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OPTIMIZATION OF PLANTING DENSITY IN CARNATION

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ABSTRACT: The experiment on optimization of plant density inside a greenhouse for growing carnation is a very important area for present day production and productivity. The results of the study on optimization of planting density in carnation led to the inference that planting density in treatment T_4 (check) (15 X 15 cm with 36 plants/m^2) proved better in terms of flower quality parameters namely early flower bud appearance, bud opening, longest duration of flowering, chlorophyll content and more number of flowers per plant due to congenial microclimate between the plants for the plant growth and flowering. Though the percentage of 'A' grade quality flowers were higher in treatment T_3 (20 X 20 cm with 20 plants per m^2), the number of plants and flower yield per sq. m. in this treatment was very less. Hence, treatment T_4 (check) with 15 X 15 cm spacing may convincingly be followed for obtaining more number of flowers per plant and per unit area and value in terms of economic success of the crop.

Keywords : *Carnation, spacing, low volume, high value, green house, flowering duration.*

Carnation (*Dianthus caryophyllus* L.) is one of the most important cut flower crops holding a major share in the cut flower market. Optimum plant spacing for the greenhouse grown crops is an important factor which needs to be optimized owing to the increasing cost of planting materials and inputs. The effective utilization of available space inside the greenhouse will produce better outcome compared to open field crops. Carnation growers adopt different spacing levels depending on availability of space inside the greenhouse and their convenience. The carnation grower should have a systematic idea to take up planting in a right time to harvest maximum number of quality flowers for the supply during the peak demanding period. This requires a proper decision regarding planting time and plant density.

Optimum spacing enables proper utilization of solar energy, avoids competition in the uptake of nutrients caused by the collision of root system, facilitates proper intercultural operations etc. So it is imperative to maintain the optimum plant density to achieve more yield and better quality. This study was taken up to optimize the planting density inside the greenhouse for carnation with the objective of increasing the yield and quality of flowers.

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MATERIALS AND METHODS

The present study was carried out at M/s. Elkhill Agrotech, Ooty, a leading carnation unit and one of the consortium partners in the National Agricultural Innovation Project with the Department of Floriculture & Landscaping, Tamil Nadu Agricultural University, Coimbatore. The experiment was carried out inside green house in a randomized block design with four treatments viz. T_1: 15 12.5 cm (42 plants /m^2), T_2: 20 15 cm (30 plants /m^2), T_3: 20 20 cm (20 plants/m^2) and T_4: 15 15 cm* (36 plants/m^2) as check* which were grown in five replications. A spacing of 15 15 cm is adopted by the growers for commercial cultivation. In this study, this spacing was maintained as the check and was compared with three other spacing treatments as detailed above. The observations on growth parameters viz., plant height (cm), number of leaves per plant, number of laterals per plant and inter nodal length (cm) were recorded at monthly intervals for three flushes of the crop. Yield parameters viz., days taken for flower bud appearance and flower bud opening, duration of flowering (days), number of flowers per plant, flower yield/m^2 and quality parameters namely length of flower stalk (cm), bud length (cm), bud circumference (cm), number of quality grade flowers/m^2, calyx splitting (%), vase life (days) and physiological parameters viz., leaf area (cm^2), and chlorophyll content (mg/g) were observed for the three flushes of flowering.

RESULTS AND DISCUSSION

The present experiment was taken up to have a scientific database pertaining to impacts of the different levels of planting density adopted in carnation cultivation and to optimize the most ideal planting density.

Growth Parameters:

Growth and development of plants were highly influenced by the imposed levels of planting density. The quantitative characters viz., plant height, number of leaves and laterals per plant and internodal length showed marked differences among the treatments. The planting density of treatment T_3 (20 20 cm with 20 plants per m^2) produced significantly taller plants with 77.30 cm, 75.80 cm and 68.20 cm and more number of leaves with 210.50, 212.12, 204.20 and maximum internodal length of 8.40 cm, 6.80 cm 6.70 cm during the first, second and third flush of flowering in comparison with higher density of plants in treatment T_1 (15 12.5 cm having 42 plants per m^2). The number of laterals per plant was higher in treatment T_4 (check) (15 15 cm) having 36 plants/m^2 with 6.20, 7.80 and 6.00. The number of plants per m^2 in treatment T_1 (15 12.5 cm) was 2.1 times more than that the treatment T_3 (20 X 20 cm) which might have ultimately resulted in lesser growth of plants due to higher plant-to- plant competition. The increase in growth characters in T_3 (20 20 cm with 20 plants per m^2) might be due to the availability of more space facilitating improved aeration, and better penetration of light which in turn might have increased photosynthetic activity and translocation of assimilates to growing parts resulting in better availability of nutrients. This is in confirmation with the findings of Schroder (11) in carnation, Mukhopadhyay and Yadav (6) in gladiolus, Belgaonkar *et al.* (3) in annual chrysanthemum, Kool (5) in rose, and Ram *et al.*, (10) and Singh and Sangama (16) in China aster.

Flower Yield and Quality Parameters

The optimum plant spacing in treatment T_4 (check) (15 15 cm) might have added in shortening the vegetative phase, leading to earliness of flower bud appearance (145.33, 166.33, 168.67 days during I, II and III rd flush of flowering, respectively) and flower bud opening (189.33, 198.00, 214.67 days) and longest of the duration of flowering (83.00, 91.33, 112.33 days) in contrast to the treatment T_1 (15 12.5 cm). This can be explained in terms of fact that flowering is significantly influenced by the amount of light penetrating into the canopy of the plant, and the level of aeration. Further, improved aeration and light penetration also reduces incidence of pests and diseases. These observations are in concurrence with the findings reported by Singatkar *et al.* (14) in gaillardia and Bhattacharya *et al.* (4) in rose. The number of quality flowers per plant was the highest in treatment T_4 (15 15 cm) with 6.20, 7.80 and 6.00 which is attributable to the optimum moisture, nutrients and sunlight available for the growth and development of plants in this treatment.

The production of flowers per m^2 was significantly more in treatment T_1 (15 12.5 cm) having 42 plants per m^2 with 243.60, 277.20 and 216.30 and it was drastically low in T_3 (20 20 cm) with 120.00, 150.00 and 117.60 flowers per m^2 during first, second and third flush of flowering, respectively (Fig.1). The high density of plants in T_1 (15 12.5 cm) produces a two fold increase in flower yield during the three flushes of flowering. However, in terms of quality of flowers, T_3 proved superior to all other treatments. The treatment T_3 produced 94.50 per cent, 4.00 per cent and 2.00 per cent of ‘A’, ‘B’ and ‘C’ grade flowers, respectively whereas T_1 (15 12.5 cm) produced with 89.30 per cent, 5.80 per cent and 4.90 per cent of ‘A’, ‘B’ and ‘C’ grade flowers, respectively. Thus it was evident that though treatment T_1 produced more number of flowers per m^2, the proportion of ‘A’ grade

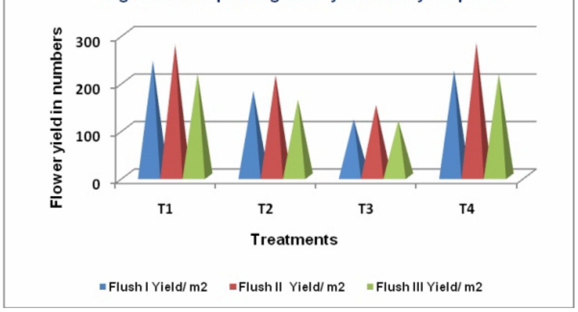

Fig.1. Effect of planting density on flower yield per m²

flowers was less and it might be due to high competition between plants for space, light, water and nutrients. This observation is in confirmation with the findings of Oydvin (7) in carnation.

Improvement in quality of floral characters viz., bud length (4.40, 4.20 and 4.00 cm) and bud circumference (7.90, 7.50 and 6.30 cm) in T_4 (check) (15 15 cm) might be due to the optimum plant spacing which in turn might have resulted in better utilization of the available resources facilitating a favourable source - sink relationship. Such observations are in accordance with the results of Pessala (9) in rose and Singh and Sangma (16) in China aster.

The length of the flower stalk was maximum in treatment T_3 (20 20 cm) with 73.80 66.10 and 62.00 cm which might be due to the fact that the plant height and internodal length was maximum in this treatment. This is in corroboration with the findings of Pandey and Mishra (8) in gladiolus.

The girth of flower stalk (1.60, 1.52 and 1.44 cm) was the highest in treatment T_3 (20 20 cm) and this is attributable to the competition-free environment. Lesser girth noticed in treatment T_1 (15 12.5 cm) 1.12, 1.05 and 0.88 cm might be due to higher density of plants. Normally the flower stalk becomes lean and lanky due to more number of plants in an unit area. This is in confirmation with the findings of Singh and Chetan (15) in gladiolus.

Higher densities of planting per m^2 were associated with the incidence of calyx splitting. The occurrence was more in treatment T_1 (15 12.5 cm) and low in T_4 (check) (15 15 cm) during the three flowering flushes. This might be due to the imbalance and competition for nutrients among the plants in the unit area. A similar trend in calyx split incidence as observed by Seager (12) and Arora and John (1) in carnation.

Observation on the keeping quality of flowers after harvest showed that the treatment T_3 (20 20 cm) with 7.67, 7.00, 6.27 days was superior and treatment T_1 (15 12.5 cm) had lowest vase life of 5.00, 6.00 and 5.00 days during the first, second and third flush of flowering, respectively. Similar results have been reported earlier by Arora and John (1) in carnation.

Physiological Parameters

Leaf area of the plant was found maximum in treatment T_3 (20 20 cm) with 18.60, 18.30 and 17.50 cm^2 (Fig.2) and it is due to the fact that the plants enjoyed more spacing and hence grew vigorously without much competition for nutrients. These results are in accordance with the findings of Shiraj and Maurya (13) in gladiolus.

The chlorophyll contents are mainly influenced by the amount of light intensities received by the plants. The treatment T_4 (check) (15 15 cm) with 0.75, 0.35 and 1.18 mg/g during first flush and 0.70, 0.30 and 1.05 mg/g during second flush and 0.68, 0.28 and 0.96 mg/g during third flush of flowering, respectively which has optimum

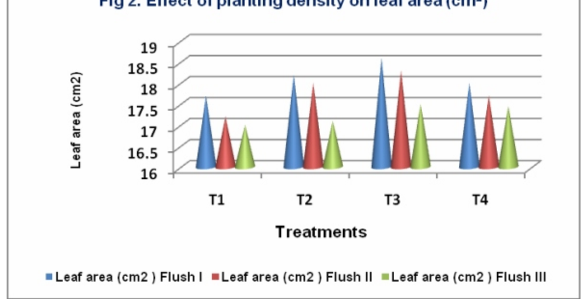

Fig 2. Effect of planting density on leaf area (cm²)

Table 1: Effect of planting density on plant height (cm) of carnation under greenhouse condition.

Treatments	Days after planting																				
	Flush I							Flush II							Flush III						
	30	60	90	120	150	180	At harvest (181–240)	270	300	330	360	390	420	At harvest (421-480)	510	540	570	600	630	660	At harvest (661–720)
T_1	8.00	14.00	20.96	30.30	51.72	66.24	69.70	22.22	30.50	43.52	52.16	56.06	62.46	69.00	22.00	35.56	45.40	56.47	59.40	62.30	64.90
T_2	8.68	15.86	22.32	31.36	53.48	66.72	71.50	22.00	33.00	45.20	55.28	58.48	64.60	71.50	26.15	37.60	46.00	56.50	58.10	63.20	65.50
T_3	10.74	18.42	23.82	32.72	59.48	74.12	77.30	25.12	34.51	46.52	59.64	64.76	69.04	75.80	29.40	40.50	53.96	57.50	64.50	67.30	68.20
T_4 (check)	9.96	16.71	21.71	30.80	55.02	69.06	74.10	22.88	33.34	45.26	58.76	60.64	67.48	73.10	26.00	38.00	47.32	54.20	60.60	64.80	67.40
Mean	9.35	16.25	22.20	31.30	54.93	69.04	73.15	23.06	32.84	45.13	56.46	59.99	65.90	72.60	25.89	37.92	48.17	56.17	60.65	64.40	66.50
C.D. (P = 0.05)	0.133	0.199	0.128	0.113	0.356	0.385	0.352	0.152	0.183	0.132	0.366	0.394	0.313	0.321	0.324	0.218	0.426	0.150	0.297	0.235	0.165

Table 2: Effect of planting density on flower bud length and circumference (cm) of carnation under greenhouse condition.

Treatments	Flush I		Flush II		Flush III	
	Flower bud length (cm)	Flower bud circumference (cm)	Flower bud length (cm)	Flower bud circumference (cm)	Flower bud length (cm)	Flower bud circumference (cm)
T_1	3.00	6.50	2.90	5.80	2.95	5.70
T_2	3.60	7.60	3.60	6.60	3.85	6.00
T_3	3.80	7.75	4.00	7.20	3.85	6.10
T_4 (check)	4.40	7.90	4.20	7.50	4.00	6.30
Mean	3.70	7.44	3.68	6.78	3.66	6.03
C.D. (P = 0.05)	0.060	0.068	0.060	0.079	0.053	0.024

spacing level utilized the received light intensity effectively for the photosynthesis and further enhanced the healthy growth of plants, early flowering, better quality stalks and yield. This is in confirmation with the report of Attridge (2) according to which such an adaptive mechanism is commonly observed in plants to maintain the photosynthetic efficiency.

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