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Nutrient management for cutting production in carnation (*Dianthus caryophyllus*)

KALKAME CH MOMIN[1], S R DHIMAN[2], Y C GUPTA[3], S K BHARADWAJ[4] and SUNIL KUMAR[5]

Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh 173 230

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ABSTRACT

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

Key words: Biofertlizers, Carnation, Cutting, Fertigation, Vermicompost

Carnation (*Dianthus caryophyllus* L.) is one of the commercially important cut flowers of the world and offers diversity of colours. It belongs to the family Caryophyllaceae. Carnations are also being cultivated in India. The major production centers are located around Pune and Bengaluru. Carnations are now being commercially grown in Solan, Shimla, Mandi, Kullu, Chamba and Bilaspur districts of Himachal Pradesh. As per the estimates of Directorate of Horticulture- Himachal Pradesh, carnation occupied 73.76 hectares out of 812.90 hectare total area under floriculture in the state during 2010. The acreage of carnation is still expected to increase because of the favourable climatic conditions for its cultivation in different parts of Himachal Pradesh and other hilly states of the country. The most important part of floriculture crop production is propagation. Commercially, carnation is propagated through shoot-tip cuttings. Success or failure of carnation crop starts with the selection of cuttings. Carrying out the production using proper and high quality seedlings is one of the most important factors affecting the efficiency positively. For obtaining optimum plant growth and higher yield, proper nutrition is essential.

One of the major bottlenecks in the carnation cultivation is the non-availability of quality planting materials. In order to produce good quality cuttings, maintenance of mother plants is an important factor. In addition, the information available on production of quality planting materials is scanty. Therefore, it is important to work out and standardize a technique which would help the farmer to secure a good planting material. Keeping this in view, present investigation was carried out with the objective to study the effect of fertilization modules on cutting production of carnation.

MATERIALS AND METHODS

The present investigation was carried out at the experimental farm, Department of Floriculture and Landscaping, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan during 2010-2011. The experiment

[1]Guest Lecturer (e mail: kalkame.momin@gmail.com), Department of Horticulture, North Eastern Hill University, Tura Campus, Chandmari, Meghalaya 794 002; [2]Professor (e mail: sitaramdhiman@yahoo.co.in), Department of Floriculture and Landscaping, [3]Professor and Head (e mail: ycgupta2006@yahoo.co.in), Department of Floriculture and Landscaping, [4]Professor and Head (e mail: sbhardwajswm@rediffmail.com), Department of Environmental Sciences, [5]Associate Professor (e mail: sunu159@yahoo.co.in), Department of Horticulture, North Eastern Hill University, Tura Campus, Chandmari, Meghalaya 794 002

was laid out in polyhouse following the factorial randomized block design with three replications. Rooted cuttings of four commercial cultivars of perpetual carnation namely White Wedding, Farida, Niva and Madras were planted on 4 December 2010 at a spacing of 15 cm × 15 cm, accommodating 36 plants/m^2. Soil: FYM: cocopeat in the ratio of 2:1:1 was used as a growing medium. The crop was raised following recommended cultural practices like watering, weeding, hoeing and control of insect-pests and diseases. A total of five fertilizer modules were programmed to carry out the work as follows: FM_1: 20-20-10 g/m^2 NPK (as basal) + 100 ppm N + 140 ppm K (as fertigation-twice a week), FM_2: 20-15-5 g/m^2 NPK (as basal) + 125 ppm N + 175 ppm K (as fertigation-twice a week), FM_3:20-10-5 g/m^2 NPK (as basal) + 150 ppm N + 210 ppm K (as fertigation-twice a week), FM_4:20-15-10 g/m^2 NPK (as basal) + 175 ppm N + 245 ppm K (as fertigation-twice a week), FM_5:20-5-5 g/m^2 NPK (as basal) + 200 ppm N + 280 ppm K (as fertigation-twice a week).

The basal dose of N, P and K fertilizers @ 20:20:10 g/m^2 along with 100 ppm N and 140 ppm K applied through fertigation was taken as a standard treatment. The frequency of fertigation was twice a week and it was given as soon as the plants gets established. The source of N, P and K fertilizers was urea, SSP and MOP, respectively. For water soluble fertilizers, NK (13-0-45) multi K, calcium nitrate (commercial grade) and urea was used. In addition to the above mentioned treatments, biofertilizers (VAM, PSB and *Azospirillum*) and vermicompost at 1 kg/m^2 was applied uniformly at the time of planting. For preparing the biofertilizer mixture, one kg each of VAM, *Azospirillum* and PSM were mixed with one kg of well rotten farmyard manure and applied directly in the root zone at 3g/plant.

RESULTS AND DISCUSSION

Effect of fertilizer modules and cultivars on diameter of the un-rooted cuttings

It is evident from the data given in Table 1, that the diameter of the stem varied significantly in all the cultivars under different fertilization modules. Maximum diameter of the un-rooted cuttings (0.75 cm) was recorded from fertilizer module FM_5 comprising of 20-5-5 g/m^2 NPK as basal application along with 200 ppm N + 280 ppm K as fertigation given twice a week. In contrast, minimum diameter of the un-rooted cuttings (0.69 cm) was observed in fertilizer modules FM_1 and FM_2. Amongst the cultivars, Madras exhibited the maximum diameter of the un-rooted cuttings (0.82 cm) while, it was recorded minimum (0.65 cm) in White Wedding. These differences may be attributed to the differences in their genetic constitution and in cultivars. The increase in diameter of the stem might be due to the positive response of nitrogen applied in appropriate amount, which caused a greater synthesis of carbohydrate and their translocation to the plant.

These results are in close conformity with the findings of Devi *et al*. (2003), Budiarto *et al*. (2006) and Kazaz *et al*.

Table 1 Effect of fertilizer modules and cultivars on the diameter of un-rooted cuttings (cm)

Cultivar (V)/	1st harvest					2nd harvest					3rd harvest					4th harvest				
Fertilizer module (FM)	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
FM_1*	0.67	0.70	0.75	0.93	0.76	0.68	0.67	0.66	0.80	0.70	0.51	0.64	0.59	0.65	0.60	0.50	0.52	0.53	0.51	0.51
FM_2	0.69	0.70	0.73	0.92	0.76	0.70	0.70	0.67	0.82	0.72	0.54	0.60	0.54	0.64	0.58	0.51	0.53	0.55	0.51	0.53
FM_3	0.70	0.77	0.78	0.96	0.80	0.73	0.74	0.69	0.87	0.76	0.56	0.68	0.61	0.69	0.64	0.51	0.51	0.51	0.52	0.51
FM_4	0.70	0.75	0.74	0.97	0.79	0.73	0.76	0.72	0.87	0.77	0.60	0.64	0.62	0.71	0.64	0.52	0.53	0.53	0.53	0.53
FM_5	0.69	0.82	0.80	0.99	0.82	0.75	0.77	0.71	0.88	0.78	0.60	0.64	0.63	0.72	0.65	0.50	0.54	0.55	0.50	0.51
Mean	0.69	0.75	0.76	0.95		0.71	0.73	0.69	0.85		0.56	0.64	0.60	0.68		0.51	0.53	0.54	0.51	
CD (P=0.05) Cultivar	0.05	0.02	0.01	NS																
Fertilizer module	0.03	0.02	0.03	NS																
V × FM	NS	NS	NS	NS																

*FM_1 : 20-20-10 g/m^2 NPK (as basal) + 100 ppm N + 140 ppm K (fertigation); FM_2 : 20-15-5 g/m^2 NPK (as basal) + 125 ppm N + 175 ppm K (fertigation); FM_3 : 20-10-5 g/m^2 NPK (as basal) + 150 ppm N + 210 ppm K (fertigation); FM_4 : 20-15-10 g/m^2 NPK (as basal) + 175 ppm N + 245 ppm K (fertigation); FM_5 : 20-5-5 g/m^2 NPK (as basal) + 200 ppm N + 280 ppm K (fertigation); V_1 : White Wedding; V_2 : Farida;V_3 : Niva; V_4 : Madras

(2011). However, the interaction effect of cultivars and fertilizer modules in increasing the diameter of the cuttings was found to be non-significant.

Effect of fertilizer modules and cultivars on weight of the un-rooted cuttings

The data presented in Table 2 indicates that the weight of the un-rooted cutting significantly increased with the increasing levels of fertilization modules. Maximum weight of the un-rooted cuttings (5.22 g) was noted from plants supplied with a basal dose of 20-5-5 g/m^2 NPK along with 200 ppm N + 280 ppm K as fertigation given twice a week (FM_5), whereas minimum weight (4.15 g) was recorded from FM_2 composed of basal application of 20-15-5 g/m^2 NPK and 125 ppm N + 175 ppm K given as fertigation-twice a week. Cultivar Madras showed maximum weight of the un-rooted cuttings (4.60 g) and was minimum (3.83 g) in White Wedding. Interaction effect revealed that fertilizer module FM_5 recorded maximum weight of the cuttings (4.55 g, 5.64 g, 5.18 g and 5.49 g, respectively) in cultivars White Wedding, Farida, Niva and Madras. Whereas, minimum weight of the cuttings (4.43 g, 3.80 g and 4.53 g) was recorded from FM_2 for cultivars Farida, Niva and Madras, respectively. While, in cultivar White Wedding, minimum weight of the cuttings (3.57 g) was noted from plants given a basal dose of 20-10-5 g/m^2 NPK and fertigation with 150 ppm N + 210 ppm K twice a week (FM_3). Higher fertilizer doses increased the weight of the un-rooted cuttings compared to lower fertilizer doses. The less weight of un-rooted cuttings with fertigation might be due to abrupt fluctuations in temperature and humidity throughout the growing season. A similar result was also reported by Gill and Grewal (1985) while producing the carnation cuttings of cv. Scania. Further, the weight of the cuttings was found to decrease with each successive harvest of cuttings. Similar findings were observed for obtaining better quality cuttings with frequent fertigation by Ruiter (1993) in chrysanthemum, El-Naggar *et al*. (2009) and Kazaz *et al*. (2011) in carnation.

Effect of fertilizer modules and cultivars on number of cuttings/plant/harvest

Data presented in Table 3 shows that maximum number of cuttings/plant/harvest (4.50) was recorded in cultivar Madras while, it was minimum in Farida (3.20). Interaction effect reveals that maximum number of cuttings/plant/harvest was noted with fertilizer module FM_5 in Farida Niva and Madras (4.53, 5.20 and 4.83, respectively), whereas in cultivar White Wedding, maximum number of cuttings/plant/harvest (5.03) recorded from fertilizer module FM_4. However, cultivars White Wedding showed minimum number of cuttings/plant (2.92) followed by Niva (2.77), respectively) with FM_2.

Effect of fertilizer modules and cultivars on total number of cuttings/plant

It is apparent from data in Table 4 that total number of

Table 2 Effect of fertilizer modules and cultivars on the weight (g) of the un-rooted cuttings

Cultivar (V)/	1st harvest					2nd harvest					3rd harvest					4th harvest				
Fertilizer module (FM)	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
FM_1*	3.81	4.51	3.88	4.63	4.21	4.31	4.88	4.27	5.31	4.69	3.45	4.15	3.70	3.77	3.77	3.10	3.34	3.38	3.38	3.30
FM_2	3.89	4.33	3.83	4.69	4.19	4.22	5.07	4.78	5.37	4.86	3.36	3.90	2.78	3.52	3.39	3.31	3.57	3.03	3.70	3.40
FM_3	3.67	4.58	3.81	5.08	4.29	4.02	5.04	4.87	5.81	4.93	3.01	4.43	3.40	3.31	3.54	3.15	3.25	2.94	3.39	3.18
FM_4	4.73	5.75	4.95	5.90	5.33	4.88	5.75	5.23	5.90	5.44	4.00	4.69	3.99	4.07	4.19	2.84	3.28	3.13	3.99	3.31
FM_5	4.75	6.38	5.73	6.25	5.78	4.80	5.68	5.42	5.99	5.47	4.11	4.86	4.40	4.23	4.40	3.11	3.61	3.66	3.62	3.50
Mean	4.17	5.11	4.44	5.31		4.45	5.28	4.91	5.68		3.58	4.41	3.66	3.78		3.10	3.41	3.22	3.62	
CD (P=0.05) Cultivar	0.13	0.20	0.29	0.27																
Fertilizer module	0.13	0.18	0.16	NS																
V × FM	0.27	0.37	0.40	NS																

*FM_1 : 20-20-10 g/m^2 NPK (as basal) + 100 ppm N + 140 ppm K (fertigation); FM_2 : 20-15-5 g/m^2 NPK (as basal) + 125 ppm N + 175 ppm K (fertigation); FM_3 : 20-10-5 g/m^2 NPK (as basal) + 150 ppm N + 210 ppm K (fertigation); FM_4 : 20-15-10 g/m^2 NPK (as basal) + 175 ppm N + 245 ppm K (fertigation); FM_5 : 20-5-5 g/m^2 NPK (as basal) + 200 ppm N + 280 ppm K (fertigation);V_1 : White Wedding; V_2 : Farida;V_3 : Niva; V_4 : Madras

Table 3 Effect of fertilizer modules and cultivars on number of cuttings/plant/harvest

Cultivar (V)/ Fertilizer module (FM)	1st harvest					2nd harvest					3rd harvest					4th harvest				
	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
FM_1*	3.10	2.43	2.97	3.10	2.90	2.97	2.77	3.03	2.93	2.93	3.43	3.70	3.30	4.17	3.65	3.57	3.40	3.33	3.63	3.48
FM_2	2.93	2.87	2.77	3.43	3.00	3.13	3.03	2.97	3.27	3.10	3.87	3.70	3.03	4.14	3.68	3.73	3.43	3.30	3.57	3.51
FM_3	3.23	3.03	3.10	3.24	3.15	3.10	2.90	2.97	3.00	2.99	3.53	3.53	4.60	4.67	4.08	3.80	4.07	3.57	3.57	3.75
FM_4	3.83	3.70	4.80	3.97	4.07	4.13	4.07	4.63	3.77	4.15	5.03	4.47	4.70	4.70	4.73	3.40	3.80	3.10	3.87	3.54
FM_5	4.03	3.97	4.67	4.00	4.17	4.43	4.40	5.20	3.77	4.45	4.33	4.53	4.50	4.83	4.55	2.93	4.10	3.87	4.33	3.81
Mean	3.43	3.20	3.66	3.55	-	3.55	3.43	3.76	3.35	-	4.04	3.99	4.03	4.50	-	3.49	3.76	3.43	3.79	-
CD (P=0.05) Cultivar	0.07	0.11	0.19	0.11																
Fertilizer module	0.15	0.15	0.26	0.22																
V × FM	0.27	0.29	0.50	0.42																

*FM_1 : 20-20-10 g/m^2 NPK (as basal) + 100 ppm N + 140 ppm K (fertigation); FM_2 : 20-15-5 g/m^2 NPK (as basal) + 125 ppm N + 175 ppm K (fertigation); FM_3 : 20-10-5 g/m^2 NPK (as basal) + 150 ppm N + 210 ppm K (fertigation); FM_4 : 20-15-10 g/m^2 NPK (as basal) + 175 ppm N + 245 ppm K (fertigation); FM_5 : 20-5-5 g/m^2 NPK (as basal) + 200 ppm N + 280 ppm K (fertigation); V_1 : White Wedding; V_2 : Farida; V_3 : Niva; V_4 : Madras

Table 4 Effect of fertilizer modules and cultivars on the total number of cuttings/plant

Cultivars (V)/ Fertilizer modules (FM)	White wedding	Farida	Niva	Madras	Means
FM_1*	13.07	12.30	12.63	13.83	12.96
FM_2	13.67	13.03	12.07	14.40	13.29
FM_3	13.67	13.00	14.23	14.48	13.85
FM_4	16.40	16.03	17.23	16.30	16.49
FM_5	15.73	17.00	18.23	16.93	16.98
Means	14.51	14.27	14.88	15.19	
CD (P=0.05) Cultivar	0.26				
Fertilizer module	0.29				
V × FM	0.58				

*FM_1 : 20-20-10 g/m^2 NPK (as basal) + 100 ppm N + 140 ppm K (fertigation); FM_2 : 20-15-5 g/m^2 NPK (as basal) + 125 ppm N + 175 ppm K (fertigation); FM_3 : 20-10-5 g/m^2 NPK (as basal) + 150 ppm N + 210 ppm K (fertigation); FM_4 : 20-15-10 g/m^2 NPK (as basal) + 175 ppm N + 245 ppm K (fertigation); FM_5 : 20-5-5 g/m^2 NPK (as basal) + 200 ppm N + 280 ppm K (fertigation); V_1 : White Wedding; V_2 : Farida; V_3 : Niva; V_4 : Madras

cuttings/plant was found maximum in cv. Madras (15.19), while minimum in cv. Farida (14.27). Further, total number of cuttings/plant was maximum (16.98) in fertilizer module FM_5 and minimum (12.96) in FM_1. Interaction effect reveals that maximum total number of cuttings/plant (17.00, 18.23 and 16.93, respectively) was observed with fertilizer module FM_5 in Farida Niva and Madras, whereas, cv. White Wedding recorded maximum no. of cuttings (16.40) with fertilizer module FM_4. Fertilizer module FM_1 showed minimum total number of cuttings in cultivars White Wedding (13.07) followed by Farida (12.30) and Madras (13.83), while, cv. Niva noted minimum total number of cuttings/plant (12.07) with FM_2.

Effect of fertilizer modules and cultivars on yield of cuttings/square meter

Data presented in Table 5 showed that maximum yield of cuttings (170.10) was recorded with fertilizer module FM_4, whereas, minimum (104.40) with FM_1. Interaction effect reveals that maximum yield of cuttings (163.20, 187.20 and 174.00, respectively) was recorded with fertilizer module FM_5 in Farida Niva and Madras, while, cultivar White Wedding recorded 181.20 cuttings/m^2 from fertilizer module FM_4. However, minimum yield of cuttings were noticed in cultivars White Wedding (105.60) followed by Niva (99.60) with FM_2. Whereas, the cultivars Farida (87.60) and Madras (105.60) gave the minimum yield of cuttings with fertilizer module FM_1.

The better growth parameters under fertilizer module FM_5 in cultivars Farida, Niva and Madras and in White Wedding with fertilizer module FM_4 may be ascribed to the more availability of nutrients and its synchronization with the uptake. But towards the end of harvesting period, i e 4th

Table 5 Effect of fertilizer modules and cultivars on the yield of cuttings/m²

Cultivar (V)/	1st harvest					2nd harvest					3rd harvest					4th harvest				
Fertilizer module (FM)	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
FM_1*	111.60	87.60	106.80	111.60	104.40	106.80	99.60	109.20	105.60	105.30	123.60	133.20	118.80	150.00	131.40	128.40	122.40	120.00	130.80	125.40
FM_2	105.60	103.20	99.60	123.60	108.00	112.80	109.20	106.80	117.60	111.60	139.20	133.20	109.20	148.80	132.60	134.40	123.60	118.80	128.40	126.30
FM_3	116.40	109.20	111.60	116.76	113.49	111.60	104.40	106.80	108.00	107.70	127.20	127.20	165.60	168.00	147.00	136.80	146.40	128.40	128.40	135.00
FM_4	138.00	133.20	172.68	142.80	146.67	148.80	146.40	166.80	135.60	149.40	181.20	160.80	169.20	169.20	170.10	122.40	136.80	111.60	139.20	127.50
FM_5	145.20	142.80	168.00	144.00	150.00	159.60	158.40	187.20	135.60	160.20	156.00	163.20	162.00	174.00	163.80	105.60	147.60	139.20	156.00	137.10
Mean	123.60	115.20	131.74	127.75		127.92	123.60	135.36	120.48		145.44	143.52	144.96	162.00		125.52	135.36	123.60	136.56	
CD (P=0.05) Cultivar	2.66	3.93	6.83	3.95																
Fertilizer module	5.33	5.41	9.48	8.11																
V × FM	9.90	10.42	18.26	15.02																

*FM_1 : 20-20-10 g/m² NPK (as basal) + 100 ppm N + 140 ppm K (fertigation); FM_2 : 20-15-5 g/m² NPK (as basal) + 125 ppm N + 175 ppm K (fertigation); FM_3 : 20-10-5 g/m² NPK (as basal) + 150 ppm N + 210 ppm K (fertigation); FM_4 : 20-15-10 g/m² NPK (as basal) + 175 ppm N + 245 ppm K (fertigation); FM_5 : 20-5-5 g/m² NPK (as basal) + 200 ppm N + 280 ppm K (fertigation); V_1 : White Wedding; V_2 : Farida; V_3 : Niva; V_4 : Madras

Table 6 Effect of fertilizer modules and cultivars on time taken for first and successive harvesting of cuttings (days)

Cultivar (V)/	Planting to 1st harvest					1st-2nd harvest					2nd-3rd harvest					3rd-4th harvest				
Fertilizer module (FM)	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean	V_1	V_2	V_3	V_4	Mean
FM_1*	109.00	108.00	111.00	110.00	109.50	30.30	32.97	28.93	30.97	30.74	26.37	26.83	26.73	26.83	26.69	25.27	25.93	25.27	25.07	25.38
FM_2	109.00	108.00	111.00	110.00	109.50	28.77	34.50	30.80	34.50	32.14	26.77	25.97	26.10	26.10	26.23	24.87	25.60	25.00	25.27	25.18
FM_3	109.00	108.00	111.00	110.00	109.50	29.20	31.47	32.20	29.70	30.64	26.97	27.00	25.93	26.73	26.66	25.03	25.13	25.53	25.60	25.33
FM_4	109.00	108.00	111.00	110.00	109.50	32.37	35.03	31.87	35.03	33.58	26.13	26.63	25.67	26.63	26.12	24.87	26.37	25.60	25.63	25.62
FM_5	109.00	108.00	111.00	110.00	109.50	29.87	34.93	30.47	31.93	31.80	27.23	26.63	26.53	26.03	26.46	24.50	25.60	24.80	25.60	25.13
Mean	109.00	108.00	111.00	110.00		30.10	33.78	30.85	32.43		26.69	26.49	26.07	26.47		24.91	25.73	25.24	25.43	
CD (P=0.05) Cultivar	NS	1.40	0.37	0.38																
Fertilizer module	NS	1.77	NS	NS																
V × FM	NS	NS	NS	NS																

*FM_1 : 20-20-10 g/m² NPK (as basal) + 100 ppm N + 140 ppm K (fertigation); FM_2 : 20-15-5 g/m² NPK (as basal) + 125 ppm N + 175 ppm K (fertigation); FM_3 : 20-10-5 g/m² NPK (as basal) + 150 ppm N + 210 ppm K (fertigation); FM_4 : 20-15-10 g/m² NPK (as basal) + 175 ppm N + 245 ppm K (fertigation); FM_5 : 20-5-5 g/m² NPK (as basal) + 200 ppm N + 280 ppm K (fertigation); V_1 : White Wedding; V_2 : Farida; V_3 : Niva; V_4 : Madras

harvest, cultivar White Wedding, gave the minimum number of cuttings/plant and total yield of cuttings with fertilizers module FM_5. It reflects that fertilizers have great importance to increase the weight and yield at a certain level afterwards increasing fertilization of macro nutrients has negative results. These results are in line with the findings of Wenzhong (2010), Khosa *et al*. (2011), Santos *et al.* (2011) and Twardowski *et al.* (2012) in herbaceous perennials.

The number of side shoots which appeared after pinching of the plants increased till the third harvest and thereafter, it started decreasing. This may be attributed due to the favourable environmental conditions prevailing in the polyhouse till the time of third harvest, i e March to May. Atherton and Harris (1980) also reported that shoot tips of plants grown in long days yielded greater amounts of diffusible gibberellins-like substances than shoot tips of plants grown in short days which ultimately resulted in faster shoot development. The changes in cutting yield might be due to a natural reduction in vigor of the cultivars towards the end of the harvest time. At times, all treatments produced similar numbers of cuttings, yet throughout the study, fertilizer module FM_5, more consistently produced the largest yield. Similar findings were observed in bougainvillea cv. Raspberry Ice and Purple Small Leaf (Cerveny 2006).

Effect of fertilizer modules and cultivars on time taken for first and successive harvesting of cuttings

The time taken for successive harvesting of cuttings ranged from 24.91 days to 111.00 days depending upon the cultivars (Table 6). Minimum number of days was taken for harvesting of cuttings in 3rd and 4th harvest during the months of May-June, whereas, successive harvesting took longer time during the winter months (February-March). It may be because of the fact that growth of the plants was slower during winter months due to prevailing low temperature and relative humidity which might have resulted in lesser metabolic activity and ultimately in slow growth of the plants. The results of the present findings are in accordance with the results obtained in carnation cv. Impala and Montana (Sharma 2000). These results may further be attributed to the fact that there is slow growth during winter season than summer when growth rates are about ten times higher under solar radiation of high flux density than those of winter (Bunt 1972).

Therefore, the present investigation revealed that different growth parameters responded to the fertilizer modules and fertilizer module FM_5 consisting of 20-5-5 g/m^2 NPK (as basal) along with 200 ppm N and 280 ppm K (fertigation twice a week) was found to be significantly superior over the treatments and gave the best results pertaining to the growth parameters for quality cuttings in carnation cv. Farida, Niva and Madras.

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