31
S. Em ±	0.76	0.69	2.26	0.63
C.D at 5%	2.27	2.05	6.72	1.88

4.2.3 Days taken for development of flower bud

The data obtained on the number of days taken for development of flower bud (from the date of visible flower bud initiation to a day before the first flower opens) of Carnation varieties are furnished in Table 8. The result showed that significant difference was observed for number of days taken for development of flower bud. Flower bud development was early in the variety Viking (14.24 days), followed by Yellow Firato (15.06 days). The next earliest types were Firato (18.07 days) and pink Shiva (18.08 days) which were on par. Varieties Aicardi (25.09 days) and Dali (24.05 days) took maximum time for flower bud development. Flower bud development was moderately late in varieties Gaudina (22.06 days), Diana (21.24 days) and Buemonde (20.27 days).

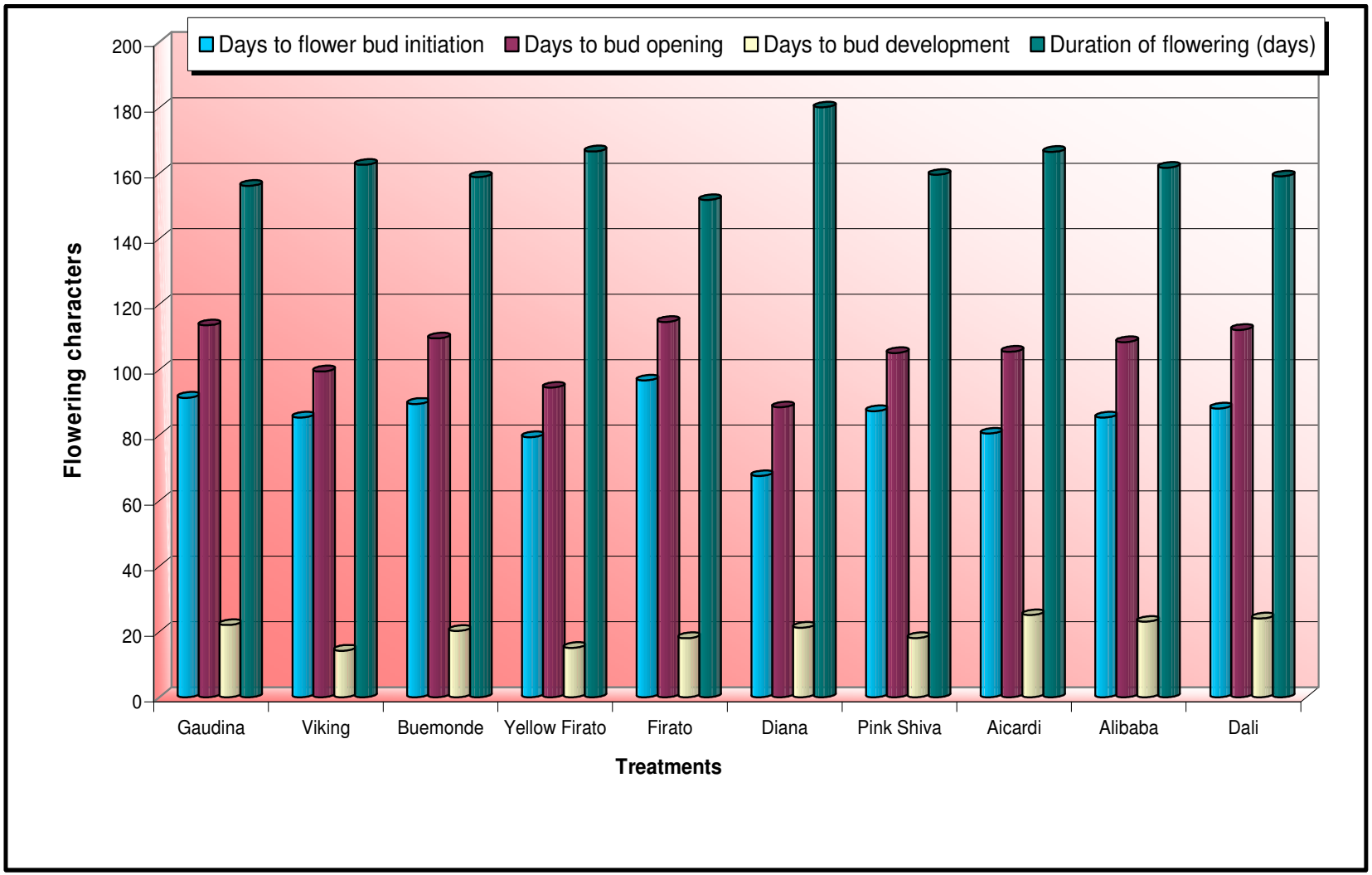

Fig.8. Number of days required for different reproductive growth in different Carnation cultivars grown under greenhouse

4.2.4 Duration of flowering

The data on duration of flowering is presented in Table 8 and depicted in Fig. 8. Significant variations were observed among the different varieties of Carnation for duration of flowering. Variety Diana (180 days) had maximum flower duration and it was superior over rest of the varieties. Variety Firato (151.8 days) had minimum duration of flowering followed by Gaudina (156.2 days), Buemonde (158.9 days) and Dali (159.1 days) which were found on par to each other. Varieties Yellow Firato (166.7 days), Aicardi (166.5 days), Viking (163.6 days), Alibaba (161.7days) and Pink Shiva (159.1 days) were on par to each other.

4.3 Flower quality parameters

The different flower quality parameter recorded were stalk length, stalk girth, flower diameter, number of petals per flower, flower length, flower weight and vase life and the data pertaining to these are presented in Table 9 and illustrated in the Fig.9.

4.3.1 Flower stalk length

Significant differences were recorded between the varieties with respect to flower stalk length. Stalk length was maximum in variety Yellow Firato (97.94 cm) and which was superior over other varieties. The next superior varieties were Diana (89.84 cm), followed by Firato (89.38 cm), Pink Shiva (86.84 cm) and Gaudina (86.52 cm) and were found on par. Variety Viking recorded minimum stalk length (76.70 cm) and was on par with Alibaba (79.64 cm). Varieties Buemonde (83.08 cm), Dali (81.86 cm) and Alibaba (79.64 cm) were found on par to each other and were medium duration types with respect to stalk length.

4.3.2 Flower stalk girth

Girth of flower stalk of different Carnation varieties was differed significantly. It was in the range of 3.66 mm to 5.07 mm. Stalk girth was maximum in 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).

The next superior ones were Gaudina (4.78 cm), Viking (4.67 cm), Buemonde (4.62 cm) and Firato (4.52 cm). The varieties Buemonde, Firato, Diana (4.45 cm) and Alibaba did not differ significantly.

4.3.3. Flower diameter

There was significant difference among the varieties with respect to flower diameter. Flower diameter was maximum in variety Gaudina (7.53 cm) which was closely followed by Aicardi (7.46 cm), Alibaba (7.25 cm) and found on par. Flower diameter was minimum in variety Yellow Firato (6.27 cm) which was on par with Firato (6.36 cm), Buemonde (6.42 cm), Pink Shiva (6.54 cm), Viking (6.64 cm), Dali (6.67 cm) and Diana (6.74 cm).

4.3.4 Number of petals per flower

There was a significant difference among the different Carnation varieties with respect to number of petals per flower. Maximum number of petals per flower were recorded in variety Gaudina (74.18) followed by Aicardi (70.53) and Alibaba (70.19). The latter two were on par. It was minimum in variety Yellow Firato (46.36). Varieties Diana (66.39) and Viking (64.36) produced medium number of petals per flower and were on par. Similarly varieties Dali (62.16) and Pink Shiva (60.10) were also on par. There was a non significant difference between the varieties Buemonde (56.32) and Firato (50.36).

4.3.5 Length of flower

There was significant difference among the varieties with respect to flower length. Length of flower was maximum in variety Gaudina (5.81) which was on par with varieties Aicardi (5.77 cm), Alibaba (5.74 cm), Diana (5.47cm), Dali (5.37 cm), Viking (5.32 cm) and Pink Shiva (5.27 cm). The length of flower was minimum in variety Yellow Firato (5.07 cm), followed by Firato (5.12 cm) and Buemonde (5.21 cm). The flower length was also on par in varieties Alibaba, Diana, Dali, Viking, Pink Shiva, and Buemonde.

Table 9. Flower quality characters in different varieties of Carnation grown under greenhouse

Treatments	Length of flower stalk (cm)	Girth of flower stalk (mm)	Flower diameter (cm)	Number of petals per flower	Length of flower (cm)	Weight of flower (g)	Shelf life (Days)
T_1: Gaudina	86.52	4.78	7.55	74.18	5.81	30.57	11.85
T_2: Viking	76.70	4.67	6.64	64.23	5.32	29.34	11.67
T_3: Buemonde	83.08	4.62	6.42	56.32	5.21	21.81	5.15
T_4:Yellow Firato	97.94	3.66	6.27	46.36	5.07	28.14	4.85
T_5: Firato	89.38	4.52	6.36	50.36	5.12	27.53	4.96
T_6: Diana	89.84	4.45	6.74	66.39	5.47	25.85	9.48
T_7: Pink Shiva	86.84	5.07	6.54	60.10	5.27	35.08	15.18
T_8: Aicardi	84.61	4.14	7.46	70.53	5.77	23.83	14.83
T_9: Alibaba	79.64	4.34	7.25	70.19	5.74	25.52	11.06
T_{10}: Dali	81.86	4.25	6.67	62.16	5.37	23.36	6.35
Mean	85.64	4.45	6.79	62.08	5.41	27.10	9.54
S. Em±	1.52	0.09	0.17	1.13	0.16	0.71	0.54
C.D at 5%	4.53	0.28	0.51	3.35	0.48	2.12	1.61

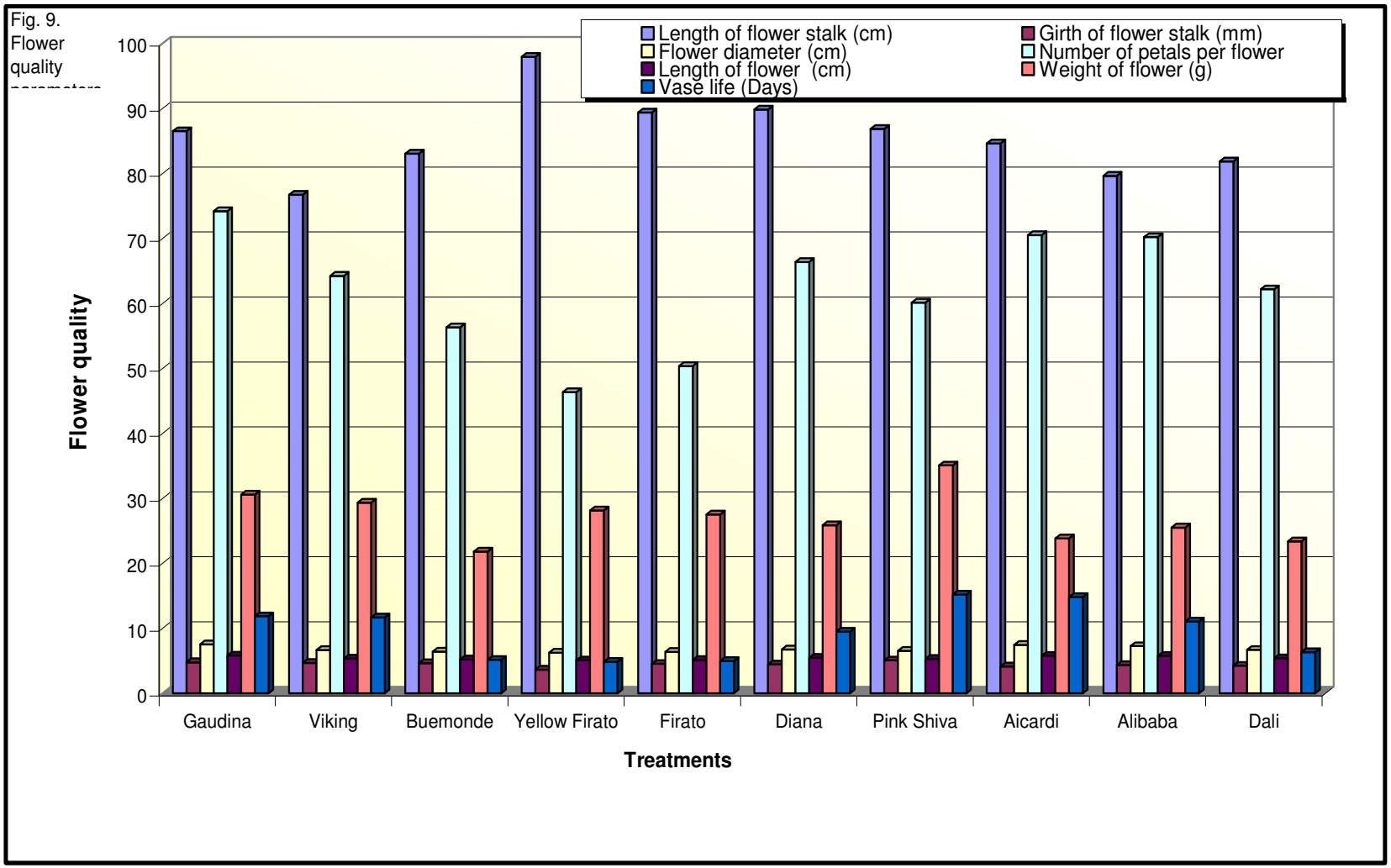

Fig. 9. Flower quality parameters in different cultivars of Carnation grown under greenhouse

Gaudina

Viking

Buemonde

Yellow Firato

Firato

Diana

Pink Shiva

Aicardi

Alibaba

Dali

Plate 4. Close view of carnation varieties

43.6 Weight of flower

Significant difference was observed among the different varieties of Carnation for weight of flower. Significantly superior variety over others for maximum flower weight was noticed in Pink Shiva (35.08 g). Next superior ones were 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) variety. The Varieties Firato (27.53 g) Diana (25.85 g) and Alibaba (25.52g) were found medium in their flower weight. Variety Viking, Yellow Firato (28.14g) and Firato were on par.

4.3.7 Shelf life

There was significant difference among the Carnation variety with respect to shelf life. Shelf life was maximum in variety Pink Shiva (15.18days) which was on par with Aicardi (14.83 days). The next superior variety was Gaudina (11.85 days), Viking (11.67 days) and Alibaba (11.06 days). The variety Yellow Firato (4.85 days) had recorded minimum shelf life, followed by Firato (4.96 days), Buemonde (5.15 days) and Dali (6.35 days). The variety Alibaba and Diana (9.48 days) were on par to each other.

4.4 Yield parameters

The yield components recorded were number of flowers per plant and number of flowers per square meter of net planted area. The data related to yield parameters as influenced by different Carnation varieties are presented in Table 10 and Fig 10.

4.4.1. Number of flowers per square meter

There was a significant difference among the varieties for flower yield per plant. Significantly the highest number of flowers was recorded in Yellow Firato (7.64) followed by Firato (7.58) and found on par. Variety Viking (5.33) produced minimum number of flowers per plant. Variety Dali (7.23), Diana (6.87), Aicardi (6.78), Buemonde (6.60) Gaudina (6.56), Pink Shiva (6.32) and Alibaba (6.19) were statistically on par to each other.

4.4.2. Number of flowers per square meter

Number of flowers per square meter varied significantly among the different varieties of Carnation grown under greenhouse. Maximum number of flowers per square meter was recorded in variety Yellow Firato (254.6) which was on par with Firato (252.6) and Dali (241.0). The next superior strains were Diana (229.0) and Aicardi (226.0), whereas variety Viking recorded minimum number of flowers per square meter (177.7). Varieties Aicardi, Buemonde (220.0) Gaudina (218.6), Pink Shiva (210.7) and Alibaba (206.3) were found on par.

4.5 Calyx splitting

The Carnation flowers are badly affected by a serious physiological disorder named calyx splitting. There was a significant difference among the different varieties of Carnation for per cent calyx splitting. The data pertaining to the same is furnished in Table 11. The per cent calyx splitting was low in variety Alibaba (0.09%), followed by Yellow Firato (0.51%) and Firato (0.94%). The two were found on par. Calyx splitting percentage was maximum in variety Viking (23.09%). There was significant difference among the varieties Aicardi (10.34%), Diana (8.51%), Gaudina (7.18%) and Dali (5.73) with respect to calyx splitting. Non significant results were recorded in varieties Buemonde (4.76%) and Pink Shiva (4.18%).

4.6 Per cent mortality of plants

Per cent mortality due to Fusarium wilt varied significantly among different varieties of Carnation. The data pertaining to the attribute is presented in Table 11. The minimum percentage of mortality was observed in variety Diana (8.27), followed by Buemonde (8.33%) and Firato (8.58%). The maximum per cent of mortality was observed in variety Alibaba (25.04) which significantly differed to other varieties. The varieties Dali (18.10%), Gaudina (16.27%), Pink Shiva (14.58%) Yellow Firato (13.76), Viking (12.44) and Aicardi (10.16%) had higher average per cent mortality.

After 5 days

After 5 days

Plate 5. Shelf life studies in carnation varieties

Table 10. Yield per plant and per square meter in different varieties of Carnation grown under greenhouse

Treatments	Flower yield (No. of stems)	
	Yield /Per plant	Yield /Per square meter
T_1: Gaudina	6.56	218.64
T_2: Viking	5.33	177.68
T_3: Buemonde	6.60	219.98
T_4: Yellow Firato	7.64	254.64
T_5: Firato	7.58	252.64
T_6: Diana	6.87	228.98
T_7: Pink Shiva	6.32	210.65
T_8: Aicardi	6.78	225.98
T_9: Alibaba	6.19	206.31
T_{10}: Dali	7.23	240.98
Mean	6.71	223.65
S. Em±	0.39	6.14
C.D at 5%	1.17	18.24

4.7 Economics

The economics of cultivation of Carnation for an area of 560 m^2 under naturally ventilated polyhouse was worked out for one year and presented in Table 12 and depicted in Appendix I.

The economic analysis revealed that the maximum gross returns (Rs. 7, 63,920/560 m^2) were obtained from variety Yellow Firato, followed by Firato (Rs. 7,57,920/560 m^2) with a net return of Rs. (Rs. 5,97,139/560 m^2 and Rs. 5, 91,139/560 m^2, respectively) compared to other varieties under polyhouse. These varieties had maximum B: C ratio of 3.58 and 3.54, respectively under polyhouse.

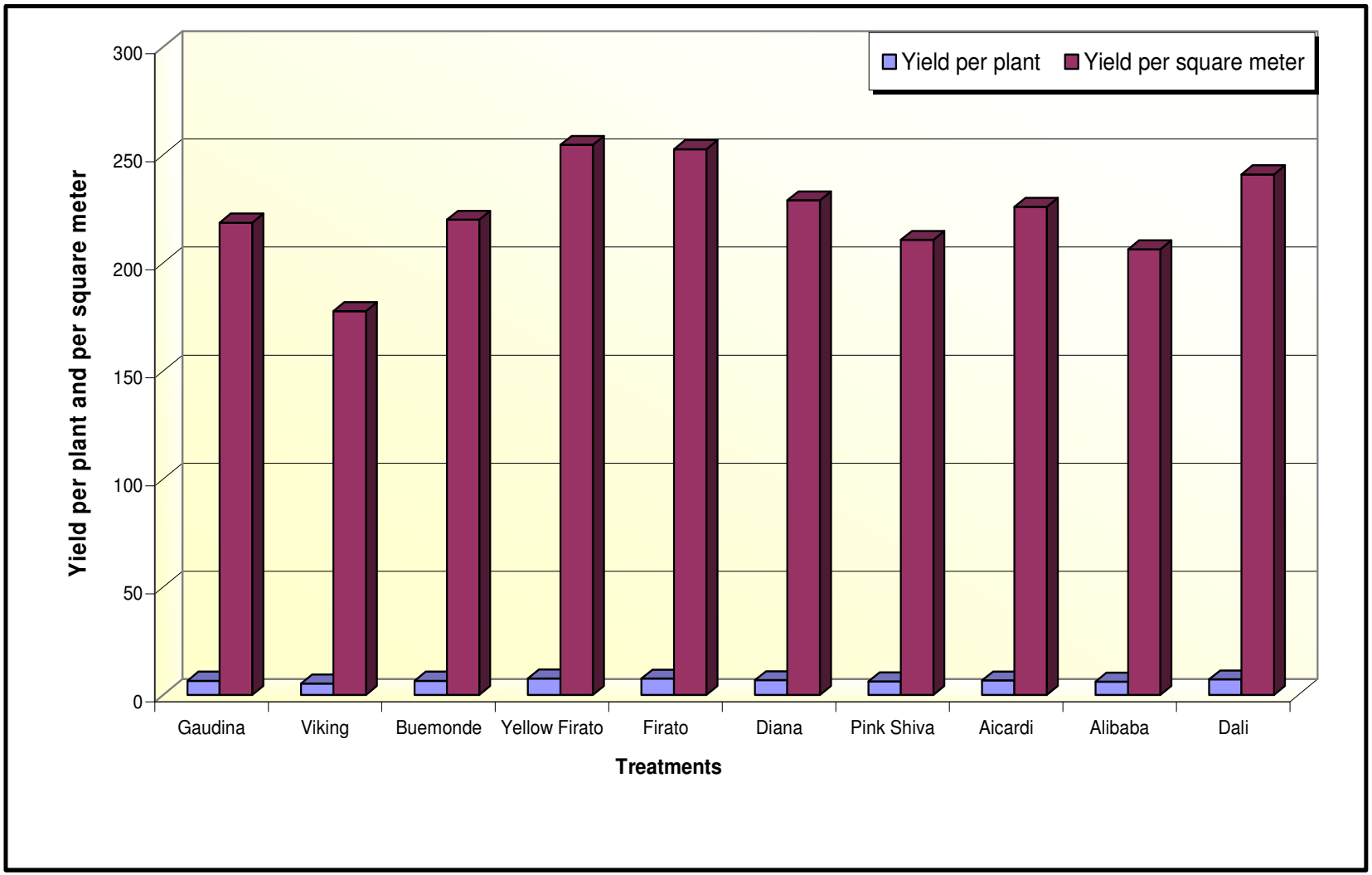

Fig. 10. Yield per plant and square meter in different cultivars of Carnation grown under greenhouse

Plate 6. *Fusarium wilt incidence in Alibaba*

Viking

Diana

Gaudina

Plate 7. Calyx splitting in carnation varieties

Table 11. Calyx splitting (%) and per cent mortality in different varieties of Carnation grown under greenhouse

Treatments	Calyx splitting (%)	Mortality (%)
T_1: Gaudina	7.18 (2.77)	16.27 (4.03)
T_2: Viking	23.09 (4.81)	12.44 (3.53)
T_3: Buemonde	4.76 (2.29)	8.33 (2.89)
T_4: Yellow Firato	0.51 (1.00)	13.76 (3.71)
T_5: Firato	0.94 (1.20)	8.58 (2.93)
T_6: Diana	8.51 (3.00)	8.27 (2.88)
T_7: Pink Shiva	4.18 (2.16)	14.58 (3.82)
T_8: Aicardi	10.34 (3.29)	10.16 (3.19)
T_9: Alibaba	0.09 (0.77)	25.04 (5.00)
T_{10}: Dali	5.73 (2.50)	18.10 (4.25)
Mean	6.53	13.55
S. Em±	0.21	0.23
C.D at 5%	0.63	0.68

Figures in the parenthesis indicate square transformed values.

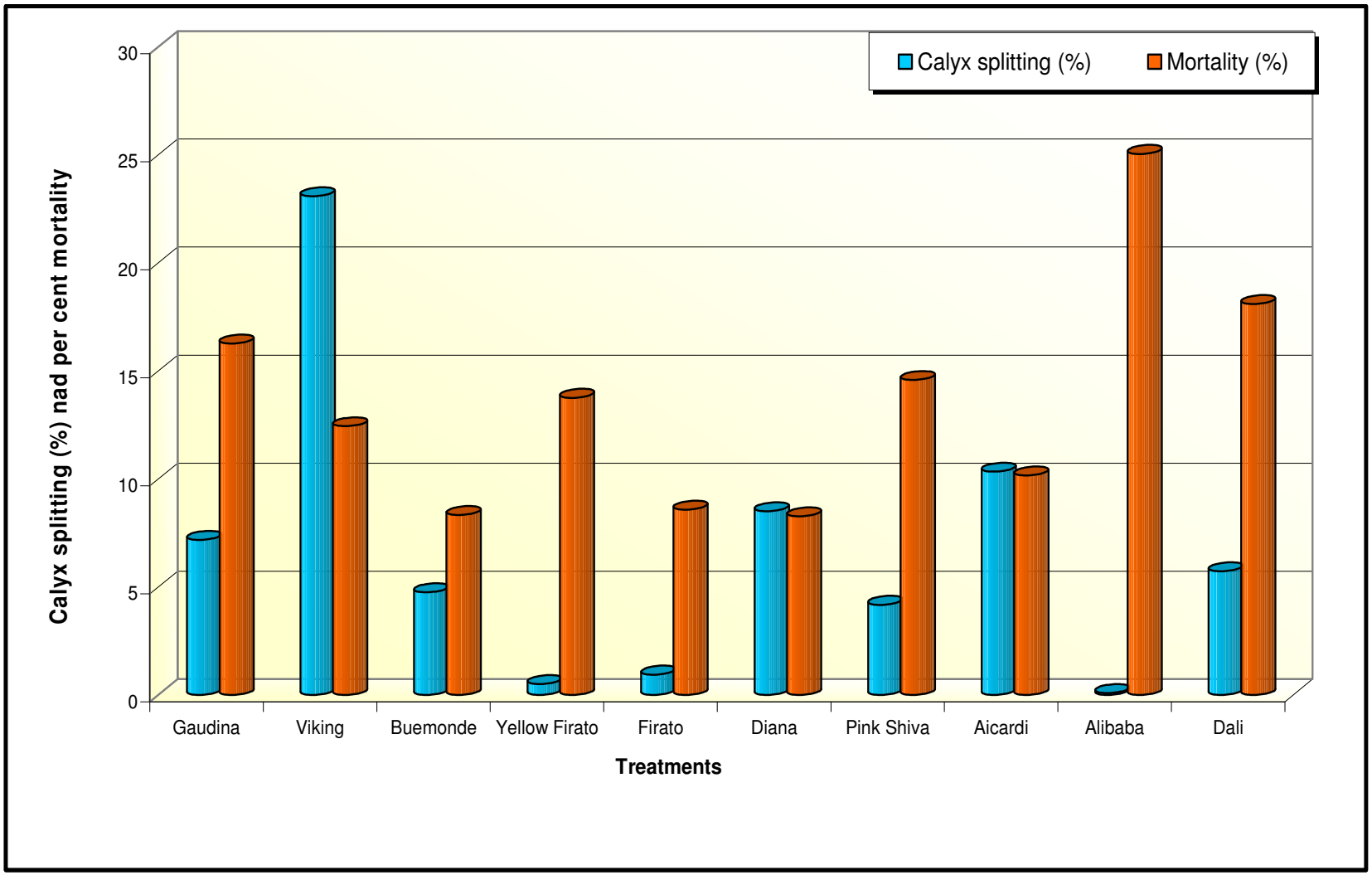

Fig. 11. Calyx splitting (%) and per mortality in different varieties of Carnation grown under greenhouse

T_5 T_6 T_4 T_7 T_1 T_8 T_3 T_{10} T_9

Plate 8. Stalk length of carnation varieties

Plate 9. Disbudding in carnation

Plate 10. Packing of carnation flowers

Table 12: Economics of cut flower production of different Carnation varieties under naturally ventilated polyhouse (560 m^2) for one year

Treatments	Total cost (Rs.)	Flower yield/560 m^2	Gross returns (Rs.)*	Net returns (Rs.)	B:C ratio
Gaudina	166780.99	218640	655920	489139	2.93
Viking	166780.99	177680	533040	366259	2.20
Buemonde	166780.99	219980	659940	493159	2.96
Yellow Firato	166780.99	254640	763920	597139	3.58
Firato	166780.99	252640	757920	591139	3.54
Diana	166780.99	228980	686940	520159	3.12
Pink Shiva	166780.99	210650	631950	465169	2.79
Aicardi	166780.99	225980	677940	511159	3.06
Alibaba	166780.99	206310	618930	452149	2.71
Dali	166780.99	240980	722940	556159	3.33

*Average price per flower Rs. 3

5. DISCUSSION

Growth, development, productivity and post-harvest quality of any flower crop largely depend on the genetic potential of the variety and environmental condition under which they are grown. The other factors are nutrition, season, pest and diseases, production technology and cultural practices can influence the performance of the crop. Every plant species has its own specific interesting characters (such as flower colour, size, growth rate and storability). The atmospheric condition under which it is grown has large bearing on the realization of its genetic potential. It is advisable to provide suitable environment to exploit genetic potentiality of variety being grown. Hence, selection of variety is an important criterion for successful cultivation of a flower crops.

Carnation is one such flower crop, which responds very well to the favourable environmental condition. Under modern production technology for standard Carnation, a greater emphasis is given to have the appropriate varieties for high yield of cut flowers with better quality and shelf life. Carnation is an important flower crop grown under greenhouse condition worldwide. The performance of Carnation varieties varies with region, season, genotypes and environment. Testing the performance of available varieties for suitable adaptability with respect to flowering, flower quality and yield has prime importance. Similarly, proper selection of variety for producing the desired quantity and quality of flowers for domestic as well as export market is of paramount importance. Hence, the present investigation is undertaken with ten varieties. The findings of the investigation are discussed under the following heading with the supporting data and available literature.

5.1 Vegetative parameters

The vegetative characters like plant height, stem girth, number of shoots, length of shoot, number of internodes, internodal length, number of leaves and length of leaves significantly differed among varieties of Carnation.

During all stages of crop growth *viz*., 30, 60, 90, 120, 150 and 180 days after the first flush (DAF), the plant height of Carnation was higher in Yellow Firato, Firato and Diana grown under naturally ventilated polyhouse condition. Varieties Viking, Alibaba and Dali recorded minimum plant height. The varieties Gaudina, Pink Shiva, Aicardi and Buemonde were medium in terms of plant height. Such a range of variability in plant height among the varieties is mainly due to genetic nature, growing environmental conditions, production technology and cultural practices. This was in accordance with the reports of Atanassova and Batchvarova (1995), Mahesh (1996), Sathisha (1997), Shiragur (2002). Patil (2001) who have also recorded vigorous growth in terms of plant height in variety Aicardi.

Girth of the stem also differed from variety to variety. It gives strength to the main stem. Varieties Pink Shiva, Alibaba and Diana had thicker and stronger stems, while variety Firato, Viking, Buemonde had weaker stems. On the other hand varieties Dali, Aicardi, Gaudina had stems of moderate thickness. These finding are in line with results obtained previously in different Carnation varieties such as Atanassova and Batchvarova (1995), Mahesh (1996) and Shiragur (2002). Thicker stems indicated that these varieties have higher capacity of storing reserve food material.

Maximum number of internodes per branch was observed in varieties Yellow Firato, Firato, Diana and Gaudina while, it was minimum in variety Dali, Viking and Buemonde. Similarly variations in number of internodes have been recorded earlier in Carnation by Hanzel *et al.* (1954), Heins *et al.* (1979) and Patil (2001). Varieties pink Shiva, Alibaba, Firato and Diana had maximum internodal length, while it was minimum in varieties Viking, Dali and Buemonde. Similarly, variation due to varieties with respect to internodal length was also recorded by Mahesh (1996) and Patil (2001) in Carnation.

Number of shoots production is greatly influenced by apical dominance. Varieties Yellow Firato, Firato, Dali and Diana recorded more number of shoots as compared to variety Viking which had more apical dominance. These results are similar to that of Shahakar *et al.* (2004), Mahesh (1996), Shiragur *et al.* (2002), Satisha (1997), Patil (2001) and Naveenkumar *et al.* (1999b). Varieties Yellow Firato, Gaudina, Firato and Diana recorded maximum length of shoot as compared to variety Alibaba and Viking which had minimum length of shoot. Similar difference with respect to shoot length was also noticed by Patil (2001) and Shiragur (2002).

Leaves are the important functional units for photosynthesis, which greatly influence the growth and flower yield of any crop. Among the varieties, number of leaves produced per plant was maximum in varieties Yellow Firato, Firato, Aicardi and Dali. This might be due to taller plant, increased number of secondary shoots and the congenial microclimate that prevailed inside the polyhouse favouring increased growth rate of plants. Similar results were obtained by Patil (2001) Shiragur (2002), Reddy (2004) and Shahakar *et al*. (2004). The variety Alibaba produced lesser number of shoots and resulted in reduced number of leaves. Similar variations in production of leaves due to varieties have been reported previously in Gerbera (Battacharjee, 1981).

Leaf length was significantly maximum throughout the growing period in variety Buemonde which was superior over rest of the varieties, while the variety Firato recorded minimum length throughout its growing period. Length of leaves differed from variety to variety and it may be due to the genetic makeup of the plant or due to influence of the environment. This was in line with the results reported by Uhlinger and Lindgren (1984) and Patil (2001). The leaf length was also affected by the planting time. The results are in agreement with the findings of Ramesh Kumar and Kartar Singh (2003).

Yellow Firato, Firato and Diana were best varieties which recorded better vegetative characters.

5.2 Flowering Parameters

Flower parameters include days to flower bud initiation, days to flower bud development, day to flower opening and flowering duration. This study revealed that, days to flower bud initiation was significantly differed among the varieties of Carnation. Varieties Diana and Yellow Firato were early to initiate flower bud, whereas varieties Firato and Gaudina were late in initiating flower bud. Similar variations due to varieties were also observed by Bhautkar (1994), Mahesh (1996), Satisha (1997), Patil (2001) and Shiragur (2002). These variations for flower bud initiation may be attributed to genetical make up of varieties as reported by Reddy *et al*. (2004). According to Besemer (1980) the flower buds initiation can be readily managed by adopting the right time of planting and pinching schedules. The variations in bud initiation may also be due to influence of solar radiation and temperature as reported by Harris and Scott (1969).

Variety Firato, Gaudina and Dali were late to bud opening, whereas variety Diana, and Yellow Firato were early to initiate flower bud opening. In varieties Diana and Yellow Firato, flower bud initiation was early; hence flower bud opening was also early, whereas in variety Firato and Gaudina flower bud initiation was late hence, there was delay in flower bud opening. Similar variation in time taken for flower bud opening in Carnation varieties was also observed previously by Patil (2001) and Shiragur *et al*. (2002).

The development of flower bud from initiation was early in variety Viking, Yellow Firato and Pink Shiva, whereas variety Aicardi took maximum time for development of its flower bud. Variations among varieties were also observed in Carnation previously by Mahesh, (1996), Sathisha, (1997), Shiragur *et al*. (2002) and Krishnappa (2000).

Among the ten varieties evaluated variety Diana exhibited free-flowering nature (flowers throughout the season), followed by Aicardi, Viking and Dali, whereas varieties Firato, Gaudina and Dali recorded minimum duration of flowering. These variations in flower duration due to varieties was also observed by Gill and Arora (1988), Patil (2001), Shiragur, (2002), Dwivedi and Kareem (2004).

The varieties Diana and Yellow Firato were early to reach their peak growth and as a result they initiate flowering earlier when compared to other varieties. Whereas, varieties Firato Gaudina and Buemonde initially exhibited slow growth and were late in their flowering. These variations were also observed by Kallihal (2005), Shiragur (2002) and Gopinath (2001).

5.3 Flower quality parameters

Flower quality parameters decide the significance of suitability of the particular variety for commercial cultivation. The important biometric characters deciding the size and nature of flowers are stalk length, stalk girth, flower diameter, number of petals per flower, flower

length, flower weight and shelf life. Significant differences were observed among the varieties for these flower quality parameters.

Length of flower stalk is a very important quality trait which is considered while grading the flowers. It also plays important role in the shelf life by extending their post-harvest life. The varieties Yellow Firato, Diana, Firato and Pink Shiva were superior in the quality in terms of stalk length of flowers. Increased number of internodes with increased internodal length resulted in increased stalk length. Variety Viking had shorter Stalk length due to less number of shorter internodes. This was in accordance with the report of Atanassova and Batchvarova (1995), Mahesh (1996), Sathisha (1997) and Patil (2001).Variation in stalk length among the Carnation varieties was observed previously by Naveenkumar *et al.* (1999), Singh *et al*. (2001).

Girth of flower stalk also plays vital role in making the flower for standard cut flower. Varieties Pink Shiva and Gaudina had strong flower stalks and Yellow Firato and Aicardi had weak flower stalks. Similar influence of flower girth among varieties was also observed previously in Carnation Mahesh (1996), Shiragur (2001), Ryagi *et al*. (2007) and Patil (2001).

Variety Gaudina, Aicardi and Alibaba found to be superior with respect to flower diameter whereas, varieties Yellow Firato, and Firato recorded minimum bud and flower diameter. Similar variations in bud and diameter among the varieties were also observed previously by Naveenkumar *et al.,* 1999, Singh and Sangama, 2003, and Reddy, 2004.

Varieties Gaudina, Aicardi and Alibaba produced maximum number of petals per flower. Minimum number of petals per flower was recorded in variety Yellow Firato. It is being genetically controlled character. The number of petals per flower varied among the varieties. It is one of the quality parameters which greatly influence the quality of cut flower density. Similar variation in number of petals per flower was noticed by Atanassova and Batchvarova (1995), Patil (2001) and Mahesh (1997).

One of the components of the flower that contributes for the increase in diameter is the flower length. Increase in flower length directly contributed for the higher flower diameter and varied among the different varieties evaluated. The flower length was maximum in variety Gaudina, followed by Aicardi and Alibaba, whereas it was recorded minimum in Yellow Firato. These results are in accordance with the results of Bhautkar (1994) and Gurav *et al.* (2004).

Variety Pink Shiva recorded significantly highest flower weight, followed by Gaudina. It was recorded less in varieties Buemonde, Dali and Aicardi. Such variations in weight of flower among the varieties were also observed by earlier workers in Carnation by Singh *et al.* (2001), Shiragur (2002), Singh and Sangama (2003). This variation in flower weight among varieties might be attributed to the higher water and carbohydrates level in the flower. Water plays a very important role to maintain flower turgidity, freshness and petal orientation. The ultimate effect of all these factors resulted into strong and long flower stalks, large sized buds or flower and finally increases in flower weight. Similar variations were also recorded previously in Carnation (Singh *et al.,* 2001, Singh and Sangama, 2003).

The vase life is one of the important traits which decide its economic value. In the present study, vase life was significantly influenced by varieties. The plants were grown under the naturally ventilated polyhouse and hence they were sturdier with longer stems. Vase life was maximum in varieties Pink Shiva, followed by Aicardi and Gaudina, whereas Cv. Yellow Firato and Firato had recorded minimum vase life. This variation in vase life among the varieties might be attributed to the variations in accumulation of carbohydrates since; these varieties could produce more number of leaves and indicated positive and significant correlation between these characters. This variation in shelf life might also be due to effective uptake of water from vase in different varieties (Sharada, 1998). Variation in vase life could also be attributed to fact that, the variation in ability to produce ethylene and sensivity to it among the different varieties. Similar variation for vase life in varieties was also reported previously in Carnation by Mahesh (1996), Sathisha (1997), Krishnappa (2000), Pathania (2000), Singh *et al*. (2007), Shahakar *et al*. (2004) and Patil (2001).

5.4 Flower Yield

In the present study variety Yellow Firato, Firato and Diana produced maximum number of flowers per plant as well as per square meter (Table 10). Variety Viking recorded

minimum number of flowers per plant. The increased flower yield might be attributed to more number of leaves resulted in production and accumulation of maximum photosynthetic material which ultimately resulted in production of more number of flowers with bigger sized flowers. Similar variation in Carnation with respect to flower yield was also observed by Sathisha (1997), Naveenkumar *et al.* (1999b), Patil (2001), Gurav (2004), Shiragur (2002), Ryagi (2007) and Shahakar *et al.* (2004).

5.5 Calyx splitting

The minimum calyx splitting was recorded in Alibaba, Yellow Firato and Firato while, maximum calyx splitting percentage was found in variety Viking which was significantly differing with other varieties. It might be attributed to extra growth, centers in the calyx and inability of calyx to contain these extra petals and petaloids according to Whealy (1992). There is a negative correlation between the calyx splitting and number of petals. The results are in accordance with the findings of Boikov (1992), Sathisha (1997), Singh *et al.* (2006) and Shiragur (2002).

5.6 Per cent mortality of plants

The mortality of the plants was mainly found due to Fusarium wilt in Carnation. The minimum mortality was observed in the variety Diana, Buemonde and Firato, whereas it was maximum in Cv. Alibaba. Variation in mortality among varieties might be attributed to response of plant to pathogen. Similar variation among the varieties has been reported previously in Carnation such as Ben Yephet *et al*. (1993), Patil (2001), Sathisha (1997) and Shiragur (2002).

Based on the present findings it can be concluded that the varieties Yellow Firato, Diana, Firato, Aicardi, and Pink Shiva performed best with respect to growth, earliness in flowering, flower yield and quality.

5.7 Economics of Carnation cultivation

The economics of cultivation of Carnation under low cost naturally ventilated polyhouse was worked out for one year for 560 meter square area. Since Carnation cultivation is an upcoming business opportunity especially in India, it is essential to work out the economics. The benefit to cost (B: C) ratio was highest (3.58) in Yellow Firato and Firato (3.54) which were found to be superior compared to other varieties studied. These two varieties are highly remunerative than the other varieties studied (Table 12). Whereas some of the varieties had less B:C ratio due to their poor performance in terms of yield (because of their flowering behaviour and susceptibility to biotic factors). This was in accordance with the reports of Ferretto (1994), Zawaneberg (1990), Totth (1984), Lin and Chin, 1990 and Mysore *et al.* (2005). From the study it can be concluded that cultivation of Carnation under polyhouse will be more economical.

5.8 Future line of work

In light of findings of present investigation, the following studies are suggested.

1. Development of high yielding cultivars
2. Evaluation of standard Carnation varieties under different growing structures to reduce cost of production
3. Standardization of suitable netting structure for higher and good quality cut flowers
4. Standardization of package of practices for reducing calyx splitting and mortality
5. Development of cultivars with resistance to *Fusarium* wilt disease

6. SUMMARY AND CONCLUSIONS

The experiment was conducted at Hi-tech Horticulture Unit, Main Agricultural Research Station, Saidapur Farm, University of Agricultural Sciences, Dharwad during February to August, 2008 to study the performance of standard Carnation (*Dianthus caryophyllus* L.) varieties under naturally ventilated polyhouse. The experiment was conducted in Randomized Block Design with three replications and ten varieties as treatments.

The rooted cutting of ten Carnation varieties were procured (Five varieties *viz.,* Guadiana, Viking, Buemonde, Firato, and Yellow Firato were from KF Bio plant Pune, while remaining five varieties *viz*., Diana, Pink Shiva, Aicardi Alibaba and Dali were from SPA Flora, Bangalore). Recommended cultural practices were followed. Observations were recorded with respect to vegetative parameters, flowering attributes, flower quality characters, yield parameter during the growing period of crop. Besides, the economic analysis was also worked out to find out the benefit cost ratio. The salient features of the experimental findings are summarized here under.

Wide and significant variations for all the parameters were observed among the different Carnation varieties. Varieties Yellow Firato, Firato, Diana and Gaudina were superior with respect to growth parameters like plant height, stem girth, number of shoots, length of shoots number of leaves and length of leaves. Variety Yellow Firato was superior for most of the vegetative characters except stem girth.

Varieties, Diana, Yellow Firato, and Aicardi were early to initiate flower buds and also opening of flower buds. Varieties Firato, Gaudina were late in flower bud initiation. Varieties Diana, Yellow Firato, Aicardi recorded longer duration of flowering as compared to other varieties. Varieties Firato, Gaudina, Buemonde and Dali required comparatively less period for development of flower buds. In general varieties Diana, Firato, Aicardi and Gaudina were early varieties.

The flower stalk length was the highest in variety Yellow Firato, followed by Diana, Firato and Pink Shiva, whereas the girth of flower stalk was highest in variety Pink Shiva, followed by Guadiana and Viking. Varieties Gaudina, Aicardi, Alibaba and Diana recorded higher diameter of flowers. Number of petals was highest in variety Pink Shiva, followed by Guadiana and Viking. Varieties Pink Shiva, Aicardi, Guadiana and Viking recorded higher vase life. The weight of flower was highest in variety Pink Shiva, followed by Gaudina, Viking and Firato. In general high quality flowers were obtained in Diana, Yellow Firato, Firato, Aicardi and Pink Shiva.

With respect to yield, varieties Yellow Firato, Firato, Dali and Diana were found superior with respect to number of flowers per plant and per square meter.

Calyx splitting which is a major disorder in Carnation was minimum in varieties Alibaba, followed by Yellow Firato and Firato; however it was maximum in variety Viking.

The per cent mortality due to Fusarium wilt (*Fusarium oxysporum* f. sp *dianthi*) was minimum in varieties Diana, followed by Buemonde, Firato and Aicardi. Variety Alibaba recorded maximum incidence of the disease.

The variety Yellow Firato was found to be superior with respect to vegetative, flowering and yield parameters and B: C ratio, however, it is poor in shelf life.

Though, the initial investment for cultivation of Carnation under polyhouse is relatively high, but it is profitable to grow Carnation under polyhouse condition. Cost economics worked out in the study indicated B:C ratio of 2.20 to 3.58 depending on the variety. Most of the flowers produced from polyhouse were of grade I quality and fetched good price.

Based on present findings, it can be concluded that varieties *viz.,* Yellow Firato, Diana, Firato, Aicardi, and Pink Shiva have emerged as promising varieties with respect to growth, earliness in flowering, flower yield and quality and tolerance to Fusarium disease during the second flush of the crop. These varieties are suitable for commercial cultivation under naturally ventilated polyhouse in Northern transitional tract of Karnataka.

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* Originals not seen

APPENDIX I

Economics of Carnation cultivation under naturally ventilated polyhouse (560 m^2) for one year

Sl. No.	Particulars	Total cost (Rs.)	Depreciation cost (Rs./year)
I.	Fixed cost		
a	Cost of polyhouse structure @ Rs. 350/m^2 for a life span of 10 years (excluding cladding material)	196000.00	19600.00
b	Cladding material with shed net (for a life span of 3 years)	120000.00	40000.00
c	Micro irrigation and fertigation system	100000.00	10000.00
	Total of Fixed cost	416000.00	69600.00
II.	Recurring contingency (ORC) (for a life span of three years)		
d)	Planting materials (10000 planting/unit @ Rs. 9/plant	90000.00	30000.00
e)	Bed preparation (FYM, vermicompost neem cake, red soil, sand excavation, labour and fertilizers	50000.00	16666.66
f)	Soil sterilization	1500.00	500.00
g)	Netting system	25000.00	8333.33
	For a life span of one year		
h)	Maintenance and repair cost	-	5000.00
h.1.	Cost of labour (1 labour per unit for 1 year @ Rs.1500/month)	-	18000.00
h.2.	Fertilizer and plant protection	-	15000.00
i)	Interest on fixed costs*@ 14%		3681.00
Total of RC			97180.99
Grand total (FC + RC)			166780.99

Average price per flower Rs. 3

$$*\frac{(a+c) \times 0.14}{10} + \frac{(b+d) \times 0.14}{3}$$

APPENDIX II

Monthly meteorological data during crop growth period at outside condition (2008-09) and the average of 58 years (1950-2008) at Main Agricultural Research Station, UAS, Dharwad

Months	Rainfall (mm)		Temperature (^{o}C)				Relative humidity (%)	
	2008-09	1950-2008	Mean maximum		Mean minimum		2008-09	1950-2008
			2008-09	1950-2008	2008-09	1950-2008		
April 2008	28.8	49.3	34.7	37.3	20.4	19.8	80.4	75.6
May 2008	55.8	80.2	35.1	33.7	20.6	21.3	85.1	66.2
June 2008	101.6	114.2	28.7	28.8	21.0	22.4	91.8	81.1
July 2008	121.0	152.4	28.2	29.1	20.7	21.0	91.3	87.1
August 2008	213.2	98.5	26.9	26.9	20.1	20.0	91.5	86.0
September 2008	162.4	104.9	27.8	28.5	20.0	19.9	91.4	82.1
October 2008	60.4	126.9	30.3	30.0	18.9	18.4	83.5	75.8
November 2008	72.2	33.0	29.3	30.1	15.9	15.9	79.4	68.0
December 2008	0.0	5.2	28.6	29.3	13.8	12.5	75.4	63.2
January 2009	0.0	0.1	29.8	29.6	13.3	14.6	66.6	63.1
February 2009	0.0	1.1	33.2	31.2	16.8	16.3	57.5	51.5
March 2009	29.0	2.3	35.0	32.4	19.9	19.5	73.0	56.0
Total	844.4	768.4						

APPENDIX III

Monthly mean weather data recorded under polyhouse condition during the experimental period from Feb- 2008 to August -2008

Months	Temperature		Relative Humidity (%)	
	Max.	Min.	Max.	Min.
February	33.40	21.31	80.14	31.21
March	35.85	22.42	77.34	30.81
April	37.48	23.58	84.19	29.48
May	39.18	23.15	84.97	44.18
June	32.52	22.14	90.58	70.43
July	27.97	23.21	89.25	78.23
August	28.35	21.53	91.33	75.32

EVALUATION OF CARNATION (*Dianthus caryophyllus* L.) VARIETIES UNDER GREENHOUSE CONDITION

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ABSTRACT

An investigation on evaluation of ten cultivars of Carnation (*Dianthus caryophyllus* L.) with respect to growth, quality, yield and economics was carried out under naturally ventilated polyhouse condition at Hi-tech Horticulture Unit, Main Agricultural Research Station, Saidapur Farm, University of Agricultural Sciences, Dharwad during February to August, 2008.

Wide and significant variations for all the parameters were observed among the different Carnation varieties. Varieties Yellow Firato, Firato, Diana and Gaudina were superior with respect to growth parameters like plant height, stem girth, number of shoots, length of shoots, number of leaves and length of leaves. Varieties, Diana, Yellow Firato, and Aicardi were early to initiate flower buds and also opening of flower buds. Varieties Diana, Yellow Firato, Aicardi recorded longer duration of flowering as compared to other varieties.

The flower stalk length was the highest in Yellow Firato. Variety Gaudina recorded higher diameter of flowers. Whereas variety Pink Shiva found superior with respect to number of petals, vase life, girth of flower stalk and weight of flower. The flower stalk length was the highest in variety Yellow Firato, followed by Diana, Firato and Pink Shiva. The variety Yellow Firato was found to be superior with respect to vegetative, flowering and yield parameters and B: C ratio, however, it is poor in shelf life.

Though, the initial investment for cultivation of Carnation under polyhouse is relatively high, it is profitable to grow Carnation under polyhouse condition. Cost economics worked out in the study indicated B:C ratio of 2.20 to 3.58 depending on the variety. Based on the present findings it can be concluded that the varieties Yellow Firato, Diana Firato, Aicardi, and Pink Shiva performed best with respect to growth, earliness in flowering, flower yield and quality.