The Pharma Innovation Journal 2021; 10(7): 1206-1210

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; 10(7): 1206-1210

www.thepharmajournal.com
Received: 19-04-2021
Accepted: 28-05-2021

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Development of precision production techniques for carnation (*Dianthus caryophyllus* L.)

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Abstract
Carnation is one of the popular cut flower and gaining more importance in the floriculture trade. The research on standardization of precision production technologies of carnation comprising of growing media consortia, planting density, planting stage, pinching techniques, calyx splitting disorder management are important components for production of quality carnation cut flowers. Growing media consortium at the ratio of 10:1:1 (30 kg of consortia) with 25 kg of farm yard manure, 2.5 kg of vermicompost, 2.5 kg of cocopeat with biofertilizers *viz*., azospirillum, phosphobacteria, VAM and biocontrol agents namely *Trichoderma viride*, *Pseudomonas fluorescens* added each @ 20 g/m^2 at bimonthly intervals is the best growing medium to achieve favourable flower yield. The research experimental study on planting density with treatment with 15 X 15 cm spacing having 36 plants in a sq.m area may convincingly be followed for obtaining more number of flowers per plant in unit area and value in terms of economic value of the crop. The experiment on planting stage and pinching level for treatment T_8 with 30 day old rooted cuttings + Single pinch at the 5th node proved to be the best in terms of number of flowers per plant (6.00, 8.30 & 5.40) and flower yield per sq.m. area (216.00, 298.80 & 194.40). Management of calyx splitting is achieved with the foliar application of 0.1 per cent borax at fortnightly intervals till flower bud initiation and at weekly intervals thereafter could reduce percentage calyx split and enhance the yield and quality of flowers.

Keywords: Growing media consortia, planting density, pinching techniques, calyx splitting

1. Introduction
Carnation (*Dianthus caryophyllus* L.), native of the Mediterranean region belongs to the family Caryophyllaceae. The legendary Greek botanist Theophrastus named it 'Dianthus' meaning 'Divine flower' or 'The Flower of Gods'. Today, carnation occupies the top slot in the global flower trade. It is an introduced cut flower in India which is grown under naturally ventilated ae**rodynamic polyhouse as a low volume high value crop. The climatic conditions prevailing in the Nilgiris, district of Tamil Nadu are most favourable for growing carnation. The awareness on the usage of cut flowers for various occasions has raised the demand for flowers in the market. Further, scientific package of practices also need to be standardized in a precise way to get maximum profit out of a unit area.

Soil, as a growing media does not fulfil all requirements for achieving maximum growth, flowering, yield and quality. So the structure, texture, porosity, water holding capacity and element composition of the growing media are major factors which determine the availability of nutrients to plants (Anil *et al.*, 2009) [1]. In modern agriculture, use of chemical fertilizers is becoming essential for higher yield, but is not eco-friendly. Therefore, it is necessary to restrict their use to certain extent. The current trend is to explore the possibility of supplementing chemical fertilizers with organics especially microorganisms (Pankaj Kumar *et al.*, 2007) [9]. For this reason, research on formulating ideal media consortia by incorporating farm yard manure, vermicompost and coco peat along with bio fertilizers and bio control agents with the existing soil in appropriate ratios has been taken up in this study.

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.

Carnation requires pinching for the regulation of flowering process (Imamura and Suto, 2001) [7]. It causes sudden reversion from flowering to vegetative phase and in turn prolongs the duration of flowering. Pinching level decides the lateral shoot development and will aide in the proper establishment of young rooted cuttings.

Hence, identifying the right age of the cuttings and the pinching level is also an important prerequisite in carnation cultivation.

Calyx splitting is a major problem in carnation production and is quite a challenge for the growers. It is a complex disorder occurring due to low boron or nitrogen content, varietal characters, temperature fluctuation, more number of petals, high potassium levels and over fertilization. Boron deficiency can aggravate the disorder up to 75 per cent.

A viable wholesome package of practices seems to be lacking. Science works best when basic principles can be translated into practical and technological solutions. The essential and basic research requirements based on the above aspects that have a big impact on the yield and quality of flowers are taken into account for developing the package which will benefit the carnation growers and the cut flower industry.

2. Material and Methods

The study was conducted in a commercial carnation growing unit under naturally ventilated polyhouse structure in Ooty, The Nilgiris, Tamil Nadu. The experiment on optimization of growing media consortia consists of farm yard manure, vermicompost, cocopoeat and biofertilizers [Azospirillum, Phosphobacteria, VAM], biocontrol agents *[Trichoderma viride*, *Pseudomonas fluorescens]* based on the C: N ratio with twelve treatments and three replications using Randomized Block design. The components were added based on the ratio of carbon-nitrogen level and as, two levels with 20 kg and 30 kg of consortia for 1 sq.m of area. After bed preparation, the media consortia components were added as per the treatment schedules. The biofertilizers azospirillum, phosphobacteria, VAM and biocontrol agents *Trichoderma viride*, *Pseudomonas fluorescens* were added @ 20 g/m^2 at bimonthly intervals except control. The observations on soil microbial populations, vegetative and flower yield characters for growing media consortia are vegetative, flower and yield characters, physiological parameters, soil and leaf nitrogen, phosphorus, potassium for three flushes of a crop.

A spacing of 15 X 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 T_1 (15 X 12.5 cm having 42 plants per m^2), T_2 (20 X 15 cm having 30 plants per m^2), T_3 (20 X 20 cm with 20 plants per m^2), T_4 (check) (15 X 15 cm having 36 plants per m^2). The experiment was conducted with four treatments and five replications using Randomized Block design.

Single pinching is the generally adopted method by carnation growers. In this experiment, cuttings of various ages namely 25, 30, 35 days were compared along with the various levels of pinching *viz.*, 4^{th}, 5^{th} and 6^{th} nodes from the base. The experiment was conducted with nine treatments and three replications using Randomized Block design.

The variety used for the experiment was Malaga, one of the leading commercial varieties in the floriculture market. The statistical analysis was done by adopting the standard procedures of Panse and Sukhatme (1985) [5] and the results were interpreted.

Plate 1a: A View of experimental polyhouse

Plate 1b: A View of experimental Field

3. Results and Discussion

The results of the study with respect to the following package has been experimented individually and discussed for standard package of practices for precision production of carnation under protected conditions.

3.1 Studies on growing media consortia

In the present experiment, farm yard manure, vermicompost and cocopeat constituted the media components of the consortium. FYM and vermicompost are additional sources of nutrients besides their ability to improve the physical, chemical and biological properties of soil. Cocopeat is a renewable peat substitute for use in horticulture, which is also known for its potential to improve the media texture. The trend in recent days is to explore the possibility of supplementing chemical fertilizers with organics and biocontrols and this concept has been tried up in carnation in this experiment. The biofertilizers have emerged as a promising component of nutrient management since they play a significant role in facilitating availability and uptake of nutrients (Mishra *et al.*, 1999) [8].

The availability of nitrogen, phosphorus and potassium in the soil is high during the stages of peak vegetative and reproductive phase during the first and second flushes and further the availability of the nutrients to the plants gets comparatively reduced during the third flush of flowering. The peak productive yield is during the first and second flush of flowering stage whereas during the third flush of flowering, the yield and quality of the flowers gets reduced and this may be due to the lesser availability of the major nutrients to the plants.

Available nitrogen in the soil is higher in treatment T_8 and this greatly influences the leaf growth, leaf area and photosynthetic rate per unit area to control production of carbohydrate and other photosynthetic products (source activity) and influences numbers and size of vegetative and

reproductive parts (sink capacity) as reported earlier by Enggels and Marschner (1995) [5]. Potassium efficiency is linked to the root growth and flowering, morphology, uptake efficiency, translocation and utilization efficiency (Fageria *et al.*, 2007) [6].

Similarly, leaf content and the uptake pattern of N, P and K is higher due to more availability of soil N, P and K in the added growing media consortia during the initial soil preparation and it plays a crucial role in holding and providing the available nutrients to the plants.

There is no limiting effect on growth and performance on crop due to high range of nutrients made available in soil by fertigation practices. By fertigation, the sufficient level of nutrients in soil is always being ensured. Growing media consortium influences mainly the initial growth stages of the crop.

It is inferred that the treatment with growing media consortium at the ratio of 10:1:1 (30 kg of consortia) with 25 kg of farm yard manure, 2.5 kg of vermicompost, 2.5 kg of cocopeat with biofertilizers *namely*, azospirillum, phosphobacteria, VAM and biocontrol agents *viz.*, *Trichoderma viride*, *Pseudomonas fluorescens* added each @ 20 g/m^2 at bimonthly intervals is the best growing medium to achieve favourable flower yield (249.48, 352.80 and 201.60 flowers per m^2 during I, II and III flushes of flowering) (Fig.1) and quality in carnation when compared with treatment (check) [180.00, 234.00 and 180.00 per m^2 during I, II and III flushes of flowering] which consists of existing soil in the bed. The results are in line with the findings of Soltani and Naderi (2016) [14] in Carnation and Arunesh *et al.* (2020) [2] in Gerbera.

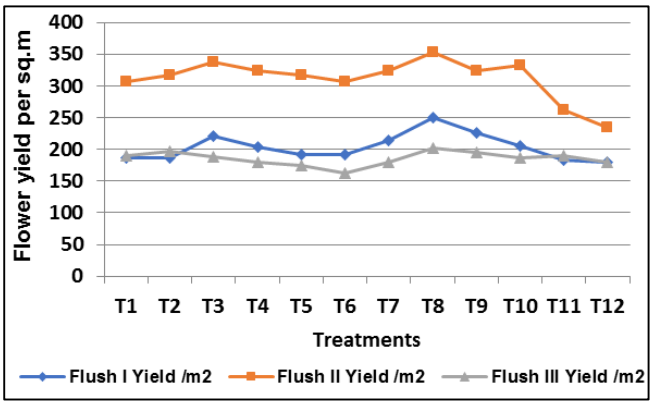

Fig 1: Effect of growing media consortia on flower yield per m^2

3.2 Studies on planting density

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 their convenience, and mainly based on the recommendations provided by the private planting material suppliers. The present research 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.

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 are 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 is very less. Hence, treatment T4 (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.

Table 1: Effect of planting density on flower yield (number of flowers) per plant and per m^2

Treatments	Flush I		Flush II		Flush III	
	Yield /plant	Yield/ m^2	Yield /plant	Yield/ m^2	Yield /plant	Yield/ m^2
T_1	5.80	243.60	6.60	277.20	5.15	216.30
T_2	6.00	180.00	7.10	213.00	5.40	162.00
T_3	6.00	120.00	7.50	150.00	5.88	117.60
T_4 (Check)	6.20	223.20	7.80	280.80	6.00	216.00
Mean	6.00	191.70	7.25	230.25	5.61	177.98
SE(d)	0.024	2.980	0.028	3.153	0.028	2.590
CD at 5%	0.053	6.494	0.062	6.871	0.061	5.643

3.3 Studies on optimization of planting stage and pinching level

The stage of planting *i.e.*, age of rooted cuttings decides the field establishment, growth and development in carnation. The main plight of carnation cultivation rests with the quality of planting material which decides the ultimate yield and quality of flowers. The rooted cuttings should be maintained in nurseries for optimum number of days to attain age of planting (*i.e.*, to develop three pairs of leaves and adequate root volume). Carnation exhibits apical dominance which influences the development of axillary shoots and flower production (Cline, 1997) [4].

The experiment on the optimization of planting stage and pinching level in carnation is carried out with the different stages of day's old rooted cuttings and pinching level. The experimental combinations of the study with different days of rooted cuttings and single pinching at three different nodal point resulted in the optimizing the days and pinching level in carnation. This will directly have an impact on the ultimate productivity of the crop. The treatment T_8 with 30 day old rooted cuttings + Single pinch at the 5th node proved to be the best in terms of number of flowers per plant (6.00, 8.30 & 5.40) and flower yield per sq.m. area (216.00, 298.80 & 194.40). The vegetative characters plant height, number of leaves per plant and laterals per plant, internodal length, quality characters *viz.*, length and girth of flower stalk, flower yield parameters and physiological characters all of which tends to increase in the overall production and quality of flower. This pinching intensity apparently tends to release apical dominance associated with reduced quantitative characters of plant. This finding is in accordance with the results of Pathania *et al.* (2000) [12] in carnation.

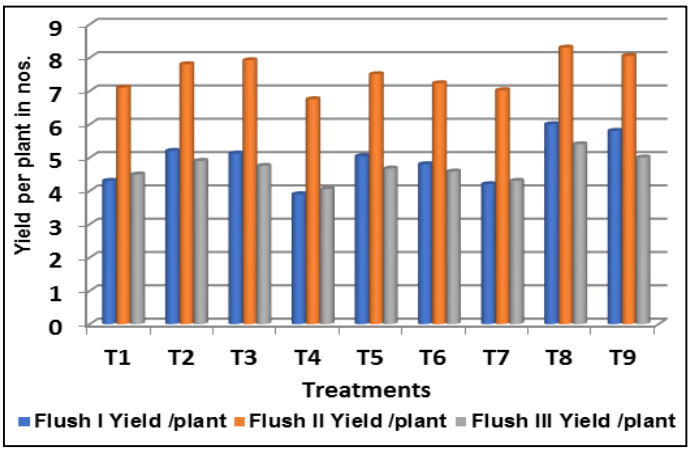

Fig 2: Effect of planting stage and pinching level on flower yield per plant

3.4 Studies on management calyx of splitting in carnation

Calyx splitting is a disorder in carnation. The treatment with foliar application of 0.1 per cent borax (T_4) recorded minimum incidence of calyx split (3.13%). T_7 (control) recorded the highest calyx split of 32.63 per cent (Fig 3.). The treatments with higher B doses namely T_5 and T_6 however recorded incidence of tip burn in the leaves which might be due to the toxicity of B. Boron has a significant role in the reproductive physiology of the plant starting from bud initiation to paint brush stage.

Earlier works have attributed calyx splitting in carnation to many factors including imbalance of nutrients higher P, lime content and low N (Winsor and Long, 1970) [16], high K application irrespective of N (Blanc *et al*., 1983) [3], low K (Uri, 1990) [15], larger differences between day and night temperature (Schneider, 1973) [13], high day temperature followed by a drastic drop in the night temperature (Pathania and Pathania, 1993) [11].

The results of the study led to the inference that foliar application of 0.1 per cent borax at fortnightly intervals till flower bud initiation and at weekly intervals thereafter could reduce percentage calyx split and enhance the yield and quality of flowers.

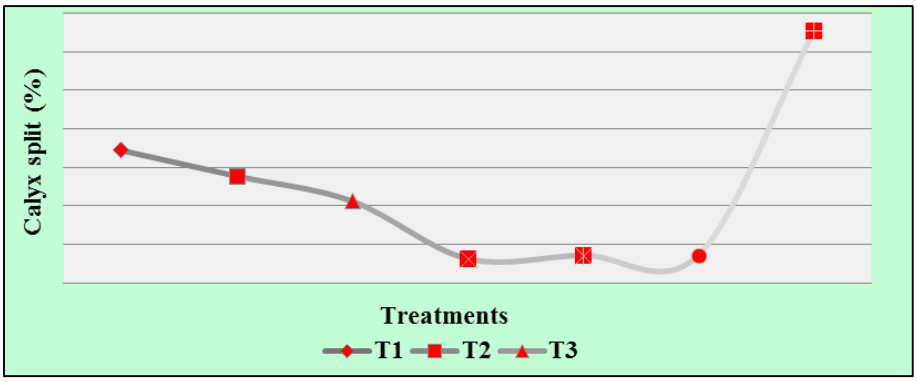

Fig 3: Effect of boron on calyx splitting (%)

4. Conclusions

Hence, it is concluded from the experiments on the studies on precision production technology of carnation growing media consortium with 10:1:1 ratio of FYM - Farm Yard Manure (25 kg sq.m): VC – Vermicompost (2.5 kg sq.m): CP - Coco peat (2.5 kg sq.m) showed better performance in terms of yield and quality attributing characters. Carnation 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. Planting of 30 day old rooted cuttings with single pinching at fifth nodal point proved to be better in terms of vegetative and physiological parameters, number of flowers per plant, yield per m^2 and quality during first, second and third flushes of flowering. Foliar application of 0.1 per cent borax at fortnightly intervals till flower bud initiation and at weekly intervals thereafter could reduce percentage calyx split and enhance the yield and quality of flowers. Based on the research results, the following package has been standardized for precision production of carnation under protected conditions.

Table 2: Show the Cultural practice recommendation

S. No.	Cultural Practice	Recommendation
1.	Media consortium	10:1:1 ratio of 30 kg of consortium with 25 kg of farm yard manure, 2.5 kg of vermicompost, 2.5 kg of cocopeat with biofertilizers azospirillum, phosphobacteria, VAM and biocontrol agents *Trichoderma viridae, Pseudomonas fluorescens* added each @ 20 g/m^2 at bimonthly intervals]
2.	Planting density	15 X 15 cm with 36 plants/m^2
3.	Planting stage and pinching level	30 day old rooted cuttings and single pinching at the 5 th node
4.	Calyx split management	Foliar application of 0.1 per cent borax at fortnightly intervals till flower bud initiation and at weekly intervals thereafter could reduce percentage calyx split and enhance the yield and quality of flowers

5. Acknowledgment
The author thankfully acknowledge the Indian Council of Agricultural Research for the financial support through the World Bank funded National Agricultural Innovation Project (NAIP) for carrying out the research and analysis.

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