STUDIES ON FERTIGATION IN CARNATION (*Dianthus caryophyllus* L.) UNDER COVER

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DIVISION OF HORTICULTURE
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STUDIES ON FERTIGATION IN CARNATION (*Dianthus caryophyllus* L.) UNDER COVER

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Affectionately dedicated to
my beloved parents
Shri. Thimme Gowda
and
Late Smt. Siddamma

DIVISION OF HORTICULTURE
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BANGALORE

CERTIFICATE

This is to certify that the thesis entitled, **"STUDIES ON FERTIGATION IN CARNATION (*Dianthus caryophyllus* L.) UNDER COVER"** submitted in partial fulfilment of the requirements for the degree of **DOCTOR OF PHILOSOPHY in HORTICULTURE** to the University of Agricultural Sciences, Bangalore, is a record of bona-fide research work carried out by **Mr. B. KRISHNA** under my guidance and supervision and that no part of the thesis has been submitted for the award of any degree, diploma, associateship, fellowship or other similar titles.

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INTRODUCTION

I INTRODUCTION

Carnation (*Dianthus caryophyllus* L. caryophyllaceae) which is indigenous to the mediterranean region is one of the most important cutflowers in the world. After the green, white and blue revolutions, India seems to be poised for another revolution, this time in the field of floriculture. India's present contribution is a meagre 0.1 per cent to the global floriculture trade which is estimated at 40 billion. Floriculture exports from India were to the tune of Rs. 57.80 crores in 1995-96, out of which Rs. 3.5 crores pertained to only cut flowers (Anon., 1996). But the figure is expected to rise by 15 per cent annualy to reach a figure of rupees two hundred crores by 2000 A.D. Apart from the popular flowers like roses, chrysanthemum, gerbera and carnations are also of great demand in abroad and given top priority in the export oriented projects.

Among the top three cut flowers in the international market, Carnation ranks third, with a value of $ 126.3 million preceeded by rose ($ 212.7 m) and chrysanthemum ($ 178.6 m) (Swarup, 1989). Carnation is prefered by growers to roses and chrysanthemums in several flower exporting countries. This is mainly due to its excellent keeping quality, wide range of form and colour, ability to withstand long distance transportation and remarkable ability to rehydrate after continuous shipping. It is being grown on a large scale under greenhouse or polythene cover in Holland, Colombia, France, Italy, Israel, Kenya and Germany. In India, its cultivation is very limited and almost all the carnations are produced in the open field. Some of the states growing carnation are Himachal Pradesh, Punjab, West Bangal, Jammu and Kashmir and Karnataka. For export quality, places having cool climate like Kashmir, Kulluvalley, Kalimpong, Bangalore etc., are potential production areas (Bhutt, 1989) for carnation.

The Government of India, in a bid to promote this industry in the country, has given full thrust and support by allocationing sufficient funds in the eight plan for the development of floriculture.

With the introduction of Government of India's liberalization of policies and floriculture developmental initiatives, several corporate houses have entered to set up 100% export oriented units. Since implementation of this new policies in 1991, 103 projects with foreign investment of more than Rs 80 crores have been approved to be set up in the country at an estimated cost of more than Rs 1000 crores (Khan *et al.*, 1995). These projects, with technology and marketing support from collaborators from the Netherlands and Israel were being set up in clusters around Pune, Bangalore, Hyderabad and Delhi mainly for rose, carnation and anthurium. Thus the area under climatically controlled greenhouses is estimated to be around 300 ha out of which many have already commenced exports and have received very encouraging results in terms of the acceptence of the quality in major markets abroad.

The carnation plants are half hardy perennial herbaceous, medium tall (0.45 - 1 m) with thick, narrow and linear succulent leaves. The petals are broad with frilled margins and calyx is cylindrical with bracts at the base. Carnation have cymose inflorescence, hence they can be cultivated as either spray types. The standard types produce large blooms on longer flower stalks whereas, the spray produce many flowers of smaller size on longer flower stalks. These sprays are better adopted to warm climate than standard types and preferred to standard types in Europe as well as in Indian market.

In a country like India, which is bestowed with diverse geographical location, having varied types of climate. Besides scientific experience, skilled and unskilled man power are also available at a cheaper cost, hence there is greater potential for the production of carnation on commercial scale. But flowers grown in open field would not meet the international standards and hence greenhouse / polyhouse is aframed structure covered with a transparent high density polyethylene film (HDPE) large enough to grow crops under partial or fully controlled environmental conditions to obtain growth and productivity. The low cost polyhouse, which needs less initial investment when compared to sophisticated high cost polyhouse can be utilized successfully to produce high quality flowers and get maximum productivity. Besides protection of crops from extreme climatic conditions and pest and diseases, it is also possible to cultivate the crop round the year.

Fertigation is a new concept recently adopted in several parts of the world in horticultural crops. Fertigation which combines irrigation with fertilizer application is well recognized as the most effective and convenient means of maintaining optimum fertility level and water supply according to the specific requirements of each crop and soil, resulting in higher yields and better quality. The fertilizers applied through this system reach the active root zone, thus helping easy absorption and its efficient utilization. However, the fertilizers applied must be completely soluble in water and should not have any adverse effect on the crop. This is only a way to ensure the nutrients entry to the root zone, besides, it also helps in economising the use of water and fertilizers and reducing the cost of cultivation by reducing the cost of water, fertilizers and the cost of labour and energy.

Though carnation is an important commercial flower crop, there is no recommended dose of fertilizer for its commercial production and the growers apply fertilizers is an arbitrary manner. On this aspect very little work has been done so for in our country. Hence the present study was initiated to determine the optimum dose of fertilizers through fertigation for the commercial production of carnation for better production.

Keeping these points in view, the research work was conducted with the following objectives.

1. To evaluate carnation cultivars suitable for cultivation under low cost polyhouse.

2. Standardize the optimum levels of fertilizers to get maximum production.

3. To workout the economics of fertigation and cultivars under low cost polyhouse.

4. Study the vase life of different cultivars.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

Carnation, a potential cut flower of great importance all over the world, has great scope for commercialization. The nutritional requirement through fertigation has not been worked out. Further information available on its nutritional requirement through soil is very little. The literature related to application of soluble NPK, Ca, Mg through fertigation and other methods of application on growth and yield of carnation and other related crops has been reviewed in this chapter.

2.1 Fertigation studies in horticultural crops

Irrigation and fertigation were regarded as very important input management practices of today. Enterprising farmers and scientists in the post attempted to let fertilizers be distributed through irrigation with yield advantage (Goldberg and Shmuelli, 1970), this concept is termed as fertigation. However the success of fertigation system dependents only when it fulfills the pre-requisites like (i) the system should be designed efficiently, so that every emitter delivers same amount of water (ii) the distribution of nutrients should be such that there are no blockage of fertilizers and chemical deposits and (iii) there should be a constant and uniform mixing of plant nutrients with irrigation water and constant water flow throughout the system (Greef, 1975a).

New approach to supply fertilizers through drip or sprinklers particularly for horticultural crops was developed by scientists and is in practice in some countries (Bester *et al.*, 1977). Fertigation is recognized to save fertilizers and labour cost in many horticultural crops. Fertigation facilitates the supply of nutrients as they are more quickly available to plant roots than dry fertilizers placed on soil surface. However, the possible disadvantages of fertigation are poor results due to improperly designed irrigation systems which do not give satisfactory coverage of fertilizers material and inability to always use the least expensive materials (Kao, 1980). Assaf (1985) reported that application of nutrients along with drip irrigation in apple reduced the water and fertilizer losses by percolation.

Taking advantages of the expansion of area under drip and sprinkler in India reaching upto 1.6 million hectares, agricultural scientists are also keen to make further advances in using these systems for supplying costly fertilizers at the same time (Sivanappan, 1994).

2.2 Movement of plant nutrients in soil under fertigation

Application of fertilizers through fertigation is highly benificial as it ensures localized addition. The movement of nutrients in the soil is largely determined by the cation exchange capacity of the soil and the electrostatic charge of the particular nutrient. The movement of the charged nutrient ions i.e., ammonium, potassium, calcium and magnesium is dependent on the degree and saturation of the exchange complex of the soil and also the exchange capacity of this complex i.e., a sandy soil has less exchange sites than a loamy soil and a loamy soil lesser than a clayey soil. Therefore, nutrient movement in sandy soil occurs more readily than on a loamy or clay soil. Neutral chemical molecules like urea and negatively charged nutrient ions such as nitrate and sulphate primarily move into the profile with the flow of the water. Thus, irrigation in excess of the plant moisture requirement could lead to leaching of urea and nitrate (Greef, 1975b).

Generally, phosphate fixation occurs in most of the soils. High concentration of phosphate are to be in the surface soil layers when conventional broadcasting of fertilizers is the practice with fertigation, more uniform phosphate gradient in the soil where phosphate are applied the system is evident. Movement of an organic phosphate, glycerophosphate in the soil columns has been reported (Rolston *et al.*, 1974).

2.3 Fertigation in carnation and other flower crops

The source and level of fertigation influence on most of the vegetative and reproductive parameters of flower crops.

2.3.1 Growth parameters

Carnation requires balanced fertilizer application for better growth and flowering. This has been confirmed by Arora and Saini (1975).

Yasui *et al.* (1980) reported that rooted carnation cuttings (cv. Lena) were grown at temperature ranging from 15-30°C and nutrient levels N at 15-50 ppm, P_2O_5 at 10-60 ppm and K_2O at 20-120 ppm. Plant response was determined by taking measurement of stem length and plant height. The best results were obtained at 20° with N, P_2O_5 and K_2O at 75, 30 and 60 ppm respectively.

Mukhopadhyay (1981) observed that N and P stimulated the vegetative growth of plant and increased flower yield per plant in carnation.

Increased plant height and number of branches and significant promotion of flower number were also recorded due to interaction of higher levels of (20, 10 and 10 g / m^2) N, P and K (Biswas *et al.*, 1982).

Application of nitrogen showed significance over control in growth parameters and floral characters, however, different doses (20, 40 and 60 g /m^2) did not alter various characters significantly (Patel and Arora, 1983).

Higher nitrogen rate, phosphorous and higher potash (2:1:3) in the carnation Cv. Dark Lena grown from rooted cuttings under a plastic tunnel promoted plant height and stem elongation in plants (Starck *et al.*, 1991).

2.3.2 Bud and flower character

Kiplinger and Tayama (1968) and Kiplinger *et al.* (1971) found that there were no significant differences between NPK treatments in the average number of days required for the emergence of flower in lillies.

Higher concentration of nitrogen more than 100 mg per litre severely delayed flowering in petunia and chrysanthemum (Pawlowski, 1966).

Delayed flowering was associated with higher rates of nitrogen application above 100 kg /ha and earliness was enhanced by higher potash rates of 200 to 600 kg/ha (Wadsworth and Butters, 1972).

Rushmini and Baldi (1974) inferred that ratio of 1:2:1 NPK increased stem length in carnation and tuberose.

Arora and Saini (1975) reported on carnation cv. marguerite scarlet planted at 25 plants per m^2, application of nitrogen and potash at 20 and 60 g per m^2 was best for obtaining larger flowers.

Flower diameter, bud length and flower thickness was highest at 120 and 180 kg/ha of nitrogen and phosphorus (Maheswar, 1977).

Shoushan *et al.* (1978) observed delayed flowering by application of nitrogen alone, while balanced application of N, P and K accelerated flowering in amaryllies.

Yasui *et al.* (1980) reported that rooted carnation cuttings (cv. Lena) were grown at temperature ranging from 15-30°C and nutrient levels N at 15-50 ppm, P_2O_5 at 10-60 ppm and K_2O at 20-120 ppm. Plant response was determined by taking measurement of stem length. The best results were obtained at 20° with N, P_2O_5 and K_2O at 75, 30 and 60 ppm respectively.

Kumara (1987) recorded early flowering at 200 Kg/ha and delayed flowering at highest levels of nitrogen (250 Kg/ha) in marigold and these results were not significant.

The diameter of carnation flower increased at both all the levels of (10, 20 and 40 g/m^2) nitrogen and phosphorus, but the lower level (10 g/m^2) of nitrogen proved better than the higher level, while the difference between the two levels of P_2O_5 was not significant (Amithabha Mukhopadhyay and Sadu, 1988).

In carnation cv. Dark Lena grown under plastic cover higher doses (2:1:3) of N and K increased the stem length and flower diameter (Starck *et al.*, 1991).

Medina (1992) reported greatest calyx splitting with potash deficiency in carnation Cv. Tanga.

Hosni and Shoura (1996) reported the effects of N 10.3 g / pot) + p (0.3 g/pot) + K (0.3, 0.6 or 0.9 g / pot) on the carnations (cv. Lucena) stem diameter which was significantly increased after treating with the highest rate of potash.

2.4 Yield parameters

Hart (1970) observed that the production of glasshouse carnation was highest in plots which received 160-230 ppm N, 130-230 ppm P_2O_5 and 130-230 ppm K_2O.

Boodley (1975) brought out the improvement and role of balanced nutrition in deciding the quality of carnation flower crops. Size of the flower as well as symmetry is important in deciding the quality.

Maheswar (1977) reported in astar that all the flower qualities were influenced by the highest level of nitrogen and phosphorus i.e. 180 and 120 Kg/ha respectively.

Nitrogen application at 120 or 240 Kg per ha in first year of Tulip production had beneficial effects on forcing in the second year (Hetman, 1978).

Mukhopadhyay (1981) observed that nitrogen (40 g/m^2) and phosphorus (20 g/m^2) helped in increasing flower yield per plant in carnation.

Carnations growing under plastic at a density of 29.6 plants /m^2 were fertilized through irrigation system weekly or every 3 weeks with a 19:9:27 NPK fertilizer. Both treatments providing 30 g NPK m^{-2} monthly frequency of NPK had no effect on flower yield or quality (Saver *et al.,* 1985).

The formulation with an NPK ratio of 1.0 : 0.25 : 0.9 gave the highest yield and highest percentage of grade one flower (Kowalezyk *et al.*, 1992).

Strojny *et al.* (1992) reported that cv. Tanga and Pallas orange carnations were grown in a summer and winter season fed with nutrient solutions containing 100 mg N+ 25 mg P+ 200 mg K/litre with every watering. First year yields were highest with 100 mg N + 25 mg P + 150 mg K/litre for both Cultivars. This treatment also gave the highest 2 year yield of cv. Tanga, but the 200 mg N + 25 mg P + 400 mg k/litre treatment gave the highest 2 year yield of pallas orange.

2.5 Varietal performance

Holley *et al.* (1951) reported that carnation cv. William Sim and White Patricon increased the production of flowers with increased dose of nitrogen.

Bunt and Powell (1982) reported that carnation cv. "White sim" was planted on 17^{th} January, 12^{th} March, 11^{th} July and 12^{th} September which planting provided the highest yield and July planting the lowest. A major part of the year's yield came from the first flush accounting for 48 per cent of the total yield in the September planting and 75 per cent in the March planting.

The Cultivars Barbara and Starlight were grown in a greenhouse in container holding a mixture of sandy soils, gravel and organic matter with major and micro nutrients. Starlight flowers yield was 97 per cent greater than that of Barbara (Zornoza *et al.,* 1989).

2.6 Dry matter and nutrient accumulation

In carnation, about 2 per cent nitrogen, 0.2 to 0.8 per cent phosphorous and 2 to 4 per cent potash in the leaf were found to be optimum for flower yields (Fernades *et al.,* 1975).

Miura (1979) observed that the most carnation blooms were produced at an exchangeable base saturation of 80 per cent potash, calcium and Mg ratio of 14:68:18. The potash in leaf content increased with increasing soil potash and Mg increased with increasing soil of Mg but decreased with increasing soil potash. The calcium leaf content remained constant what ever the soil calcium content.

In chinaaster highest (180 and 120 Kg/ha) nitrogen or phosphorus or nitrogen phosphorus levels increased the dry weight of plants.

Yasui *et al.* (1980) observed that rooted carnation cuttings (cv. Lena) were grown at temperatures ranging from 15-30°C and nutrient levels of nitrogen at 50-150 ppm P_2O_5, 10-60 ppm K_2O and 20-120 ppm. The best results were obtained at 20°C with N, P_2O_5 and K_2O at 75, 30 and 60 ppm respectively. This resulted in a plant dry weight increase of 11.5 g where as other treatments gave increase of approximately 5-10 g, plant growth was considerably less at 30°C regardless of nutrient level.

In carnation highest fresh weight and dry weight were obtained when fertilizers were applied every 2 weeks to give a total of 160, 40 and 180 Kg/1000 m^2 N, P_2O_5 and K_2O respectively. Lower, rates of nitrogen were significantly less effective (Magnifico *et al.*, 1985).

Sonneveld and Vooget (1986) reported that the younger leaves of peduncles harvested should contain potassium 900 m mol 01 per Kg dry matter, calcium and magnesium a content of 350 and 150 m mol per Kg respectively.

Farina and Lupi (1987) reported that application of N, P and K levels of 130 g, 77 g and 182 g per m^2 annually. Leaf tissue concentrations were 3.12 - 3.5, 0.228 - 0.427 and 3.10 - 3.50 per cent NPK respectively. Leaf nitrogen and soil nitrogen levels were highly correlated with each other as were leaf potash and soil levels and leaf analysis appeared a suitable method of diagnosing the N and Potash requirements of the plants.

Hasegawa (1992) found that nutritional diagnosis of carnation using small amount of exudate from the leaf base. The level of nitrogen in the exudate showed a relationship with the soil nitrogen level and decreased as the plant increased in weight. The level of potash in the exudate tended to increase as plant weight increased.

Medina (1992) studied the effects of NPK and Ca, Mg on carnation cv. Tanga and found that nitrogen deficiency reduced the dry matter production by 30 per cent.

Hosni and Shoura (1996) reported the effects of N (0.3 g / pot) + P (0.3 g P_2O_5/pot) + K (0.3, 0.6 or 0.9 g K_2O/pot) on fresh weight. The fresh weight of carnation was significantly increased in the treatment with the highest rate of potash.

2.7 Fusarium wilt

High dose of nitrate nitrogen, soil amendment with sulphur or peat, shortage of calcium increased the disease severity (Blanc *et al.,* 1983).

Lyakh (1986) reported increased resistance in carnation to *Fusarium oxysporum* with basal dressing with Mg at 50-150 mg /litre.

Orlikowski *et al.* (1990) reported decreased *Fusarium oxysporium* on carnation cv. scania 3c with pH 7.5 and fertilization using calcium nitrate significantly.

2.8 Vase life

Heavily coated slow release 14:14:14 fertilizer was applied at 900-2000 Kg per ha in a single application before planting and 2400-7200 Kg /ha was broad casted in two equal split doses. Keeping quality was reduced with higher fertilizer especially nitrogen rates were reduced. During second half of the growing season keeping quality of cut flower was improved (Waters and Woltz,1964-65). Similarly, increased nitrogen or fertilizer levels reduced the vase life and (Woltz and Waters, 1967) observed reduction in keeping quality of chrysanthemum due to increased duration of nitrogen application.

Higher potash rates of 600 Kg/ha lengthened the vase life (Wadsworth and Butters, 1972) of chrysanthemum. But vase life was reduced by nitrogen above 100 Kg per ha (Gilly, 1977).

Paull *et al.* (1992) reported that the influence of temperature and fertilizer application on post harvest life of Anthurium. Effects of mean and maximum temperature during two months before harvest was positively related to post harvest life. High nitrogen fertilization reduced vase life and moderate to high potassium levels improved vase life, while phosphorus had no effect.

2.9 Varietal performance

Cultivars white sim and scania (Sim group) and cultivars Oscar, Rubino, Astor, Cabrills-4, Alice and Londenella (Mediterranean group) were evaluated for cut flower production. Total flower production was higher in Mediterranean type than in the sim cultivars and was highest (4-8 flowers / plant) in cv. Astor (Adillon *et al.*, 1985).

The degree of complex coverage of the most decorative and commercial characters in the Bulgarian cultivars is very high (80 per cent on an average). Highest is the percentage complexity in the cultivars Poema, Vihren, Violina and Triumph. In the sim and Mediterranean cultivars it is considerably lower 30 per cent and 50 per cent respectively (Bolkov, 1992).

Satish (1997) observed that green house grown carnation cultivars performed better with respect to all the vegetative and reproductive attributes when compared to that grown under open condition with shade. Among the cultivars of carnation, IAHS-23 of standard type and IAHS-27 of spray type performed better compared to other cultivars.

2.9.1 Growth parameters

Vidale (1982) studied the performance of carnation under glass house and polythene tunnel and reported that the corresponding flower stem length were 72.36 cm and 68.66 cm for cv. Le Reve and 76.55 cm and 70.16 cm for cv. scania.

Loeser (1986) reported that out of ordinary carnations studied cv. Castelleno was the tallest (140 cm) with longest stem (> 60 cm).

Among large flowerd Sim type and Mediterranean type carnation cultivars studied for their suitability to cut flower production, the Mediterranean type cultivar had fewer shoots compared to Sim type (Snijbloementelt, 1987).

Kim *et al.* (1992) studied 15 carnations cultivars to asses their suitability for cut flower production and reported that Gallil, Rimon and Beta of standards had longer flower stems. However, the genotype white with red edge had least and Sterile Dop had more number of primary branches ranging from 1.87 to 4.20 (Mahesh, 1996).

Satish (1997) observed that maximum (80 cm and 6.84 no's) stem length and number of branches in cv. IAHS 23 and minimum (71.10 cm and 6.70 no's) in cv. IAHS-5. Further, maximum stem girth (0.49 cm)and minimum girth (0.47 cm) in cv. IAHS-5 and IAHS-25 respectively.

2.9.2 Flower character

In carnation cultivars Corvelle, Arthursim. Clear Yellow Sim and Carvelle Saugus were outstanding with respect to flower diameter (Oszkinis and Kus, 1971).

Miske (1982) found that the earliest flowering carnation cultivars were Minister, Goldstar, Minigold, Pepitolancruso, Landrino flowered early, while late flowering was observed in Yellow Stone and Jolvitte cultivars.

Among ordinary carnations studied cv. Castellan had the largest flower diameter of 76 mm (Loeser, 1986).

Mahesh (1996) observed that flower diameter ranged from 4.66 cm in (White) to 7.11 cm in (Arthursim).

The budlength, bud diameter and flower diameter of standard carnations grown under polyhouse were maximum for the cv. IAHS-23 (3.45, 2.13 and 7.10 cms, respectively) and minimum in cv. IAHS-5 (3.34, 1.79 and 7.10 cms, respectively) (Satish, 1997).

2.9.3 Yield parameters

Satish (1997) reported that the flower per plant, per sqm and percentage of marketable of standard carnation grown under polyhouse were maximum for the cv. IAHS-23 (5.24, 172.76 flw/sqm and 82.43 per cent respectively) and minimum in cv. IAHS-5 (5.17, 107.42 fl/sqm and 72.40 per cent respectively). However, the higher percentage of unmarketable flowers under polyhouse condition was produced by cv. IAHS-5 (27.60) compared to lowest in cv.-IAHS-23 (17.57).

Szendel (1937) reported that the percentage of carnation flowers (cv. Sopheria) with split calyxes and number of petals per flower increased as the temperature was reduced. However, in another experiment with carnation cv. spectrum supreme it was found that the splitting greater when the right temperature reduced twice each month. Also the plants grown at high night temperature and occasionally given a low night temperature resulted in the production more splits than those grown at a continueous low temperature.

Halliday and Watson (1953) studied the effect of temperature on calyx splitting of carnation cultivars Northland, William Sim and Millers yellow was greater than in the other cultivar at 40° F night temperature.

In case of carnation flowers, as the flower buds open and petals approach their full size, the calyx may split down either half or completely causing calyx splitting. Thus petals are deprived of support, which results into bending down of petals, there by regularity of shape and structure of the flower are destroyed and rending it as useless (Arora and Jhon, 1976). The primary causes for calyx splitting is unknown, the general opinion is that there is no single factor responsible for splitting, but is the result of genetic, environmental, nutritional and cultural factor (Arora and Jhon, 1978).

Gill and Arora (1988) reported that highest splitting was observed in variety Scania (15.7 %) and lowest was in Clear yellow (10.3 %).

2.9.4 Pinching

Pinching once increased the flower yield of carnation cultivar scania 33 per cent in addition to improving the quality (Hong *et al.*, 1977).

Four carnation cultivar planted on 15th May and pinched back once on 30th May flowered in July, where as, those pinched back twice 30th May and 20th June, flowered in November (Raskauskas *et al.*, 1983).

However, in another experiment with carnation cv. Margurite Scarlet, pinching delayed flowering and the delay increased with severity of pinching (Khanna *et al.*, 1986).

2.10 Fusarium wilt

Evans (1976) reported that control of wilt caused by Fusarium oxysporum F dianthi was obtained by drenching of Benomyl at 3.6 g a.i./5.5 ltr/m^2 when applied soon after planting and subsequently at three monthly intervals.

Further, Schickedanz and Hentschel (1978) reported that both phialophora cinerescens wilt and Fusarium oxysporum f. dianthi wilt can be controlled with systemic fungicides. Soil sterilization with Terabol (Methyl bromide) at 50 g/m^2 controlled fusarium wilt, eventhough, methyl bromide could cause phytotoxicity under some conditions.

Carnation wilt in greenhouses, caused by several fungi viz., fusarium oxysporum F. dianthi, Fusarium roseum, Rhizoctania solani and Phytophresa nicoteanae var. parasitica was successfully controlled with a sequence of treatments. Dipping of cuttings in 0.2 - 0.3 per cent Benomyl solution for 10 hours or application of Mycodifol (captafol + fo/pet) at 0.2 per cent to the rooting medium and treating the soil, after transplanting with Benlate or derosol at 0.1 - 0.2 per cent + Mycodifol at 0.2 per cent gave effective control of wilt (Costache *et al.*, 1979).

Gullino and Garibaldi (1983) reported that the symptoms induced by pathogen 2 and 4 of fusarium oxyosporum f. dianthi were markedly reduced by the combined use of partially suppressive, soil, varieties partially tolerant of the fungus and soil drenches with Captofol at $4g/m^2$ or Benomyl at 2 g $/m^2$ every 2 week, when the inoculum level was low.

Application of Benomyl and Carbendazim as soil drenching before transplanting carnation seedlings were more effective than root dipping, in controlling the disease (Gamboa, 1986).

2.11 Vase life

Typically, cut flowers initially increase and subsequently decreases in fresh weight (Roger, 1973).

Robinson (1978) reported that, a solution containing 0.003 per cent $AgNo_3$ and 4 per cent sugar was most effective in prolonging vase life of cut carnations, whereas, flower life was extended was only slightly beyond that of control when sugar or $AgNo_3$ alone was added to the vase water. Besides, there was a profuse fungus growth on the stem of flowers in the sugar solution.

For improving quality and prolonging vase life of carnation flowers, it is necessary to inhibit microbial contamination and ethylene production, increase fresh weight, water uptake flower diameter and leaf chlorophyll content. The solution containing 5 per cent sucrose, 50 ppm silver nitrate and 300 ppm 8-hydroxy-quinoline seems the most effective preservative to delay senesecence by contributing the above mentioned physiological actions (Lee *et al.*, 1980).

Piskornik and Mareczek (1987) reported that, the mean vase life was longest (16.8 days) in a solution containing 5 per cent sucrose + 0.63 mM 8-

hydroxy quinoline sulphate + silver thiosulphate, compared to 5.94 days in the distilled water, a control.

Jung and Kampf (1989) studied the vase-life of cut carnation cv. white sim, Le Reve and Scania and reported that, holding in silver thiosulphate + 10 per cent sucrose gave the longest life (8.7 days) compared with 5.3 days for controls in distilled water. However, Le Reve and White Sim had a longer vase life than scania.

Rupnick *et al.* (1989) reported that marketable improved keeping quality when flowers were kept in solution containing 50 mg/l $AgNo_3$ and 50 g/l sucrose compared with control.

Ketsa *et al.* (1987) reported that flowers pulsed in the solution containing 68 mg litre $AgNo_3$ + 794 mg/l, $Na_2S_2O_3$ + $5H_2O$ + 10 per cent sucrose had the longest vase life (4.03 days) while the control vase life was 2.05 days.

Koyama and Uda (1994) studied the effect of temperature, light intensity and sucrose concentration (0.15 %) on carnation cvs. Nova and Coral after harvest and reported that the number of days to anthesis was shortest and vase life was longest at the highest temperature (30°C). As the sucrose concentration increased, flower diameter increased and vase life was extended, also at higher concentration petal colour was intensified.

2.12 Cost of cultivation

Protected crops are twice as profitable, but demand greater initial investments, their extension is not advised unless export markets can be generated as reported by Zouari (1976). While describing the cultural practice and costs and returns of carnation cultivation. However Kuyvenhoven (1978) concluded by analysing the costs and returns of spray carnation crops that with average returns the crop is not profitable, but the returns can vary greatly.

The highest gross income was obtained from carnation cv. scania 3.c planted at 75-100 / m^2 and also, six monthly cultivation in untreated tunnels gave a gross income similar to that obtained from year round cultivation in greenhouse. However, the risk involved in growing carnations under unheated tunnels, had no great effect on the gross income when calculated over several years (Rejman and Mynett, 1979).

Totth (1986) reported that cultivation of carnations for cut flowers was no longer profitable due to increasing production costs. However, profitability can be improved by adopting improved cultural methods and also by the introduction of highly productive good quality cultivars.

In an economic analysis of production of gypsophila, carnation, gerbera and lillies under protective structures, the profit margin was higher in gypsopila as compared to carnation and lillies. For all species, labour costs were high, while stock was the major production cost in carnations (Lin and Chiu, 1990).

Ferratto and Benedeotto (1994) studied the effect of supplementary heating on the yield and profitability of greenhouse grown carnations and found that the gross margin was positive in both, however, the net return starts to become negative if prices are lowered by more than 15 per cent. It was concluded that a 30 per cent total increase in yields and prices was necessary to obtain a positive economic results.

Though greenhouse cultivation results in higher returns by producing higher yields of good quality produce, the initial higher investments and maintenance costs will reduce the extra returns unless they are managed intensively. Therefore, growers should be provided with the latest technology and optimum structures at lower costs to suit local situations. This would result in better feasibility and profitability (Khan *et al.*, 1995).

2.13 Effect of polyhouse

Polyhouse is a framed structure cladded with polyethylene film which can provide the favourable condition for the growth of the plants in several ways, viz., favourable environmental conditions, protection from heavy winds, pests and diseases and other adverse climatic conditions.

Vidale (1982) evaluated carnation cultivar LeReve and Scania, grown in a glass house and polyethylene tunnel and reported that, both yielded about 12 and 17 flowers per plant, respectively. However, the corresponding flower stem lengths were 72.36 cm and 68.66 cm for LeReve and 76.55 cm and 70.16 cm for scania cultivars.

Similarly, carnation cultivar Scania, Fiesta and Etna grown under single-span greenhouse with polyethylene film cladding showed better flower quality and earliness (Grassotti *et al.,* 1983).

Guttal and Takte (1993) while studying the effect of low cost polyhouses on the production of chrysanthemum, obtained significant results with respect to yield (20.19 t/ha), average weight of flower per plant (389 g), diameter of flower (6.5 cm), vase life (12 days) and attractive colour as compared to its cultivation under open condition.

2.13.1 Environmental factors

A. Light intensity

Neubert and Kunert (1977) studied the effect of light intensities of 1000 lx, 1800 lx or 29000 lx, giving a total of 1800 1x h/day, 14400 1x h /day on 23000 lx h/day on the plants of carnation cultivar Arthur Sim and Shocking pink sim and reported that flower formation occurred only on plants receiving the highest level of illumination.

Sometimes, there is a need to reduce the light intensity and temperature during summer, which can be achieved by covering the plants by shade net and irrigating the plants with cool water during the hottest part of the day (Blank, 1980). However, Byrne (1982) found that increasing light intensity (from dusk to dawn) from 0 to 10-15 foot candles when shoots had 4-6 pairs of leaves, decreased the number of days to flowering in sim carnation from 123 to 93 days.

Kim and Choi (1983) reported that, installing of a 15 mesh white screen net, 17 mesh black screen net and arced blind, reduced the full sunlight by 59 per cent, 45 per cent and 20 per cent respectively. However, 15 mesh white screen net shading treatment produced twice the fresh and dry weight of control plants of carnation.

In summer, 55-80 per cent shade was found to be the most suitable for the improvement in growth of hybrid geranium plants. While, 55 per cent shade favoured flowering the overall growth was highest with 70 per cent shade than under full sun (Hong *et al.*, 1986). Where as Evamoria *et al.* (1987) in Hibiscus, observed increased flower diameter, larger and darker green leaves with high plant quality of hibiscus under 50 per cent shading than those under full sun.

B. Photoperiod

Beisland (1975) observed that the cultivars Sam's pride, Scorlet, Miniqueen and Roylette, on illuminated at 20 w/m^2 for 2, 3 or 4 weeks during the night, induced flowering 23, 18 and 17 days earlier, respectively, compared to non-illuminated control. In addition, Neubert and Kunert (1978) reported that supplementary lighting may increase the efficiency of hormone production to induce early flowering and critical level carnation to flower was 24,000 lx h/day.

A long day treatment for about 45 days starting from the development of the first three to eight pairs of leaves accelerated flowering and flowers had longer stems with fewer nods in spray carnations (Yonemura *et al.*, 1981). Further, Hoeven (1987) reported that in white sim (standard) and silvery pink (spray) cultivars of carnation cultivars of carnation the advancement in flowering was greatest with a treatment of 12 h cyclic lighting. Whereas short night break with continuous or cyclic lighting advanced flowering only slightly.

C. Temperature

Hanan (1959) reported that when the temperature was increased from 65° F to 75° F, there was corresponding increase in stem elongation, dry weight, stem strength and decrease in flower size significantly. However, in another study on the effect of day /night temperature on carnation cv. C.S.V. pink, it was revealed that, the highest quality flowers were produced by 1 year old plants at 24°C/9°C although some loss in colour was caused by the low night temperature (Munoz and Holley, 1975). Further Bunt (1978) found that flower diameter was largely dependent upon temperature. High temperatures produced smaller flowers in carnation cv. White Sim. The environmental conditions to required produced good quality flowers were high solar radiation integrals, coupled with low ambient temperatures.

In an another study to find out the effect of night temperatures on miniature carnation cultivars white Feathers, Starfire, Tinkerbell and Goldlocks it was found that the temperature regimes had no effect on the number of cut flowers stem/m^2. However, significantly more buds and flower per stem were produced at 49°F and 52°F than at the higher temperatures of 55°F and 58°F (Hansen *et al.*, 1979).

MATERIAL AND METHODS

III MATERIAL AND METHODS

The present investigation on the "Studies on fertigation in carnation under cover" was carried out at Horticultural Research Station" Gandhi Krishi Vignana Kendra, Bangalore during the year 1996 and 1997.

3.1 Geographical location and climate

Horticultural farm is situated at 12°58' North latitude and 77°35' East longitude with an elevation of 930 m above the mean sea level. The meterological data of the experimental period (1996-97) is furnished in Appendix-I.

3.2 Soils of experimental site

The experiment was conducted in red sandy loam soil with pH 5.5-6.0. Soil samples were collected in each block upto a depth of 0.30 m. The available NPK status of soil was estimated by standard procedure.

3.3. Experimental details

3.3.1 experimental design and treatments

The experiments were laid out adopting split plot design.

3.3.2 Number of treatments - 12

3.3.3 Number of replications -3

3.3.4 Number of plants per sq m - 36

Area of the net plot -40 m^2

spacing - 15 x 15 cm

date of planting - August, 1996

3.3.5 Growing condition

1) Polyhouse (U.V. Stabilized LDPE film with 50 % shade) (Plate 1)

3.3.6 Cultivars with details

The description of four standard cultivars which were tried in combination of different fertigation level is as fallows as depicted in Plate 2 to 5.

CULTIVARS	DESCRIPTION
1. Kristina (K)	Light pink with dark margin
2. Aleda (A)	Dull white
3. Master (M)	Red
4. Vienna (V)	White with red mottled

Treatment detail

The fertilizer levels were fixed according to the package of practice for carnation. (Anon, 1994).

A. Recommended dose (F_2)

From planting to end of pinching - $g/m^2/week$

N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55

From end of pinching to until harvesting start $g/m^2/week$

N/4.69 : P/1.50 : K/5.58 : Ca/2.72 : Mg/0.51

During harvest

N/4·86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50

B. 80 per cent of Recommended fertilizer (F_1)

From planting to end of pinching - g/m^2 / week

N/3.71 : P/1.20 : K/2.90 : Ca/2.18 : Mg/0.44

From end of pinching to until harvest start - g/m^2/week

N/3.89 : P/1.20 : K/4.46 : Ca/2.18 : Mg/0.40

During harvest

N/3.89 : P/1.20 : K/5.62 : Ca/2.47 : Mg/0.40

C. 120 per cent of recommended fertilizer (F_3)

From planting to end of pinching - g/m^2 /week

N/5.57 : P/1.94 : K/4.34 : Ca/3.06 : Mg/0.66

From end of pinching to until harvest start -g/m^2 /week

N/5.63 : P/1.80 : K/6.70 : Ca/3.26 : Mg/0.61

During harvest

N/5.83 : P/1.80 : K/8.44 : Ca/3.70 : Mg/0.60

Treatments details

1. F_1 + Kristina
2. F_1 + Aleda
3. F_1 + Master
4. F_1 + Vienna
5. F_2 + Kristina
6. F_2 + Aleda
7. F_2 + Master

Plate 1 : General view of low cost green house

Plate 1

Plate 2 : Carnation cultivar Master

Plate 3 : Carnation cultivar Kristina

Plate 4 : Carnation cultivar Aleda

Plate 5 : Carnation cultivar Vienna

Plate 2

Plate 3

8. F_2 + Vienna

9. F_3 + Kristina

10. F_3 + Aleda

11. F_3 + Master

12. F_3 + Vienna

3.4 Experimental procedure

3.4.1 Construction of polyhouse

A low cost, naturally ventilated polyhouse (East-West orientation) of 100 m^2 area was constructed using GI pipe, for the purpose of evaluating the carnation cultivars. The polyhouse had the dimensions of 19.5 m length and 5.4 m width, having side height of 2.5 m and central height of 3.7 m (Plate 1).

A U.V. stabilized high density polyethylene film (HDPE) of 200 μ (800 gauge) used as cladding material for polyhouse. All the sides of the polyhouse were covered with rambonet (60 mesh) for natural ventilation and to protect the crop from the pests. Besides rambonet, a rollable flap was also provided inside to regulate the temperature and humidity depending on the seasons. Shade net (50 %) was also provided inside the polyhouse to reduce the light intensity and temperature.

3.4.2 Bed preparation

Land area inside the polyhouse was thoroughly dug to a depth 30 cm, 30 days prior to planting. Weeds, stubbles etc. were completely removed and soil was brought to a fine tilth.

Raised beds of 1 m width, 20 cm height and 18 m length were prepared with a walking space of 30 cm between the beds. Beds were incorporated with well decomposed farm yard manure, sand and coir pith at a ratio 2:1:1 and was mixed thoroughly.

3.4.3 Bed fumigation

The beds were treated thoroughly with two per cent formalin and covered using black polyethylene film for 48 hours. Then the film was removed and beds were aerated for 24 hours. Later the beds were thoroughly irrigated three times to drain out the chemical residue.

3.4.5 Planting

Healthy rooted cuttings were obtained and were planted at a spacing of 15 x 15 cm for standards. Then beds were irrigated thoroughly to maintain the optimum soil moisture condition.

3.4.6 Irrigation

Drip irrigation system was installed providing three laterals per bed for irrigation. The laterals had drippers at 30 cm apart and were placed away from the plant to avoid rotting. The beds were irrigated by giving nine litres of water per m / day.

3.4.7 Fertilizer application

The fertilizers for the fertigation treatment were given through the fertilizers tank containing soluble fertilizers which was connected to the irrigation pipe at the supply pump (The soluble fertilizer used in the trail was from HAISOL company).

3.4.8 Netting / wiring

This is an important agrotechnique followed in carnation cultivation to get quality flowers with long and straight stalks. Totally 5 layers of nylon nets were provided at 15 cm interval for stalking purpose. These layers of nylon nets had 7.5 cm square at the bottom layer and remaining layers of nylon nets had 15 cm square and branches were allowed to grow within these square of nylon nets, in order to reduce the incidence of weak and crooked stems.

3.4.9 Pinching

This is another cultural operation to produce good quality flowers. In pinching, the growing tip was removed when the plant had about 6-7 pairs of leaves, approximately 30 days after planting. This single pinching resulted in the production of lateral shoots and of these only five shoots were retained in each stem.

3.4.9.1 Disbudding

This is also an important cultural practice followed in carnation cultivation. In case of standards, the axillary buds were removed to promote the growth of terminal flower bud. In sprays, terminal flower buds were removed to promote the growth of lateral flower buds.

3.4.9.2 Polyhouse management

The optimum range of day and night temperatures that influence the growth and flowering of carnations were 18-23°C and 10-18°C, respectively. Whenever the temperature inside the polyhouse was higher, the rollable flap was rolled up and sufficient irrigation was given to bring down the temperature.

But, under low temperature conditions, the rollable flap was rolled down and limited irrigation was given to conserve the heat inside.

3.4.9.3 Weeding and plant protection measures

Hand weeding was followed to keep the entire plot free of weeds. Disease like fusarium wilt, philophora wilt, were controlled by drenching the beds with 0.2 per cent Bavistin regularly as a prophylactic measures . Alternaria blight was controlled by spraying 0.2 per cent mancozeb. Among pests, mites, aphids, thrips and white flies were controlled whenever they occurred by spraying Kelhan (2.25 ml/lt), Endosulfan (2.5 ml/lt) and Mayuric (1.5 ml/lt).

Flowers were harvested at the base leaving 3-4 nodes, to encourage the side shoots. Harvested flowers were graded into marketable and unmarketable flowers.

Standard carnation flowers were harvested when outer petals clearly visible and unfolded nearly perpendicular to the stem.

3.5 Growth attributes

3.5.1 Observations recorded

A. Plant height

Five plants were randomly selected and were labelled to record the plant height at fortnight interval. Height of the plants were measured from ground level of the main stem to growing tip and mean values computed.

B. Number of branches

The number of branches after pinching were recorded. Later (around 55-60 days) the excess lateral branches were removed, retaining only 5 laterals in each plant.

C. Days taken for first flower bud initiation

The period taken for the initiation of the flower bud from planting in each treatment was recorded on five randomly labelled plants. Five buds initiated in each treatment was tagged for further observations.

D. Days taken for flower bud opening

The number of days taken from the flower bud initiation to flower bud opening was recorded. The flower opening was decided when the buds started showing the colour of petals.

F. Bud length (cm)

Length from the base of the bud to the tip of the bud was measured by using vernier caliper.

G. Bud diameter (cm)

The diameter of the bud at its maximum width, was recorded by using a vernier caliper.

H. Stem length at harvest (cm)

The length of the stem was measured from just below the bud till the base of the stalk at harvest from the five randomly labelled plants.

I. Stem girth at harvest (cm)

The girth of the stem was recorded by taking the average girth at three parts (lower, middle and top) on the stem and was measured by using vernier caliper on the five randomly selected stems. The mean values are computed.

J. Flower diameter (cm)

From each treatment from randomly selected plants, fully opened flowers diameter was measured by using vernier caliper and mean values were worked out and expressed in cm.

K. Number of petals

The total number of petals in a flower were counted on randomly selected 15 carnation flowers in each treatment and their mean value was computed.

L. Calyx splitting

The number of flowers whose calyx were split open was recorded from each treatment.

M. Mortality rate

Number of plants died due to disease and poor establishment during the crop period was recorded and expressed in percentage.

3.5.2 Yield attributes

a. Number of flowers per plant

Five plants were selected randomly from each experimental net plot and total number of flowers per plant were recorded.

b. Number of flowers per m^2

The flower yield per plot was recorded after at every harvest.

c. Flower number per hectare

The flower number per hectare was computed by converting the flower number per plot into flower number per hectare deducting 30 per cent of areas for bunds and other convenient uses.

d. Flower yield per m^2 (Kg)

Thirty flowers were selected randomly from each replication and total weight of flowers per m^2 was recorded.

e. Flower yield per hectare (Kg)

The flower yield per hectare was computed by converting the flower number per plot into flower number per hectare, deducting 30 per cent of areas for bunds and other convenient uses.

f. Number of marketable flowers

The flowers possessing with all good qualities of cut flower such as straight and long stem, symmetrical flower shape and size characteristic to the cultivar, absence of split flower, free from pest and disease attack etc. were considered as marketable flowers.

g. Number of unmarketable flowers

The number of flowers which had split calyx, crooked stem, disorted flower buds, malformed and also which did not posses the quality characters of good flowers were considered as unmarketable and discarded. Their number was counted in each harvest.

3.6 Chemical analysis

Soil samples collected were analysed for available nitrogen, phosphorus and potassium. Plant samples were analysed for nitrogen, phosphorus and potassium content.

3.6.1 Soil analysis

Soil pH : Ten grams of soil was stirred well with 25 ml of water for 30 minutes. pH of the suspension was measured using pH meter fitted with combination electrode.

3.6.2 Available nitrogen

The available nitrogen contents was determined through alkaline permanganate method (Subbaiah and Asija, 1956) by digestion, distillation and collection of NH_3 in two per cent boric acid and then titrating it against standard sulphuric acid.

3.6.3 Available phosphorus

Available phosphorus in the soil was extracted with the help of Bray's No.1 extract (0.03 N ammonium fluoride to .025 N Hcl). Further phosphorus in the filtered extract was determined by chloro stancus reduced molybdo phosphate blue colour method (Tandon, 1993). The intensity of colour was read on U.V. spectrometer.

3.6.4 Available potassium

The potassium content was estimated in 10 ml of aliquot (Made upto 50 ml) by feeding it to flame photometer (Jackson, 1967).

3.7 Plant analysis

Oven dried plant parts were grounded to fine powder. Samples were taken for analysing different nutrient in leaves individually.

3.7.1 Total nitrogen

Total nitrogen was determined by Microjeldahl's method (Piper, 1957). NH_3 liberated by using 40 per cent NaOH was collected in 4 per cent boric acid with mixed indicator and later titrated against standard H_2SO_4.

3.7.2 Phosphorus (wet acid digestion)

One gram of plant sample was digested with triacid mixture containing nitric acid perchloric acid and sulphuric acid and then made utpo 50 ml with 6 N Hcl (10:4.1 v/v/) phosphorous. In a suitable aliquot yellow colour was developed by vanadomolybdate method. Intensity of the colour was measured at 420 manometer by using spectrophotometer(Jackson, 1967).

3.7.3 Potassium

Wet digested samples were diluted and fed to the flame photometer to estimate potash content (Jackson, 1967).

3.7.4 Calcium and Magnesium

All these elements were estimated by an atomic absorption spectrometer (Perkin Elmer model - 5000) using hallow cathode lamps emitting radiant energy of suitable wave lengths (Baker and Shur, 1982).

3.7.5 Dry matter accumilation and dry weight

Plant from each replication was uprooted during morning hours at the time of final harvest these plants were kept for drying in hot air oven at 70°C till constant weight was obtained. The dry weight of these plants were obtained and presented as dry matter production.

3.7.6 Nutrient uptake

Nutrient uptake by carnation plants was computed on dry weight basis by multiplying nutrient content and dry weight of the plant.

EXPERIMENT - II

3.8 Vase life

Design : CRD Factorial

Replications : 3

Fertigation levels : 3

Fertigation F_1, F_2 and F_3

Cultivars : 4

Kristina, Aleda, Master and Vienna.

Preservatives : 8

Preservatives T_1, T_2, T_3, T_4, T_5, T_6, T_7 and T_8.

Treatments : 3 x 4 x 8 = 96

T_1 - 5 % sucrose + 50 ppm AgNo3 + 300 ppm HQS

T_2 -7. 5 % sucrose + 50 ppm AgNo3 + 300 ppm HQS

T_3 - 5 % sucrose + 60 ppm AgNo3 + 300 ppm HQS

T_4 - 7.5 % sucrose + 50 ppm AgNo3 + 300 ppm HQS

T_5 - 5 % sucrose + 40 ppm AgNo3 + 300 ppm HQS

T_6 - 7.5 % sucrose + 40 ppm AgNo3 + 300 ppm HQS

T_7 - Deionized water

T_8 - Tapwater (control).

All the treatment combinations were evaluated for their vase life using sucrose at concentration of 5 per cent and 7.5 per cent and silvernitrate 40 ppm, 50 ppm + 8 HQS 300 ppm in combination and tap water as control under room conditions on post harvest physiology of cut carnation flowers.

All the solutions were prepared in deionized water and only freshly prepared solutions were used. For vase life studies, flowers were obtained from the bulk plots. The flowers harvested were placed in flask containing 250 ml of the solutions.

3.8.1 Vase life

The point of termination of vase life (days) varies from the first sign of wilting or fadding to the total death of all flowers with all the intermediate values between these points (Halevy and Mayak, 1979 ; Narayanagowda, 1990).

Withering and senescence of more than 50 per cent of the flowers was considered to the end of potential useful longevity of the flowers and the number of days taken for this was recorded on alternative days till they were found unfit for continuing in the vase.

This investigation was carried out using silvernitrate and with germicides like 8-hydroxy quinoline sulphate and in combination with sucrose on objective of finding their on effect on cumulative fresh weight, number of days taken for flower opening and vase life of cut carnation flowers.

3.8.2 Preparation of plant material

Carnation flowers were harvested with stalk when they were tight bud stage and flowers were sorted out based on their size to maintain uniformity within the replication. The flower stalk were cut into uniform length after removing all the bottom leaves adhering to the stalk. After recording the fresh weight three uniform flowers were placed in 500 ml bottle containing 250 ml deionized water of different chemicals with different concentrations as in the treatment combinations.

3.9 Observation recorded

3.9.1 Fresh weight of flower

The difference between the weights of bottle + solution + flower and the weights of bottle + solution on any given alternative day represents the fresh weight of the flower and expressed in cumulative fresh weight of the flower.

3.9.2 Flower opening

The number of days taken from the flower bud kept in solution to full flower opening.

3.9.3 Vase life days

Withering and senescence of more than 50 per cent of the flower was considered to the end of useful longevity of the flowers and the number of days taken for this was recorded by the every day of observation of flowers till they were found unfit for continuing the vase.

3.10 Second season crop

The experiment was continued further after taking the first season crop which lasted for 165 days. After which plants were given rest for 30 days and later fertigation was initiated to get the second season crop. The flowers of the first season were harvested leaving 15 cm from surface of the soil so as to get the crop in the second season. New sprouts developed from the basal nodes within this from 15 cm of the previous season growth. Immediately after given nutrients in the form of fertigation, there were a number of new sprouts developing from each of these stalk left from the previous season. Disbudding was done so as to maintain only one sprouts, so as to get a single stalk from the previous season. Stalk left after harvesting the flowers. The observations were recorded taking into consideration the number of days taken from the rest period of 30 days.

3.11 Economics

The cost of cultivation in polyhouse (100 m^2) was calculated for one year period (Anon. 1995).

Cost of cultivation

1. Fixed cost

a. Cost of structure (excluding clading material)
b. Life of structure (In season per year)
c. Depreciation (a/b)
d. Cost of clading material
e. Life of clading material

f. Depreciation per season (d/e)

2. Repair and maintenance cost

3. Interest cost per season

a x b x 18 %

Number of seasons

4. Total operation cost per seasons

Ic + 1f + 2 + 2

GH area in sq/m.

5. Cost of cultivation per square metre

6. Yield of the flower (per sq/m)

7. Market price (Rs/flower)

8. Revenue (Rs. / sq/m)

9. Net profit / season / sq/m.

10. Net profit under GH condition

11. Cost benefit ratio of GH

3.12 Statistical analysis

The data on various biometric parameters recorded during the crop period of this study was subjected to statistical analysis as per the procedure outlined by Sundar Raj *et al.* (1972). The results have been presented and discussed at probability level of 5 per cent.

EXPERIMENTAL RESULTS

IV EXPERIMENTAL RESULTS

Studies on "fertigation in carnation (*Dianthus caryophylus* L.) under cover" was conducted at the Horticultural Research Station, Bangalore during 1996 and 1997 are presented in this chapter.

4.1 Growth parameters

The data pertaining to the plant height, number of branches, days taken for first flower bud initiation and bud opening of different carnation cultivars at different stages of growth as influenced by fertigation and their interactions are presented in Table 1 and 2.

4.1.1 Plant height at various stages of crop growth

4.1.2 Fifteen days after planting

The cultivars differed significantly in plant height. The highest plant height (21.55 cm) was recorded in cv. Aleda, this was followed by Master (20.00 cm) and Kristina (19.44 cm) and were at par whereas, Vienna recorded a significantly lowest plant height (15.22 cm).

The fertigation levels and interaction effect between fertigation levels and the cultivars on plant height was non-significant (Table 1).

4.1.3 Thirty days after planting

The plant height differed significantly in the different cultivars. Highest plant height (32.17 cm) was recorded in cv. Aleda, which was on par with cv. Master (31.42 cm) and these were followed by cv. Kristina (29.43 cm). The cv. Vienna recorded a significantly lowest plant height (26.43 cm), compared to other cultivars.

The fertigation levels and interaction effect between cultivars and fertigation levels on plant height was non-significant (Table 1).

4.1.4 Forty five days after planting

The cultivars differed significantly in their plant height, cv. Aleda recorded significantly highest plant height (32.72 cm) than other cultivar, this was followed by cv. Master (31.11 cm) and Kristina (29.89 cm). Significantly lowest plant height was recorded in cv. Vienna (24.78 cm) compared to other cultivars.

The fertigation levels and interaction effect between cultivars and fertigation levels on plant height did not differ significantly (Table 1).

4.1.5 Sixty days after planting

The fertigation levels did not show significant difference on plant height (Table 1).

Cultivar Aleda recorded significantly highest plant height (37.56 cm) than other cultivars. It was followed by cv. Master (35.67 cm) and Kristina (32.78 cm) and the differences between them being significant. Cultivar Vienna recorded significantly lowest plant height (26 cm).

The interaction between cultivars and fertigation levels on plant height was significant. The maximum plant height (38.67 cm) was in cv. Aleda with F_3 fertigation, which was on par with cv. Aleda with F_2 fertigation (38.00 cm). Significantly lowest plant height (23.67 cm) was observed in cultivar Vienna with F_1 fertigation level.

4.1.6 Seventy five days after planting (DAP)

The fertigation levels had no significant influence on plant height (Table 1).

The cultivar differed significantly in their plant height at 75 DAP. Highest plant height (44.78 cm) was recorded in cv. Aleda, cv. Kristina (41.11 cm) and Master (40.89 cm) were at par. Significantly lowest plant height was in cv. Vienna (32.78 cm).

The interaction effect of cultivar and fertigation levels on plant height was significant. Highest plant height (46.00 cm) was in cv. Aleda with F_3 fertigation, which was on par with cv. Aleda with F_2 fertigation (45.00 cm), and Aleda with F_3 fertigation (43.33 cm) followed by cv. Kristina with F_3 fertigation, Master with F_3 fertigation, Master with F_2 fertigation and Master with F_1 fertigation (41.00, 41.00, 40.67 cm) and the differences amongst them being significant. The significantly lowest plant (31.00 cm) height was observed in cv. Vienna with F_1 fertigation which was on par with Vienna with F_2 fertigation (32.00 cm).

4.1.7 Ninty five days after planting

The fertigation levels differed significantly in the plant height. Highest plant height (60.66 cm) was recorded in F_3 fertigation. F_2 and F_1 fertigation (55.50 and 55.00 cm) were at par the latter recorded lowest.

Cultivars differed significantly in the plant height. Highest plant height was recorded in cv. Master (63.78 cm), which was on par with cv. Aleda (63.67 cm) followed by Kristina (57.11 cm) differences between them being significant. Significantly lowest plant height was recorded in cv. Vienna (43.67 cm).

In interaction effect plant height in Master with F_3, Aleda with F_3 and Master with F_2 fertigation (68.33, 67.67 and 64.33 cm) were at par. Master with F_2, Aleda with F_2 and Aleda with F_1 and Kristina with F_3 fertigation (64.33, 62.00, 61.33 and 60.67 cm) were also at par. Lowest plant height was recorded in Vienna with F_1 fertigation (41.67 cm), which was on par with Vienna with F_2 and Vienna with F_3 fertigation (43.33 and 46.00 cm).

4.1.8 One hundred and five days after planting

The fertigation levels did not show significant influence on plant height (Table 1).

Cultivars differed significantly in their plant height. Significantly highest plant height (81.22 cm) was recorded in cv. Aleda followed by cv. Master (77.33 cm) and Kristina (73.22 cm) and the differences amongst them being significant. The cv. Vienna recorded significantly lowest plant height (63.22 cm).

The interaction between cultivars and fertigation levels on plant height was significant. The highest plant height (83.67 cm) was observed in cv. Aleda with F_3 fertigation, which was on par with cv. Master with F_3 fertigation (82.67 cm) and Aleda with F_2 fertigation, Kristina with F_1 fertigation and Aleda with F_1 fertigation (81.00, 79.67 and 79.00 cm). The lowest plant height (61.67 cm) was in cv. Vienna with F_1 fertigation level.

4.1.9 One hundred and twenty days after planting

The fertigation levels had non-significant influence on plant height (Table 1).

The plant height differed significantly in the different cultivars. Highest plant height (93.22 cm) was recorded in cv. Aleda, which was on par with Master (90.44 cm) followed by Kristina (87.56 cm), where as cv. Vienna recorded significantly lowest plant height (78.89 cm).

The interaction between cultivar and fertigation levels on the plant height was significant. The highest plant height (96.33 cm) was observed in cv. Aleda with F_3 fertigation which was on par with cv. Aleda with F_2 fertigation and Master with F_3 fertigation (94.67 and 93.33 cm). Significantly lowest plant height (73.67 cm) was in cultivar Vienna with F_2 fertigation.

4.1.10 One hundred and thirty days after planting

Cultivars differed significantly in their plant height. Highest plant height (101.33 cm) was recorded in cv. Aleda, which was on par with Master (99.11 cm) significantly lowest (81.67 cm) was in cv. Vienna.

The fertigation levels and interaction effect of cultivars and fertigation levels on plant height was non-significant (Table 1).

4.1.11 One hundred and fifty days after planting

The fertigation levels had no significant influence on plant height (Table 1).

The cultivars differed significantly in the plant height. Significantly highest plant height (106.44 cm) was observed in cv. Aleda and followed by cv. Master (104.00 cm) and cv. Kristina (102.33 cm), the differences amongst them being significant. The significantly lowest plant height (88.33 cm) was in cv. Vienna.

Table 1 : Plant height of carnation cultivars at different stages of growth as influenced by fertigation and their interaction.

Treatments	Days After Planting										
	15	30	45	60	75	90	105	120	135	150	165
Fertigation levels(F)											
F_1	18.34	29.54	29.14	32.00	39.00	55.00	74.34	86.34	92.75	98.16	101.41
F_2	18.12	29.74	29.59	33.00	39.75	55.50	72.45	86.25	93.25	100.39	103.66
F_3	19.92	30.31	30.14	34.00	40.92	60.66	74.50	89.79	96.66	102.24	105.83
SEm±	0.46	0.39	0.41	0.29	0.54	0.27	0.87	1.07	0.99	1.18	0.72
C.D. at 5 %	NS	NS	NS	NS	NS	1.05	NS	NS	NS	NS	NS
Cultivar (c)											
Kristina (K)	19.44	29.43	29.89	32.78	41.11	57.11	73.22	87.56	94.78	102.33	103.78
Aleda (A)	21.55	32.17	32.72	37.56	44.78	63.67	81.22	93.22	101.33	106.44	110.33
Master (M)	20.00	31.42	31.11	35.67	40.89	63.78	77.33	90.44	99.11	104.00	109.11
Vienna (V)	15.22	26.43	24.78	26.00	32.78	43.67	63.22	78.89	81.67	88.33	91.33
SEm±	0.48	0.47	0.36	0.29	0.47	1.06	1.03	0.76	0.88	0.65	0.52
C.D. at 5 %	1.41	1.53	1.07	0.87	1.39	3.14	3.05	2.25	2.62	1.93	1.55
C x F											
KF_1	18.67	29.47	29.00	33.00	40.00	58.33	79.67	86.67	93.00	99.67	101.67
AF_1	21.00	31.00	31.80	36.00	43.33	61.33	79.00	88.67	101.00	105.67	110.00
MF_1	19.00	31.67	31.10	35.33	40.67	58.67	77.00	89.00	97.00	102.00	107.33
VF_1	14.67	26.00	24.67	23.67	31.00	41.67	61.67	81.00	80.00	85.33	86.67
KF_2	19.00	29.83	30.00	31.67	41.00	52.33	71.00	87.67	94.67	101.33	102.67
AF_2	21.67	32.47	32.87	38.00	45.00	62.00	81.00	94.67	100.67	106.57	110.33
MF_2	20.00	30.80	30.83	35.67	41.00	64.33	72.33	89.00	98.33	104.33	109.00
VF_2	15.00	25.87	24.67	26.67	32.00	43.33	65.33	73.67	79.33	89.33	92.67
KF_3	20.67	29.00	30.67	33.67	41.33	60.67	69.00	88.33	96.67	106.00	107.00
AF_3	22.00	33.00	33.50	38.67	46.00	67.67	83.67	96.33	102.33	107.00	110.67
MF_3	21.00	31.80	31.10	36.00	41.00	68.33	82.67	93.33	102.08	105.67	111.00
VF_3	16.00	27.43	25.00	27.67	35.33	46.00	62.67	82.00	85.67	90.33	94.67
SEm±	0.85	0.80	0.68	0.53	0.89	1.60	1.77	1.57	1.65	1.53	1.06
C.D. at 5%	NS	NS	NS	1.73	2.97	4.82	5.64	5.35	NS	5.44	3.61

F_1 - 80 % of the recommended fertilizer (g/m^2/week)

F_2 - Recommended fertilizer, from planting to end of pinching, N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55
from end of pinching to until harvesting start, N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51

During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50

F_3 - 120 % of the recommended fertilizer

NS - Non-significant

The interaction effect of between cultivar and fertigation levels on plant height showed significant differences. The highest plant height (107.00 cm) was recorded in cv. Aleda with F_3 fertigation, which was on par with cv. Aleda with F_2 fertigation, Aleda with F_1 fertigation, Master with F_1 fertigation, Master with F_2 and Master with F_1 fertigation (106.50, 105.67, 105.67, 104.33, and 102.00 cm). The lowest plant height (85.33 cm) was observed in cultivar Vienna with F_1 fertigation, which was on par with Vienna with F_2 and Vienna with F_3 fertigation (89.33 and 90.33 cm).

4.1.12 One hundred and sixty five days after planting

The fertigation levels had no significant influence on plant height (Table 1).

The plant height differed significantly in the different cultivars, highest plant height (110.33 cm) was recorded in cv. Aleda, which was on par with cv. Master (109.11 cm). The cv. Vienna recorded significantly lowest plant height (91.33 cm).

The interaction between cultivar and fertigation levels on plant height showed significant difference. The highest plant height (111.00 cm) was observed in cv. Master with F_3 fertigation level. Which was on par with cv. Aleda with F_3 fertigation, Aleda with F_2 fertigation, Aleda with F_1 fertigation and Master with F_2 fertigation (110.67, 110.33, 110.00 and 109.00 cm). The lowest plant height (86.67 cm) was in cultivar Vienna with F_1 fertigation.

4.2 Number of branches

The data pertaining to number of lateral branches produced after pinching of different carnation cultivars as influenced by fertigation levels and their interaction are presented in Table 2.

Table 2 : Number of branches, days taken for bud initiation and bud opening of carnation cultivars as influenced by fertigation and their interaction

Treatments	Number of lateral branches	Days taken for flower bud inititation	Days taken for flower bud open
Fertigation levels (F)			
F_1	6.30	136.54	30.75
F_2	6.84	133.25	30.42
F_3	7.25	130.20	31.25
SEm±	0.55	1.14	0.42
C.D. at 5 %	NS	NS	NS
Cultivar (C)			
Kristina (K)	7.59	130.50	32.56
Aleda (A)	8.78	119.67	29.78
Master (M)	6.83	138.83	33.33
Vienna (V)	4.04	145.17	27.56
SEm±	0.29	1.15	0.86
C.D. at 5 %	0.86	3.43	2.56
C x F			
KF_1	6.50	134.12	31.33
AF_1	8.67	121.67	31.00
MF_1	6.33	139.33	31.67
VF_1	3.73	151.00	29.00
KF_2	7.93	130.33	31.33
AF_2	8.67	119.67	30.33
MF_2	6.67	138.33	32.33
VF_2	4.07	144.67	27.67
KF_3	8.33	127.00	35.00
AF_3	9.00	117.67	28.00
MF_3	7.50	136.33	36.00
VF_3	4.33	139.83	26.00
SEm±	0.70	2.06	1.36
C.D. at 5%	NS	NS	NS

F_1 - 80 % of the recommended fertilizer (g/m^2/week)

F_2 - Recommended fertilizer, from planting to end of pinching

N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55

from pinching to until harvesting start,

N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51

During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50

F_3 - 120 % of the recommended fertilizer

NS - Non-significant

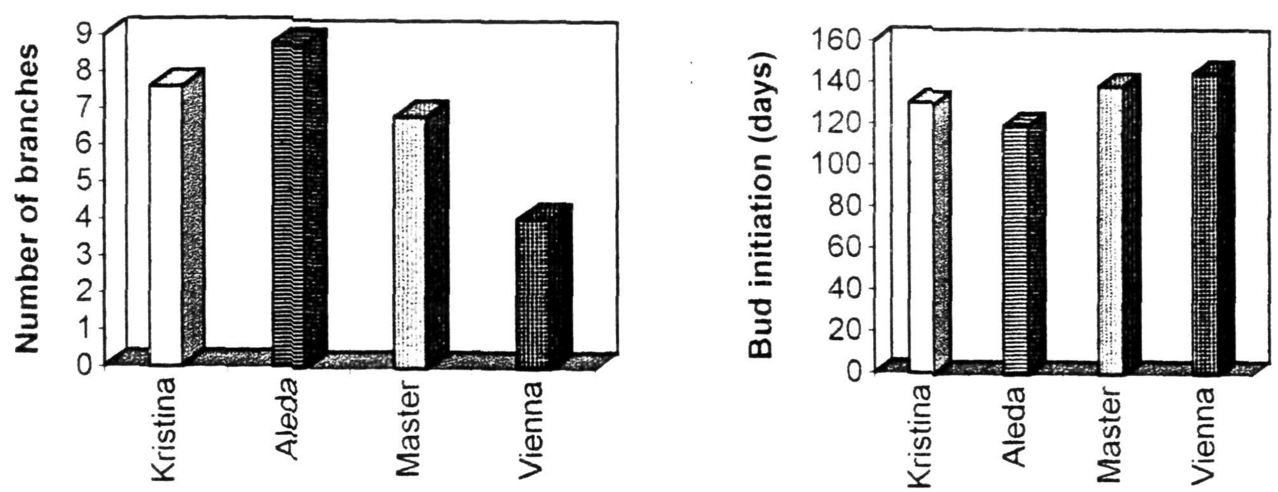

Fig. 1 : Number of lateral branches after pinching and days taken for bud initiation **in carnation cultivars**

The fertigation levels had no significant influence on number of branches per plant (Table 2).

Cultivar differed significantly in the number of lateral branches produced after pinching. Significantly highest number of branches per plant (8.78) was recorded in cv. Aleda followed by cultivar cv. Kristina and cv. Master (7.59 and 6.83) and were at par where as cultivar Vienna recorded significantly lowest number of branches per plant (4.04) (Fig. 1).

Interaction effect between the cultivars and fertigation levels on number of lateral branches per plant showed non-significant difference (Table 2).

4.3 Days taken for flower bud initiation

The fertigation levels had no significant influence on days taken for bud initiation (Table 2).

The cultivars differed significantly in days taken for bud initiation. Cultivar Aleda recorded significantly lowest number of days taken for bud initiation (119.67) than other cultivars. It was followed by cv. Kristina (130.50) and Master (138.83) where as cv. Vienna recorded significantly highest number of days (145.17) taken for bud initiation (Fig. 1).

The interaction effect of cultivars and fertigation levels on days taken for bud initiation was significant. The lowest number of days taken (117.67) for bud initiation was recorded in cv. Aleda with F_3 fertigation which was on par with cv. Aleda with F_2 fertigation (119.67) and cv. Aleda with F_1 fertigation (121.67). The highest number of days taken for bud initiation (151.00) was observed in cv. Vienna with F_1 fertigation level, which was on par with Vienna with F_2 fertigation (144.67 cm).

4.4 Days taken for bud opening

The data related to number of days required for flower bud opening from its bud initiation of different carnation cultivars as influenced by fertigation and their interaction are presented in Table 2.

The cultivars differed significantly in days taken for bud opening. Cultivar Vienna recorded significantly lowest number of days (29.56) taken for bud opening, which was on par with cv. Aleda (29.78) and the highest number of days (33.33) taken for bud opening was in cv. Master which was on par with Kristina (32.56).

The fertigation levels and interaction effect between cultivars and fertigation levels on days taken for bud opening was non-significant (Table 2).

4.5 Bud and flower characters

Data pertaining to some of the reproductive characters such as bud diameter, bud length, diameter of flower, stem length at harvest and stem girth at harvest are presented in Table 3.

4.5.1 Bud length

The data on flower bud length (at tight bud stage) of carnation cultivars as influenced by fertigation levels and interaction are presented in Table 3.

The fertigation levels had no significant influence on bud length (Table 3).

Cultivars differed significantly in their bud length, cv. Kristina recorded significantly highest bud length (3.91 cm) compared to other cultivars and followed by cv. Aleda (3.57 cm) and Master (3.57 cm) which were at par. The cv. Vienna recorded significantly lowest bud length (3.39 cm).

The interaction effect on bud length was significant. Highest bud length (4.00 cm) was recorded in cv. Kristina with F_3 fertigation, which was on par with cv. Kristina with F_2 fertigation (3.93 cm). The lowest bud length (3.30 cm) was observed in cv. Vienna with F_1 fertigation level.

4.5.2 Bud diameter

The data pertaining to bud diameter (at tight bud stage) of different carnation cultivars as influenced by fertigation and their interaction are presented in Table 3.

The fertigation levels did not influence significantly on bud diameter (Table 3).

The cultivars differed significantly on bud diameter, cv. Kristina recorded significantly highest bud diameter (2.46 cm) compared to other cultivars followed by cv. Aleda (2.37 cm) and cv. Master (2.33 cm) which were at par. The cultivar Vienna recorded significantly lowest bud diameter (2.27 cm).

The interaction effect on bud diameter showed significant differences. The highest bud diameter (2.53 cm) was recorded in cv. Kristina with F_3 fertigation, which was on par with cv. Kristina with F_2 fertigation and cv. Master with F_3 fertigation (2.47 and 2.40 cm). The lowest bud diameter (2.23 cm) was recorded in cv. Vienna with F_1 fertigation, which was on par with Vienna with F_2 and Vienna with F_3 fertigation (2.27 and 2.30 cm).

4.5.3 Flower diameter

The data related to flower diameter of carnation cultivars as influenced by fertigation are presented in Table 3.

The fertigation levels did not show significant influence on flower diameter (Table 3).

The cultivars differed significantly on flower diameter. Significantly highest flower diameter (8.26 cm) was recorded in cv. Kristina, than compared to other cultivars followed by cv. Aleda (8.02 cm) and cv. Master (7.98 cm) and were at par. The cultivar Vienna recorded significantly lowest (7.61 cm) flower diameter.

In interaction effect significant differences were recorded on flower diameter. The highest flower diameter (8.37 cm) was recorded in cv. Kristina with F_3 fertigation, which was on par with cv. Kristina with F_2 fertigation (8.24 cm). The differneces amongst cv. Kristina with F_2 fertigation and Kristina with F_1 fertigation (8.17 cm) were being non-significant. The significantly lowest flower diameter (7.52 cm) was in cv. Vienna with F_1 fertigation.

4.5.4 Stem length at harvest

The data pertaining to the stem length of different carnation cultivars at harvest as influenced by fertigation levels and their interaction effect are presented in Table 3.

The fertigation levels had no significant influence on stem length (Table 3).

Table 3 : Bud length, bud diameter, flower diameter, stem length and stem girth of carnation cultivars at harvest as influenced by fertigation and their interaction

Treatments	Bud length (cm)	Bud diameter (cm)	Flower diameter (cm)	Stem length (cm)	Stem girth (cm)
Fertigation levels (F)					
F_1	3.52	2.31	7.89	93.92	0.79
F_2	3.63	2.36	7.95	95.66	0.85
F_3	3.68	2.40	8.05	98.19	0.89
SEm±	0.03	0.03	0.02	0.67	0.04
C.D. at 5 %	NS	NS	NS	NS	NS
Cultivar (C)					
Kristina (K)	3.91	2.46	8.26	92.67	0.92
Aleda (A)	3.57	2.37	8.02	104.56	0.95
Master (M)	3.57	2.33	7.98	102.00	0.85
Vienna (V)	3.39	2.27	7.61	84.44	0.66
SEm±	0.03	0.03	0.02	0.76	0.04
C.D. at 5 %	0.08	0.08	0.07	2.65	0.10
C x F					
KF_1	3.80	2.37	8.17	91.67	0.86
AF_1	3.50	2.37	7.97	103.00	0.88
MF_1	3.49	2.27	7.90	100.33	0.80
VF_1	3.30	2.23	7.52	80.67	0.65
KF_2	3.93	2.47	8.24	91.67	0.95
AF_2	3.60	2.37	8.01	105.00	0.97
MF_2	3.60	2.33	7.97	101.67	0.85
VF_2	3.40	2.27	7.58	84.33	0.65
KF_3	4.00	2.53	8.37	94.67	0.96
AF_3	3.62	2.37	8.08	105.67	1.00
MF_3	3.63	2.40	8.02	104.00	0.90
VF_3	3.47	2.30	7.72	88.33	0.70
SEm±	0.06	0.04	0.04	1.32	0.64
C.D. at 5%	0.18	0.13	0.14	NS	NS

F_1 - 80 % of the recommended fertilizer ($g/m^2/week$)

F_2 - Recommended fertilizer, from planting to end of pinching

N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55

from pinching to until harvesting start,

N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51

During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50

F_3 - 120 % of the recommended fertilizer

NS - Non-significant

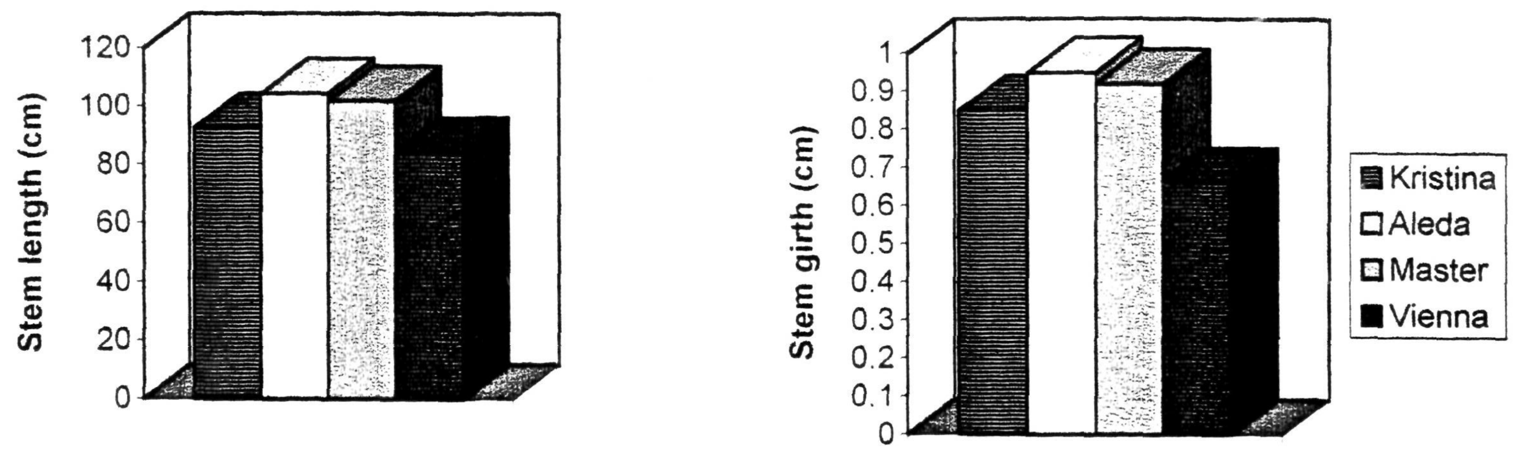

Fig. 2 : Stem length and stem girth at harvest in carnation cultivars

Plate 6 : Stem length at harvest as influenced by carnation cultivars

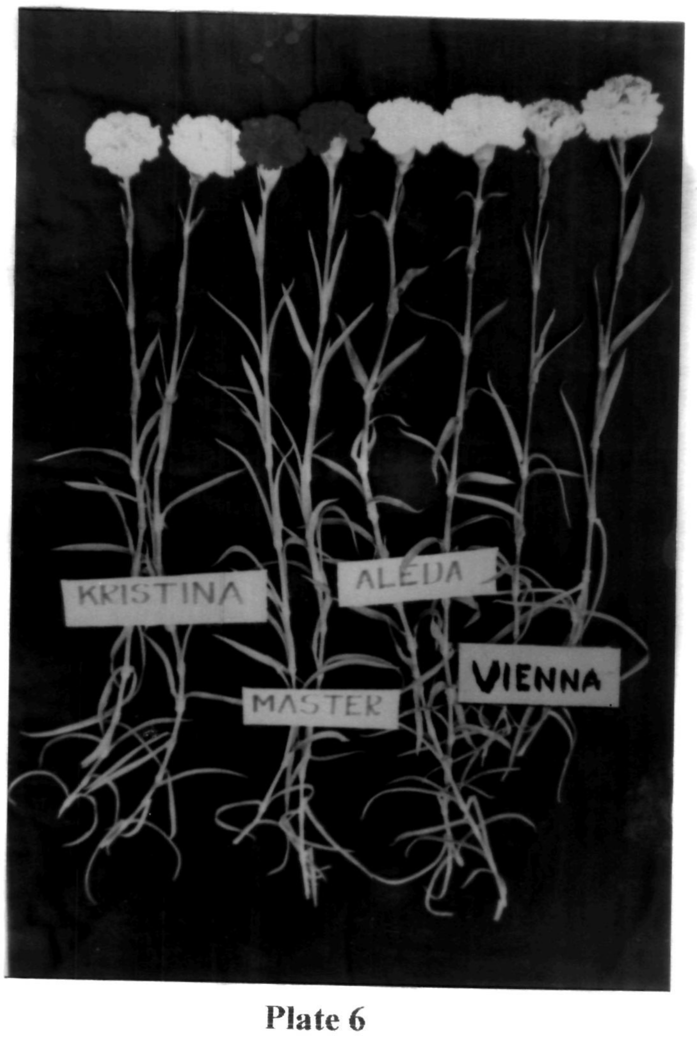

Plate 6

Cultivar differed significantly on their stem length at harvest. The highest stem length (104.56 cm) was recorded in cv. Aleda, which was on par with cv. Master (102 cm) and followed by Kristina (92.67 cm). Cultivar Vienna recorded lowest stem length (84.44 cm) (Fig. 2 and Plate 3).

The interaction effect on stem length at harvest was non-significant (Table 3).

4.5.5 Stem girth at harvest

The data related to the stem girth of different carnation cultivars at harvest as influenced by fertigation levels and their interaction are presented in Table 3.

The fertigation levels and interaction effect on stem girth at harvest were non-significant.

Cultivars differed significantly in their stem girth at harvest. The highest stem girth (0.95 cm) was recorded in cv. Aleda, which was on par with cv. Kristina (0.92 cm) and cv. Master (0.85 cm) whereas cultivar Vienna recorded significantly lowest stem girth (0.66 cm).

4.6 Yield parameters

4.6.1 Number of petals per plant

The data on the number of petals per flower of different carnation cultivars as influenced by fertigation levels and their interaction are presented in Table 4.

The fertigation levels differed significantly in number of petals per flower. Significantly highest number of of petals per flowers (82.86) was recorded with F_3 fertigation followed by F_2 fertigation (80.03). Significantly lowest number of petals per flower (78.75) was recorded in F_1 fertigation level.

Cultivar differed significantly in their number of petals per flower. Significantly highest number of petals per flower (94.81) was recorded in cv. Kristina followed by cv. Aleda (77.81) and cv. Master (76.24). The cultivar Vienna recorded significantly lowest number of petals per flower (73.97).

The number of petals per flower differed significantly in the interaction effect. Significantly highest number of petals (99.34) was recorded in cv. Kristina with F_3 fertigation. Significantly lowest number of petals per flower (69.23) was was in cv. Vienna with F_1 fertigation.

4.6.2 Yield

4.6.2.1 Number of flowers per square metre

The data regarding yield of carnation flowers per square metre, of different carnation cultivars as influenced by fertigation levels and their interaction are presented in Table 4.

The fertigation levels and interaction effect between cultivars and fertigation levels had no significant influence on yield of flowers per square metre (Table 4).

The cultivar differed significantly in yield of flowers per square metre. Highest yield was recorded in cv. Master (179.22), than compared to other cultivars followed by Kristina (174.22) and Aleda (170.33). Significantly lowest yield (142.00) was recorded in cv. Vienna (Fig. 3).

Table 4 : Number of petals per flower, number of flower per m2 and per hectare of carnation cultivars as influenced by fertigation and their interactions

1.05

Treatments	Number of petals per flower	Number of flowers per m^2	Number of flowers per hectare thousands
Fertigation levels (F)			
F_1	78.75	165.33	1157.31
F_2	80.03	166.50	1665.50
F_3	82.86	167.50	1172.50
SEm±	0.23	0.56	6.64
C.D. at 5 %	0.92	NS	NS
Cultivar (C)			
Kristina (K)	94.81	174.22	1219.54
Aleda (A)	77.81	170.33	1192.31
Master (M)	76.24	179.22	1254.54
Vienna (V)	73.97	142.00	999.00
SEm±	0.27	0.89	6.33
C.D. at 5 %	0.80	2.64	18.82
C x F			
KF_1	94.03	172.66	1208.62
AF_1	75.48	168.66	1180.62
MF_1	76.24	179.00	1253.00
VF_1	69.23	141.00	987.00
KF_2	91.05	174.66	1222.67
AF_2	77.01	170.00	1190.00
MF_2	74.29	179.00	1253.00
VF_2	77.78	142.33	997.00
KF_3	99.34	176.00	1232.00
AF_3	79.03	172.00	1204.00
MF_3	78.18	179.33	1253.00
VF_3	74.89	142.66	994.00
SEm±	0.47	1.44	11.59
C.D. at 5%	1.50	NS	NS

F_1 - 80 % of the recommended fertilizer (g/m^2/week)

F_2 - Recommended fertilizer, from planting to end of pinching,
N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55
from end of pinching to until harvesting start,
N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51

During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50

F_3 - 120 % of the recommended fertilizer

NS - Non-significant

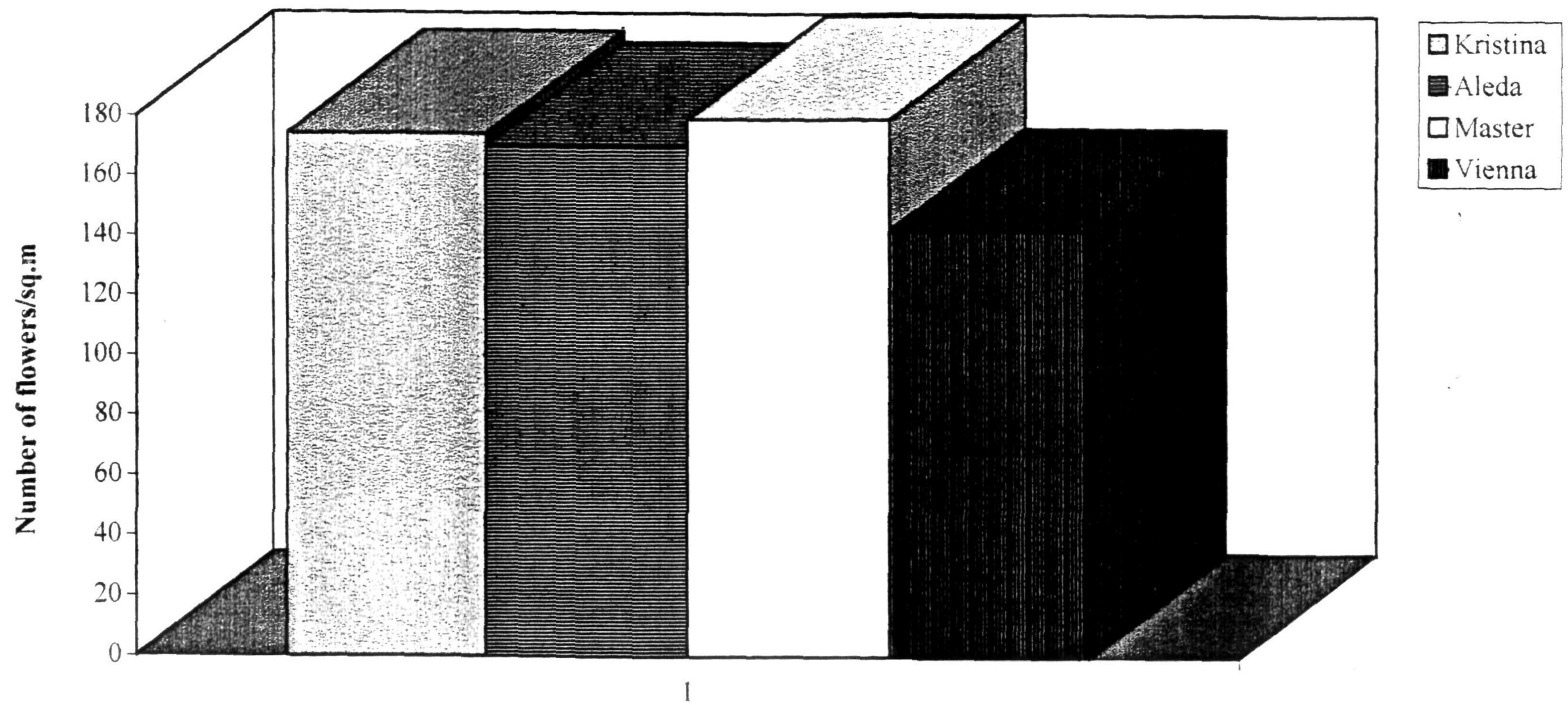

Fig. 3 : Number of flowers per square metre in carnation cultivars

4.6.2.2 Number of flower per hectare

The data pertaining to yield of carnation flowers per hectare of different carnation cultivars as influenced by fertigation levels and their interaction are presented in Table 4.

The fertigation levels and interaction effect between cultivars and fertigation levels were non-significant influence on yield of flowers per hectare (Table 4).

The cultivar differed significantly in their yield of flower per hectare. Cultivar Master recorded significantly highest yield (1254.54 thousands/ha) than other cultivars. It was followed by cv. Kristina (1219.54 thousands/ha) and cv. Aleda (1192.31 thousands/ha). Significantly lowest yield (999.00 thousands/ha) was recorded in cv. Vienna.

4.6.2.3 Yield of flowers per square metre

The data regarding yield of carnation flowers per square metre (kg) of different carnation cultivars as influenced by fertigation levels and their interaction are presented in Table 5.

The fertigation levels and interaction effect between cultivars and fertigation levels had no significant influence on yield of flowers per square metre.

The cultivar differed significantly in their yield of flower per square metre. Highest yield (4.86 Kg/m^2) was recorded in cv. Kristina, which was on par with Master (4.84 Kg/m^2) followed by Aleda (4.67 Kg/m^2). The significantly lowest yield (3.28 Kg/m^2) was recorded in cv. Vienna.

Table 5 : Yield of flowers per m² and per hectare of carnation cultivars as influenced by fertigation and their interaction

1.05

Treatments	Yield of flower	
	(Kg/m²)	(t/ha)
Fertigation levels (F)		
F_1	4.40	30.80
F_2	4.41	30.87
F_3	4.43	31.01
SEm±	0.02	0.52
C.D. at 5 %	NS	NS
Cultivar (C)		
Kristina (K)	4.86	34.02
Aleda (A)	4.67	32.69
Master (M)	4.84	33.88
Vienna (V)	3.28	22.96
SEm±	0.02	0.58
C.D. at 5 %	0.07	1.73
C x F		
KF_1	4.85	33.95
AF_1	4.63	32.41
MF_1	4.83	33.81
VF_1	3.29	23.03
KF_2	4.85	33.95
AF_2	4.66	32.62
MF_2	4.83	33.81
VF_2	3.26	22.89
KF_3	4.89	34.23
AF_3	4.73	33.17
MF_3	4.85	33.95
VF_3	3.29	22.89
SEm±	0.04	1.02
C.D. at 5%	NS	NS

F_1 - 80 % of the recommended fertilizer (g/m²/week)
F_2 - Recommended fertilizer, from planting to end of pinching,
N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55
from end of pinching to until harvesting start,
N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51
During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50
F_3 - 120 % of the recommended fertilizer
NS - Non-significant

4.6.2.4 Yield of flowers per hectare

The data on the yield of carnation flower per hectare of different carnation cultivars as influenced by fertigation levels and their interaction are presented in Table 5.

·The fertigation levels and interaction effect between cultivars and fertigation levels had no significant influence on yield of flowers per hectare.

The cultivar differed significantly in their flower yield per hectare. Highest yield (34.02 t/ha) was observed in cv. Kristina, which was on par with cv. Master and cv. Aleda (33.88 and 32.69 t/ha) and the differences between them being non significant. The significantly lowest yield (22.96 t/ha) was observed in cv. Vienna.

4.6.3 Calyx splitting

The data on the occurrence of calyx splitting (per cent) of different carnation cultivars as influenced by fertigation levels and their interaction are presented in Table 6.

The fertigation levels had no significant influence on calyx splitting.

The cultivar Master recorded significantly less calyx splitting (0.74 %) than other cultivars. Cultivar Vienna recorded highest calyx splitting (1.80 %), which was on par with cv. Aleda (1.70 %) and cv. Kristina (1.78 %).

The interaction effect between cultivars and fertigation levels on calyx splitting was significnat. Lowest calyx splitting (0.56 %) was recorded in cv. Master with F_3 fertigation, which was on par with cv. Master F_2 fertigation and

Table 6 : Calyx splitting, marketable and unmarketable flowers of carnation cultivars as influenced by fertigation and their interaction

1.05

Treatments	Calyx splitting	Marketable flowers	Unmarketable flowers
	Percentage		
Fertigation levels (F)			
F_1	1.38	88.66	11.34
F_2	1.37	89.47	10.53
F_3	1.32	90.16	9.84
SEm±	0.04	0.71	0.71
C.D. at 5 %	NS	NS	NS
Cultivar (C)			
Kristina (K)	1.78	93.94	6.06
Aleda (A)	1.70	87.99	12.01
Master (M)	0.74	93.98	6.02
Vienna (V)	1.80	81.78	18.22
SEm±	0.09	0.46	0.46
C.D. at 5 %	0.28	1.35	1.35
C x F		p	
KF_1	1.11	93.67	6.33
AF_1	1.54	87.72	12.28
MF_1	0.93	94.04	5.96
VF_1	2.11	79.21	20.79
KF_2	1.12	94.02	5.98
AF_2	2.15	89.16	10.84
MF_2	0.74	93.67	6.33
VF_2	1.66	81.04	18.96
KF_3	1.30	94.26	5.74
AF_3	1.40	87.10	12.90
MF_3	0.56	94.23	5.77
VF_3	1.63	85.08	14.91
SEm±	0.15	0.99	0.99
C.D. at 5%	0.45	3.43	3.43

F_1 - 80 % of the recommended fertilizer (g/m^2/week)

F_2 - Recommended fertilizer, from planting to end of pinching,

N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55

from end of pinching to until harvesting start,

N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51

During harvesting : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50

F_3 - 120 % of the recommended fertilizer

NS - Non-significant

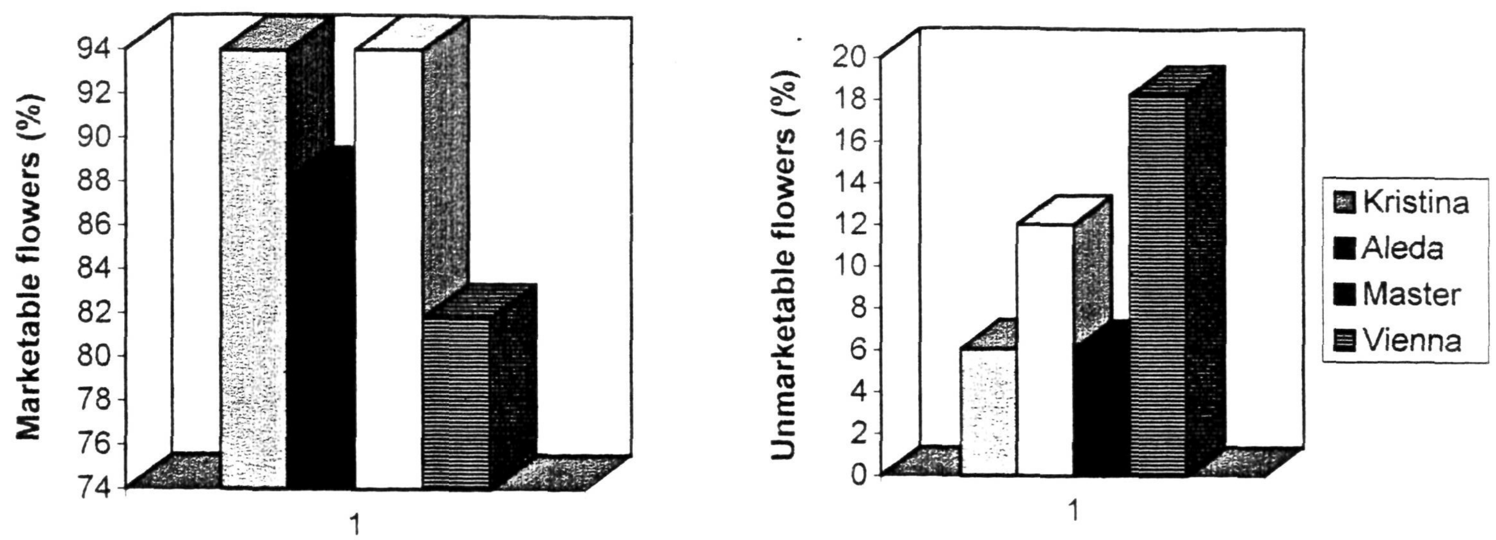

Fig. 4 : Marketable and unmarketable flowers in carnation cultivars

Master with F_1 feretigation (0.74 and 0.93 %). The incidence of calyx splitting was significantly highest in cv. Aleda with F2 fertigation (2.15 %).

4.6.4 Marketable flowers

The production of marketable flowers (per cent) of different carnation cultivars as influenced by fertigation and their interaction are furnished in Table 6.

The fertigation levels had no significant influence on marketable flowers (Table 6).

The cultivar Kristina and Master recorded significantly highest marketable flowers (93.94 and 93.98 %) than other cultivars and followed by cv. Aleda (87.99 %). Cultivar Vienna recorded significantly lowest marketable flowers (81.78 %) (Fig. 4).

The interaction effect between cultivars and fertigation levels on marketable flowers were significant. The highest marketable flowers (94.26 %) was recorded in cv. Kristina with F_3 fertigation, which was on par with cv. Master with F_3 fertigation Master with F_1 fertigation, Kristina with F_2 fertigation, Master with F_2 fertigation and Kristina with F_1 fertigation (94.23, 94.04, 94.02, 93.67 and 93.67 %). Significantly lowest marketable flowers (79.21 %) were recorded in cv. Vienna with F_1 fertigation and Vienna with F_2 fertigation (81.04 %).

4.6.5 Unmarketable flowers

The fertigation levels were at par on the production of unmarketable flowers (Table 6).

The cultivar differed significantly in the per cent unmarketable flowers. Lowest unmarketable flowers (6.02 %) was recorded in cv. Master, which was on par with Kristina (6.06 %). Cultivar Vienna recorded significantly highest unmarketable flowers (18.22 %) (Fig. 4).

The interaction effect between cultivars and fertigation levels on per cent unmarketable flowers was significant. The lowest unmarketable flowers (5.67 %) were recorded in cv. Master with F_3 fertigation, which was on par with cv. *Kristina with F_3 fertigation, Kristina with F_1 fertigation and Master F_3* fertigation (5.74, 6.33 and 6.33 %). Highest unmarketable flowers (20.79 %) was recorded in Vienna with F_1 fertigation (20.79 %) which was on par with cv. Vienna with F_2 fertigation (18.96 %).

4.7 Vase life of flower - first season

The data on effect of chemical preservatives, fertigation, cultivars and their interaction on number of days taken for bud opening (from flowers kept in solution) number of days stays in different solution and cumulative fresh weight of carnation cultivars are presented in Tables 7a,7b, 8a, 8b and 9a, 9b.

4.7.1 Number of days taken for bud opening

The data on effect of chemical preservatives, fertigation, cultivars and their interactions on number of days taken for bud opening are presented in Table 7a and 7b.

Cultivars had a significant effect on number of days taken for bud opening. More number of days (6.38) taken for bud opening was in cultivar

Table 7a : Effect of chemical preservatives, fertigation, cultivars and their interactions on number of days taken for flower bud opening

Treatments	F_1	F_2	F_3	Mean
Cultivars (c)				
Kristina	6.29	6.29	6.29	6.29
Aleda	6.25	6.25	6.29	6.26
Master	6.42	6.38	6.38	6.38
Vienna	6.04	6.00	6.13	6.05
Fertigation mean (F)	6.25	6.23	6.27	
Preservatives (T)				
T_1 (5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	7.00	7.00	7.42	7.13
T_2 (7.5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	7.00	6.92	6.92	7.94
T_3 (5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	6.67	6.50	6.42	6.53
T_4 (7.5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	6.33	6.50	6.42	6.42
T_5 (5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	6.25	6.25	6.17	6.22
T_6 (7.5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	6.17	6.08	6.00	6.08
T_7 Deionized water	5.25	5.25	5.58	5.36
T_8 Tap water	5.33	5.33	5.25	5.31
	Kristina	Aleda	Master	Vienna
Preservatives (T)				
T_1 (5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	7.11	7.00	7.56	6.89
T_2 (7.5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	7.00	7.00	7.11	6.66
T_3 (5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	6.44	6.67	6.56	6.44
T_4 (7.5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	6.44	6.33	6.44	6.44
T_5 (5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	6.33	6.33	6.22	6.00
T_6 (7.5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	6.22	6.00	6.11	6.00
T_7 Deionized water	5.44	5.44	5.56	5.00
T_8 Tap water	5.33	5.33	5.56	5.00

	SEm±	CD at 5 %
C	0.06	0.16
F	0.05	NS
T	0.08	0.23
C x F	0.10	NS
C x T	1.17	NS
F x T	0.43	NS

F_1 - 80 % of the recommended fertilizer ($g/m^2/week$)

F_2 - Recommended fertilizer, from planting to end of pinching,

N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55

from end of pinching to until harvesting start,

N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51

During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50

F_3 - 120 % of the recommended fertilizer

NS = Non-significant

fl = Flower

Table 7b : Effect of chemical preservatives, fertigation, cultivars and their interactions on number of days taken for flower bud opening

	Kristina			Aleda			Master			Vienna		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
T_1	6.68	6.68	7.00	6.33	6.33	6.68	6.33	6.68	7.00	6.33	6.33	6.68
T_2	6.68	6.68	6.68	6.68	6.68	6.68	6.68	6.68	7.00	6.33	6.68	6.68
T_3	6.33	6.33	6.33	6.00	6.33	6.68	6.00	6.00	6.33	6.00	6.00	6.33
T_4	6.33	6.33	6.68	6.33	6.68	6.68	6.68	6.68	6.68	6.33	6.33	6.68
T_5	6.00	6.00	6.00	6.00	6.00	6.33	6.00	6.00	6.33	6.00	6.00	6.33
T_6	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.00	6.00
T_7	5.00	5.33	5.33	5.00	5.33	5.33	5.33	5.68	5.68	5.00	5.33	5.68
T_8	5.00	5.00	5.00	5.00	5.00	5.33	5.00	5.00	5.33	5.00	5.33	5.33

	SEm±	CD at 5%
C x F x T	0.28	NS

Master, which was on par with Kristina (6.29). Kristina (6.29) and Aleda (6.26) were also at par. Cultivar Vienna recorded significantly less number of days (6.05) for bud opening.

Preservatives had a significant effect on number of days taken for bud opening. Significantly maximum number of days taken for bud opening was in T_2 preservatives (7.94days) followed by T_1 preservatives (7.13days). T_3 and T_4 preservatives (6.53 and 6.42) were at par. T_4 and T_5 (6.42 and 6.22) were also at par. Least days taken for flower opening (5.31) was in tap water, which was on par with deionized water (5.36).

Fertigation levels and interactions were non significant (Table 7a and 7b).

4.7.2 Vase life of flowers

The data on effect of chemical preservatives, fertigation cultivars and their interactions on vase life of flowers are presented in Table 8a and 8b.

Fertigation levels showed significant influence on vase life. Longest vase life (10.82 days) was observed in F_3 fertigation Shortest vase life was in F_1 fertigation (10.39 days), which was on par with F_2 fertigation (10-50 days) (Fig. 5).

Cultivar had a significant influence on vase life. Highest vase life (11.00 days) was recorded in cv. Master, which was on par with Kristina (10.92 days)

Table 8a : Effect of chemical preservatives, fertigation, cultivars and their interactions on vase life of flower

Treatments	F_1	F_2	F_3	Mean
Cultivars (c)				
Kristina (K)	10.75	10.88	11.13	10.02
Aleda (A)	10.54	10.50	10.83	10.63
Master (M)	10.79	10.92	11.29	11.00
Vienna (V)	9.45	9.71	10.04	9.74
Fertigation mena (F)	10.39	10.50	10.82	
Preservatives (T)				
T_1 (5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	**12.83**	**12.83**	**13.42**	**13.03**
T_2 (7.5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	**12.92**	**13.08**	**13.42**	**13.13**
T_3 (5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	**11.08**	**11.25**	**11.50**	**11.28**
T_4 (7.5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	11.33	11.42	11.83	11.53
T_5 (5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	10.83	10.83	10.91	10.86
T_6 (7.5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	10.58	10.83	11.42	10.94
T_7 Deionized water	6.83	7.00	7.33	7.06
T_8 Tap water	6.67	6.75	6.75	6.72
	Kristina	Aleda	Master	Vienna
Preservatives (T)				
T_1 (5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	13.56	13.11	13.89	11.56
T_2 (7.5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	13.78	13.11	14.00	11.67
T_3 (5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	11.67	11.44	11.44	10.56
T_4 (7.5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	12.00	11.67	11.78	10.67
T_5 (5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	11.22	11.00	11.11	10.11
T_6 (7.5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	11.11	11.00	11.44	10.22
T_7 Deionized water	7.33	7.00	7.22	6.67
T_8 Tap water	6.67	6.67	7.11	6.64
	SEm±		5	
C	0.06		**0.16**	
F	0.05		**0.14**	
T	0.08		**0.23**	
C x F	0.10		**NS**	
C x T	0.17		**0.47**	
F x T	0.15		**NS**	

F_1 - 80 % of the recommended fertilizer (g/m^2/week)

F_2 - Recommended fertilizer, from planting to end of pinching,
N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55
from end of pinching to until harvesting start,
N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51

During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50

F_3 - 120 % of the recommended fertilizer

NS = Non-significant

fl = Flower

Table 8b : Effect of chemical preservatives, fertigation, cultivars and their interactions on vase life of flower

	Kristina			Aleda			Master			Vienna		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
T_1	13.33	13.33	14.00	13.00	13.00	13.33	13.68	13.68	14.33	11.33	11.33	12.00
T_2	13.68	13.68	14.00	13.00	13.00	13.33	13.68	14.00	14.33	11.33	11.68	12.00
T_3	11.33	11.68	12.00	11.33	11.33	11.68	11.33	11.33	11.68	10.33	10.68	10.68
T_4	11.68	12.00	12.33	11.68	11.33	12.00	11.68	11.68	12.00	10.33	10.68	11.00
T_5	11.33	11.33	11.00	11.00	11.00	11.00	11.00	11.00	11.33	10.00	10.00	10.33
T_6	11.00	11.00	11.33	10.68	10.68	11.68	11.00	11.33	12.00	9.68	10.33	10.68
T_7	7.00	7.33	7.68	7.00	7.00	7.00	7.00	7.00	7.68	6.33	6.68	7.00
T_8	6.68	6.68	6.68	6.68	6.68	6.68	7.00	7.33	7.00	6.33	6.33	6.68

	SEm±	CD at 5 %
C x F x T	0.29	NS

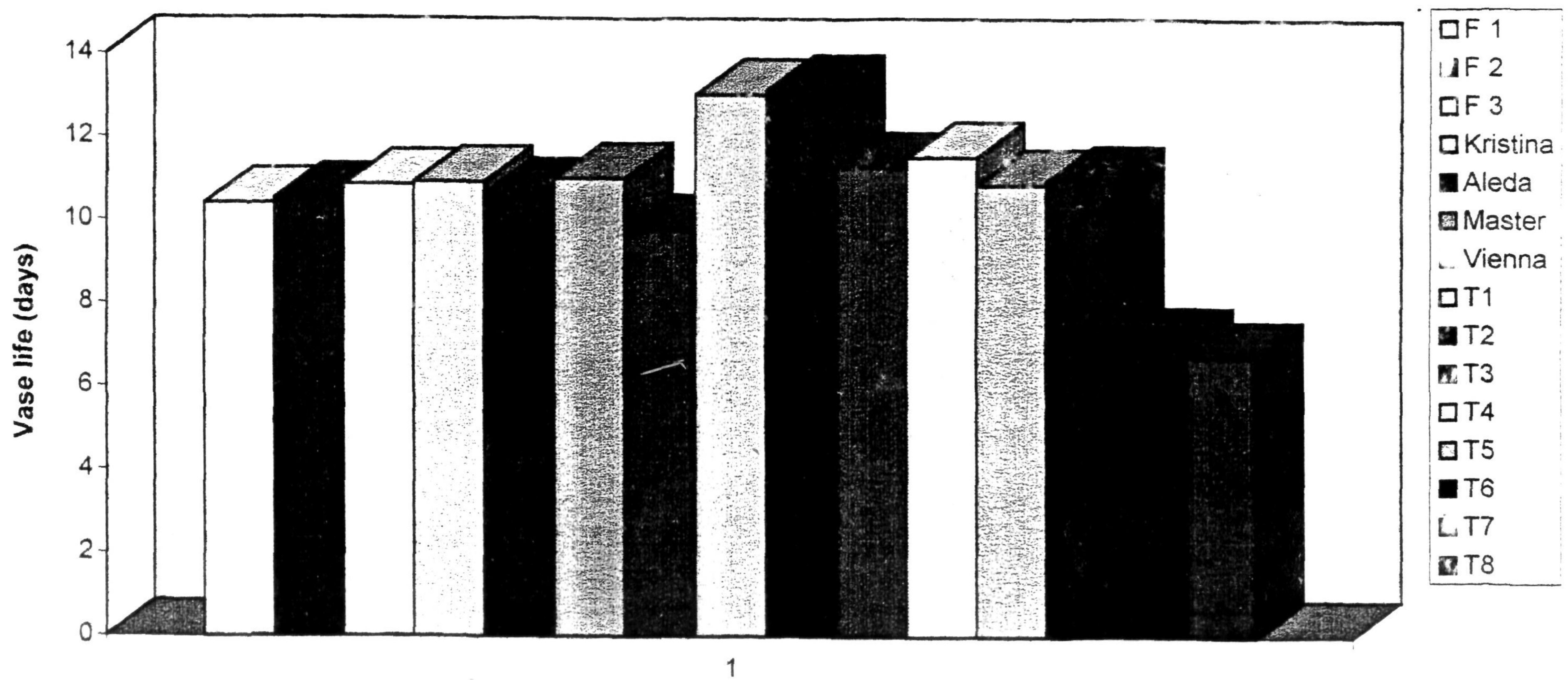

Fig. 5 : Effect of fertigation levels, cultivars and preservatives on vase life of flowers (days)

Plate 7 : Vase life of flower (6 days after harvest) cv. Master

Plate 8 : Vase life of flower (6 days after harvest) cv. Kristina

Plate 9 : Vase life of flower (6 days after harvest) cv. Aleda

Plate 10 : Vase life of flower (6 days after harvest) cv. Vienna

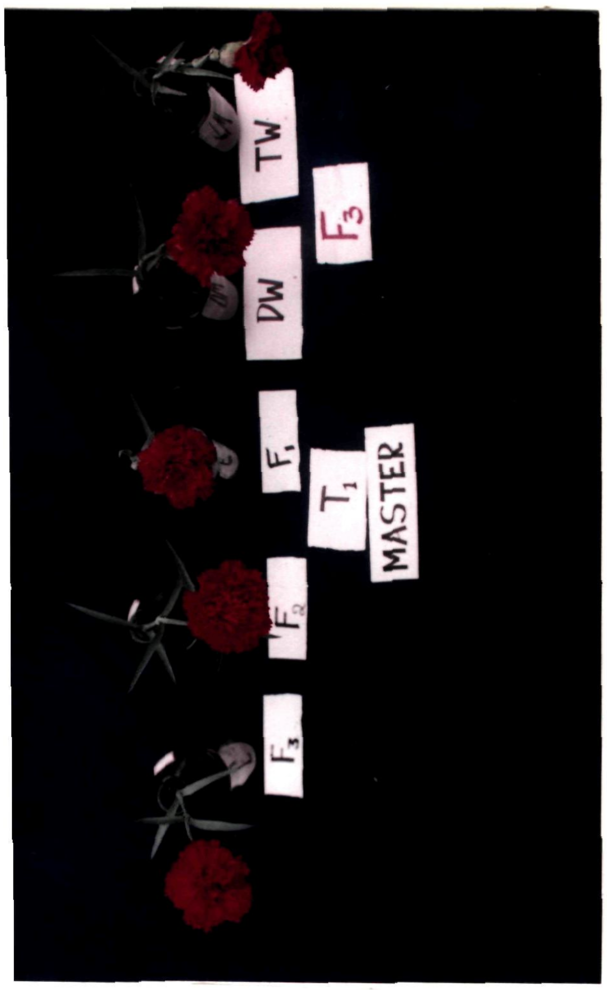

Plate 7

Plate 10

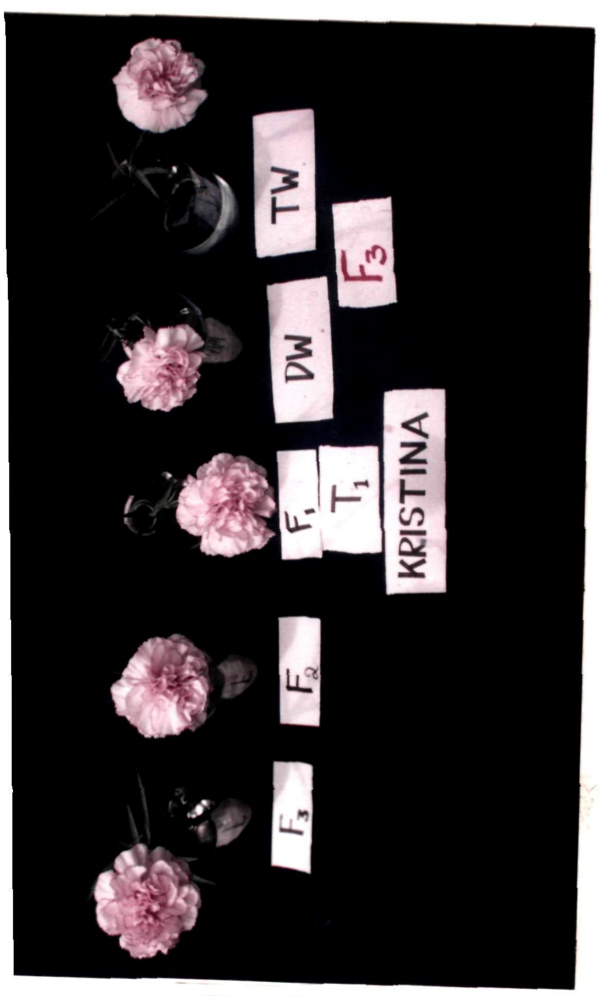

Plate 8

Plate 9

Plate 11 : Vase life of flower (12 days after harvest) cv. Master

Plate 12 : Vase life of flower (12 days after harvest) cv. Kristina

Plate 13 : Vase life of flower (12 days after harvest) cv. Aleda

Plate 14 : Vase life of flower (11 days after harvest) cv. Vienna

Plate 11

Plate 14

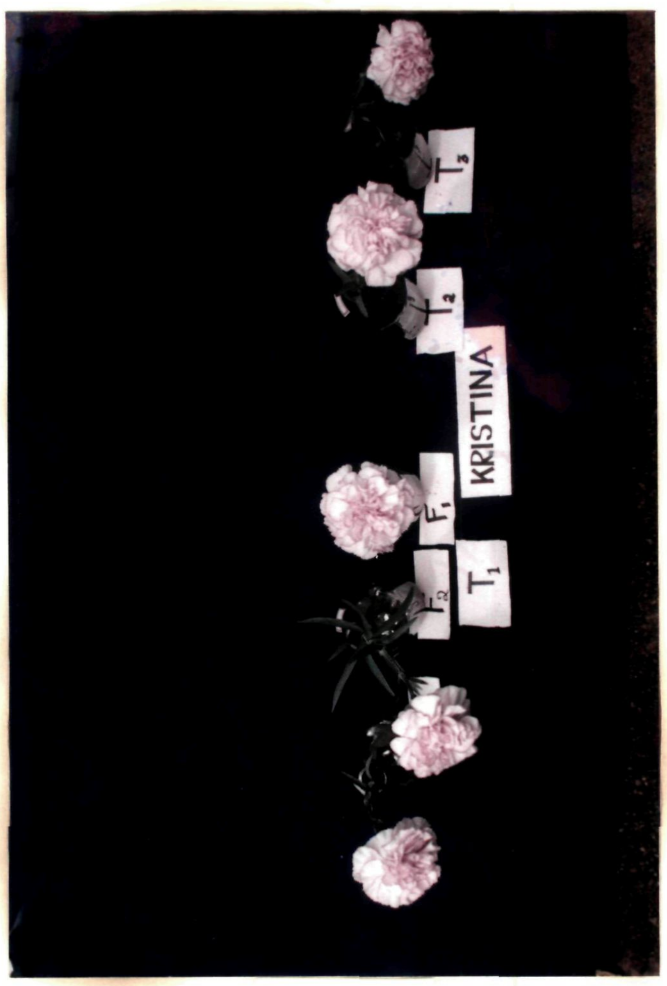

Plate 12

Plate 13

followed by Aleda (10.63 days). Cultivar Vienna recorded significantly shortest (9.74 days) vase life (Fig. 5).

Preservatives differed significantly in the vase life. Significantly longer vase life (13.13 and 13.03 days) was observed in T_2 and T_1 preservatives respectively. Significantly shortest vase life (6.72 days) was observed in tap water (Fig. 5).

Interaction effect between cultivars and preservatives differed significantly in their vase life. Longest vase life (14.00 days) was observed in T_2M, which was on par with T_1M, T_2K and T_1K (13.98, 13.78 and 13.56 days). T_1K, T_1A and T_2S (13.56, 13.11 and 13.11 days) were at par. Shortest vase life was recorded in tap water with cv. Vienna (6.64 days), which was on par with,. tap T_8A. T_8K, T_7A and T_8M (6.67, 6.67, 7.00 and 7.11 days) (Plate 7 to 14).

. Interaction effect between cultivar and fertigation levels, fertigation and preservatives and cultivars, fertigation and preservatives had no significant influence on vase life of the flower (Table 8a and 8b).

4.7.3 Cumulative fresh weight (CFW)

Data on the effect of flowers of chemical preservatives, fertigation cultivars and their interactions on cumulative fresh weight of flowers are presented in Table 9a and 9b.

Table 9a : Effect of chemical preservatives, fertigation, cultivars and their interactions on cumulative fresh weight (g/flower)

Treatments	F_1	F_2	F_3	Mean
Cultivars (c)				
Kristina	136.79	139.10	142.41	139.43
Aleda	145.37	147.21	148.28	146.95
Master	132.67	137.64	143.51	137.97
Vienna	104.96	109.50	112.96	109.14
Fertigation mean (F)	129.95	133.36	136.79	
Preservatives (T)				
T_1 (5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	151.45	155.58	161.13	156.05
T_2 (7.5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	150.42	153.96	160.38	154.92
T_3 (5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	143.46	144.88	151.68	146.97
T_4 (7.5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	137.42	143.79	146.33	142.51
T_5 (5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	139.54	141.58	142.17	141.10
T_6 (7.5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	133.42	136.71	137.75	135.96
T_7 Deionized water	94.17	98.71	100.29	97.72
T_8 Tap water	89.70	91.69	94.58	91.99
	Kristina	Aleda	Master	Vienna
Preservatives (T)				
T_1 (5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	161.21	171.56	165.17	126.28
T_2 (7.5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	161.83	168.56	162.50	126.79
T_3 (5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	150.17	165.00	155.08	116.44
T_4 (7.5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	147.22	160.28	147.11	115.44
T_5 (5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	154.39	157.22	139.11	113.67
T_6 (7.5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	141.08	148.63	140.00	114.11
T_7 Deionized water	100.17	109.56	100.67	80.50
T_8 Tap water	99.39	94.81	93.87	79.89
	SEm±		CD at 5 %	
C	0.31		0.85	
F	0.26		0.73	
T	0.43		1.19	
C x F	0.53		1.46	
C x T	0.86		2.39	
F x T	0.75		2.07	

F_1 - 80 % of the recommended fertilizer (g/m^2/week)
F_2 - Recommended fertilizer, from planting to end of pinching,
N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55
from end of pinching to until harvesting start,
N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51
During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50
F_3 - 120 % of the recommended fertilizer
NS = Non-significant
fl = Flower

Table 9b : Effect of chemical preservatives, fertigation, cultivars and their interactions on cumulative fresh weight (g/flower)

	Kristina			Aleda			Master			Vienna		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
T_1	158.97	160.33	164.33	170.68	171.00	173.00	156.00	168.00	171.50	120.17	123.00	135.68
T_2	159.00	159.83	166.68	168.17	168.50	169.00	153.50	163.00	171.00	121.00	124.50	134.83
T_3	144.68	150.83	155.00	164.68	165.33	165.00	155.50	147.83	161.90	109.00	115.50	124.83
T_4	143.50	145.00	153.17	160.68	160.50	159.68	138.50	151.33	151.50	107.00	118.33	121.00
T_5	153.83	152.83	156.50	154.68	158.00	159.00	133.50	142.33	141.50	116.17	113.17	11.68
T_6	141.83	142.00	139.47	142.68	150.83	152.40	137.68	133.83	148.50	111.50	120.17	110.68
T_7	97.00	101.83	101.68	109.00	109.83	109.83	93.68	102.83	105.50	77.00	80.33	84.17
T_8	95.50	100.17	102.50	92.44	93.68	98.33	93.00	91.93	96.68	77.83	81.00	80.83

	SEm±	CD at 5%
T x F x C	1.49	4.13

Fertigation levels showed significant differences on cumulative fresh weight of flowers. Significantly highest cumulative fresh weight (136.79 g/flower) was recorded in F_3 fertigation and was superior than F_2 and F_1 fertigation (1.33.36 and 129.959.95 g/flower) and the latter was recorded lowest. Cultivars had a significant effect on cumulative fresh weight of flower. Cultivar Aleda recorded significantly highest CFW (146.95 g/flower) followed by Kristina and Master (139.43 and 137.94 g/flower). Significantly least CFW was in Vienna (109.14 g/flower).

Preservatives differed significantly in their CFW of flower. Highest CFW (156.05 g/flower), was recorded in T_1 which was on par with T_2 (154.92 g/flower) followed by T_3, T_4, T_5 and T_6 (146.97, 142.51, 141.10 and 135.96 g/flower). And the differences amongst them being significant. Lowest CFW was recorded in T_8 (91.99 g/flower).

Interaction effect between cultivars and fertigation showed significant differences. Highest CFW was recorded in AF_3 (148.28 g/flower), which was on par with AF_2 (147.21 g/flower) followed by AF_1. MF_3 and KF_3 (145.37 and 142.41 g/flower) were at par. Lowest CFW was in VF_1 (104.96 g/flower), which was on par with VF_2 (109.50 g/flower).

Interaction between fertigation and preservatives showed significant differences. Highest CFW (161.13 g/flower), was recorded in T_1F_3 which was on par with T_2F_3 (160.38 g/flower) followed by T_1F_2 and T_2F_2 (155.58 and 153.96 g/flower) and the differences between them being significant, T_3F_3, T_1F_1 and T_2F_1 (151.68, 151.45 and 150.42 g/flower) were at par. Lowest CFW (89.70 g/flower) was recorded in T_8F_1, which was on par with T_8F_2 (91.69 g/flower).

Interaction between cultivars and preservatives differed significantly in their CFW. Significantly highest CFW (171.56 g/flower) was recorded in T_1A followed by T_2A (168.56 g/flower) and the differences among them being significant. T_1K and T_4A and (161.21, 160.28 g/flower) were at par. The least fresh weight was recorded in T_8V (79.89 g/flower), which was on par with T_7V (80.50 g/flower).

In interaction effect of cultivars, fertigation and preservatives on the CFW differed significantly. Highest CFW was in T_1F_3A, T_1F_3M, T_1F_3M, T_1F_2A and T_1F_1A (173.00, 171.50, 171.50, 171.00 and 170.68 g/flower) were at par. Lowest was in T_7F_1V (77.00 g/flower), which was on par with T_8F_1V, T_7F_2V. T_8F_3V, and T_8F_2V (77.83, 80.33, 80.83 and 81.00 g/flower).

4.8 Growth parameters of the second crop

The data pertaining to the plant height, number of branches, days taken for first flower initiation and bud opening of different carnation cultivars at various stages of crop growth as influenced by fertigation and their interaction are presented in Tables 10 and 11.

4.8.1 Plant height at various stages of crop growth

4.8.2 Thirty days after rest period

The fertigation levels had no significant influence on plant height (Table 10).

The cultivars differed significantly in their plant height. Significantly highest plant height (21.73 cm) was recorded in cultivar Aleda than other cultivars. The cultivar Vienna recorded lowest plant height (14.77 cm), which was on par with cv. Master (15.22 cm).

The interaction effect between cultivars and fertigation levels on plant height was non-significant (Table 10).

4.8.3 Forty five days after rest period

The fertigation levels differed significantly in the plant height. Highest plant height (23.52 cm) was recorded in F_3 fertigation, which was on par with F_2 fertigation (23.01). Significantly lowest plant height (21.32 cm) was recorded with F_1 fertigation.

The cultivars differed significantly in their plant height. Highest plant height (26.80 cm) was recorded in cv. Aleda, which was on par with Kristina (26.44 cm). Significantly lowest plant height was in cv. Vienna (18.20 cm).

The interaction effect between cultivars and fertigation levels on plant height was significant. Significantly highest plant height (28.73 cm) was recorded in cv. Aleda with F_3 fertigation. Lowest plant height (17.70 cm) was recorded in cv. Vienna with F_1 fertigation, which was on par with cv. Master with F_1 fertigation (17.93 cm) and Master with F_2 fertigation (18.87 cm).

4.8.4 Sixty days after rest period

The fertigation levels and interaction effect between cultivars and fertigation levels had no significant influence on plant height (Table 10).

The cultivars differed significantly in their plant height. Significantly higher plant height were recorded in cv. Aleda, cv. Kristina (32.84 and 31.93 cm). The cv. Vienna recorded significantly lowest plant height (22.96 cm).

4.8.5 Seventy five days after rest period

The fertigation levels and interaction effect between cultivars and fertigation levels had no significant influence on plant height (Table 10).

Cultivar Aleda recorded significantly highest plant height (42.04 cm) compared to other cultivars. Significantly lowest plant height (28.07 cm) was in cv. Vienna.

4.8.6 Ninety days after rest period

The fertigation levels did not show significant influence on the plant height (Table 10).

The cultivars differed significantly in their plant height. Significantly highest plant height was recorded in cv. Aleda (52.98 cm) than other cultivars. Cultivar Vienna recorded significantly lowest plant height (38.30 cm).

In interaction effect plant height in Aleda with F_3, Aleda with F_1, Aleda with F_2 and Kristina with F_2 (54.73, 52.47, 51.73 and 49.33 cm) were at par. Vienna with F_1 fertigation and Master with F_1 fertigation (35.17 and 38.23 cm) were at par the latter recorded lowest

Table 10 : Plant height of carnation cultivars at different stages of growth as influenced by fertigation and their interaction (second season crop)

1.05

Treatments	Days After Rest Period									
	30	45	60	75	90	105	120	135	150	165
Fertigation leves (F)										
F_1	18.38	21.32	27.70	33.19	42.66	52.94	64.22	76.51	85.20	91.52
F_2	17.93	23.01	29.17	35.36	46.12	57.43	67.87	78.59	88.11	93.12
F_3	17.75	23.52	28.02	36.64	47.96	58.52	70.62	83.30	91.41	94.79
SEm±	0.30	0.18	0.49	0.68	1.13	0.87	0.32	0.66	0.81	0.19
C.D. at 5 %	NS	0.73	NS	NS	NS	3.42	1.27	2.60	3.18	0.74
Cultivar (C)										
Kristina (K)	20.37	26.44	31.93	38.68	48.51	60.04	70.04	81.70	91.09	95.76
Aleda (A)	21.73	26.80	32.84	42.04	52.98	65.32	76.84	89.68	94.38	98.70
Master (M)	15.22	19.03	25.46	31.49	42.53	53.44	66.60	80.13	92.29	97.99
Vienna (V)	14.77	18.20	22.96	28.07	38.30	46.38	56.80	66.43	75.23	80.10
SEm±	0.41	0.27	0.50	0.67	0.44	0.47	0.60	0.55	0.52	0.41
C.D. at 5 %	1.21	0.80	1.47	1.98	1.30	1.41	1.79	1.62	1.54	1.22
C x F										
KF_1	21.10	25.90	31.83	35.17	44.77	56.70	65.40	76.33	86.37	93.83
AF_1	21.73	23.77	32.27	40.10	52.47	64.47	77.40	90.70	91.62	98.10
MF_1	15.53	17.93	24.57	31.07	38.23	48.37	60.37	75.33	89.40	95.67
VF_1	15.17	17.70	22.13	26.43	35.17	42.33	53.73	63.70	73.40	78.50
KF_2	20.87	27.07	32.57	40.07	49.37	61.67	71.07	82.10	93.13	96.37
AF_2	20.53	27.90	33.83	41.87	51.73	65.03	75.07	85.63	95.67	99.03
MF_2	15.60	18.87	36.00	30.73	44.00	55.27	68.83	82.40	92.07	98.57
VF_2	14.73	18.20	24.30	28.77	39.37	47.73	56.53	64.22	71.60	78.50
KF_3	19.13	26.37	31.40	40.80	51.40	61.77	73.67	86.67	93.77	97.07
AF_3	22.93	28.73	32.43	44.17	54.73	66.47	78.07	92.70	95.80	99.00
MF_3	14.53	20.30	25.80	32.69	45.37	56.70	70.60	82.70	95.40	99.73
VF_3	14.40	18.70	22.43	29.00	40.37	49.17	60.13	71.37	80.67	83.37
SEm±	0.68	0.44	0.89	1.20	1.31	1.16	0.96	1.05	1.12	0.64
C.D. at 5%	NS	1.39	NS	NS	4.82	3.99	2.96	3.53	3.89	1.97

F_1 - 80 % of the recommended fertilizer (g/m^2/week)

F_2 - Recommended fertilizer. During rest period (30 days) N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55
from rest period to until harvesting start. N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51

During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50

F_3 - 120 % of the recommen F_3 - 120 % of the recommended ferilizer

NS - Non-significant

4.8.7 One hundred and five days after rest period

The fertigation levels showed significant difference in the plant height. F_3 and F_2 fertigation (58.52 and 57.43 cm) were at par. Significantly lowest plant height was recorded in F_1 fertigation (52.94 cm).

The cultivars differed significantly in their plant height. Significantly highest plant height (65.32 cm) was recorded in cv. Aleda, than other cultivars. Cultivar Vienna recorded significantly lowest plant height (46.38 cm).

The interaction effect between cultivars and fertigation levels on plant height was significant. Highest plant height (66.47 cm) was recorded in cv. Aleda with F_3 fertigation, which was on par with cv. Aleda with F_2 fertigation (65.03 cm) and cultivar Aleda with F_1 fertigation (64.47 cm). Significantly lowest plant height (42.33 cm) was recorded in cv. Vienna with F_1 fertigation.

4.8.8 One hundred and twenty days after rest period

Significantly highest plant height (70.62 cm) was recorded in F_3 fertigation followed by F_2 fertigation (67.87 cm). Significantly lowest plant height (64.22 cm) was recorded in F_2 fertigation.

The cultivars differed significantly in the plant height. Significantly highest plant height (76.84 cm) was recorded in cv. Aleda, than other cultivars. It was followed by cv. Kristina (70.04 cm) and cv. Master (66.60 cm). The cultivar Vienna recorded significantly lowest plant height (56.80 cm).

In interaction effect highest plant height (78.07 cm) was recorded in cv. Aleda with F_3 fertigation, which was on par with cv. Aleda with F_1 fertigation, Aleda with F_2 fertigation (77.40 and 75.07 cm). Significantly lowest plant height (53.73 cm) was in cv. Vienna with F_1 fertigation.

4.8.9 One hudnred and thirty five days after rest period

The fertigation levels differed significantly in the plant height. Fertigation F_3 recorded significantly highest plant height (83.30 cm) than F_2 fertigation and F_1 fertigation (78.59 and 76.51 cm). Fertigation F_2 and F_1 were at par.

The cultivars differed significantly in the plant height. Cultivar Aleda recorded significantly highest (89.68 cm) plant height than other cultivars. Cultivar Kristina and Master (81.70 and 80.13 cm) were at par. Cultivar Vienna recorded significantly lowest plant height (66.43 cm).

The interaction effect between cultivars and fertigation levels on plant height was significant. Highest plant height (92.70 cm) was recorded in cv. Aleda with F_3 fertigation, which was on par with cv. Aleda with F_1 fertigation (90.70 cm), this was followed by cv. Kristina with F_3 fertigation and Aleda with F_2 fertigation (86.67 and 85.63 cm), the differences between them being significant. Lowest plant height (63.70 cm) was recorded in cv. Vienna with F_1 fertigation which was on par with cv. Vienna with F_2 fertigation (64.22 cm).

4.8.10 One hundred and fifty days after rest period

The fertigation levels differed significantly in the plant height. Significantly highest plant height (91.41 cm) was recorded in F_3 fertigation. Lowest plant height (85.20 cm) was recorded in F_1 fertigation which was on par with F_2 fertigation (88.11 cm).

The cultivar differed significantly in the plant height. Significnatly highest plant height (94.38 cm) was recorded in cv. Aleda followed by Kristina and Master (91.09 and 92.29 cm) were at par. Significantly lowest plant height (75.23 cm) was in cv. Vienna.

The interaction effect between cultivar and fertigation levels on plant height was significant. Highest plant height (95.80 cm) was recorded in cv. Aleda with F_3 fertigation, which was on par with cv. Aleda with F_2 fertigation, Master with F_3 fertigation, Kristina with F_2 fertigation and cv. Master with F_2 fertigation (95.67, 95.40, 93.13 and 92.07 cm). Lower plant height (71.60 cm) was recorded in Vienna with F_2 fertigation, which was on par with cv. Vienna with F_1 fertigation (73.40 cm).

4.8.11 One hundred and sixty five days after rest period

The fertigation levels differed significantly in the plant height. Significantly highest plant height was recorded in F_3 and F_2 fertigation (94.79 and 93.12 cm). Lowest plant height (91.52 cm) was recorded in F_1 fertigation.

The cultivar differed significantly in their plant height. Cultivar Aleda recorded highest plant height (98.70 cm), which was on par with cv. Master (97.99 cm). Significantly lowest plant height (80.10 cm) was recorded in cv. Vienna.

In interaction effect, plant height in Master with F_3, Aleda with F_2, Aleda with F_3, Master with F_2, Aleda with F_1, Kristina with F_3 and Kristina with F_2 fertigation (99.73, 99.03, 99.00, 98.57, 98.10, 97.07 and 96.37 cm) were at par. Vienna with F_2 and Vienna with F_1 fertigation (78.50 and 78.50 cm). were at par.

4.9 Number of lateral branches

The data on the number of lateral branches produced after rest period of different carnation cultivars as influenced by fertigation levels and their interaction are presented in Table 11.

Table 11 : Number of branches, days taken for bud initiation and bud opening of carnation cultivars as influenced by fertigation and their interaction (second season crop) 1.05

Treatments	Number of lateral branches	Days taken for flower bud inititation	Days taken for flower bud open
Fertigation levels (F)			
F_1	10.30	122.96	31.33
F_2	10.95	121.68	30.92
F_3	12.50	119.95	31.82
SEm±	0.31	0.40	0.29
C.D. at 5 %	1.21	1.61	NS
Cultivar (C)			
Kristina (K)	12.22	117.80	31.47
Aleda (A)	13.70	108.70	31.73
Master (M)	11.22	128.76	33.10
Vienna (V)	7.86	130.87	29.64
SEm±	0.23	1.21	0.97
C.D. at 5 %	0.69	3.53	NS
C x F			
KF_1	10.00	113.83	29.17
AF_1	13.03	108.67	31.83
MF_1	11.00	132.33	32.65
VF_1	7.17	138.33	31.67
KF_2	12.60	122.80	31.57
AF_2	12.40	110.10	31.87
MF_2	11.00	127.67	30.60
VF_2	18.40	126.17	29.67
KF_3	14.67	116.72	23.67
AF_3	15.67	107.33	30.00
MF_3	11.67	126.27	36.03
VF_3	8.00	128.10	27.06
SEm±	0.46	1.85	1.49
C.D. at 5%	1.57	5.59	NS

F_1 - 80 % of the recommended fertilizer (g/m^2/week)

F_2 - Recommended fertilizer, During rest period (30 days)

N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55

from rest period to until harvesting start,

N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51

During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50

F_3 - 120 % of the recommended fertilizer

NS - Non-significant

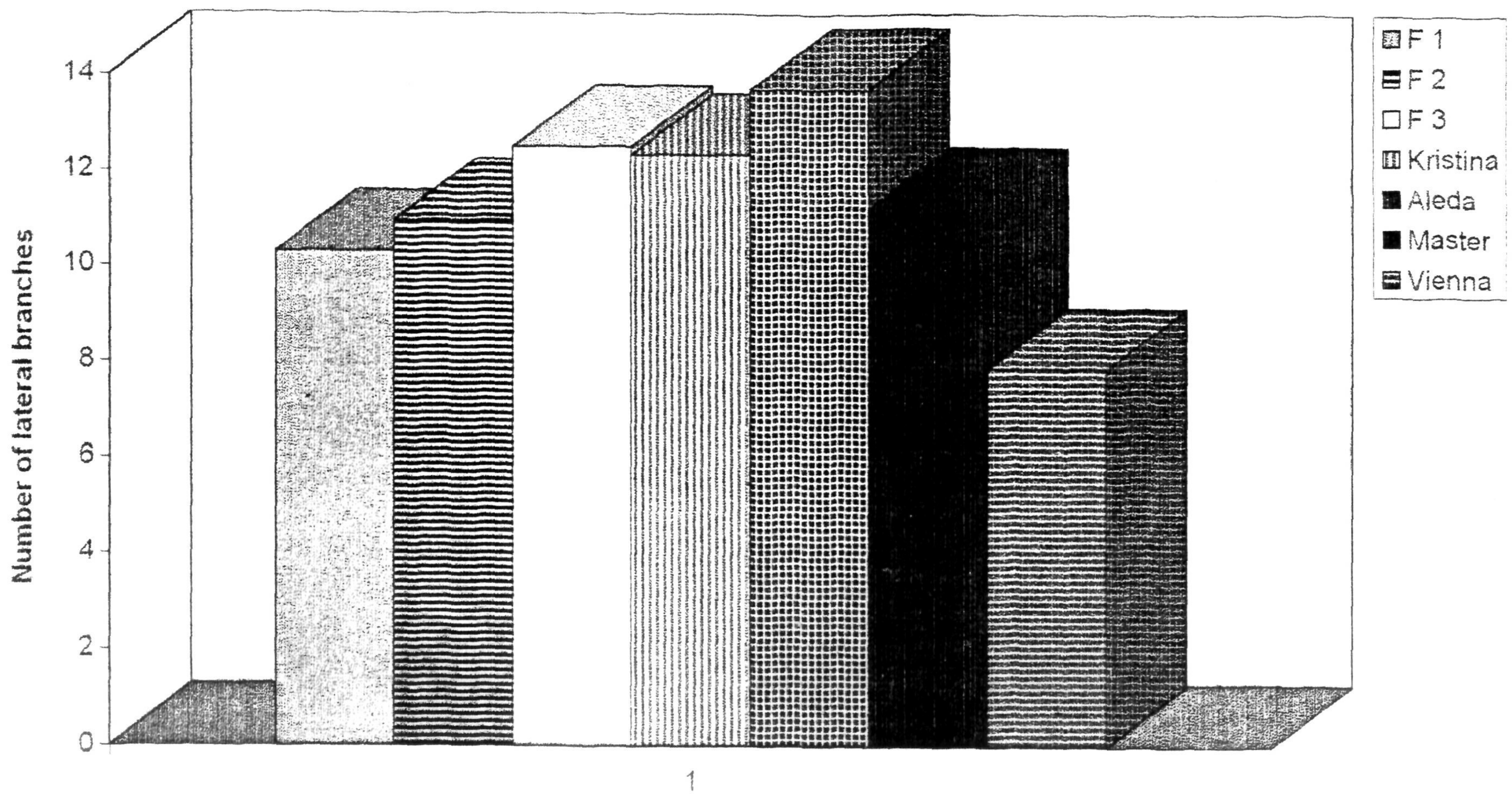

Fig. 6 : Number of lateral branches after rest period in carnation cultivars and fertigation levels

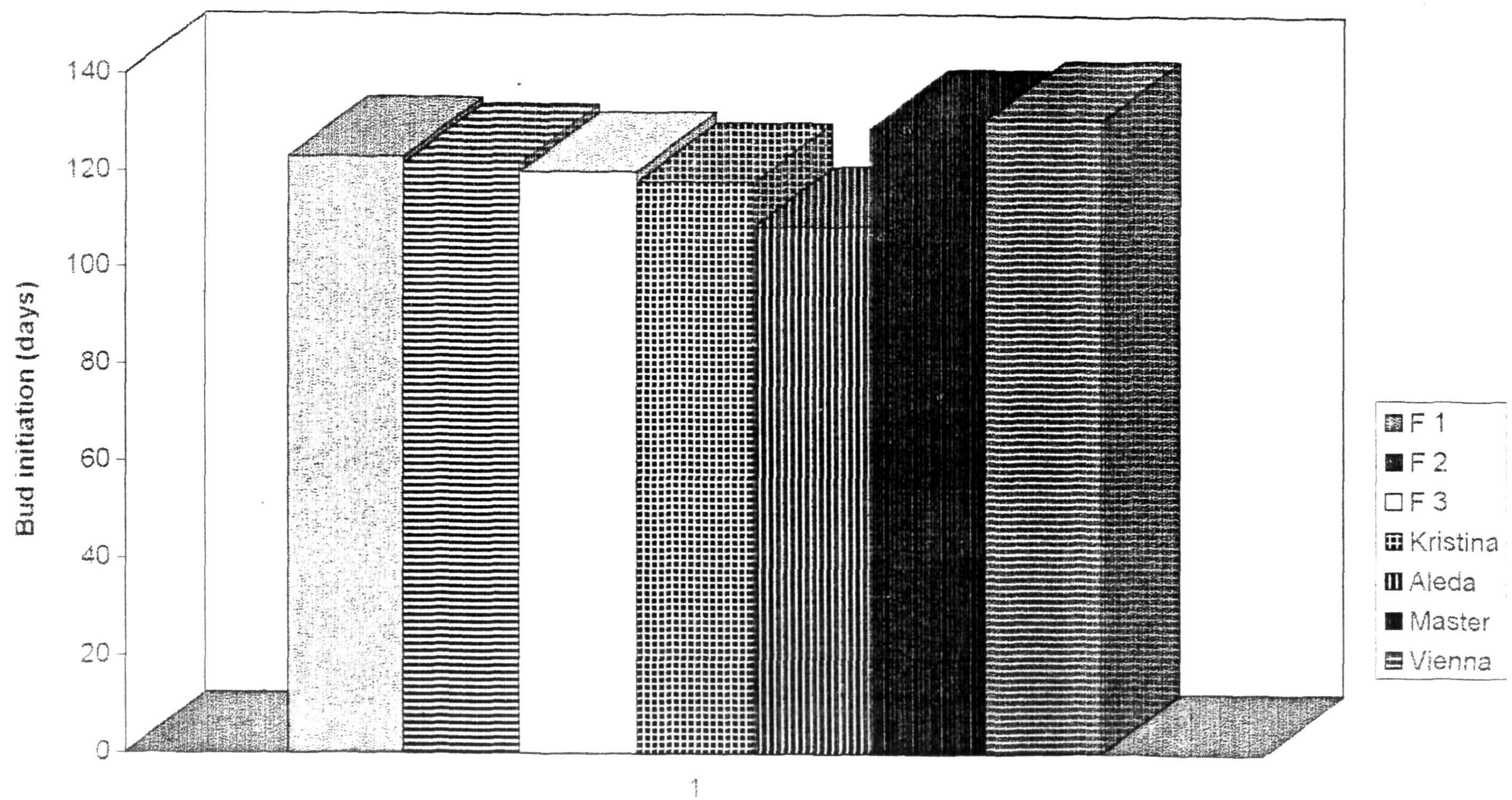

Fig. 7 : Number of days taken for flower bud initiation in carnation cultivars and fertigation levels

The fertigation levels differed significantly in the numoer of lateral branches produced after rest period. Fertigation F_3 recorded significantly highest number of branches per plant (12.50). Fertigation F_2 and F_1 fertigation (10.95 and 10.30) were at par (Fig. 6).

The cultivar differed significantly in their number of lateral branches produced after rest period. Significantly highest number of branches per plant (13.70) was recorded in cv. Aleda this was followed by cv. Kristina (12.22) and Master (11.22). Cultivar Vienna recorded significantly lowest number of branches per plant (7.86) (Fig. 6).

In interaction effect highest number of lateral branches after rest period was recroded in Aleda with F_3 and Kristina with F_3 fertigation (15.67 and 14.67) and were at par. Aleda with F_1, Kristina with F_2, Aleda with F_2 and Master with F_3 fertigation (12.60, 12.40 and 11.67) and were also at par. Vienna with F_2, Vienna with F_3 and Vienna with F_1 (8.40, 8.00 and 7.17) wer also at par, latter recorded the lowest.

4.10 Days taken for flower bud initiation

The data on the number of days taken for bud initiation after rest period of different carnation cultivars as influenced by fertigation levels and their interaction are presented in Table 11.

The fertigation levels differed significantly in days taken for bud initiation. Fertigation F_3 recorded significantly lowest number of days (119.95) taken for bud initiation than other levels of fertigation. Highest number of days (122.96) taken for bud initiation was recorded in F_1 fertigation, which on par with F_2 fertigation (121.68) (Fig. 7).

The cultivars differed significantly in days taken for bud initiation. Cultivar Aleda took significantly lowest number of days (108.70) for bud initiation than other cultivars, this was followed by cv. Kristina (117.80). Highest number of days (130.87) taken for bud initiation was recorded in cv. Vienna which was on par with cv. Master (128.76) (Fig. 7).

In interaction effect days taken for bud initiation was significant. The lowest number of (107.33) days taken for bud initiation was recorded in cv. Aleda with F_3 fertigation, which was on par Aleda with F_2 and Aleda with F_1 fertigation (110.10 and 108.67). Highest number of days taken for bud initiation (138.33) was in cv. Vienna with F_1 fertigation level, this was followed by cv. Master with F_1 fertigation, Vienna with F_3 fertigation, Master with F_2 fertigation (132.33, 128.10 and 127.67,) were at par.

4.11 Days taken for bud opening

The data related to number of days taken for flower bud opening from its bud initiation of different carnation cultivars as influenced by fertigation and their interaction are presented in Table 11.

The fertigation levels, cultivars and their interaction effect on days taken for bud opening was non-significant (Table 11).

4.12 Bud and flower characters

Data pertaining to bud diameter, bud length, flower diameter, stem length and stem girth at harvest are presented in Table 12.

4.12.1 Bud length

The data on flower bud length (at tight bud stage) of carnation cultivars as influenced by fertigation levels and their interaction are presented in Table 12.

The fertigation levels had no significant influence on bud length (Table 12).

Cultivar differed significantly in their bud length, cultivar Kristina recorded significantly highest bud length (3.73 cm) than other cultivars this was followed by Master and Aleda (3.45 and 3.40 cm) which were at par. Lowest bud length was recorded in cv. Vienna (3.35 cm) which was on par with cv. Aleda and cv. Master (3.45 and 3.40 cm).

In interaction, highest bud length was recorded in Kristina with F_3 and Kristina with F_2 fertigation (3.83 and 3.80 cm) were at par. Kristina with F_1, Aleda with F_3, Aleda with F_1 and Master with F_3, Vienna with F_3 and Master with F_3 fertigation (3.57, 3.57, 3.43, 3.43 and 3.43 cm) wer also at par. Master with F_2, Master with F_1 and Vieena with F_2 fertigation (3.40, 3.37 and 3.23 cm) were also at par.

4.12.2 Bud diameter

The fertigation level and interaction between cultivar and fertigation levels had no significant influence on bud diameter (Table 12).

The cultivars differed significantly on bud diameter. Cultivar Kristina recorded significantly highest bud diameter (2.36 cm) which was on par with cv. Aleda (2.28).Cultivar Aleda and cv. Master (2.21 cm) were as par. Lowest bud length (2.14 cm) was observed in cv. Vienna which was on par with cv. Master.

Table 12 : Bud length, bud diameter, flower diameter, stem length and stem girth of carnation cultivars at harvest as influenced by fertigation and their interaction (second season crop)

Treatments	Bud length (cm)	Bud diameter (cm)	Flower diameter (cm)	Stem length (cm)	Stem girth (cm)
Fertigation levels (F)					
F_1	3.44	2.22	7.77	85.49	0.79
F_2	3.45	2.22	7.80	87.36	0.80
F_3	3.57	2.30	7.88	89.13	0.82
SEm±	0.04	0.03	0.06	0.36	0.03
C.D. at 5 %	NS	NS	NS	1.40	NS
Cultivar (C)					
Kristina (K)	3.73	2.36	8.13	85.52	0.87
Aleda (A)	3.45	2.28	7.96	93.62	0.89
Master (M)	3.40	2.21	7.88	92.19	0.83
Vienna (V)	3.35	2.14	7.31	77.98	0.63
SEm±	0.03	0.03	0.05	0.40	0.03
C.D. at 5 %	0.10	0.08	0.13	1.20	0.09
C x F					
KF_1	3.57	2.30	8.07	84.20	0.87
AF_1	3.43	2.23	8.03	92.37	0.87
MF_1	3.37	2.13	7.73	91.17	0.61
VF_1	3.40	2.20	7.27	74.20	0.87
KF_2	3.80	2.33	8.13	86.03	0.83
AF_2	3.37	2.27	8.00	92.67	0.81
MF_2	3.40	2.17	7.83	93.73	0.87
VF_2	3.23	2.13	7.23	77.03	0.65
KF_3	3.83	2.43	8.20	86.33	0.87
AF_3	3.57	2.33	7.83	95.83	0.97
MF_3	3.43	2.33	8.07	91.67	0.80
VF_3	3.43	2.10	7.43	82.70	0.63
SEm±	0.05	0.05	0.09	1.70	0.05
C.D. at 5%	0.17	NS	0.30	2.25	NS

F_1 - 80 % of the recommended fertilizer (g/m^2/week)
F_2 - Recommended fertilizer, During rest period (30 days)
N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55
from rest period to until harvesting start,
N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51
During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50
F_3 - 120 % of the recommended fertilizer
NS - Non-significant

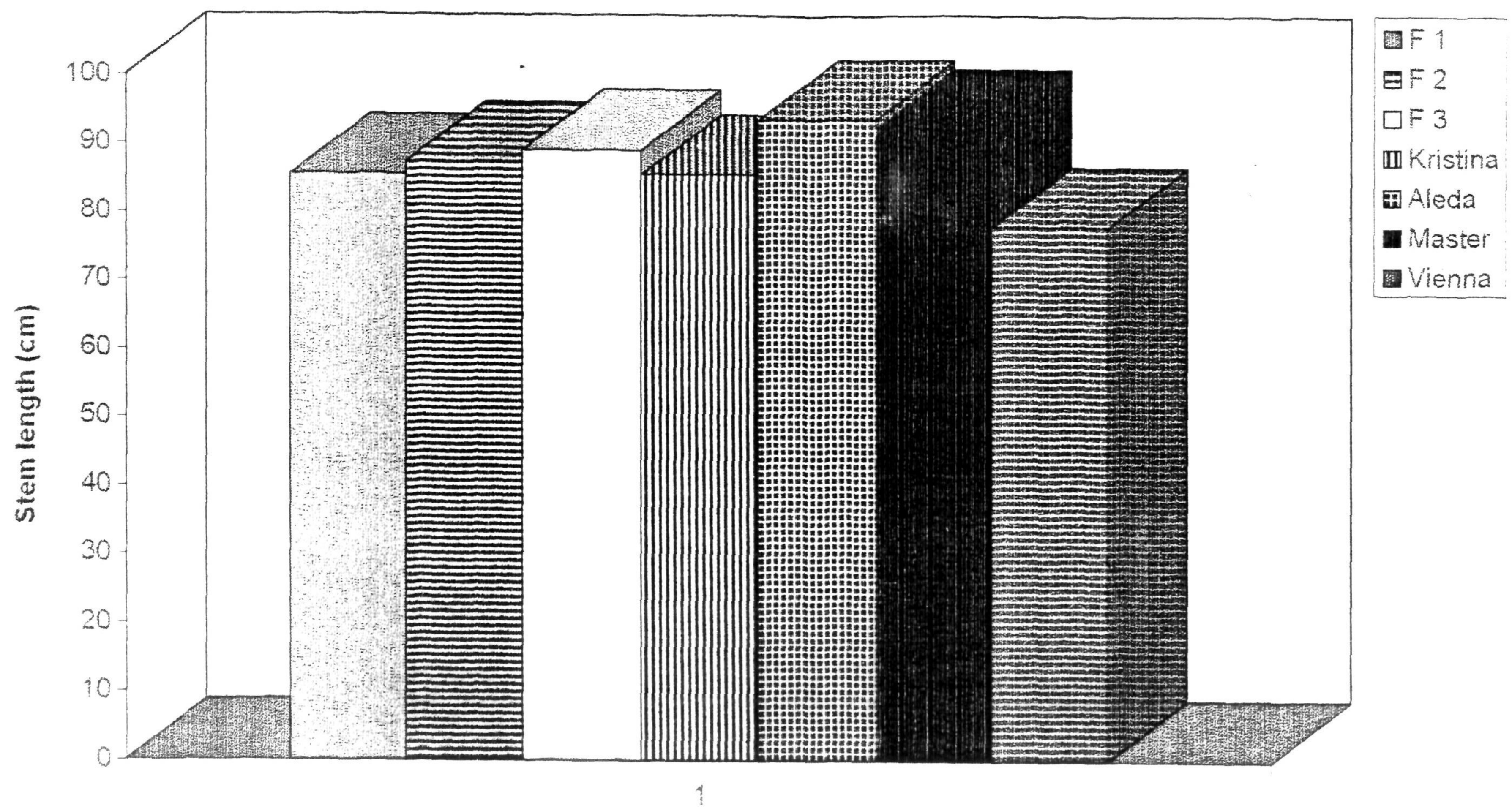

Fig. 8 : Stem length at harvest in fertigation levesl and carnation cultivars

4.12.3 Flower diameter

Significant differences were not observed in flower diameter of carnation cultivars due to varying fertigation levels (Table 12).

The cultivar differed significantly in flower diameter. Significantly highest flower diameter (8.13 cm) was observed in cv. Kristina. Cultivar Aleda and cv. Master (7.96 and 7.88 cm) were at par. Cultivar Vienna recorded significantly lowest flower diameter (7.31 cm).

The interaction between cultivars and fertigation levels on flower diameter was significant. Highest flower diameter (8.20 cm) was observed in cv. Kristina with F_3 fertigation, which was on par with cv. Kristina with F_2 fertigation, cv. Kristina with F_1 fertigation, Master with F_3 fertigation, cv. Aleda with F_1 fertigation and cv. Aleda with F_2 fertigation (8.13, 8.07, 8.07, 8.03 and 8.00 cm). The lowest flower diameter (7.27 cm) was recorded in cv. Vienna with F_1 fertigation, which was on par with Vienna with F_1 and F_2 fertigation(7.27 and 7.43 cm).

4.12.4 Stem length at harvest

The data pertaining to the stem length of different carnation cultivars at harvest as influenced by fertigation levels and their interaction are presented in Table 12.

The fertigation levels differed significantly in their stem length at harvest. Significantly highest stem length (89.13 cm) at harvest was recorded in F_3 fertigation followed by F_2 fertigation (87.36 cm). Significantly lowest (85.49 cm) stem length at harvest was recorded in F_1 fertigation (Fig. 8).

Plate 15 : Stem length at harvest of cv. Master influenced by fertigation

Plate 16 : Stem length at harvest of cv. Kristina influenced by fertigation

Plate 17 : Stem length at harvest of cv. Aleda influenced by fertigation

Plate 15

Plate 17

Cultivar differed significantly on their stem length at harvest. Significantly highest stem length (93.62 cm) was recorded in cv. Aleda than other cultivars where as cultivar Vienna recorded significantly lowest stem length (77.98 cm) at harvest (Fig. 8 and Plate 15 to 17).

In interaction effect, highest stem length was recorded in Aleda with F_3 (95.83 cm) followed by Master with F_2 (93.73 dm) and were at par. Master with F_2, Aleda with F_2, Aleda with F_1 and Master with F_3 fertigation (93.73, 92.67, 92.37 and 91.67 cm) wer at par. The lowest (74.20 cm) was in Vienna with F_1 which was on par with Vienna with F_2 fertigation (77.03 cm).

4.12.5 Stem girth at harvest

The fertigation levels and interaction effect between cultivars and fertigation levels on stem girth at harvest had non-significant difference (Table 12).

Cultivar differed significantly in their stem girth at harvest. The highest stem girth (0.89 cm) was recorded in cv. Aleda, which was on par with cv. Kristina (0.87 cm) and cv. Master (0.83 cm). Significantly lowest stem girth (0.63 cm) was recorded in cv. Vienna.

4.13 Yield parameters

4.13.1 Number of petals per flower

The data pertaining to the number of petals per flower of different carnation cultivars as influenced by fertigation levels and their interaction are presented in Table 13.

Table 13 : Number of petals per flower, number of flower per m^2 and per hectare of carnation cultivars as influenced by fertigation and their interaction (second season crop)

Treatments	Number of petals per flower	Number of flowers per m^2	per hectare thousands
Fertigation levels (F)			
F_1	76.91	156.00	1100.75
F_2	77.65	158.58	1103.08
F_3	81.43	162.16	1132.83
SEm±	1.42	0.35	2.71
C.D. at 5 %	NS	1.37	10.63
Cultivar (C)			
Kristina (K)	91.57	169.77	1188.44
Aleda (A)	75.57	160.22	1121.56
Master (M)	76.93	170.66	1195.44
Vienna (V)	79.77	134.77	943.44
SEm±	1.36	0.50	3.34
C.D. at 5 %	4.03	1.47	9.92
C x F			
KF_1	90.83	167.66	1175.67
AF_1	73.90	156.33	1094.31
MF_1	75.43	170.66	1194.62
VF_1	67.47	129.33	905.33
KF_2	88.80	170.64	1194.48
AF_2	75.10	159.33	1115.33
MF_2	73.30	170.66	1194.62
VF_2	73.40	133.66	935.62
KF_3	94.50	171.00	1197.00
AF_3	77.70	165.00	1155.00
MF_3	82.07	171.33	1199.37
VF_3	71.43	141.33	989.30
SEm±	2.48	0.82	5.69
C.D. at 5%	NS	2.58	18.14

F_1 - 80 % of the recommended fertilizer (g/m^2/week)
F_2 - Recommended fertilizer, During rest period (30 days)
N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55
from rest period to until harvesting start,
N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51
During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50
F_3 - 120 % of the recommended fertilizer
NS - Non-significant

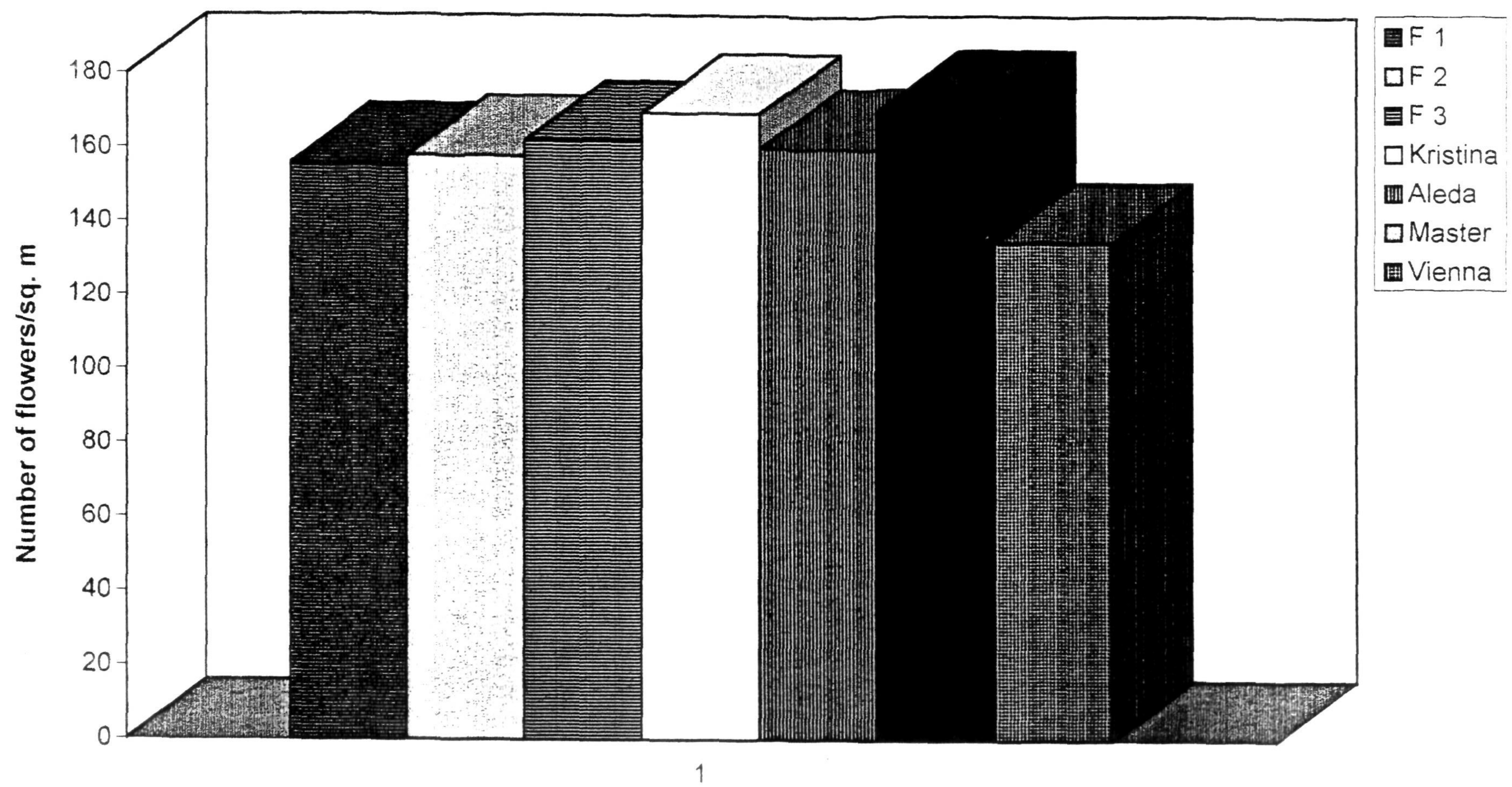

Fig. 9 : Number of flowers per square metre in fertigation levels and carnation cultivars

The fertigation levels and interaction effect between cultivars and fertigation levels on number of petals per flower was non-significant.

Cultivar differed significantly in their number of petals per flower. Significantly highest number of petals per flower (91.57) were recorded in cv. Kristina. Cultivar Master and cv. Aleda (76.93 and 75.57) were at par Significantly lowest number of petals per flower (70.77) was in cv. Vienna.

4.13.2 Number of flowers per square metre

The data data on the number of flowers per square metre of different carnation cultivars as influenced by fertigation levels and their interaction are presented in Table 13.

The fertigation levels differed significantly in number of flowers per square metre. Significantly highest number of flowers were recorded in F3 fertigation (162.16) followed by F2 fertigation (158.58) the differences between them being significant. Significantly lowest number of flowers were recorded in F1 fertigation (156.00) (Fig. 9).

The cultivars differed significantly in the number of flowers per square metre. Cultivar Master recorded highest number of flower (170.66), which was on par with cv. Kristina (169.77). Significantly lowest number of flowers (134.77) was in cv. Vienna than other cultivars (Fig. 9).

In Interaction effect on number of flower per square metre was significant. Highest (171.33) number of flowers were recorded in cv. Master with F_3 fertigation followed by with cv. Kristina with F_3 fertigation cv. Master with F_1 fertigation, Master with F_2 and cv. Kristina with F_2 fertigation (171.00, 170.66, 170.66, and 170.64) and they were at par. Significantly lowest number of flowers (129.33) were recorded in cultivar Vienna with F_1 fertigation.

4.13.3 Number of flowers per hectare

Data pertaining to number of flowers per hectare of different carnation cultivars as influenced by fertigation levels and their interaction are presented in Table 13.

The fertigation levels differed significantly in number of flowers per hectare. Significantly highest number of flowers were recorded in F_3 fertigation (1132.83 thousands). F_2 and F_1 fertigation (1103.08 and 1100.75 thousands) and were at par.

The cultivar differed significantly in their number of flowers per hectare. Highest number of flowers per hectare (1195.44 thousand) was recorded in cv. Master, which was on par with cv. Kristina (1188.88 thousands) . The significantly lowest number of flowers per hectare (943.44 thousands) was recorded in cv. Vienna.

The interaction effect between cultivar and fertigation levels on number of flowers per hectare was significant. Highest number of flowers per hectare (1199.31 thousands) was recorded in cv. Master with F_3 fertigation, which was on par with cv. Kristina with F_3 fertigation, Master with F_2 fertigation, Master with F_1 fertigation, and Kristina with F_2 fertigation, (1197.00, 1194.48, 1194.62 and 1194.62 thousands). Significantly lowest yield was recorded in cv. Vienna with F_1 fertigation (905.33 thousands).

4.13.4 Yield of flowers per square metre

The data regard to yield of carnation flowers per square metre of different carnation cultivars as influenced by fertigation levels and their interaction are presented in Table 14.

Table 14 : Yield of flowers of carnation cultivars as influenced by fertigation and their interaction (second season crop)

Treatments	Yield of flower	
	(Kg/m^2)	(t/ha)
Fertigation levels (F)		
F_1	4.13	28.91
F_2	4.17	29.19
F_3	4.25	29.75
SEm±	0.01	0.04
C.D. at 5 %	0.02	0.15
Cultivar (C)		
Kristina (K)	4.59	32.13
Aleda (A)	4.38	30.66
Master (M)	4.59	32.13
Vienna (V)	3.10	21.70
SEm±	0.01	0.08
C.D. at 5 %	0.04	0.25
C x F		
KF_1	4.63	32.41
AF_1	4.35	30.45
MF_1	4.58	32.06
VF_1	2.98	20.86
KF_2	4.52	31.64
AF_2	4.28	29.96
MF_2	4.59	32.13
VF_2	3.06	21.42
KF_3	4.59	32.13
AF_3	4.38	30.16
MF_3	4.61	32.27
VF_3	3.10	21.19
SEm±	0.02	0.13
C.D. at 5%	0.06	0.41

F_1 - 80 % of the recommended fertilizer (g/m^2/week)
F_2 - Recommended fertilizer, During rest period (30 days)
N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55
from rest period to until harvesting start,
N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51
During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50
F_3 - 120 % of the recommended fertilizer
NS - Non-significant

Fertigation levels differ significantly in the yield of flowers per square metre. Significantly highest yield was recorded in F3 fertigation (4.25 kg/m^2) than other levels of fertigation.. The Significantly lowest yield was recorded in F_1 fertigation (4.13 kg/ha).

Cultivar differed significantly in their yield of flowers per square metre. Significantly highest yield was recorded in cv. Master and cv. Kristina (4.59 and 4.59 kg/ha) followed by cv. Aleda (4.38 kg/ha). Cultivar Vienna recorded significantly lowest yield (3.10 kg/ha).

Interaction effect between cultivars and fertigation levels on yield of flowers per square meter. was significant. Highest yield was recorded in cv. Kristina with F_1 fertigation (4.63 kg/m^2), which was on par with cv. Master with F_3 fertigation. Kristina with F_3 fertigation Master with F_2 and Master with F_1 fertigation (4.61, 4.59, 4.59 and 4.58 kg/m^2 respectively). Significantly lowest yield was recorded in cv. Vienna with F_1 fertigation (2.98 kg/m^2) than other interaction.

4.13.5 Yield of flower per hectare

The data pertaining to yield of flowers (kg/ha) of different carnation cultivars as influenced by fertigation levels and their interaction are presented in Table 14.

Fertigation levels differed significantly in the yield of flowers per hectare. Significantly highest yield was recorded in F_3 fertigation (29.75 t/ha) than other levels of fertigation. Significantly lowest yield was in F_1 fertigation (28.91 t/ha).

Cultivar differed significantly in their yield of flowers per hectare. Highest yield was recorded in cv. Master and Kristina (32.13 and 32.13 t/ha) followed by cv. Aleda (30.66 t/ha). Cultivar Vienna recorded significantly lowest yield (21.70 t/ha).

In interaction effect between cultivars and fertigation levels on flower yield per hectare was significant. Highest yield (32.41t/ha) was recorded in cv. Kristina with F_1 fertigation, which was on par with cv. Master with F_2 fertigation and Kristina with F_3 fertigation (32.13 and 32.13 t/ha respectively). Significantly lowest yield (20.86 t/ha) was in cv. Vienna with F_1 fertigation.

4.13.6 Calyx splitting

The fertigation levels had no significant influence on calyx splitting (Table 15).

The cultivar Master recorded less calyx splitting (0.91 %), which was on par with cv. Kristina (0.92 %). Significantly highest (1.75 %) calyx splitting was in cv. Vienna.

The interaction effect between cultivars and fertigation levels on calyx splitting was significant. Lowest calyx splitting was recorded in cv. Kristina with F_2 fertigation (0.60 %), which was on par with cv. Master with F_3 fertigation, Master with F_1 fertigation and Kristian with F_1 fertigation (0.78, 0.98 and 0.98 %). The incidence of calyx splitting was found to be significantly highest in cv. Vienna with F_1 fertigation (2.32 %).

4.13.7 Marketable flowers

The fertigation levels had no significant influence as marketable flowers (Table 15).

Table 15 : Calyx splitting, marketable and unmarketable flowers of carnation cultivars as influenced by fertigation and their interaction (second season crop)

Treatments	Calyx splitting	Marketable flowers	Unmarketable flowers
	Percentage		
Fertigation levels (F)			
F_1	1.39	90.54	9.47
F_2	1.15	91.48	8.52
F_3	1.14	92.74	7.26
SEm±	0.08	0.50	0.49
C.D. at 5 %	NS	NS	NS
Cultivar (C)			
Kristina (K)	0.92	94.36	5.64
Aleda (A)	1.32	91.73	8.27
Master (M)	0.91	95.18	4.82
Vienna (V)	1.75	85.07	14.93
SEm±	0.09	0.64	0.64
C.D. at 5 %	0.26	1.91	1.91
C x F			
KF_1	0.98	93.04	6.96
AF_1	1.46	92.53	7.47
MF_1	0.98	95.52	4.48
VF_1	2.32	81.04	18.96
KF_2	0.60	93.74	6.26
AF_2	1.28	93.96	6.04
MF_2	0.98	94.54	5.46
VF_2	1.75	83.70	16.31
KF_3	1.17	96.28	3.72
AF_3	1.21	88.70	11.30
MF_3	0.78	95.50	4.51
VF_3	1.18	90.48	9.52
SEm±	0.16	1.08	1.08
C.D. at 5%	0.51	3.43	3.43

F_1 - 80 % of the recommended fertilizer (g/m^2/week)
F_2 - Recommended fertilizer, During rest period (30 days)
N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55
from rest period to until harvesting start,
N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51
During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50
F_3 - 120 % of the recommended fertilizer
NS - Non-significant

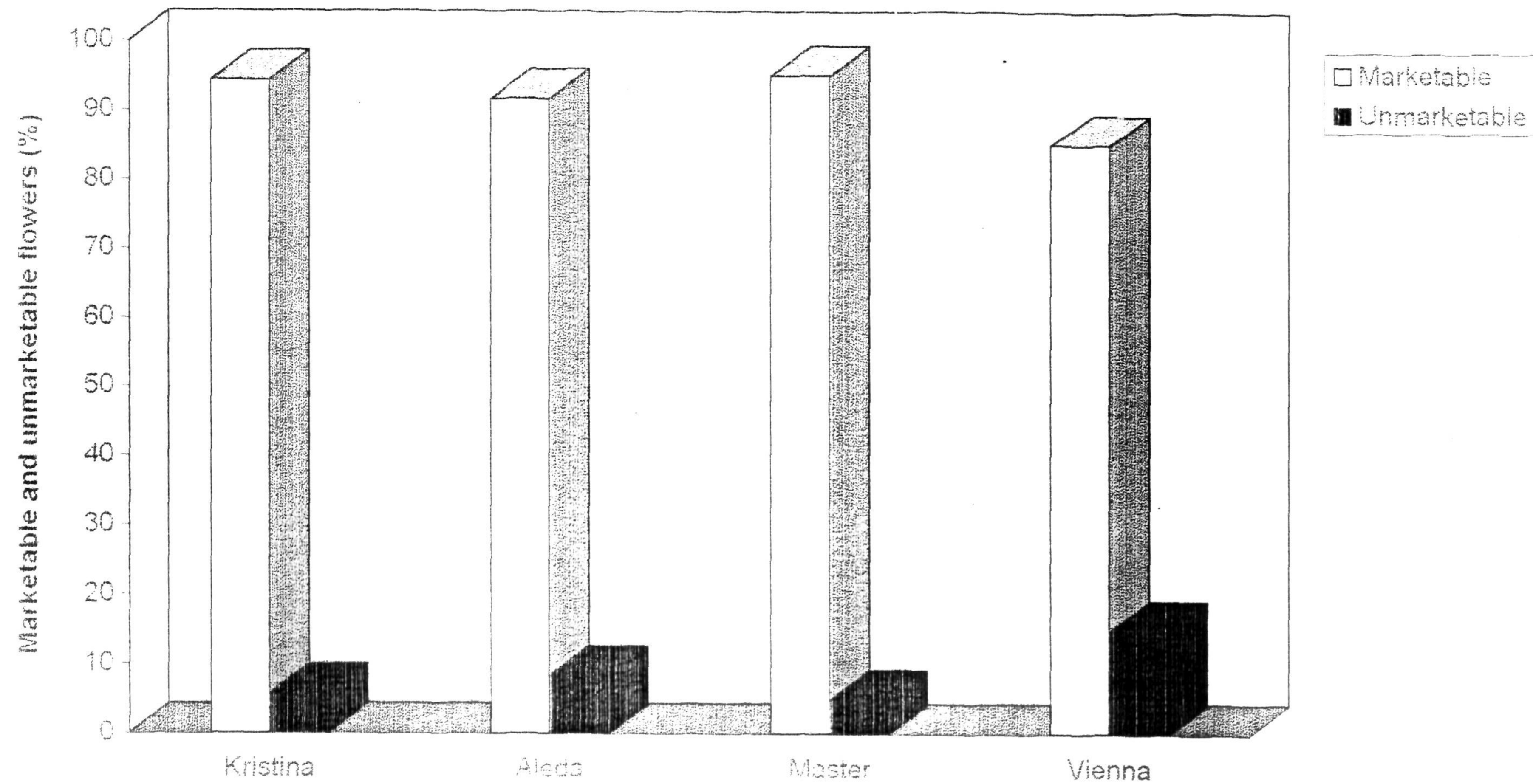

Fig. 10 : Marketable and unmarketable flowers in carnation cultivars

The cultivar Master recorded the highest marketable flowers (95.18%), which was on par with cv. Kristina (94.36 %). Significantly less marketable flowers (85.07%) was in cv. Vienna.(Fig 10)

The interaction effect had significant influence on marketable flowers. The highest marketable flowers (96.28 %) was recorded in cv. Kristina with F_3 fertigation, which was on par with cv. Master with F_1 fertigation Master with F_3 fertigation, Master with F_2 fertigation, Aleda with F_2 fertigation Kristina with F_2 fertigation and Kristina with F_1 fertigation (95.52, 95.50, 94.54, 93.96 93.74 and 93.04 %). Less marketable flowers was recorded in cv. Vienna with F_1 fertigation (81.04 %), which was on par with cv. Vienna with F_2 fertigation (83.70 %).

4.13.8 Unmarketable flowers

The fertigation levels had no significant influence on unmarketable flowers (Table 15).

The cultivar differed significantly in their per cent unmarketable flowers. Lowest unmarketable flowers (4.82 %) was recorded in cv. Master, which was on par with cv. Kristina (5.64%) followed by cv. Aleda (8.27%). Cultivar Vienna recorded significantly more unmarketable flowers (14.93%) (Fig 10)

The interaction effect on percent unmarketable flowers was significant. The lowest unmarketable flowers (3.72%) was recorded in cv. Kristina with F_3 fertigation, which was on par with cv. Master with F_3 fertigation, cv. Master with F_2 fertigation, Kristina with F_2 fertigation and cv. Kristina with F_1 fertigation (4.51, 5.46, 6.26 and 6.96 %). Significantly highest unmarketable flowers (18.96%) was recorded in cv. Vienna with F_1 fertigation, which was on par with cv. Vienna with F_2 fertigation (16.31%).

Table 16 : Mortality rate of carnation cultivars as influenced by fertigation and their interaction (second season crop)

Treatments	Mortality rate (%)
Fertigation levels (F)	
F_1	6.48
F_2	6.48
F_3	5.09
SEm±	0.49
C.D. at 5 %	NS
Cultivar (C)	
Kristina (K)	4.32
Aleda (A)	8.02
Master (M)	4.63
Vienna (V)	7.10
SEm±	0.62
C.D. at 5 %	1.83
C x F	
KF_1	3.70
AF_1	9.20
MF_1	4.63
VF_1	8.33
KF_2	4.63
AF_2	9.26
MF_2	4.63
VF_2	7.41
KF_3	4.63
AF_3	5.56
MF_3	4.63
VF_3	5.56
SEm±	1.05
C.D. at 5%	NS

F_1 - 80 % of the recommended fertilizer (g/m^2/week)
F_2 - Recommended fertilizer, During rest period (30 days)
N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55
from rest period to until harvesting start,
N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51
During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50
F_3 - 120 % of the recommended fertilizer
NS - Non-significant

4.13.9 Mortality rate

Data on the pertaining to the mortality rate in different cultivars as influenced by fertigation and their interaction are presented in Table 16.

The fertigation levels and interaction effect between cultivars and fertigation levels had no significant influence on percent mortality (Table 16).

Cultivar differed significantly in the mortality. Highest mortality (8.02%) was observed in cv. Aleda, which was on par with cv. Vienna (7.10%). Less mortality (4.32%) was observed in cv. Kristina which was on par with cv. Master (4.63%).

4.14 Vase life of flower

The data regarding on the effect of chemical preservatives, fertigation cultivars and their interactions on number of days taken for bud opening (From flowers kept in solution), number of days stay in solution and cumulative fresh weight are presented in Table 17a, 17b, 18a, 18b, 19a, 19b respectively.

4.14.1 Number of days taken for bud opening

. Preservatives had a significant effect on number of days taken for bud opening. Significnatly highest number of days taken for bud opening was in T2, T1 and T4 preservatives (6.67, 6.58 and 6.53) which were at par. Lowest

Table 17a : Effect of chemical preservatives, fertigation, cultivars and their interactions on number of days taken for flower bud opening (second season crop)

Treatments	F_1	F_2	F_3	Mean
Cultivars (c)				
Kristina	6.04	6.08	6.12	6.10
Aleda	6.10	6.08	6.25	6.10
Master	6.20	6.23	6.33	6.25
Vienna	6.14	6.15	6.20	6.16
Fertigation mean (F)	6.12	6.10	6.24	
Preservatives (T)				
T_1 (5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	6.42	6.50	6.83	6.58
T_2 (7.5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	6.58	6.67	6.75	6.67
T_3 (5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	6.08	6.17	6.42	6.22
T_4 (7.5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	6.42	6.50	6.67	6.53
T_5 (5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	6.00	6.00	6.25	6.08
T_6 (7.5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	6.33	6.25	6.25	6.28
T_7 Deionized water	5.08	5.42	5.50	5.33
T_8 Tap water	5.00	5.08	5.25	5.11
	Kristina	Aleda	Master	Vienna
Preservatives (T)				
T_1 (5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	6.78	6.44	6.67	6.44
T_2 (7.5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	6.67	6.67	6.78	6.56
T_3 (5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	6.33	6.33	6.11	6.61
T_4 (7.5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	6.44	6.56	6.67	6.44
T_5 (5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	6.00	6.11	6.11	6.11
T_6 (7.5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	6.33	6.33	6.33	6.11
T_7 Deionized water	5.22	5.22	5.86	5.53
T_8 Tap water	5.00	5.11	5.41	5.48

	SEm±	CD at 5 %
C	0.06	NS
F	0.05	NS
T	0.08	0.22
C x F	0.10	NS
C xT	0.16	NS
F x T	0.14	NS

F_1 - 80 % of the recommended fertilizer (g/m^2/week)
F_2 - Recommended fertilizer, During rest period (30 days)
N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55
from rest period to until harvesting start,
N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51
During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50
F_3 - 120 % of the recommended fertilizer
NS - Non-significant
fl = Flower

Table 17b : Effect of chemical preservatives, fertigation, cultivars and their interactions on number of days taken for flower bud opening (second season crop)

	Kristina			Aleda			Master			Vienna		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
T_1	7.00	7.00	7.33	7.00	7.00	7.00	7.33	7.33	8.00	6.68	6.68	7.33
T_2	7.00	7.00	7.00	7.00	7.00	7.00	7.33	7.00	7.00	6.68	6.68	6.68
T_3	6.68	6.33	6.33	6.68	6.68	6.68	6.68	6.68	6.33	6.68	6.33	6.33
T_4	6.33	6.68	6.33	6.33	6.33	6.33	6.33	6.68	6.33	6.33	6.33	6.68
T_5	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.33	6.00	6.00	6.00	6.00
T_6	6.33	6.33	6.00	6.00	6.00	6.00	6.33	3.00	6.00	6.00	6.00	6.00
T_7	5.33	5.33	5.68	5.33	5.33	5.68	5.33	5.33	6.00	5.00	5.00	5.00
T_8	5.33	5.33	5.33	5.33	5.33	5.33	5.68	5.68	5.33	5.00	5.00	5.00

	SEm=	CD at 5%
T x F x C	0.29	NS

Plate 18 : Vase life of flower (11 days after harvest) cv. Master as influenced by preservatives

Plate 19 : Vase life of flower (11 days after harvest) cv. Kristina as influenced by preservatives

Plate 20 : Vase life of flower (11 days after harvest) cv. Aleda as influenced by preservatives

Plate 21 : Vase life of flower (11 days after harvest) cv. Vienna as influenced by preservatives

Plate 18

Plate 21

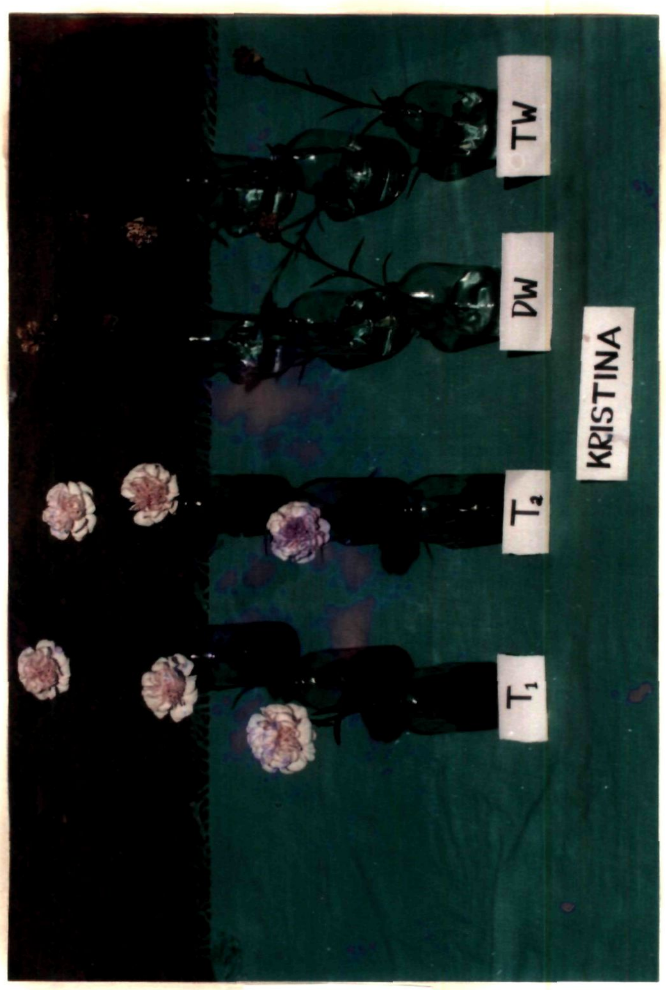

Plate 19

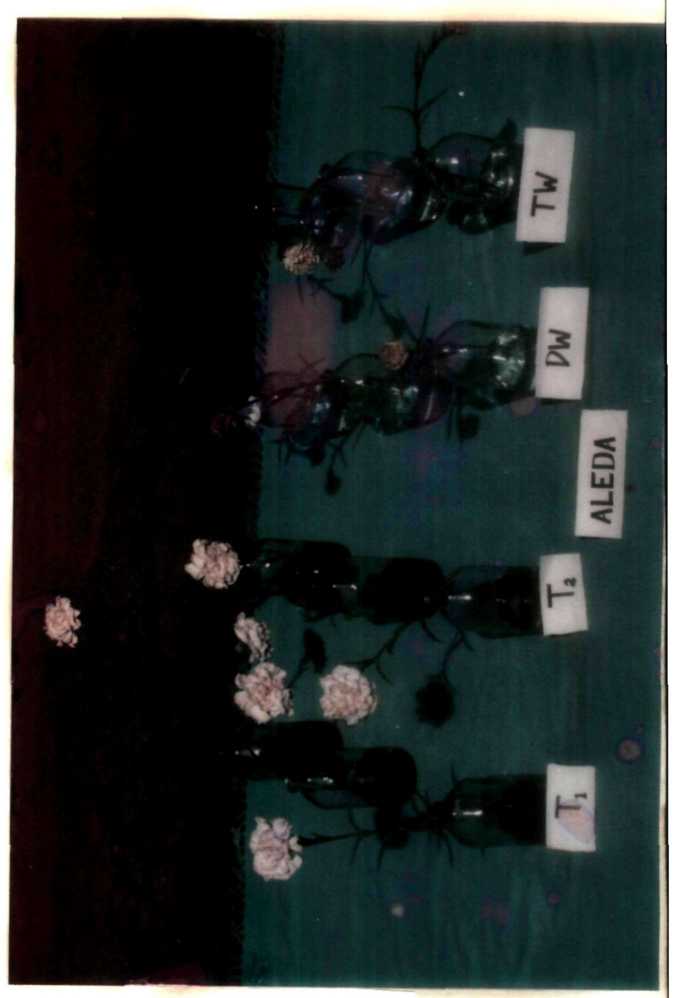

Plate 20

number of days was taken for bud opening was in tap water (5.11), which was on par with deionized water (5.33).

Cultivars, fertigation, cultivars and fertigation, cultivars and preservatives and fertigation and preservatives did not differ significantly on number of days taken for bud opening (Table 17a and 17b).

4.14.2 Vase life of flowers in days

The data on to effect of chemical preservatives, fertigation cultivars and their interaction on vase life are presented in Table 18.

Fertigation levels showed significant differences in vase life of flowers. Significantly longest vase life (9.51 days) was in F_3 fertigation, which was significantly superior to F_2 (9.24 days) and F_1 fertigation (9.05 days). (Fig.11).

Amongst the cultivars Master showed Significnatly longest (9.60 days) vase life of flowers Kristina and Aleda (9.35 and 9.25 days) were at par. Cultivar Vienna recorded significantly shortest (8.88 days) vase life (Fig.11).

Preservatives differed significantly in the vase life of flowers. Highest vase life (11.22 days) was recorded in T_2, which was on par with T_1 preservative (11.11 days). Significnatly shortest vase life of flower was in tap water and deionized water (5.88 and 6.33 days) (Fig. 11 and Plate 18 to 21).

Table 18a : Effect of chemical preservatives, fertigation, cultivars and their interactions on vase life of flower (second season crop)

Treatments	F_1	F_2	F_3	Mean
Cultivars (c)				
Kristina	9.17	9.29	9.58	9.35
Aleda	9.00	9.25	9.50	9.25
Master	9.42	9.58	9.79	9.60
Vienna	8.63	8.83	9.17	8.88
Fertigation mean (F)	9.05	9.24	9.51	
Preservatives (T)				
T_1 (5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	**10.83**	**11.08**	**11.42**	**11.11**
T_2 (7.5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	**10.92**	**11.17**	**11.58**	**11.22**
T_3 (5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	**9.83**	**9.83**	**10.25**	**9.97**
T_4 (7.5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	10.17	10.25	10.67	10.36
T_5 (5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	9.25	9.67	9.92	9.61
T_6 (7.5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	9.58	9.75	9.58	9.63
T_7 Deionized water	9.17	6.33	6.50	6.33
T_8 Tap water	5.67	5.83	6.17	5.88
	Kristina	Aleda	Master	Vienna
Preservatives (T)				
T_1 (5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	11.53	11.00	11.44	10.67
T_2 (7.5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	11.33	11.11	11.56	10.89
T_3 (5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	10.11	9.78	10.44	9.56
T_4 (7.5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	10.33	10.44	10.56	10.11
T_5 (5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	9.78	9.56	10.00	9.11
T_6 (7.5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	9.44	9.56	10.00	9.56
T_7 Deionized water	6.44	6.56	6.67	5.67
T_8 Tap water	6.00	6.00	6.11	5.44
	SEm±		CD at 5 %	
C	0.07		0.19	
F	0.06		0.16	
T	0.1		0.27	
C x F	0.12		NS	
C x T	0.19		NS	
F x T	0.17		NS	

F_1 - 80 % of the recommended fertilizer (g/m^2/week)

F_2 - Recommended fertilizer. During rest period (30 days)

N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55

from rest period to until harvesting start,

N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51

During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50

F_3 - 120 % of the recommended fertilizer

NS - Non-significant

fl = Flower

Table 18b : Effect of chemical preservatives, fertigation, cultivars and their interactions on vase life of flower (second season crop)

	Kristina			Aleda			Master			Vienna		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
T_1	11.00	11.33	11.68	10.68	11.00	11.33	11.33	11.33	11.68	10.33	10.68	11.00
T_2	11.00	11.33	11.68	10.68	11.00	11.68	11.33	11.68	11.68	10.68	10.68	11.33
T_3	10.00	10.00	10.33	9.68	9.68	10.00	10.33	10.33	10.68	9.33	9.33	10.00
T_4	10.33	10.00	10.68	10.33	10.33	10.68	10.33	10.33	11.00	9.68	10.33	10.33
T_5	9.33	10.00	10.00	9.00	9.68	10.00	9.68	10.00	10.33	9.00	9.00	9.33
T_6	9.68	9.33	9.33	9.68	9.68	9.33	9.68	10.33	10.00	9.33	9.68	9.68
T_7	6.33	6.33	6.68	6.33	6.68	6.68	6.68	6.68	6.68	5.33	5.68	6.00
T_8	5.68	6.00	6.33	5.68	6.00	6.33	6.00	6.00	6.33	5.33	5.33	5.68

	SEm±	CD at 5%
T x F x C	0.33	NS

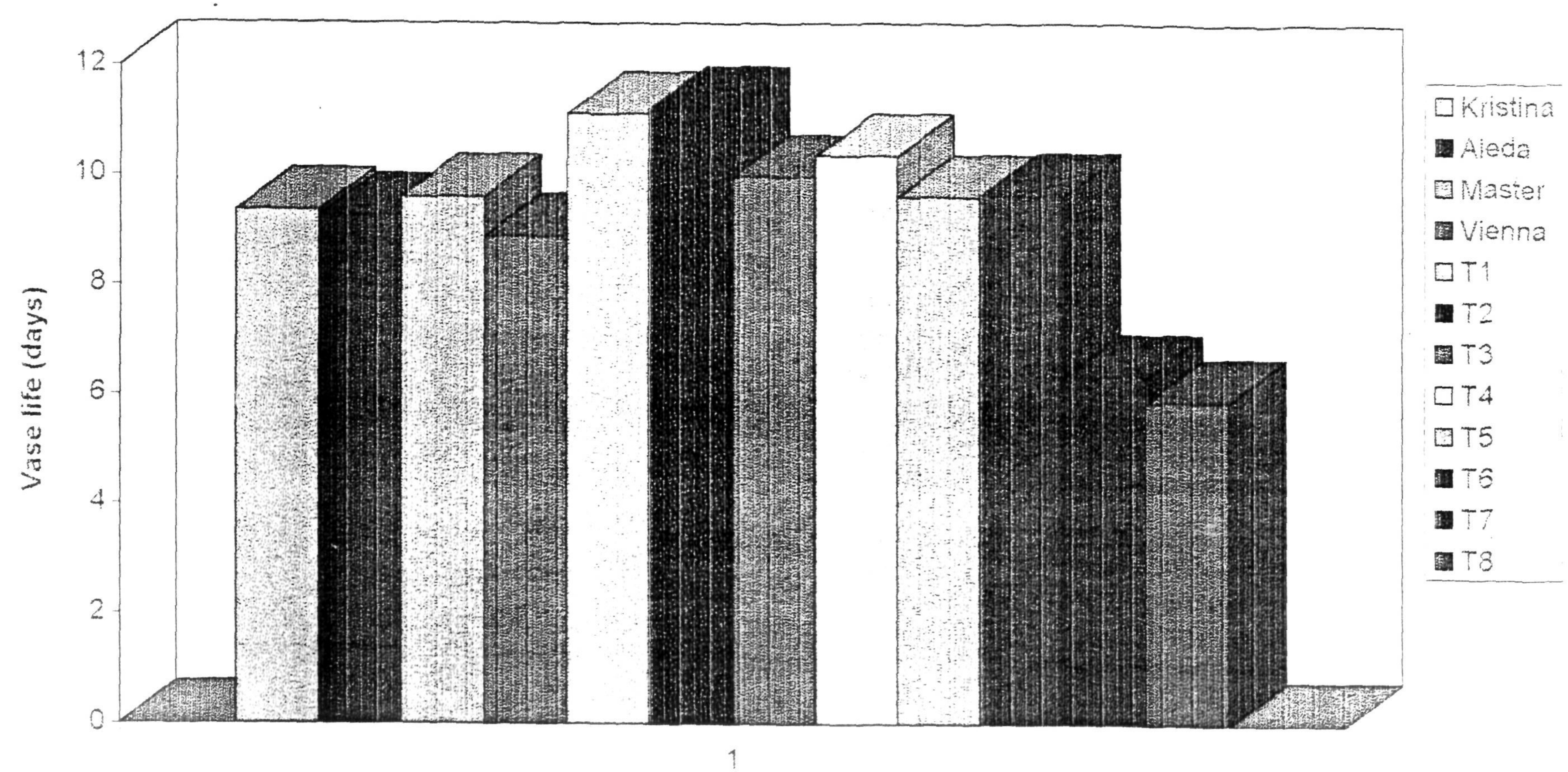

Fig. 11 : **Effect** of cultivars and preservatives on vase life of flowers

Interactions did not differ significantly on vase life of flower (Table 18a and 18b).

4.14.3 Cumulative fresh weight (CFW) of flower

The data on effect of chemical preservatives, fertigation cultivar and their interactions on cumulative fresh weight are presented in Table 19a and 19b.

Fertigation levels showed significant differences in CFW. Significantly highest CFW (116.40 g/flower) was in F_3 fertigation followed by F_2 (114.43 g/flower) differences between them being significantly. F_1 fertigation recorded significnatly lowest (112.35 g/flower) CFW.

Cultivars differed Significnatly in their CFW. Significantly highest CFW (120.33 g/flower) was in Aleda Master and Kristina (114.88 and 113.91 g/flower) and were at par. Cultivar Vienna recorded significantly lowest CFW (108.45 g/flower).

Preservatives had a significant effect on the CFW of flower. Highest CFW (131.26 g/flower) was recorded in T_1 preservative, which was on par with T_2 preservative (129.90 g/flower) followed T_3 preservatives (124.35 g/flower) and differences between them being significant. T_4 and T_5 preservatives (121.94 and 121.76 g/flower) were at par. Lowest CFW was recorded in

Table 19a : Effect of chemical preservatives, fertigation, cultivars and their interactions on cumulative fresh weight (g/flower) (second season crop)

Treatments	F_1	F_2	F_3	Mean
Cultivars (c)				
Kristina	111.23	114.65	115.85	113.91
Aleda	118.07	120.33	122.58	120.93
Master	112.75	114.71	117.17	114.88
Vienna	107.35	108.01	110.00	108.45
Fertigation mean (F)	112.35	114.43	116.40	
Preservatives (T)				
T_1 (5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	**128.54**	**131.03**	**134.21**	**131.26**
T_2 (7.5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	127.25	129.67	132.79	129.90
T_3 (5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	120.60	125.02	127.42	124.35
T_4 (7.5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	120.17	121.33	124.33	121.94
T_5 (5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	121.42	121.25	122.63	121.76
T_6 (7.5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	116.67	118.25	119.21	118.04
T_7 Deionized water	87.71	85.68	86.15	84.44
T_8 Tap water	81.46	83.19	84.47	85.03
	Kristina	Aleda	Master	Vienna
Preservatives (T)				
T_1 (5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	131.61	138.44	132.33	122.66
T_2 (7.5% sucrose + 50ppm $AgNO_3$ + 300ppm HQS)	129.17	137.00	130.50	122.94
T_3 (5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	122.28	131.13	125.33	118.64
T_4 (7.5% sucrose + 60ppm $AgNO_3$ + 300ppm HQS)	118.17	128.61	123.72	117.28
T_5 (5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	121.17	128.83	121.44	115.61
T_6 (7.5% sucrose + 40ppm $AgNO_3$ + 300ppm HQS)	115.44	124.00	118.28	114.44
T_7 Deionized water	86.67	89.06	84.76	78.90
T_8 Tap water	86.80	85.56	82.64	77.16
	SEm±		CD at 5 %	
C	0.37		1.02	
F	0.32		0.88	
T	0.52		1.44	
C x F	0.64		NS	
C x T	1.04		2.88	
F x T	0.9		NS	

F_1 - 80 % of the recommended fertilizer (g/m^2/week)

F_2 - Recommended fertilizer, During rest period (30 days)

N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55

from rest period to until harvesting start,

N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51

During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50

F_3 - 120 % of the recommended fertilizer

NS - Non-significant

fl = Flower

Table 19b : Effect of chemical preservatives, fertigation, cultivars and their interactions on cumulative fresh weight (g/flower) (second season crop)

	Kristina			Aleda			Master			Vienna		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
T_1	129.68	123.68	132.50	135.68	137.50	142.17	129.17	131.17	136.68	119.68	112.80	125.50
T_2	123.33	130.33	133.83	136.83	136.17	138.00	128.68	129.83	133.00	120.00	112.83	126.33
T_3	115.68	125.00	126.17	125.90	131.68	135.83	123.00	125.33	127.68	117.83	118.08	120.00
T_4	116.17	116.83	121.50	125.68	128.83	131.33	121.50	124.00	125.67	117.33	115.68	118.84
T_5	123.17	120.68	119.68	128.00	128.00	130.50	119.00	121.17	124.17	115.50	115.17	116.17
T_6	113.50	116.50	116.33	122.68	124.00	125.33	116.17	118.33	120.33	114.33	114.17	114.84
T_7	84.17	88.50	87.33	86.50	89.83	90.83	82.83	85.33	86.10	77.33	79.03	80.33
T_8	84.17	86.73	89.50	83.33	86.68	86.68	81.68	82.53	83.73	76.68	76.84	77.97

	SEm=	CD at 5%
T x F x C	1.80	NS

deionized water (84.44 g/flower), which was on par with tap water (85.03 g/flower).

Interaction between cultivars and preservatives showed significant effect on CFW. Highest CFW (138.44 g/flower) was recorded in T_1A, which was on par with T_2A (137.00 g/flower). T_1M, T_1K, T_3A, T_2M and T_2K (132.33, 131.61, 131,13, 130.50 and 129.17) were at par. T_2M, T_2K and T_5A (13.50, 129.17 and 128.83 g/flower) were also at par. The lowest CFW (77.16 g/flower) was in T_8V, which was on par with T_7V (78.90 g/flower).

Interaction between cultivar and fertigation, fertigation and preservatives and fertigation, cultivar and preservatives had no significant influence on CFW of flower (Table 19a and 19b).

4.15 Dry weight of plant

4.15.1 Dry matter production per hactare

The data pertaining to dry matter production as influenced by fertigation levels, cultivars and their interaction are presented in Table 20.

Significant differences were observed to varying levels of fertigation in respect of dry matter production. The highest dry matter production (9350.83 kg/ha) was recorded in F_3 fertigation, which was on par with F_2 (9135.00 kg/ha) The lowest dry matter production was recorded in F_1 fertigation

Table 20 : Effect of varying levels of fertigation, cultivars and their interaction on the dry matter production (second season crop)

Treatments	Dry matter production (Kg/ha)
Fertigation levels (F)	
F_1	8943.33
F_2	9135.00
F_3	9350.83
SEm±	55.89
C.D. at 5 %	219.41
Cultivar (C)	
Kristina (K)	9356.67
Aleda (A)	9768.81
Master (M)	9318.89
Vienna (V)	8127.78
SEm±	45.90
C.D. at 5 %	136.37
C x F	
KF_1	9170.00
AF_1	9356.67
MF_1	9220.00
VF_1	8026.67
KF_2	9356.68
AF_2	9776.68
MF_2	9263.33
VF_2	8143.33
KF_3	9543.33
AF_3	10173.33
MF_3	9473.33
VF_3	8213.33
SEm±	88.68
C.D. at 5%	297.10

F_1 - 80 % of the recommended fertilizer (g/m²/week)
F_2 - Recommended fertilizer, During rest period (30 days)
N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55
from rest period to until harvesting start,
N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51
During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50
F_3 - 120 % of the recommended fertilizer
NS - Non-significant

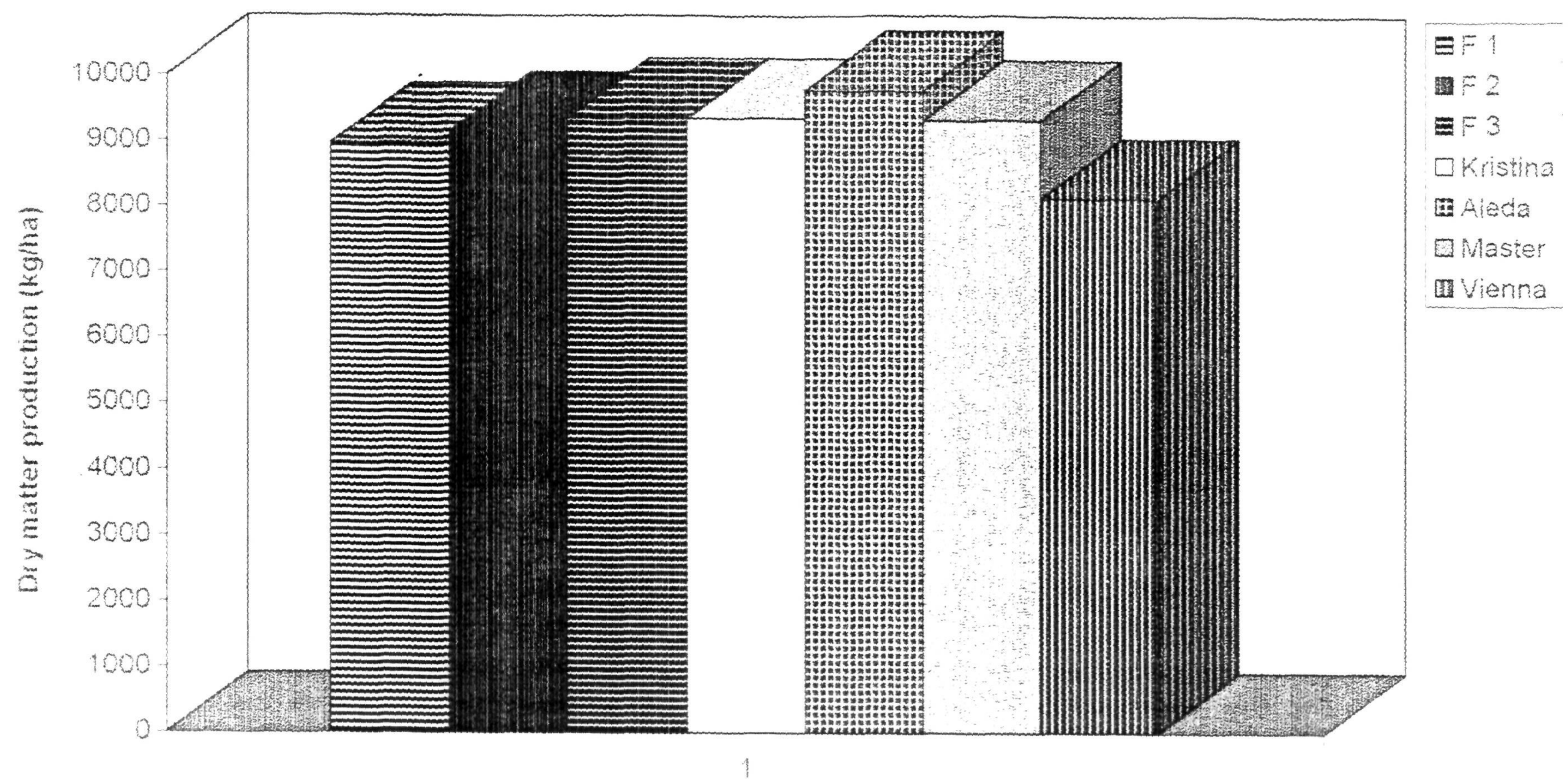

Fig. 12 : Dry matter production as influenced by fertigation levels and cultivars

(8943.33 kg/ha) which was on par to height G_2 fertigation (9135.00 kg/ha). in dry weight of plants/ha (Fig. 12).

The significantly highest dry weight (9768.89 kg/ha) was recorded in Aleda followed by Kristina and Master (9356.67 and 9318.89 kg/ha) and were at par. Cultivar Vienna recorded significantly lowest (8127.78 kg/ha) dry weight (Fig. 12).

Significant differences were observed in the interaction effect. Significantly highest dry mater production (10173.33 kg/ha) was recorded in Aleda with F_3 fertigation. Aleda with F_2 fertigation and Kristina with F_2 fertigation (9776.68, 9356.68 kg/ha and were at par. However, the dry matter production in Kristina with F_3, Master with F_3, Kristina with F_2, Aleda with F_1 and Master with F_2 fertigation (9543.33, 9473.33, 9356.68, 9356.67 and 9263.33 kg/ha) were also at par. The lowest was in Vienna with F_1 (8026.67 kg/ha), which was on par with Vienna with F_2 and Vienna with F_3 fertigation (8143.33 and 8213.33 kg/location).

4.16 Nutrient content in plant

At end of the second crop effect of varying levels of fertigation, cultivars and their interactions on the nutrient content in plant after second crop are presented in Table 21.

4.16.1 Nutrient content of N in plant:

Data on the effect of varying levels of fertigation, cultivars and their interaction on the nitrogen content in plant are presented in Table 21.

Table 21 : Efffect of varying levels of fertigation, cutivars and their interaction on the nuetrient content in plant

Treatments	Nitrogen	Phosphorous	Potassium	Calcium	Magnesium
	Nutrient content in plant (%)				
Fertigation levels (F)					
F_1	1.76	0.21	2.79	1.02	0.53
F_2	1.79	0.22	2.84	1.05	0.52
F_3	1.81	0.24	3.03	1.06	0.54
SEm±	0.01	0.01	0.04	0.01	0.01
C.D. at 5 %	0.04	0.03	0.18	NS	NS
Cultivar (C)					
Kristina (K)	1.94	0.23	3.15	1.03	0.53
Aleda (A)	1.73	0.22	3.01	1.10	0.61
Master (M)	1.63	0.21	2.84	1.10	0.50
Vienna (V)	1.82	0.22	2.54	1.00	0.50
SEm±	0.01	0.01	0.06	0.02	0.01
C.D. at 5 %	0.03	0.02	0.19	0.05	0.03
C x F					
KF_1	1.96	0.21	3.10	1.02	0.49
AF_1	1.70	0.21	2.79	1.10	0.63
MF_1	1.59	0.20	3.01	1.10	0.54
VF_1	1.79	0.22	2.26	1.00	0.50
KF_2	1.94	0.24	3.13	1.03	0.54
AF_2	1.73	0.22	2.93	1.10	0.61
MF_2	1.63	0.21	2.68	1.10	0.50
VF_2	1.83	0.23	2.63	1.00	0.50
KF_3	1.94	0.26	3.23	1.03	0.56
AF_3	1.78	0.24	3.34	1.10	0.61
MF_3	1.69	0.23	2.85	1.10	0.50
VF_3	1.87	0.23	2.72	1.00	0.50
SEm±	0.02	0.01	0.10	0.03	0.02
C.D. at 5%	NS	NS	0.33	NS	0.05

F_1 - 80 % of the recommended fertilizer (g/m^2/week)
F_2 - Recommended fertilizer, During rest period (30 days)
N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55
from rest period to until harvesting start,
N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51
During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50
F_3 - 120 % of the recommended fertilizer
NS - Non-significant

The nitrogen content of plant differed significantly to varying levels of fertigation. Highest nitrogen (1.81 %) content in plant was in F_3 fertigation, which was on par with F_2 fertigation (1.79 %). Lowest content of N (1.76 %) was in F_1 fertigation (1.76 %).

Cultivars had a significant effect on nitrogen content in plants. Significantly highest nitrogen content in plants (1.94 %) was observed in cv. Kristina, followed by Vienna (1.82 %) and Aleda (1.73 %). Significantly lowest nitrogen content was in Master (1.63%).

The interaction effect between cultivars and levels of fertigation on nitrogen content did not differ significantly. (Table 21).

4.16.2 Nutrient content of phosphorus in plant

The data on the effect of varying levels of fertigation, cultivars and their interactions in the nutrient content of phosphorus in plant are presented in Table-21.

Significant differences were not observed in the nutrient content of phosphorus to the interaction effect (Table 21)

The phosphorus content in plant differed significantly to varying levels of fertigation. Highest content of phosphorus (0.24%) was recorded in F_3 fertigation which was on par with F_2 fertigation (0.22%). Lowest content of phosphorus was in F_1 (0.21%) which was on par with F_2 fertigation (0.22%).

Amongst the cultivar, Kristina recorded highest content of P(0.23%), which was on par with Aleda and Vienna (0.22 and 0.22%). The lowest was in Master (0.21-1), which was on par with Vienna and Aleda (0.22 and 0.22%).

4.16.3 Nutrient content of potassium in plant.

The data on the effect of varying levels of fertigation, cultivars and their interaction on the potassium content in plant are presented in Table-21.

The phosphorus content of plants differ significantly to varying levels of fertigation. Significantly highest potassium content (3.03%) was in F_3 fertigation, where as F_2 and F_1 fertigation (2.84 and 2.79%) were at par.

Cultivars differed significantly in the content of potassium. Highest content of potassium (3.15%) was in Kristina which was on par with Aleda (3.01). Aleda and Master (3.01 and 2.84%) were also at par. Significantly lowest content of K was in Vienna (2.54%).

In interaction effect, highest potassium was in Aleda with F_3 fertigation (3.34%) which was on par with Kristina with F_3, Kristina with F_2, Kristina with F_1, Master with F_1 fertigation (3.23, 3.13, 3.10 and 3.01%). Kristina with F_2, Kristina with F_1, Master with F_1, Aleda with F_2, Mater with F_3 fertigation (3.13, 3.10, 3.01, 2.93 and 2.85%) were at par. Significantly lowest was in cv. Vienna with F_1 fertigation (2.26%).

4.16.4 Nutrient content of calcium in plant

The fertigation levels and interaction effect between cultivars and fertigation levels had no significant influence on calcium content in plant. (Table 21)

Cultivars differed significantly in the calcium content in plant. Cultivar Aleda and cv. Master (1.10 and 1.10%) were at par. Cultivars Kristina and Vienna (1.03 and 1.00%) were at par.

4.16.5 Nutrient content of Magnecium in plant

The fertigation levels did not show significant differences in magnecium content in plants (Table-21).

. The magnecium content in plant differed significantly in the cultivars. Aleda recorded significantly highest content of mg (0.61%). Cultivars Kristina, Master and Vienna (0.53, 0.50 and 0.50 %) were at par.

In interaction effect highest content of mg (0.63%) was in Aleda with F_1 fertigation followed by Aleda with F_3 and Aleda with F_2 fertigation (0.61 and 0.61%) and were at par. However, Aleda with F_3 Aleda with F_2 and Kristina with F_3 fertigation (0.61, 0.61 and 0.56%) were also at par. Lowest was in Kristina with F_1 fertigation (0.49%) which was on par with Vienna with F_3, Vienna with F_2, Master with F_2, Vienna with F_1 Kristina with F_2 and Master with F_1 *fertigation (0.50, 0.50, 0.50, 0.50, 0.50, 0.54 and 0.54%).*

Table 22 : Effect of varying levels of fertigation, cultivars and their interaction on the nutrient content in leaf

Treatments	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium
	Percentage				
Fertigation levels (F)					
F_1	1.82	0.32	2.93	1.05	0.57
F_2	1.84	0.28	2.99	1.10	0.59
F_3	1.86	0.29	3.12	1.12	0.57
SEm±	0.01	0.02	0.06	0.05	0.01
C.D. at 5 %	NS	NS	NS	NS	NS
Cultivar (C)					
Kristina (K)	1.98	0.36	3.29	1.10	0.54
Aleda (A)	1.79	0.27	3.14	1.17	0.69
Master (M)	1.71	0.26	2.94	1.10	0.56
Vienna (V)	1.87	0.28	2.69	0.98	0.53
SEm±	0.02	0.04	0.05	0.03	0.02
C.D. at 5 %	0.06	NS	0.14	0.10	0.05
C x F					
KF_1	1.96	0.50	3.20	1.05	0.53
AF_1	1.78	0.26	3.00	1.15	0.68
MF_1	1.69	0.25	2.90	1.09	0.54
VF_1	1.85	0.28	2.62	0.90	0.53
KF_2	1.98	0.29	3.27	1.12	0.57
AF_2	1.77	0.28	3.11	1.17	0.69
MF_2	1.70	0.26	2.94	1.10	0.57
VF_2	1.89	0.28	2.65	1.00	0.54
KF_3	2.00	0.30	3.39	1.13	0.53
AF_3	1.82	0.28	3.30	1.19	0.69
MF_3	1.74	0.27	2.98	1.12	0.56
VF_3	1.88	0.29	2.80	1.05	0.51
SEm±	0.03	0.06	0.09	0.07	0.03
C.D. at 5%	NS	NS	NS	NS	NS

F_1 - 80 % of the recommended fertilizer (g/m^2/week)
F_2 - Recommended fertilizer, During rest period (30 days)
N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55
from rest period to until harvesting start,
N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51
During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50
F_3 - 120 % of the recommended fertilizer
NS - Non-significant

4.17 Nutrient content in leaf

4.17.1 Nitrogen content (%) in leaf.

The fertigation levels and interaction effect on nitrogen content in leaf did not differ significantly (Table 22).

Cultivars differed significantly in the nitrogen content in leaf. Significantly highest nitrogen (1.98 %) content in leaf was in Kristina. Significantly lowest was in Master (1.71 %).

4.17.2 Potassium content in leaf

The fertigation levels and interaction effect had no significant influence on potassium content in leaf (Table 22).

Cultivars differed significantly on potassium content of leaf. Significantly highest content of potassium was in Kristina (3.29 %) followed by Aleda and Master (3.14 and 2.94 %). The difference amongst them being significantly lowest was in Vienna (2.69 %).

4.17.3 Calcium content in leaf

The fertigation levels and interaction effect did not show significant differences on calcium content in leaf. Among the cultivar Aleda recorded highest calcium content (1.17 %) in leaf, which was on par with Kristina and Master (1.10 and 1.10 %). Significantly lowest was in Vienna (0.98 %).

4.17.4 Magnesium content in leaf

The fertigation levels and interaction effect had no significant influence on magnesium content in leaf.

Among the cultivar Kristina recorded significantly highest magnesium content (0.69 %). Master, Kristina and Vienna (0.56, 0.54 and 0.53).

4.18 Nutrient uptake by plant

Effect of varying levels of fertigation, cultivars and their interaction on the nutrient uptake by plant are presented Table 23.

4.18.1 Nitrogen uptake

The data on the effect of varying levels of fertigation, cultivars and their interaction, cultivars and their interaction on the uptake of nitrogen are furnished in Table 23.

The uptake of nitrogen by plants differed significantly to the varying levels of fertigation. Significantly highest nitrogen uptake on plants (170.21 kg/ha) was recorded in F_3 fertigation than other fertigation levels. F_1 fertigation recorded significantly lowest nitrogen uptake (157.06 kg/ha) (Fig. 13).

Amongst cultivar Kristina recorded significantly highest nitrogen uptake (182.47 kg/ha) followed by Aleda (169.94 kg/ha) and differences between them being significant. Master and Vienna (151.82 and 150.10 kg/ha) were at par, and the latter recorded lowest.

Table 23 : Effect of varying levels of fertigation, cultivars and their interaction on the nutrient uptake by plant

Treatments	Nitrogen	Phosphorus	Potassium	Calcium	Magnesium
	(kg/ha)				
Fertigation levels (F)					
F_1	157.06	18.69	242.32	91.62	47.53
F_2	163.54	20.67	260.62	96.16	49.57
F_3	170.21	22.48	286.00	99.10	51.23
SEm±	0.28	0.57	2.12	0.96	1.21
C.D. at 5 %	1.08	2.23	8.31	3.75	3.59
Cultivar (C)					
Kristina (K)	182.47	22.16	295.48	96.71	49.77
Aleda (A)	169.94	21.85	295.49	107.06	60.21
Master (M)	151.82	19.90	254.36	100.49	48.01
Vienna (V)	150.19	18.51	206.61	78.40	39.82
SEm±	1.49	0.44	2.28	1.69	2.09
C.D. at 5 %	4.42	1.31	6.78	5.01	6.21
C x F					
KF_1	179.38	19.25	284.56	94.15	44.62
AF_1	159.60	19.63	260.33	102.01	58.91
MF_1	143.80	18.20	243.26	96.75	49.13
VF_1	145.45	17.64	181.14	73.56	37.44
KF_2	181.59	22.71	293.24	97.07	50.52
AF_2	169.47	21.50	286.38	106.59	59.36
MF_2	151.58	19.43	248.22	100.67	47.64
VF_2	151.47	19.01	214.68	80.33	40.43
KF_3	186.43	24.50	308.64	98.92	54.13
AF_3	180.75	24.40	339.76	112.60	62.07
MF_3	160.10	22.01	271.60	104.03	47.36
VF_3	153.57	18.90	224.02	81.30	41.60
SEm±	2.25	0.87	4.02	2.70	1.92
C.D. at 5%	NS	2.94	13.02	NS	NS

F_1 - 80 % of the recommended fertilizer (g/m^2/week)

F_2 - Recommended fertilizer, During rest period (30 days)

N/4.64 : P/1.62 : K/3.62 : Ca/2.55 : Mg/0.55

from rest period to until harvesting start,

N/4.69 : P/1.50 : K/5.58 Ca/2.72 : Mg/0.51

During harvest : N/4.86 : P/1.50 : K/7.03 : Ca/3.09 : Mg/0.50

F_3 - 120 % of the recommended fertilizer

NS - Non-significant

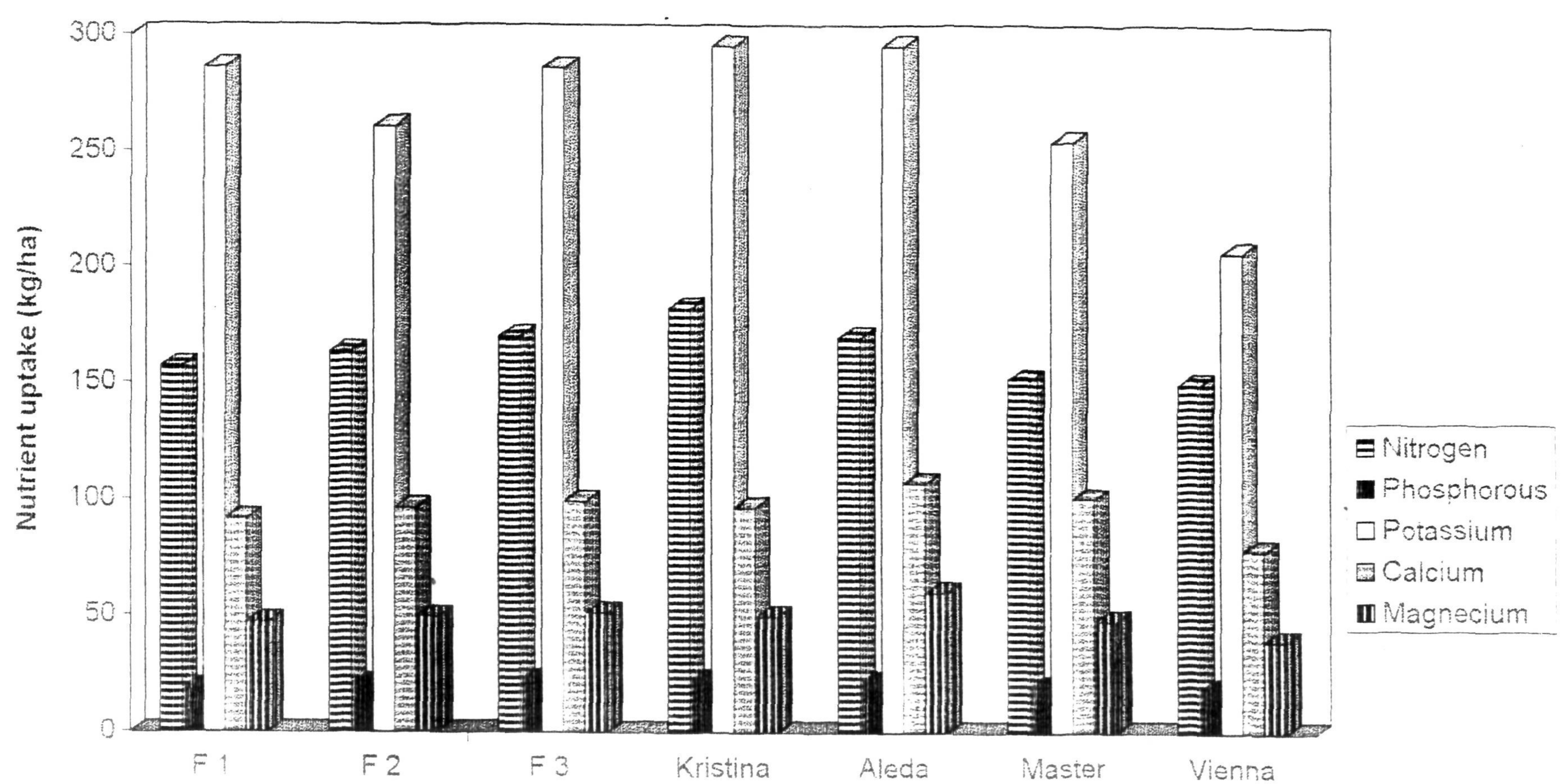

Fig. 13 : Nutrient uptake by plants as influenced by fertigation levels and cultivars

The interaction effect significant differences here not observed (Table 23).

4.18.2 Phosphorus uptake

The data on the effect of varying levels of fertigation, cultivars and their interaction on the uptake of phosphorus are furnished in Table 23.

The uptake of phosphorus differed significantly to varying levels of fertigation. Highest phosphorus uptake was recorded in F_3 fertigation (22.48 kg/ha) followed by F_2 fertigation (20.67 kg/ha) and were at par. F_2 fertigation and F_1 fertigation (20.67 and 18.69 kg/ha) were also at par and the latter recorded lowest.

Amongst the cultivars phosphorus uptake in Kristina and Aleda (22.16 and 21.85 kg/ha) were at par. cultivar Aleda and Master (21.85 and 19.90 kg/ha) were also at par. Significantly lowest uptake in Vienna (18.51 kg/ha).

In interaction effect phosphorus uptake was highest in Kristina with F_3 fertigation (24.50 kg/ha) followed by Aleda with F_3, Kristina with F_2, Master with F_3 fertigation (24.40, 22.71 and 22.01 kg/ha) and were at par. Aleda with F_3, Kristina with F_2, Master with F_3 and Aleda with F_2 fertigation (24.40, 22.77, 22.01 and 21.50 kg/ha) were also at par. The lowest was in Vienna with F_1 fertigation (17.64 kg/ha), which was in par with Master with F_1, Vienna with

F_3, Vienna with F_2, Kristina with F_1, Master with F_2 and Aleda with F_1 fertigation (18.2, 18.9, 19.01, 19.25, 19.43 and 19.63 kg/ha).

4.18.3 Potassium uptake

Data on the effect of varying levels of fertigation, cultivars and their interaction on the uptake of potassium are furnished in Table 23.

Significantly highest potassium uptake (286.00 kg/ha) was recorded in F_3 fertigation followed by F_2 fertigation level (260.20 kg/ha) and F_1 fertigation (242.32 kg/ha) and the differences amongst them being significant.

Amongst the cultivars, significantly highest potassium uptake (295.49 kg/ha was recorded in Aleda followed by Kristina and Master (295.48 and 254.36 kg/ha) and were at par. Significantly lowest potassium uptake (206.61 kg/ha) was recorded in Vienna.

In interaction effect, significantly highest potassium uptake (339.76 kg/ha) was recorded in Aleda with F_3 fertigation followed by Kristina with F_3 fertigation (308.64 kg/ha) the differences between them being significant Kristina with F_2, Aleda with F_2, Kristina with F_1 fertigation (293.24, 286.38 and 284.56 kg/ha) were at par. Significantly lowest (181.14 kg/ha) potassium uptake was in Vienna with F_1 fertigation.

4.18.4 Calcium uptake

The data on the effect of varying levels of fertigation, cultivars and their interaction on the uptake of calcium are presented in Table 23.

The uptake of Ca differed significantly to varying levels of fertigation. Highest Ca uptake (99.21 kg/ha) was recorded in F_3 fertigation which was on par with F_2 fertigation (96.16 kg/ha). Significantly lowest uptake of Ca (91.62 kg/ha) was in F_1 fertigation level.

Among the cultivars significantly highest Ca uptake (107.06 kg/ha) was recorded in Aleda, Master and Kristina (100.49 and 101 kg/ha) were at par. Vienna recorded significantly lowest calcium uptake (78.40 kg/ha).

Interaction effect did not differ significantly (Table 23).

4.18.5 Magnesium uptake

The data on effect of varying levels of fertigation, cultivars and their interaction on the uptake of Mg are furnished in Table 23.

The uptake of Mg differed significantly to varying levels of fertigation. Highest Mg uptake (51.23 kg/ha) was recorded in F_3 fertigation, which was on par with F_2 (49.57 kg/ha). The lowest (47.53 kg/ha) was in F_1 fertigation and was on par with F_2 fertigation (49.57 kg/ha).

Table 24 : Economics of carnation cultivation under low cost green house (100sq.m.) for one year

Particulars	Total cost	Depreciated cost	Cost of cultivation for different fertigation levels		
			F_1	F_2	F_3
1. Fixed costs					
a) Structure (excluding cladding material) at Rs. 250 Sq for the life span of 10 years.	25000	2500	-----	-----	-----
b) Cladding material + Shade net at Rs. 35 sq. m. for Rs. 380 per sq. m. [280 + 100 sq.m.] for the life span of 3 years	13300	4433	-----	-----	-----
c) Irrigation system [drip] at Rs. 45/sq.m. for the life span of 10 years	4500	450	-----	-----	-----
d) Planting material at Rs. 8/cutting (24 cuttings/sq.m.)	28800	9600	-----	-----	-----
e) Supporting at Rs. 17.5 /sq.m. for the life span of 3 years	1750	583	-----	-----	-----
	73350				
2. Repair and maintenance	-----	500	-----	-----	-----
3. Interest on fixed cost*	-----	2586	-----	-----	-----
4. Total apportional costs **	-----	20652	-----	-----	-----
5. Cost of cultivation at different fertigation	-----	-----	20850	20652	20652
6. Total cost of cultivation (4 + 5)	-----	-----	41502	42152	42852
7. Revenue from different fertigation	-----	-----	96900	101320	102000
8. Net profit	-----	-----	55398	59168	59148
9. Cost benefit ratio	-----	-----	1:2.34	1:2.40	1:2.38

* = $\frac{(a + c)\ 0.18}{\text{No. of years (10)}} + \frac{(b + d + e)\ 0.18}{\text{No. of years (3)}}$

** = All depreciated costs of (a+b+c+d+e) + 2 +3

Revenue from different fertigation, flower yield /sq.m./year

F_1 fertigation = 285, F_2 fertigation = 298 and F_3 fertigation = 300 Rs. per flower @ 3.40

Cost of cultivation for different fertigation /sq.m. /year

F_1 fertigation = Rs. 208.50 , F_2 fertigation = Rs. 215.00

F_3 fertigation = Rs. 222.00

Inputs : NPK (Haisol purple, yellow and Haisol K) @ Rs. 15.00 /kg

Calcium and Magnesium ($CaNo_3$ and $MgNo_3$) = Rs. 20 /kg

Among the cultivars, significantly highest Mg uptake (60.21 kg/ha) was recorded in Aleda. Kristina and Master (49.77 and 48.05 kg/ha) and were at par. Significantly lowest was in Vienna (39.82 kg/ha).

The interaction effect had no significant influence on the uptake of Mg.

4.19 Cost of cultivation

The economics of cultivating carnation in an area of 100 m^2 under low cost greenhouse for the different fertigation levels were calculated for one year are presented in Table 24.

Studies have shown that net income was maximum (Rs. 59168 and Rs. 59148) with the application of nutrient at F_2 fertigation and F_3 fertigation levels. The lowest income was obtained in F_1 fertigation (Rs. 55398).

The cost benefit ratio was maximum (1:2.40) in F_2 fertigation which was closely followed by F_3 and F1 fertigation (1:2.38 and 1:2.34).

DISCUSSION

V DISCUSSION

The experimental "Studies on fertigation in carnation (*Dianthus caryophuyllus*) under cover" were conducted to study the growth and productivity of four cultivars of standard carnation namely. Aleda, Kristina, Master and Vienna. The present investigation to evaluate the performance of these cultivars under low cost green house with fertigation are discussed in this chapter.

5.1.1 Plant height, number of branches days taken for flower initiation and bud opening

Significant difference in plant height was observed among cultivars, throughout its growth period. Highest plant height was recorded in cv. Aleda which was on par with Master followed by Kristina. The above variation in plant height may be attributed to cultivars difference rather than cultural practices. The results are in accordance with those of Kim *et al.* (1992) and Satish (1997).

In interaction, highest plant height was recorded in cv. Master with F_3 fertigation level. This is mainly due to differential response of cultivars at a given fertigation level.

Significant variation in number of branches was recorded amongst cultivar, Aleda, Kristina and Master were at par. These results are in accordance with Kim *et al.* (1992), Mahesh (1996) and Satish (1997).

Cultivar Aleda has taken significantly less number of days for bud initiation. This may be due to genetic make up of the cultivars. The results are in agreement with the findings of Miske (1982), Khanna *et al.* (1986) reported that variation could be attributed to pinching and increased with severity, position of pinch on the stem, place of origin of branches on plant, genetic and physiological differences among the cultivars. In interaction, less number of days taken for bud initiation was in Aleda with F_3 fertigation. this may be mainly due to cultivars response to different levels of fertigation. Cultivar Vienna has taken less number of days taken for bud opening. The results are in accordance with the findings of Satish (1997).

5.2 Bud and Flower characters

5.2.1 Bud length, bud diameter and flower diameter

Cultivars differed Significantly in their bud length, bud diameter and flower diameter. Significantly highest bud length, bud diameter and flower diameter was in cv. Kristina. This may be due to better growth traits the cultivar had which helped in the better performance of the cultivar and also to genetic potential of the cultivar. Oszkinis and Kus (1971), Loeser (1986), Mahesh (1996) and Satish (1997) also reported similar results. In interaction effect highest bud length, bud diameter and flower diameter was in Kristina with F_3 fertigation. This is mainly due to differential response of cultivar at a given fertigation level.

5.2.2 Stem length and stem girth at harvest

Among the cultivars, Aleda recorded highest stem length and stem girth. The above variation among the cultivars may be due to genetic potentiality of the cultivar and better growth trait of the cultivar. The results are in accordance with the findings of Loeser (1986), Kim *et al.* (1982), Mahesh (1996) and Satish (1997).

5.3 Yield parameters

5.3.1 Flower yield per sq. m. and per ha.

Cultivars differed significantly in their number of flowers per sq. m and per ha. Highest yield was recorded in cv. Master which was on par with Kristina followed by Aleda.

Cultivars differed Significantly in their yield per sq m and per ha. Highest yield was recorded in cv. Kristina (4.67 kg per sq m and 34.02 t/ha). Which was on par with Master followed by Aleda. The above results have clearly indicated that, even under similar growing condition, the differences in yield among the cultivars, attributed to their genetic potential and their interaction with the environment. Zornoza *et al* (1989), Adillon *et al* (1985) and Satish (1996) also reported similar results.

5.3.2 Calyx splitting

This is one of the important disorders where in the calyx splits down resulting in bending of petals without any support and flower becomes use less, as it directly affects the quality. In the present investigation, the occurrence of splitting was significantly less in cv. Master (0.74 %). There is no single factor responsible for splitting, but is the result of genetic, environmental, nutritional and cultural factors Gill and Arora (1988) studied the performance of Sim carnations and reported that calyx splitting was common in all the cultivars and ranged from 10.3 to 15.7 per cent.

In the present investigation, the occurrence of splitting was significantly less in cv. Master (0.74 %). The results are in accordance with the findings of Gill and Arora (1988).

In interaction effect less calyx splitting was recorded in cv. Master with F_3 fertigation, which was on par with cv. Master with F_2 fertigation and Master with F_1 fertigation. This may be due to differential response of cultivars at a given fertigation level.

5.3.3 Marketable and unmarketable flowers

Irrespective of yield, It is the percentage of marketable and unmarketable flowers, which decide the economy of production. The ratio of marketable and unmarketable flowers should be high for the cultivation to be profitable. In the present investigation, among the cultivars Master and Kristina were recorded significantly highest marketable flowers (93.98 and 93.941 %) followed by Aleda (87.99%). In interaction, effect highest marketable flowers were recorded in cv. Kristina with F_3 fertigation (94.26%), which was on par with Master with F_2 fertigation. However, less unmarketable flowers (6.02%) was recorded in cv. Master, which was on par with Kristina followed by Aleda. In interaction, less unmarketable flowers (5.67%) was recorded in cv. Master with F_3 fertigation, which was on par with Kristina with F_3 fertigation, Kristina with F_1 fertigation and Master with F_3 fertigation. The production of highest percentage of marketable and lower percentage of unmarketable flowers under similar growing condition varied. It may be attributed to genetic potential of the individual cultivar and less calyx splitting. The results are in agreement with the finding of Satish (1997).

5.4 Vase life of cut flower

The vase life of cut flower is one of the important trait which decides its economic value coronation has good vase life, however it can be extended by using preservatives. To prolong the vase life of cut flowers, it is necessary to inhibit microbial activity and ethylene production, and also to increase the fresh weight and flower diameter, which can be achieved by using preservatives.

5.4.1 Number of days taken for flower bud opening

Among the cultivars, more number of days taken for bud opening was in Master (6,.38) which was on par with Kristina. This is mainly due to cultivar response to different preservatives.

Preservatives differed significantly in their number of days taken for bud opening. Significantly highest number of days taken for bud opening was recorded in T_2 preservatives (7.5 % sucrose, + 300 ppm HQS) and closely followed by T_1 (5% sucrose + 50 ppm $AgNo_3$ + 300 ppm HQS).

5.4.2 Vase life of flower

The present investigation has clearly shown that among the fertigation levels F_3 fertigation showed significantly longer vase life (Table 8). This may be due to higher potassium supplied at the later stage of crop may influence the vase-life by increasing the higher uptake of water. Wadsworth and Butters (1972) reported that higher potassium lengthened the vase life of Chrysanthemum, Paull *et al.* (1992) also reported that moderate to high potassium level improved vase life of Anthurium.

Among the cultivars Master recorded highest vase life (11.00 days) which was on par with Kristina where as Vienna recorded shortest vase life (9-74 days). These results are accordance with Jung and Kampf (1989).

Among the preservative T_1 (5.1 sucrose + 5.0 ppm $AgNo_3$ + 300 ppm HQS) and T_2 (7.5 sucrose + 5.0 ppm $AgNo_3$ + 300 ppm HQS) preservatives showed significantly longer vase life. These results are in line with the findings of Lee *et al.* (1980) and Rupnic *et al.* (1989).

and T_1 with Kristina. This may be due to genetic potentiality of the cultivar response to particular level of preservatives.

5.4.3 Cumulative fresh weight (CFW)

Among the fertigation levels, F_3 fertigation showed significantly highest cumulative fresh weight. This increase may be attributed to potassium supplied at later stages of plant development might have indirectly helped in easy permeability of water through cell membrane there by increasing the fresh weight. Among the cultivars, Aleda recorded significantly highest (146.95 g/fl) CFW followed by Kristina and Master. This above variation in CFW may be due to genetical make up of cultivar rather than preservative.

Preservatives differed significantly in the CFW of flower. Highest CFW was recorded in T_1 (5% sucrose, 50 ppm silver nitrate + 300 ppm 8 HQS) preservatives, which was on par with T_2 preservatives. This may be due to the fact that, sucrose serves as a source of energy for the metabolic process. Further, silver nitrate reduces the ethylene synthesis, hence delaying senescence of flowers, where as HQS inhibits microbial activity, there by an increase in the water uptake, which inturn may have increased the cumulative fresh weight. These results on in accordance with Lee *et al.* (1980).

In interaction effect, highest CFW was recorded cv. Aleda with F_3 fertigation, T_1 preservatives with F_3 fertigation and cv. Aleda with T_1 preservatives, which was on par with Aleda with F_2 fertigation, T_2 preservatives with F_3 fertigation, respectively.

In interaction effect between cultivars, fertigation and preservatives had significant influence on CFW. Highest CFW was recorded in T_1F_3A (173.00 g/flower) which was on par with T_1F_3M, T_1F_2A, T_2F_3M and T_1F_1A. This may be due to combined contribution of preservatives, cultivars and fertigation was additive when they are combined.

In interaction effect between cultivars and preservatives and significantly longest was life in (14.00 days) T_2 preservative with Master.

5.5 Growth parameters of second crop

5.5.1 Plant height, number of branches, days taken for flower initiation and opening

The nutrient supplied to the plant had a significant influence on the plant height and number of branches. Significantly highest in F_3 fertigation.

The cultivars responded differently to varying fertigation levels in the second season crop only. The above response may be due to depletion of nutrients from the soil as the crop of the first season had utilized these nutrients for their growth and productivity. Hence the second season crop responded significantly to the added nutrients in the form of fertigation at higher than the recommended dose (Appendix I). Similar results were also reported by Arora and Saini (1975), Biswas *et al.* (1982) and Starck *et al.* (1991).

The cultivars differed significantly in the plant height. Highest plant height (98.07 cm) was in cv. Aleda which was on par with cv. Master. The variation in plant height may be due to genetic make up of the cultivar responding to fertigation. This is in accordance with the findings of Kim *et al.* (1992) and Satish (1997).

The interaction effect was highest in plant height in cv. Master with F_3 fertigation, which was on par with Aleda with F_2 and Aleda with F_3 fertigation.

Number of branches per plant was significantly more in cv. Aleda. This variation in number of branches may be due to genetic make up of the cultivar responding to fertigation. This is in agreement with the findings of Satish (1997).

In interaction effect highest number of branches per plant was recorded in cv. Aleda with F_3 fertigation, which was on par with Kristina at the same level of fertigation. This increase in number of branches may be attributed to additive effect of cultivars and fertigation level. These results are in line with Biswas *et al.* (1982).

Among the fertigation levels, significantly less number of days was taken for flower initiation in F_3 fertigation. This may be due to the increased levels of potassium given to the plant from the second month after rest period. which might have enhance the reproduction development of the plant. Pawlowski (1966), Wadsworth and Butters (1972) and Shoushan *et al.* (1978) also reported similar results.

Among the cultivars, Aleda took significantly less days for bud initiation. The results are in agreement with Miske (1982) and Khanna *et al.* (1986). The variation could be due to pinching which delayed flowering and the delay increased with severity, position of pinch of the stem, place of origin of branches on plant, genetic and physiological differences among the cultivars.

In interaction effect, less number of days taken for bud initiation was in cv. Aleda with F_3 fertigation, which was on par with Aleda with F_1 fertigation. This may be due to complimentary effect of cultivars with the fertigation level.

5.6 Flower and bud characters

5.6.1 Bud length, bud diameter and flower diameter

Cultivar Kristina recorded significantly highest bud length, bud and flower diameter. Master and Kristina were at par. This may be due to better growth traits of the cultivar, which helped in the better performance of the cultivar and also to genetic potential of the cultivar. Oszkinis and Kus (1971), Loeser (1986), Mahesh (1996) and Satish (1997) also reported similar results.

Flower diameter and bud length differed significantly to interaction effect. Highest flower diameter and bud length was observed in cv. Kristina with F_3 fertigation, Master with F_1 fertigation, cv. Aleda with F_2 fertigation. This may be due to genetic make up of cultivars and fertigation levels. Similar results have been reported by Arora and Saini (1975).

5.6.2 Stem length and girth at harvest

Nutrient supplied to the cultivars had significant influence on the stem length. It was observed that stem length was significantly highest in F_3 fertigation. This may be due to cell division and cell enlargement. These results are fall in with Arora and Saini (1975), Mukhopadhyay (1981) and Starck *et al.* (1991).

Among the cultivars, significantly highest stem length was recorded in cv. Aleda followed by Master and Kristina. Similarly, cultivar differed significantly in the stem girth. Highest stem girth was recorded in cv. Aleda, which was on par with Kristina and Master. This variation among the cultivars may be due to genetic makeup of cultivar. The results are in accordance with the findings of Loeser (1986), Kim *et al.* (1982), Mahesh (1996) and Satish (1997).

In interaction effect significantly highest stem length was in cv. Aleda with F_3 fertigation. This may be due to cultivars, fertigation and environmental effect.

5.7 Yield parameters

5.7.1 Flower yield per sq. m. and per ha

Varying levels fertigation had a significant influence on the flower yield. Number of flower and yield (kg) of flowers per sq. m. and per ha was significantly highest in F_3 fertigation. High nitrogen supplied in early stage of growth might have increased the number of flowers in two ways (I) by increasing the number of primary branches and (ii) by increasing shoot growth and numbers of secondary branches and hence the ultimate size of the plant, there by increasing the number of potential sites where flower could develop. The results are in agreement with Holley *et al.* (1951), Hart (1970), Strojny *et al.* (1992) and Kowlezyk *et al.* (1992).

The number of flowers and yield (kg) of flowers per sq. m. and ha was significant. Highest number of flowers was in Master, which was on par with Kristina. This above variation among the cultivars may be due to genetic potentiality of the cultivar and better growth trait of the cultivar. The results are in accordance with the findings of Zornoza *et al.* (1989), Adillon *et al.* (1989) and Satish (1997).

In interaction effect, highest number and yield was recorded in Kristina with F_3 fertigation Master with F_3, Kristina with F_1, Kristina with F_3 and Master with F_3 fertigation were at par. This variation in yield due to cultivars, fertigation level and environmental effects. Arora and Saini (1975) also reported that the number of flowers increased with the application of higher levels of N, P and K and Strojny *et al.* (1992).

5.7.2 Calyx splitting

Among the cultivars less calyx splitting was recorded in Master and Kristina were at par. There is no single factor responsible for splitting, but is the result of genetic, environmental, nutritional and cultural factor. Gill and Arora (1988) studied the performance of Sim carnations and reported that calyx splitting was common in all the cultivars and ranged from 10.3 to 15.7 per cent. In interaction effect less calyx splitting was recorded in the cv. Kristina with F_2, Master with F_3 and Master with F_1 fertigation were at par. This may be due to cultivar response to fertigation levels.

5.7.3 Marketable and unmarketable flowers

Among the cultivars highest marketable and less unmarketable flowers was recorded in Master and Kristina which were at par. The production of highest percentage of marketable and lowest percentage of unmarketable flowers under similar growing condition varied. This may be due to genetic potentiality of the individual cultivars. Satish (1997), who also evaluated the performance of carnation cultivars under low cost green house condition (unmarketable longer from 14.13 to 27.60).

In interaction, significantly highest marketable flowers were recorded in Kristina with F_3 fertigation, similarly significantly less unmarketable flowers were recorded in Kristina with F_3 fertigation. This may be attributed due to differential response of cultivars at a given fertigation level.

5.8 Mortality rate

The loss of plants due to mortality could result in the loss of crop and additional investment for replacement in commercial cultivation. Among the cultivars Kristina recorded less mortality (4.32 %) which was on par with cv. Master. This variation under similar growing condition may be due to genetic potential of the cultivar. These results are in accordance with the findings of Satish (1997), who reported mortality rate ranged from 13.57 to 25 per cent.

5.9 Vase life of cut flower

The vase life of cut flowers is one of the important parameters which decide its economic value.

5.9.1 Number of days taken for bud opening

The preservatives differed significantly in the number of days taken for bud opening. Significantly longer days taken for bud opening was recorded T_2 (7.5 per cent sucrose + 50 ppm $AgNo_3$ + 300 HQS) and T_3 (5 per cent sucrose + 60 ppm $AgNo_3$ + 300 ppm HQS) preservatives.

5.9.2 Vase life in days

Among the fertigation levels F3 fertigation showed significantly longer vase life. This may be due to higher potassium supplied at the later stages of the crop growth. Wadsworth and Butters (1972) reported that higher potash rates lengthened the vase life of chrysanthemum. Paull *et al.* (1992) also reported that moderate high potassium levels improved vase life of Anthurium.

Among the cultivars Master showed significantly longest vase life followed by Kristina and Aleda. These results are in conformity with the findings of Jung and Kampf (1989).

Preservatives differed significantly in the vase life. Significantly longest vase life was recorded in T_1 and T_2 preservatives (5 per cent sucrose + 50 ppm $AgNo_3$ + 300 ppm HQS, 7.5 per cent sucrose + 50 ppm $AgNo_3$ + 300 ppm HQS). These results are in accordance with the findings of Lee *et al.* (1980)

in T_2M, which was on par with T_1M, T_2K and T_1K. This is may be due to cultivars response to particular concentration of preservatives.

5.9.3 Cumulative fresh weight (CFW)

Among the fertigation levels. F_3 fertigation showed significantly highest cumulative fresh weight. This increase may be due to higher potassium supplied at later stage of plant growth might have indirectly helped in easy permeability of water through cell membrane there by increasing the fresh weight. Among the cultivars Aleda recorded significantly highest CFW followed by Master and Kristina. This above variation in CFW may be due to genetic potentiality of cultivar differences rather than preservatives.

Preservatives differed significantly highest CFW was recorded in T_1 and T_2 preservatives. This may probably be due to the fact that, sucrose serves as a source of energy for the metabolic process. Further, silver nitrate, further, silver nitrate reduces the ethylene synthesis, hence delaying senescence of flowers, where as HQS inhibits microbial activity, there by an increase in the water uptake, which inturn may have increased the cumulative fresh weight. There results are in accordance with Lee *et al.* (1980). In interaction, significantly highest CFW was recorded in T_1 preservative with Aleda which was on par with F_2 preservative with Aleda. This may be due to effect of preservatives and cultivar genetic make up.

5.10 Dry matter accumulation

Dry matter accumulation in plant was significantly highest in F_3 fertigation. This may be due to the increased availability macro nutrients. These results are in concurrence with the findings of Magnifico *et al.* (1985).

Amongst the cultivars Aleda recorded significantly highest dry matter accumulation per ha. The may be attributed to the genetic make up of the cultivar and their reaction to agroclimetic condition. These results are in conformity with the findings of Medina (1992). In interaction effect significantly highest dry matter accumulation was in cv. Aleda with F_3 fertigation. This may be due to genetic make up of cultivar with the fertigation level.

5.10.1 Nutrient content in plant

Nutrinet content in plant was significantly highest in F_3 fertigation and F_2 fertigation levels. As the fertigation level increased the accumulation of nutrient increased.

Among the cultivars, significantly highest accumulation of NPK was recorded in cv. Kristina. The increased accumulation of nutrient in plant may be attributed to inherent characteristics of the cultivars to absorb the nutrient more availability of nutrients. In interaction effect, significantly highest content of potassium was in Aleda with F_3 fertigation. This increase in plant may be attributed the variation in solution concentration of nutrient and more availability of potassium in F_3 fertigation. These results are in concurrence of with the findings of Hasegawa (1992).

5.10.2 Nutrient content in leaf

Significantly highest nitrogen and potassium content in leaf was in Kristina. This is due to more absorption of N and K plant, concequented to pH adjustments towards nutrients within the plant. Similarly, calcium and magnesium was highest in cv. Aleda. These results are conformity with the finding of Fernades *et al.* (1975), Miura (1979) and Farina and Lupi (1987).

5.11 Nutrient uptake

Among the fertigation levels, F3 fertigation recorded highest uptake of NPK 'Among the cultivars, significantly highest. The NPK in cv. Aleda, increased uptake may be attributed due to genetic make up of the cultivar and also application of NPK, Ca and Mg nutrients resulted in the increased availability of NPK and they might have increased the root growth leading to more absorption of nutrients. Interaction effect P and K nutrient uptake was significantly highest in Kristina with F_3 fertigation. This may be due to genetic make up of cultivar and more availability of nutrients and more absorptive area of the plant. These results are in accordance with the findings of Miura (1979).

Among the secondary nutrients (Ca and Mg) significantly highest uptake was in F_3 fertigation and cultivar Aleda. The increased uptake by plant may be due to higher availability of secondary nutrients and genetic make up of cultivar.

5.12 Cost of cultivation

The economics for cultivation of carnation under low cost green house under three levels of fertigation was calculated for one year from on area of 100 sq. m. The results clearly indicated that net returns was comparatively higher in (Rs. 59168) F_2 level of fertigation. Which was closely followed by F_3 and F_2 fertigation level (Rs. 59148 and 55398). Since the resultant out put of cost benefit ratio are comparatively marginal amongst the fertigation levels. Hence the F_1 fertigation level are recommended.

Practical application of the result

1. From the above trials conducted it is revealed that F_1 fertigation level (*From planting to end of pinching - g/m² / week* N/3.71 : P/1.20 : K/2.90 : Ca/2.18 : Mg/0.44 *From end of pinching to until harvest start - g/m²/week* N/3.89 : P/1.20 : K/4.46 : Ca/2.18 : Mg/0.40 *During harvest* N/3.89 : P/1.20 : K/5.62 : Ca/2.47 : Mg/0.40) was the best.

2. Cultivars Kristina and Master were found to be promising under southern region of Karnataka.

3. In post harvest treatment of carnation cut flower in 5 % sucrose of 50 ppm $AgNo_3$ + 300 ppm HQS extended the vase life.

Future line of work

Studies may be carried on the following aspects

1. Dry matter and nutrient accumulation at various stages of crop growth for assessing the nutrient requirement of crop.

2. Fertigation studies with higher doses of nutrients may be studied as F_3 fertigation recorded significantly higher flower yield.

3. The effect of macro nutrient on the accumulation of micro nutrients at different stages of crop growth.

4. The nutrient balance sheet for the micro nutrients may be worked out.

5. The peak period of nutrient requirement of the crop may be worked out.

SUMMARY

VI SUMMARY

The present investigation on "Studies on fertigation in carnation under cover" were conducted during the year 1996 and 1997 at Horticultural Research Station, University of Agricultural Sciences, GKVK, Bangalore. The salient features and findings of the investigation is here with summarized.

The plant height recorded at main stages of crop growth shows marked differences amongst cultivar. Highest plant height (110.33 cm) was recorded in cv. Aleda which was on par with Master. The interaction effect on plant height showed significant difference. Plant height shoed significant differences. Highest plant height (111.00 cm) was observed in cv. Master with fertigation F_3.

Among the cultivars Aleda recorded significantly highest number of branches per plant (8.78). Significantly lowest number of days taken (119.67) taken for bud initiation was in cv. Aleda. In interaction effect, the lowest number of days (117.67) taken for bud initiation was in Aleda with fertigation F_3.

Cultivars differed significantly in the days taken for bud opening. Cultivar Vienna recorded significantly lowest number of days (27.56) taken for bud opening.

Bud length, bud diameter and flower diameter was significantly highest (3.91, 2.46 and 8.26 cm) in cv. Kristina. Interaction effect revealed that bud length, bud diameter and flower diameter was highest (4.00, 2.53 and 8.37 cm) in Kristina with fertigation F_3.

Cultivar differed significantly in the stem length at harvest. The highest stem length (104.56 cm) was recorded in cv. Aleda which was on par with Master (102 cm). Similarly, highest stem girth (0.95 cm) was in cv. Aleda.

Significantly highest number of petals per flower (82.86) was in fertigation F_3. Among the cultivar Kristina recorded significantly higher number of petals (94.81) per flower. In interaction effect significantly highest number of petals (99.34) was in cv. Kristina with fertigation F_3.

Significantly highest yield per m^2 (179.22) and per ha (1254.54 thousands) was in Master followed by Kristina.

The cultivars differed significantly in the yield of flower per square metre and hectare. Highest yield (4.86 kg/m^2 and 34.02 t/ha) was in cv. Kristina.

Calyx splitting was significantly less in cv. Master (0.74 %). In interaction effect, lowest calyx splitting (0.56 %) was in cv. Master with fertigation F_3, which was on par with Cv. Master with fertigation F_2 and F_1.

The cultivar differed significantly in the marketable and unmarketable flowers. Highest marketable and less unmarketable flowers (93.98 and 6.02 %) were in Master and Kristina which were on par. In interaction effect, highest marketable flowers (94.26 %) was in cv. Kristina with fertigation F_3 and less unmarketable flowers (5.74 %) was in cv. Kristina with fertigation F_3.

Cultivars differed significantly in the number of days taken for bud opening. Highest number of days (6.38) taken for bud opening was in cv. Master, which was on par with Kristina. Significantly highest number of days (7.94) taken for bud opening was in preservatives T_2 (7.5 per cent sucrose + 50 ppm $AgNo_3$ + 300 ppm HQS).

Vase life of flower was significantly highest (10.82 days) in fertigation F_3. Among the cultivars highest vase life (11.00 days) was in cv. Master, which was on par with Kristina. In interaction effect longest vase life (14.00 days) was in T_2 (7.5 per cent sucrose, + 50 ppm $AgNo_3$ + 300 ppm HQS) with Master, which was on par with preservative T_1 Cv. Master, preservative T_2 Cv. Kristina and preservative T_1 Cv. Kristina.

Cumulative fresh weight was significantly highest in fertigation F_3 (136.79 g/flower) and amongst cultivar it was cv. Aleda (146.95 g/flower). In interaction effect, highest cumulative fresh weight was in Aleda with fertigation F_3 (148.28 g/flower), which was on par with Aleda with fertigation F_2.

Highest cumulative fresh weight (156.05 g/flower) was recorded in preservative T_1 (5 per cent sucrose + 50 ppm $AgNo_3$ + 300 ppm HQS), which was on par with preservative T_2. In interaction effect, highest cumulative fresh weight (161.13 g/flower) was recorded in preservative T_1 fertigation F_3. Significantly highest cumulative fresh weight (171.56 g/flower) was recorded in preservative T_1 with Aleda.

In interactions effect between cultivars, fertigation and preservatives differed significantly. Highest cumulative fresh weight was in T_1F_3 A (173.00 g/flower), which was on par with T_1F_3M, T_1F_2A, T_1F_3A and T_1F_1A.

In the second season the plant height was highest in fertigation F_3 (93.12 cm), which was on par with fertigation F_2. Among the cultivars Aleda recorded highest plant height (98.07 cm), which was on par with Kristina.

Fertigation F_3 recorded significantly highest number of branches (12.50) per plant. Significantly highest number of branches per plant (13.70) was in cv. Aleda. In interaction effect, highest number of branches (15.67) was recorded in Aleda with fertigation F_3, which was on par with Kristina with fertigation F_3.

Fertigation F_3 recorded significantly lowest number of days (119.95) taken for bud initiation. Cultivar Aleda took significantly lowest number of days (108.70) for bud initiation. In interaction effect, lowest number of days taken for bud initiation (107.33) was in cv. Aleda with fertigation F_2, which was n par with Aleda with fertigation F_1 and F_2.

Bud length was significantly highest (3.73 cm) in cv. Kristina. Interaction effect, highest bud length was recorded in Kristina with fertigation F_3 and F_2 (3.83 and 3.80 cm).

Bud diameter was highest (2.36 cm) in cv. Kristina, which was on par with Aleda. The flower diameter was significantly highest (8.13 cm) in cv. Kristina. In interaction effect on flower diameter was significant. Highest flower diameter (8.20 cm) was in cv. Kristina with fertigation F_3.

Stem length was significantly highest (89.13 cm) in fertigation F_3. Among the cultivars significantly highest stem length (93.62 cm) was recorded in Aleda. In interaction effect, highest stem length was recorded in cv. Aleda with fertigation F_3, which was on par with cv. Master with fertigation F_2.

Stem girth was highest (0.89 cm) in cv. Aleda which was on par with cv. Kristina and Master. Significantly highest number of petals per flower (91.57) was recorded in cv. Kristina.

Number of flowers per plant square metre (162.66) and per hectare (1132.83 thousands) was significantly highest in fertigation F_3. Cultivar Master recorded the highest number of flowers (170.66), which was on par with Kristina. In interaction effect, on number of flowers per square metre was significant. Highest (171.33) number of flowers was in cv. Master with fertigation F_3 (171.33).

Highest number of flowers per hectare (1195.44 thousands) was recorded in cv. Master, which was on par with cv. Kristina. In interaction effect on number of flowers per hectare was significant. Highest number of flowers per hectare (1193.31 thousands) was in cv. Master with fertigation F_3.

Significantly highest yield per square metre (4.25 kg) and per ha (29.75 t/ha) was recorded in fertigation F_3. Among the cultivars Kristina and Master recorded significantly highest yield per square metre (4.59 and 4.59 kg/ha) and per ha (32.13 and 32.13 t/ha). In interaction effect on yield of flower per square metre and per ha was significant. Highest yield per square metre (4.63 kg/m^2) and per ha (32.41 t/ha) was recorded in Kristina with fertigation F_1.

Calyx splitting was lowest (0.91 %) in cv. Master which was on par with Kristina. In interaction effect lowest calyx splitting (0.60 %) was in Kristina with fertigation F_3.

The cultivar Master recorded highest marketable and less unmarketable flowers (95.18 and 4.82 %) which was on par with Kristina. In interaction effect had significant influence on marketable and unmarkatable flowers. Highest marketable and lowest unmarketable (96.28 and 4.82 %) was recorded Kristina with fertigation F_3. Mortality rate was highest (8.02 %) in cv. Aleda, which was on par with cv. Vienna. Significantly highest number of days taken for bud opening was in preservatives T_2, T_1 and T_4 (6.67, 6.58 and 6.53). Vase life was significantly highest (9.51 days) in fertigation F_3. Among the cultivars Master showed longest vase life of flowers (9.60 days). Among the preservatives highest vase life of flowers (11.22 days) was in preservative T_2 which was on par with preservative T_1.

Significantly highest CFW (116.40 g/fl) was in fertigation F_3. Among the cultivars Aleda recorded significantly highest CFW (126.33 g/fl). Similarly, highest CFW (131.26 g/fl) was recorded in preservative T_1, which was on par with preservative T_2. In interaction effect showed significant differences on CFW. Highest CFW (138.44 g/fl) was recorded in preservative T_1 with Aleda.

The highest dry matter production was recorded in fertigation F_3 and F_2 (9350.83 and 9135.00 kg/ha) were at par. Among the cultivar Kristina recorded significantly highest dry matter accumulation (9768.89 kg/ha). Significantly highest dry matter production was recorded in Aleda with fertigation F_3. Aleda with fertigation F_2 and Kristina with fertigation F_2 (10173.33, 9776.68 and 9543.33 kg/ha) and were at par.

Significantly highest nitrogen content (1.98 %) in leaf was observed in Kristina. Potassium content was significantly highest in Kristina and Aleda (3.29 and 3.14 %). Highest nutrient content of calcium was in Kristina and Master (1.10 and 1.10). Similarly, significantly highest mg content (0.69 %) was recorded in Aleda.

Highest nitrogen (1.81 %) content in plant was in fertigation F_3, which was on par with fertigation F_2. Among the cultivar Kristina recorded significantly highest nitrogen (194 %).

Highest content of phosphorous recorded in fertigation F_3 and F_2 (1.24 and 0.22 %) were at par. Among the cultivars, Kristina recorded highest content of phosphorous (0.23 %). Significantly highest potassium content (3.03 %) was in fertigation F_3. Highest content of potassium was in Kristina and Aleda (3.15 and 3.01 %) were at par. In interaction effect, highest potassium was in Aleda with fertigation F_3 (3.34 %) The calcium content in plant was highest in Aleda and Master were at par. Magnesium content in plant was significantly highest cv. Aleda (0.61 %). In interaction effect highest content of magnesium, in plant was in Aleda with fertigation F_1 (0.63 %).

Significantly highest nitrogen uptake by plant was in fertigation F_3 (170.20 kg/ha). Among the cultivars Kristina recorded significantly highest nitrogen uptake (182.47 kg/ha). Highest phosphorous uptake was in fertigation F_3 (22.48 kg/ha). Among the cultivars phosphorous uptake was highest in Kristina and Aleda (22.16 and 21.85 kg/ha) were at par. In interaction effect phosphorus uptake was highest in Kristina with fertigation F_3.

Significantly highest potassium uptake (286.00 kg/ha) was recorded in fertigation F_3. Cultivar Aleda recorded significantly highest potassium uptake (295.49 kg/ha). In interaction effect, significantly highest potassium uptake (333.76 kg/ha) was in Aleda with fertigation F_3.

Highest calcium uptake was recorded in fertigation F_3 (91.21 kg/ha), which was on par with fertigation F_2 (91.21 kg/ha). Among the cultivars significantly highest calcium uptake (107.06 kg/ha) was recorded in Aleda.

Significantly highest magnesium uptake was recorded fertigation F_3 and F_2 (51.23 and 49.22 kg/ha). Among the cultivars Aleda recorded highest magnesium uptake (60.21 kg/ha).

The cost benefit ratio of fertigation F_2 and F_1 (1:2.40 and 1:2.34) indicates that the most economic level for getting maximum net profit is in fertigation F_2 and F_1 (Rs. 59168 and 55398).

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* Originals not seen

APPENDICES

Appendix I

Soil reaction and nutrient status of the soil before planting of trial and after the end of the second crop

Details	Before planting	Nutrient status of the soil under different fertigation level after the second season crop		
		F_3 fertigation	F_2 fertigation	F_1 fertigation
pH	6.80	6.30	6.50	6.60
Nitrogen (kg/ha)	367.50	300.00	257.50	200.00
Phosphorous (kg/ha)	94.18	83.33	58.33	47.50
Potassium (kg/ha)	261.68	233.33	210.00	190.00

Appendix II : Environmental parameters (mean) recorded under greenhouse during crop growth period from 1996 and 1997

Green house		
Month	Temperature (°C)	Relative humidity
August 96	34.20	72.6
Sept 96	33.80	75.8
Oct 96	32.10	73.4
Nov 96	28.80	79.2
Dec 96	26.30	78.1
Jan 97	27.50	73
Feb 97	30.90	62
March 97	33.00	60
April 97	32.02	59
May 97	34.00	64
June 97	31.40	56
July 97	26.00	62
Aug 97	25.00	70
Sept 97	24.00	74
Oct 97	25.00	73
Nov 97	24.00	75

Appendix III : Environmental parameters recorded in vase life room

	Green house	
Month	Temperature (°C)	Relative humidity
August 96	27.00	63
Sept 96	27.50	62
Oct 96	27.00	63
Nov 96	25.00	64
Dec 96	20.00	62
Jan 97	25.00	60
Feb 97	26.00	50
March 97	29.00	55
April 97	30.00	50
May 97	30.00	55
June 97	29.00	69
July 97	26.00	70
Aug 97	26.00	71
Sept 97	24.00	70
Oct 97	28.00	67
Nov 97	25.00	70