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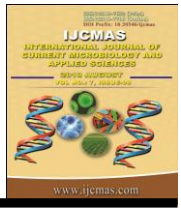

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Fertigation Effect on Carnation under Polyhouse in North Bihar Agro-Climatic Conditions

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A B S T R A C T

A study on "Fertigation Effect in Carnation under Polyhouse in North Bihar Agro-climatic conditions" was carried out under twelve (12) treatments, i.e., 3 main treatments on variety, namely; V_1: Loris; V_2: Pingu and V_3: Gioele, and 4 sub- treatments on fertigation, i.e., F_1: 80 % fertigation of RDF of NPK; F_2: 100% fertigation of NPK; F_3: 120% fertigation of NPK and F_4: 100% application of RDF (control) adopting split plot design. The average daily month wise water requirement per plant of Carnation was computed minimum 0.12cm in January and maximum 0.56 cm April. The total water requirement during crop period was found to be 66.56 cm. Among different varietal treatments, the treatment V_2 (Pingu) recorded maximum number of branches (9.80); minimum days for bud initiation (89.83 days) and flowering(164.83 days); maximum flower diameter (7.83cm) and stalk length (60.22cm) and girth (4.43 mm) as well as maximum number of flowers per m^2 area 353.The fertigation treatment F_3 (120% fertigation of RDF of NPK) was found very effective, might be due to application of higher doses, resulted maximum plant heights 87.18cm at 210 DAT. Also, the number of branches (11.59); minimum time for bud formation (87.89 days), minimum days to flowering (165.11 days), maximum stalk length (57.83cm) and girth (4.91mm) as well as maximum number of flower per m^2 area (353.22). The b/c ratio was also found highest in treatment F_3, i.e. 2.60, 2.56 and 2.59 whereas lowest 0.81, 0.96 and 0.85 found in control treatment (F_4) for Loris, Pingu and Gioele respectively.

Introduction

India is the second largest producer of flowers after China (http://business.gov.in). During the tenth plan an additional 10000 ha have been brought under the traditional flower sector by the end of 2004–05 to register an overall area of 1.16 lakh ha. Indian exports of floriculture products is valued at Rs. 100 crores. There has been an impressive growth in the export of cut flowers from Rs. 1 crore in 1987-88 to Rs 100 crores in 1998. The floriculture industry is growing at the rate of 7-10 percent per annum. During 2004, the turnover was Rs.30 billion

with a contribution of Rs. 5 billion from Delhi alone followed by Rs 4.5 billion from Bangalore. The industry is characterized by sale of most loose flowers and the export surplus from the cut-flower (rose, carnation, gerbera, orchids and anthuriums) industries. With the growing competitiveness, floriculture units in India have been facing several constraints, so there is a need to develop optimum conditions for growing cut flowers.

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

Amongst different prevailing flower varieties under cultivation in north Bihar agro climatic condition, the carnation is quite new. Its feasibility evaluation under north Bihar agroclimatic condition has been filt essential considering its increasing demand in the state. The use of a greenhouse along with the MI system for irrigation and fertigation for carnation cultivation will certainly provide a conducive result on yield, quality and longivity in the carnation harvesting span. Considering aforesaid points in view, an attempt has been made to explore the feasibility of carnation cultivation inside the polyhouse under a specific topic entitled "Fertigation effect on carnation under polyhouse in North Bihar Agro-climatic conditions ". The study is the part of the research scheme entitled "Precision Farming Development Centre (PFDC)" financed by the National Committee on Plasticulture Applications in Agriculture and Horticulture (NCPAH), Ministry of Agriculture, Govt. of India. The specific objectives of the research work to evaluate the water requirement of the carnation crop under poly house condition, fertigation effects and evaluate the cost-economics of carnation cultivation.

Aydnsakir *et al.,* (2009) conducted a study to determine the effects of different irrigation levels on flowering and flower quality of carnation in greenhouse using drip irrigation. Two irrigation intervals (10 and 20 mm pan evaporation) and four pan coefficient levels (0.60, 0.90, 1.20 and 1.50 Epan) were applied. Result revealed that high frequency irrigations using high pan coefficients increased flower stem length, flower stem diameter, stem weight, flower diameter, vase life and yield as compared to the low frequency irrigation with lower pan coefficients. Yamanaka *et al.,* (2011b) evaluated the effects of flower bearing types and pinching methods on the characteristics of water consumption in winter-spring harvest cropping type carnation under fertigation treatment. They developed regression equation amongst amount of water consumption integrated solar radiation and the leaf number as $y=0.00697X_1+0.00930X_2-1.36616$, regardless of cultivar or pinching methods. Krishna *et al.,* (1999) conducted research trial on carnation cultivars Kristina, Aleda, Master and Vienna grown from the cuttings and fertigated at the level of 80, 100

and 120% of the recommended fertilizer dose. They reported that the fertigation levels had no significant effect on plant height up to 90 days after planting (DAP), bud length, bud diameter, flower diameter, stem length, number of flowers, flower yield etc. Interactions between fertigation and cultivars were formed for plant height after 105 DAP.

Yamanaka *et al.,* (2011a) evaluated the effect of three planting patterns i.e. two-row-planting high density (25 plants.m^2), two-row-planting low density (12.5 plants.m^2), and four-row-planting (25 plants.m^2) on carnation (*Dianthus caryophyllus* L.) cv. 'Barbara' and 'Cherry Tessino' with fertigation. There was no difference in cut flower quality between two-row-planting high density and four-row-planting in both the cultivars. Cut flower weight and stem diameter of two-row-planting with low density was superior as compared to two-row-planting high density or four-row-planting. In nut shel, the result indicates that two-row-planting high density is suitable for carnation.

Bhautkar (1994) reported variation in number of branches ranging from 10 in varieties Lena, Scania and Arthur Sim to 18 in Eveline under greenhouse condition. Patil (2001) noticed that the variety Madame Collette recorded maximum number of branches (4.52), followed by Desio (4.35) and Alma (4.22), while Leon recorded minimum number of branches (2.85) at 180 DAP. Singh and Singh (2005) reported that, the maximum number of branches (9.5) were observed in the treatment of double pinching and application of 500 ppm nitrogen, followed by (9.1) in double pinching and 200 ppm nitrogen application. Bhautkar (1994) conducted study to evaluate the performance of 10 varieties under greenhouse and reported that cultivar Barbara was the earliest to initiate. However, cultivar Eveline took 119 days for bud initiation. In another study reported that the cultivar Sterile DOP (spray) was found earliest (122.06 days), whereas cultivar Pink (Standard) late (166.77 days) for bud initiation (Mahesh, 1996). Krishnappa *et al.,* (2000) reported that the varieties differed significantly for number of days taken for bud opening under low cost greenhouse. The cultivar Master took maximum number of days (63.8) for bud opening, while Vienna took minimum number of days (60.6) for bud opening. Shahkar *et al.,* (2004) studies various verities regarding bud opening under greenhouse. They reported that the cultivar Salsa took minimum number of days (20.60 days) for flower opening, while cultivar Super green noticed maximum number of days for flower opening. Singh *et al.,* (2006) noted maximum flower diameter (6.61cm) in case of availability of 4 hour additional light, and minimum (5.76 cm) under natural day length.

Materials and Methods

The experiment was carried out at the Hi-Tech Horticulture centre, Rajendra Agricultural University Pusa Samastipur Bihar under "Precision Farming Development Centre (PFDC)" financed by the National Committee on Plasticulture Application in Agriculture and Horticulture (NCPAH), Ministry of Agriculture and farmers welfare, GoI, New Delhi, running in the department of Soil and Water Conservation Engineering, College of Agricultural Engineering, R, A. U., Pusa, Samastipur. It is situated at 25^{0}59'N latitude and 85^{0}48'E longitude. Altitude of the site is 52.92 m above mean sea level. Experimental site is under humid sub-tropical climate, greatly influenced by the south-west monsoon. The main characteristic of the climate is hot-dry summer followed by cold winters. Average annual rainfall is 1270 mm, out of which about 1026 mm is received during the monsoon season from June to October. Soil type is sandy clay loam with average available moisture content 12.01%

The experiment consists of twelve treatments viz., four fertigation levels 80%, 100%, 120% and 100% (traditional) of recommended fertilizer dose (140:80:120 g NPK/m^2) and three standard varieties (Loris, Pingu, Gioele) under split plot design (SPD).

Treatments details

A. Main plot: (03) Varieties

V_1	Loris
V_2	Pingu
V_3	Gioele

B. Sub plot: (04) Fertigation level

F_1	80 % Fertigation of RDF of NPK
F_2	100 % Fertigation of RDF of NPK
F_3	120 % Fertigation of RDF of NPK
F_4	100 % Application of RDF manually

Layout plan

The experiment was laid out considering split plot design (SPD) with varieties in main plots and fertigation levels in sub-plots for three replications. The details of layout plan of experimental design showing the allocation of different treatments (main and sub-main)

Details of field layout

Crop	Carnation (*Diathus caryaphylles* L.)
Varieties	V_1,V_2 and V_3
Spacing:-	
row to row	20 cm
plant to plant	15 cm
Design	Split plot
Main plot treatments	3 (V_1,V_2 and V_3)
Sub-plot treatments	4 (F_1, F_2, F_3 and F_4)
Replications	3
Total number of plots	36
Total plot area	20 m ×10 m
Net plot size	17 m × 8 m (Deducing 20 cm as path width between treatment/replications)

Crop water requirement

The daily water requirement to be applied for irrigation to carnation inside green house was calculated using following formula (Anonymous 1997)

$$ET_c = E_P \times K_P \times K_C \times W_P \qquad 2.1$$

Where,

ET_c = Evapotranspiration rate in mm/day

E_P = pan evaporation in mm/day

K_P = Pan- Coefficient

K_C = Crop factor/crop coefficient

W_P = Wetted area factor

The data on daily pan evaporation was collected by installing pan evaporimeter inside green house, planted with carnation, for the period October 2012 to June 2013.To compute the water requirement of carnation under greenhouse, the values of other requisite parameters are taken K_p varies from 0.6 to 0.8

but for USWB Class-A pan evaporimeter it is recommended to be 0.8.The value of K_c depends on the of crop, growing stage, metrological condition mainly It's value for carnation crop for different growing stages is consider as per follows (FAO 56).

Initial stage=0.60 Development stage = 0.70 to 0.90, Middle stage = 1.0 to 1.20

Late stage = 1.10, the value of wetted factor for carnation (W_p) was taken 0.9.

Fertilizer dose and application

The RDF used in practice at Hi tech Horticulture RAU Pusa, is to the tune of 140:80:120 g/m^2 NPK respectively, in which 50% of RDF was applied as basal dose, and rest 50% was applied through fertigation.

Also, the quantity of fertilizers/FYM used to apply nutrients (N,P & K) as per recommended dose under different treatments (F_1,F_2, F_3 & F_4) were workout.

Irrigation and fertigation schedule

Carnation is very sensitive to moisture stress. A little moisture affects the plant growth and development of branches in the plant, significantly. Emergence of branches results into yield of flowers or yield. Considering this in the view of irrigation was scheduled at daily basis, to feed daily water requirement.

Application of fertilizer (NPK) as per required dose under different treatments (F_1, F_2, F_3 & F_4) was carried out along with irrigation water, through fertigation unit equipped in drip systems.

In present study, the venture type fertigation system along with fertilizer tank was used for fertigation. The requisite amount of fertilizer under different treatments was dissolve in water and formed a kind of fertilizer solution, was kept in to fertilizer tank. On drip system operation, the fertilizer solution kept in fertilizer tank gets automatically sucked by the venture system, and mixed in water flow.

Vegetative growth parameters

The plant height, total number of lateral shoots produced per plant after pinching of the tagged plants was measured from the base to the tip of plant at monthly interval in treatment wise. Flowering parameters such as number of days of bud opening from transplanting, flower's stalk length, stalk girth, diameter, quality parameter, number of flowers per plant and number of flowers per square meter was measurement recorded.

Evaluation of cost- economics of carnation crop

The cost-economics of carnation crop was evaluated for different treatments separately in terms of benefit-cost ratio (b/c). Computation was carried out based on the following input costs.

Cost of cultivation

The total incurred cost, i.e. the cost of cultivation under drip irrigation system for irrigating and fertigation crop was determined as the sum of 1. Cost of greenhouse, 2. Operating cost of tube well and pump 3. Operating cost of drip system; and 4. Cost of field experiment.

Benefit- cost ratio: The b/c ratio was computed as the ratio of benefit realized to the costs invested under cultivation, given as below:

$$b/c = \frac{\text{Benefit realized from cultivation}}{\text{Cost of cultivation}} \quad \text{..2.2}$$

Results and Discussion

Crop water requirement

The water requirement varies from maximum 16.67 cm in April to minimum 3.66 cm in the month of December. However, the monthly water requirements for the months October, November, January, February, March and May were computed to the tune of 4.32 cm, 5.05 cm, 3.97 cm, 5.67cm, 12.75cm and 14.65cm, respectively. Overall, in terms of the total depth of water requirement of carnation during the entire crop period was estimated to be 66.56cm. In terms of average daily depth of water required per plant, it was 0.15, 0.17, 0.12, 0.12, 0.20, 0.41, 0.56 and 0.47cm were computed for the months October to May. Overall, carnation requires very little water for survival.

Response on fertigation applications on plant height

An appraisal of data regarding plant height as shown in Table 1 reveals that carnation is very sensitive to fertilizer dose, e.g. at 30 DAT the plant maximum height (28.88 cm) was observed under fertigation treatment F_3 (application on 120% fertigation of NPK of RDF) followed by treatment F_2 (application on 100% fertigation of NPK of RDF), F_1 (application on 80% fertigation of NPK of RDF), and minimum in treatment F_4 (100% application of RDF manually) to the tune of 26.08 cm, 22.98cm, 20.72cm, respectively. Similarly, at 60, 90, 120, 150, 180 and 210 DAT, the maximum plant height 28.83cm, 45.31cm, 62.20cm, 80.33cm, 85.21cm and 87.18cm, respectively in treatment F_3, i.e when 120%, RDF was fertigated. The effect of fertigation treatment F_1 (application of 80% of RDF) was found at par with treatment F_4. In treatment F_2 (application of 100% RDF), the effect on plant height was noticed in between treatment F_3 and F_4. The recorded plant heights under F_2 are to the tune of 26.84cm, 41.32cm, 59.58cm, 76.80cm, 81.89cm and 83.83cm respectively at 60, 90, 120, 150, 180 and 210DAT. Statistically, the CV values of plant heights vary from minimum 3.72 at 150DAT and maximum 6.07 at 60DAT, whereas CD was minimum 1.34 at 30DAT and maximum 3.00 at 180 and 210DAT. Overall, the interaction between varieties and fertigation treatments was found non-significant.

Yield number of flower per square meter

The data on number of flowers per square meter as affected by varieties and fertigation levels are presented in Table 2.

Effect of varieties

With regard to the effect of varieties on number of flower per square meter area, there is variety wise variation. Amongst all the variety V_2(Pingu) appeared to produce highest number of flowers per square meter area, i.e 281.00, followed by variety V_3(Gioele) 273.75 and V_1(Loris) 269.25 flowers per square meter area. Statistically, it was non significant at 5% CD, the CV value is found 3.74.

Effect of fertigation

Perusal of data revealed that the fertigation levels have significant effect on yielding the number of flowers per square meter area. Amongst different fertigation levels, the maximum number of flowers per square meter (352.22) was recorded in treatment F3 (application on 120% fertigation of NPK of RDF) which is superior over treatment F_2 (application on 100% fertigation of NPK of RDF), 301.56 flowers per square meter area, F_1 (application on 80% fertigation of NPK of RDF) 274.56 flowers/m^2 and F_4(100% application of RDF manually) 170.33 flowers/$m^{2.}$ The treatment F_1 was statistically

at par with control treatment F_4. Overall, in comparison to control treatment the percentage increase in number of flowers per square meter area was estimated to be 61.20% in F_1; 77.04% in F_2 and 106.78% in treatment F_3.The CD and CV values are found 10.17 and 3.74, respectively.

Cost of cultivation

In order to evaluate the feasibility of carnation cultivation under greenhouse with fan and pad cooling system, the response of different varieties of carnation were used under research study. The benefit/cost ratio was analyzed for each variety. On comparison, it was found that there is little variation in the b/c ratio amongst different varieties, but there was a significant difference in respect of fertigation doses. This fact reveals that carnation is very sensitive to nutrient. The fertigation treatment F_3 in which 120% RDF was applied through fertigation, resulted highest b/c ratio to the tune of 2.60, 2.59 and 2.56 in varities V_1 (Loris), V_3 (Gioele) and V_2 (Pingu) respectively. On the other hand, the fertigation treatment F_4 (100% RDF application through, manually) showed a minimum b/c ratio in all the varieties, 0.96, 0.85, 0.81 in V_2, V_3 and V_1, respectively. The treatment F_2 (100% RDF through fertigation) was next to F_3 for resulting b/c ratio, which was 2.27, 2.11 and 2.00 in varieties V_2, V_3 and V_1, respectively, followed by treatment F_1, 1.89, 1.87 and 1.79 in varieties V_2, V_3 and V_1, respectively. Overall, amongst different varieties the variety V_2, which is Pingu, relatively good, followed by V_3 (Gioele)

In conclusion, the fertigation which combines irrigation with fertilizers is the most effective and convenient means of maintaining optimum fertility level and water supply according to the specific requirement of crops with drip system. Drip irrigation is the precise water application method which saves water by reducing the size of wet soil surface and thus decreasing the amount of direct evaporation and excess water percolation from the root zone.

Table.1 Effect of plant height (cm) on carnation under different varieties and different levels of Fertigation

	30 DAT	**60 DAT**	**90 DAT**	**120 DAT**	**150 DAT**	**180 DAT**	**210 DAT**
V_1	28.12	29.92	44.55	62.92	82.30	87.64	90.10
V_2	23.65	23.36	39.94	54.40	70.62	74.53	77.48
V_3	22.23	22.45	37.11	56.11	74.50	78.58	81.63
S.Em (±)	0.49	0.64	0.81	1.02	0.80	1.11	0.81
CD	1.93	2.51	3.19	4.01	3.14	4.35	3.16
CV	6.92	8.79	6.92	6.12	3.66	4.78	3.36
F_1	22.98	23.32	37.64	55.24	74.98	79.04	82.74
F_2	26.08	26.84	41.32	59.58	76.80	81.89	83.83
F_3	28.88	29.97	45.31	62.20	80.33	85.21	87.18
F_4	20.72	21.97	37.85	54.21	71.11	74.86	78.83
S.Em (±)	0.45	0.51	0.66	0.83	0.94	1.00	1.01
CD	1.34	1.52	1.95	2.46	2.80	3.00	2.99
CV	5.49	6.07	4.83	4.29	3.72	3.76	3.64
VxF	NS	NS	NS	NS	NS	NS	NS

(V_1 =Loris;V_2 = Pingu and V_3 = Gioele**)**

Table.4 Average daily water requirement of carnation plant during different months

Month	Avg. Daily evaporation (Ep) (mm/day)	Pan coefficient (K_p)	Crop coefficient (K_c)	Average wetted Area factor(W_P)	Area (m^2)	Crop water requirement		Monthly depth of water applied (mm)
						Liters /day /plant	Daily (Av.) water requirement (mm)	
Oct, 2012	3.57	0.8	0.6	0.9	0.03	0.05	1.5	43.2
Nov, 2012	3.37	0.8	0.7	0.9	0.03	0.05	1.7	50.5
Dec, 2012	2.05	0.8	0.8	0.9	0.03	0.04	1.2	36.6
Jan, 2013	1.89	0.8	0.9	0.9	0.03	0.04	1.2	39.7
Feb, 2013	2.81	0.8	1.0	0.9	0.03	0.06	2.0	56.7
March, 2013	4.76	0.8	1.2	0.9	0.03	0.12	4.1	127.5
April, 2013	6.43	0.8	1.2	0.9	0.03	0.17	5.6	166.7
May, 2013	5.96	0.8	1.1	0.9	0.03	0.14	4.7	146.5
							Total	**665.6**

Table.2 Effects of varieties and fertigation levels on number of flowers per square meter area

Sub-Treatment(Fertigation)	Main treatment(Varieties)				
	V_1	V_2	V_3	Mean	Percentage variation over control
F_1	267.00	276.67	280.00	274.56	61.20
F_2	290.33	316.67	297.67	301.56	77.04
F_3	353.33	350.00	353.00	352.22	106.78
F_4	166.33	180.67	164.00	170.33	-
Mean	269.25	281.00	273.75		-
Treatments	S.Em (±)	CD (5%)		CV	
Main treatment	4.83	NS		6.08	
Sub treatment	3.43	10.17		3.74	

(V_1 =Loris; V2 = Pingu and V_3 = Gioele**)**

Table.3 Performance of carnation under poly house

Treatments	Avg. number of braches	Avg. length of flower stake (cm)	Avg. flower bud length (cm)	Avg. flower diameter (cm)	Numbers of flowers/ Sqm	Benefit Cost ratio
V1F1	9.33	59.40	5.17	6.40	267.00	1.79
V1F2	10.47	62.83	5.53	6.58	290.33	2.00
V1F3	11.60	64.13	5.33	6.39	353.33	2.60
V1F4	6.53	54.50	5.33	6.31	166.33	0.81
V2F1	9.93	46.50	4.53	7.34	276.67	1.89
V2F2	10.87	52.73	4.53	7.35	316.67	2.27
V2F3	11.97	53.33	4.27	7.83	350.00	2.56
V2F4	6.43	46.43	4.27	4.37	180.67	0.96
V3F1	9.47	50.93	4.23	6.38	280.00	1.87
V3F2	10.20	51.97	4.10	6.33	297.67	2.11
V3F3	11.20	56.83	4.17	6.40	353.00	2.59
V3F4	6.23	46.27	4.00	6.40	164.00	0.85

On the basis of data recorded and analysed under different treatments the pertinent findings with respect to different objectives under taken, are concluded below: The water requirement varies from maximum 166.7 mm in April to minimum 36.6 mm in the month of December (Table 4). The total depth of water requirement of carnation during the entire crop period was estimated to be 665.6mm (Table 3).

Amongst different treatments on fertigation, selected under study the treatment F_3 (120% fertigation with RDF) proved to be very effective. The maximum plant height was recorded in variety V_1 (Loris) at different growth stages, *i.e.*, at 30,60,90,120,150,180 and 210 DAT which was 28.12 cm, 29.92 cm, 44.55cm, 62.92cm, 82.30cm, 87.64cm and 90.10cm, respectively. The fertigation treatment F_3 recorded higher plant height at 30, 60, 90,120,150,180 and 210 DAT *i.e.*, 28.88cm, 28.83cm, 45.31cm, 62.20cm, 80.33cm, 85.21cm and 87.18cm, respectively.

The benefit-cost ratio, justifies the feasibility of carnation cultivation under polyhouse in north-Bihar agro-climatic condition which was found to be highest in fertigation treatment F_3, i.e. 2.60, 2.56 and 2.59 for the varieties V_1, V_2 and V_3, respectively. The lowest b/c ratio 0.81, 0.96 and 0.85, was recorded in control treatment (F_4), for all three varieties i.e. Loris, Pingu and Gioele, respectively.

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