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PERFORMANCE of CARNATION (DIANTHUS CARYOPHYLLUS L.) GENOTYPES for QUALITATIVE and QUANTITATIVE PARAMETERS to ASSESS GENETIC VARIABILITY among GENOTYPES

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Abstract: *Eight genotypes of Carnation were evaluated for growth, flowering, flower yield, flower quality and vase life parameters to assess spectrum of genetic variability between these characters under NVPH. Genotypes Soto, Dona and White Dona proved to have better vegetative growth whereas, for flowering parameters Soto, Golem and White Dona were early to initiate flower buds thereby earlier to reach the peak flowering. Flower quality parameters like flower stalk length was highest in Soto, Big Mama and Harish, White Dona and Dona while, maximum stalk girth was recorded in White Dona, Soto and Dona. Other quality parameters like flower diameter, flower stalk weight found best in Soto, White Dona, Dona, Big Mama and Harish. Maximum vase life and highest yield per plant were recorded in Cv. Soto followed by Dona and White Dona. Correlation between flower yield v/s 23 quantitative traits, showed higher genotypic to phenotypic correlation coefficients for most of the characters studied. Flower yield per square meter showed highly significant association with number of branches, nodes per stalk and nodes per plant, stem girth, number of leaves, leaf area, total dry matter and duration of flowering, and significant association with plant spread, girth of flower and flower length and negative correlation with days taken to flower bud initiation, first harvest and peak flowering at genotypic level. Whereas, nodes per plant and duration of flowering exhibited positive and highly significant correlation with yield, however, significant with plant spread, number of branches, nodes per stalk, stem girth, number of leaves and vase life at phenotypic level. Thus, these traits may serve as an effective selection parameter of carnation.*

Key words: *Carnation, NVPH, Crop improvement, Genotypic, Phenotypic, Correlation.*

I. Introduction

Carnation *(Dianthus caryophyllus*) is an important flower crop in Caryophyllaceae family having great commercial value as a cut flower due to its excellent keeping quality, wide array of colour and forms, also ability to withstand long distance transportation and remarkable ability to rehydrate after continuous shipping. Carnations are preferred to roses and Chrysanthemums, in several exporting countries as cut flower can also become useful in gardening for bedding, edging, borders, pots, and rock gardens. From medicinal point of view, the Carnation flowers are considered to be cardiotonic, diaphoretic and alexiteric [15].

In this modern era, with the increasing demand, development of Carnation cultivars with more desirable floral characteristics and higher productivity are found to be very important. The crop is need to be grown under protected structure as performance of varieties varies with region, season, genotypes and growing environment. In India, there is wide fluctuations exist with respect to temperature, light intensity and humidity which not only affect the yield and quality of flowers but also limit their availability for a particular period of a year. Hence it is necessary to grow Carnation under polyhouse condition for obtaining good quality flowers.

Superiority of Carnation as a cut flower is judged based on its quality which plays a vital role in the International cut flower trade. Hence testing of the available varieties for suitability and adaptability with respect to flowering, flower quality, and yield parameters are of prime importance. It is essential for plant breeders to estimate the type of variation available in the germplasm also, clear assessment of association exist between the flower yield and various quantitative traits is of at most importance to understand the association between the characters and their relative contribution to the flower yield to bring about rational improvement in carnation.

Further, there is a need of superior varieties suitable to our conditions. Hence, knowledge of the nature and the extent of variability present between the yield and yield contributing characters are considered to be of greater importance in selection of superior variety for planning an efficient breeding programme and to produce the desired quantity and quality of flowers for domestic as well as export market to meet the International demand. Keeping all these point in view the present investigations was undertaken to study the various biometrical parameters and to ascertain the nature and extent of correlation present in vegetative and flowering eight genotypes to identify the elite genotype to be used in the hybridization programme to bring the desired improvement for cut flower yield in this crop.

II. Materials and methods

The present investigation was carried out at Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere from July 2011 to June 2012, to evaluate the performance of eight different genotypes of Carnation *viz.,* Dona, White Dona, Harish, Big Mama, Soto, Liber, Golem and Big Net procured in pro-trays with coco peat media from M/S Florence Flora Ltd. Bengaluru grown under naturally ventilated polyhouse. The design followed was Randomized Complete Block Design (RCBD) with eight treatments and three replications. Raised beds of 30 cm height were prepared having one meter width with a row spacing of 20 cm and 15 cm between plants. Rooted cuttings of Carnation plants were planted and grown by following standard cultivation practices like soil sterilization, irrigation, nutrition, pinching, netting, disbudding, harvesting etc. as per the standard package of practice. The data collected from five randomly selected tagged plants 30 days after pinching from each replication and analyzed as described by [12]. Vase life data analyzed for each treatment following completely randomized design [20]. Simple correlation coefficients pertaining to the phenotypic and genotypic variations for various characters of carnation genotypes were computed as per [17]. The values of correlation coefficient (r) were calculated and the test of significance was applied as per the procedure outlined by [6]. The observations on growth, flowering flower quality, flower yield, vase life and genotypic and phenotypic correlation between those characters in different genotypes of carnation are presented in the Table 1, 2, 3 & 4.

III. Results and discussion

Flower yield is an important parameter which decides the significance of suitability of the particular genotypes for commercial cultivation, which ultimately reflects on cost of cultivation. Maximum number of flowers per plant was recorded in the cultivars Soto, Dona and White Dona whereas, it was registered minimum in Big Net and Big Mama. The study revealed that, greater leaf area, more number of leaves and branches per plant as well as plant spread, dry matter accumulation resulted in the accumulation of maximum photosynthates. All these parameters contributed for production of more number bigger sized of flowers. The results are in consonance with the findings of [15], [7].

Flower quality parameter decides the significance of suitability and economic value of the particular genotypes in the International cut flower trade. Flower stalk length is very important quality trait which decides the quality of Carnation cut flowers and also plays an important role in vase life extension by improving their post-harvest life. Maximum flower stalk length was observed in Soto followed by Big Mama, Harish, Dona, and White Dona (Table 1) however, Liber had shorter stalk. The difference in stalk length among the genotypes may be attributed to the inherent genetic character associated with the genotypes, also due to the growing environmental conditions as reported by [13], [5] and [7].

Girth of flower stalk also plays vital role in making the flower for standard cut flower. Cultivar White Dona, Soto, Dona and Harish had better and strong flower stalks whereas, Big Mama had weak flower stalks by having lesser stalk girth might be due to the genetical constitution of the genotypes [13], [7]. Being a genetically controlled character, flower diameter was found superior in cultivars Soto, Big Mama, Harish and White Dona might be attributed to the presence of more number of petals per flower whereas, cultivar Liber produced small sized flowers due to the less number of petals in its flower bud [18]. Cultivar Soto found superior in terms of flower weight, followed by White Dona while, it was less in cultivar Liber. Variation in flower weight could be expected among the genotypes as the attribute is generally a genetic character [7]. The variations with respect to flower weight among varieties might also be the result of higher water and carbohydrates level in the flower. Water plays a very important role to maintain flower turgidity, freshness and petal orientation. Similarly, carbohydrates serve as energy source for growing bud, flower opening and longevity. The ultimate effect of all these factors resulted into strong and long flower stalks, large sized buds or flower and finally increases in flower weight. This variation might be due to the varietal characters as reported by [8]. Similar variations were also observed previously in Carnation by [18].

Vase life is one of the important criteria which decide the economic value of flower. Cultivars Soto (10.00 days), Dona (9.50 days) and White Dona (9.33 days) recorded higher vase life however, Big Mama registered minimum (6.17 days). These variations in vase life among the genotypes might be the result of increased accumulation of carbohydrates since, these cultivars could produce more number of leaves and higher chlorophyll content, which might have led to increased photosynthesis and increased carbohydrates. Variation in vase life could also be attributed to fact that, the variation in ability to produce ethylene and sensitivity to it among the different genotypes. Similar variations for vase life were also observed previously in Carnation by [13] and [7]. Significant differences were observed among different Carnation genotypes with respect to flowering parameters (Table 1). The cultivar Soto was first to show its visible flower bud by taking 95.16 days after planting followed by Golem whereas, Big mama (135.34 days) and Big Net (130.01 days) were very late to initiate variable buds. Similarly Soto was the earliest to reach peak flowering (143.30 days). Other cultivars like Dona (152.12 days), Golem (153.12 days) and Liber (156.08 days) were moderately early whereas, cultivars Big Mama (191.71 days) and Big Net (187.36 days) initially exhibited slow growth and reached their peak flowering late in the season this resulted in late flowering. These variations might be attributed to genetical make up and physiological difference among the genotypes as reported by [4] & [7].

Vegetative growth is measured in a better way in terms of plant height, number of shoots, number of leaves per plant, total dry matter accumulation etc (Table 1). These factors are significantly important as they play a key role in deciding the ultimate crop yield.

Cultivars Soto, Big Mama, Harish, Dona and White Dona were vigorous in their growth whereas, Big Net and Golem were medium whereas, cultivar Liber was dwarf, recording minimum plant height (Table-1). Genetical make-up of the genotype, growing environmental conditions, production technology and cultural practices followed might have resulted in such variations with respect to plant height among the genotypes. This was in accordance with the reports of [7].

Number of shoots production is greatly influenced by apical dominance. It was registered maximum (6.80) Cv. Soto followed by White Dona (6.07), Big Mama (5.87), Dona (5.73) and Harish (5.60) which exhibited lesser apical dominance as compared to Cv. Big Net (4.60). Leaves are the prime important functional units for photosynthesis, which greatly influence the growth and flower yield of any crop. Significantly maximum number of leaves per plant (149.73) was recorded in cultivar Soto throughout the growing period followed by Dona (110.00), White Dona (105.20) and Harish (104.00) however, minimum was recorded in Big Net (79.07).The production of more number of leaves per plant in these genotypes was due to increased plant height, number of nodes and branches per plant. Similar results were obtained by [7].

Physiological parameters like leaf area, and total dry matter (TDM) production varied significantly within the genotypes. Genotype Soto has recorded maximum (2279.88 cm^2) leaf area per plant whereas, it was least in Golem (903.91 cm^2). Similarly, Soto has recorded maximum (89.12 g/plant) TDM followed by White Dona, Harish and Dona whereas, it was registered minimum in cultivar Big Net. These variations might be due to increased number of leaves, shoots and plant spread which in turn helped in maintaining higher leaf area which ultimately might have increased the dry matter production per plant in such superior genotypes. The results are in agreement with the findings of [11] in Carnation.

Variability in the population is a prerequisite especially for characters where improvement is required. Success of plant breeding programmes largely depend on the amount of genetic variability present in a given crop species for the character under improvement. Phenotypic and genotypic correlation coefficients were computed between character pairs for all the twenty three parameters studied *i.e.,* flower yield v/s ten vegetative, eight qualitative and four flowering traits of eight carnation genotypes are presented in Table 2, 3 and 4, respectively. A positive correlation between desirable characters is favourable to the plant breeder because it helps in simultaneous improvement of both the characters.

Correlation coefficient analysis measures the mutual relationship between various plant characters and determines the component characters on which the selection is based for genetic improvement for a particular character [14]. Generally genotypic correlation coefficient were high in magnitude than the corresponding phenotypic correlation coefficients for all the attributes under study, indicating a strong inherent association between various characters and was masked by environmental component with regard to phenotypic expression as reported by [9]. In many cases genotypic and phenotypic correlations were very close indicating less environmental influence.

The genotypic correlation of flower yield per meter square exhibited positive and highly significant correlation with number of branches, nodes per stalk and nodes per plant, stem girth, number of leaves, leaf area, total dry matter and duration of flowering and significant association with plant spread, girth of flower and flower length at genotypic level. Whereas, at phenotypic level nodes per plant and duration of flowering exhibited positive and highly significant association with yield and significant association with plant spread, number of branches, nodes per stalk, stem girth, number of leaves and vase life at phenotypic level. Similar results were also observed by [10] in roses for flower diameter and by [19] for vase life in Chrysanthemum. Hence, selection on the basis of these characters may not be effective as they are controlled by non-additive gene action.

With respect to qualitative parameters length of flowers stalk exhibited positive and highly significant correlation with flower diameter number of petals and flower length and significant association with flower bud

diameter and flower weight at genotypic level. However, had positive and highly significant association with flower diameter and number of petals and showed significant correlation with flower length and weight at phenotypic level. Girth of flower stalk had positive and significant association with flower length, vase life and yield at genotypic level whereas, significant association was observed with vase life at phenotypic level.
Flower bud diameter exhibited positive and highly significant correlation with flower weight and significant with flower diameter, number of petals and flower length at genotypic level whereas, significant association was observed with flower weight at phenotypic level. Diameter of flower had positive and highly significant association with number of petals, flower length and flower weight at genotypic level, and the same character showed significant correlation with above parameter at phenotypic level.
Number of petals per flower exhibited positive and highly significant association with flower length and flower weight at genotypic level. Whereas, had positive and significant association with flower length and flower weight at phenotypic level. Flower length showed positive and highly significant association with flower weight and significant with yield at genotypic level while, significant association found with flower weight at phenotypic level. None of the characters showed significant association with flower weight at both genotypic and phenotypic level. Vase life exhibited positive and significant correlation with yield at phenotypic level. These results are in line with the findings of [16] in dahlia.
Days to flower bud emergence exhibited positive and highly significant association with days to flower opening and days to peak flowering at genotypic and phenotypic level, respectively. Days to flower opening had positive and highly significant association with days to peak flowering at both genotypic and phenotypic level respectively. Duration of flowering showed positive and highly significant association with yield both at genotypic and phenotypic level respectively. None of the characters showed significant association with days taken for peak flowering at both genotypic and phenotypic level. These results are consonance with [1] in gerbera.

Vegetative parameters like plant height exhibited positive and highly significant association with plant spread, nodes per stalk and per plant, number of leaves, leaf area and total dry matter, however, exhibit significant association with number of branches and internodal length at genotypic level. Whereas, plant spread showed positive and highly significant association with number of branches, nodes per plant, number of leaves, leaf area, total dry matter and significant association with stem girth, internodal length and yield at genotypic level. In case of number of branches exhibited positive and highly significant association with nodes per plant, internodal length, number of leaves, leaf area, total dry matter and yield whereas, significantly associated with stem girth. Similar heritability estimates were reported by [3] in Chrysanthemum.
Nodes per stalk exhibited positive and highly significant correlation with nodes per plant, number of leaves, leaf area, total dry matter and yield while correlated significantly with stem girth at genotypic level. Nodes per plant exhibited positive and highly significant correlation with number of leaves, leaf area, total dry matter and yield at both genotypic and phenotypic level and significant correlation with stem girth at genotypic level. Stem girth showed positive and highly significant association with leaf yield and significantly correlated with leaf area and total dry matter at genotypic level. Internodal length exhibited positive and significant correlation with number of leaves, leaf area and total dry matter. Number of leaves showed positive and highly significant association with leaf area, total dry matter and yield at genotypic level. Leaf area exhibited positive and highly significant association with yield at genotypic level. However, total dry matter showed highly significant relationship with yield at genotypic level. The results are supported by [11] in Carnation. This reveals that indirect selection of any one of these characters shall lead to concomitant increase in cut flower yield.
Flower yield per square meter exhibited positive and highly significant correlation for most of the characters both at phenotypic and genotypic levels. It has got interdependent relationship with the vegetative parameters like number of branches, nodes per stalk and per plant, stem girth, number of leaves, leaf area, total dry matter production which might have resulted in the production of flower quality parameters like flower length, flower girth thereby bud and flower diameter and number of petals per flower and number of flowers per plant due to maximum duration of flowering. Due to all these positive and significant inter relationship the flower yield per square meter was increased. It clearly indicated that, all the above characters were interrelated and interdependent for enhancing the cut flower yield of carnation as it was evidenced by highly positive and significant correlation observed at phenotypic and genotypic levels (Table 2, 3 and 4). The results were corroborated with the findings of [2] in Marigold.

IV. Conclusion

Based on present findings, it can be concluded that cultivars *viz.,* Soto, White Dona and Dona have emerged as promising genotypes with respect to growth, earliness in flowering, flower yield and quality parameters during the entire period of its growth. Correlation studies revealed that, flower yield has got inter-dependent relationship with the vegetative parameters like, number of branches, nodes per stalk and nodes per plant, stem girth, number of leaves, leaf area and total dry matter production which might have resulted in the production of flower quality parameters like flower length, flower girth thereby bud and flower diameter and number of petals per flower and ultimately increased the number of flowers per plant. Hence, selection of the above stable characters in the promising genotypes will helpful in improving the flower yield and these characters should be given prime emphasis during selection for improvement of carnation.

Table 1: Vegetative growth, flowering, Flower quality and yield parameters in different genotypes of Carnation grown under protected cultivation

Sl. No.	Genotypes	Plant height (cm)	No. of Shoots/plant	No. of leaves/ plant	Total Dry matter (TDM)	Days to flower bud initiation	Days to peak flowering	Length of Flower stalk (cm)	Girth of Flower stalk (mm)	Flower dia. (cm)	Flower stalk weight (g)	Flower Yield/ plant (No's)	Vase life (days)
1.	Dona	97.63	5.73	110.00	56.75	110.04	152.12	84.50	4.60	5.43	39.35	10.00	9.50
2.	White Dona	96.73	6.07	105.20	76.93	106.19	161.55	84.27	5.70	5.62	52.12	9.50	9.33
3.	Harish	93.27	5.60	104.00	62.50	123.09	175.31	86.20	4.23	5.69	36.69	7.70	7.33
4.	Big Mama	91.53	5.87	95.47	48.33	135.34	191.71	88.33	3.67	5.69	48.00	7.00	6.17
5.	Soto	111.13	6.80	149.73	89.12	95.16	143.30	93.57	4.99	5.86	53.37	11.67	10.00
6.	Liber	56.96	5.60	81.60	34.18	112.85	156.08	51.37	4.36	4.70	26.44	8.50	8.67
7.	Golem	63.59	5.40	89.87	30.20	102.34	153.12	57.57	4.22	5.20	35.56	7.80	9.17
8.	Big Net	76.73	4.60	79.07	24.67	130.01	187.36	77.32	4.39	5.03	35.46	6.33	7.33
S. Em±		2.33	0.13	7.51	0.71	1.01	1.61	0.75	0.12	0.09	1.30	0.24	0.27
CD @ 5%		7.03	0.39	22.77	2.14	3.07	4.87	2.28	0.38	0.26	3.93	0.74	0.80

Table 2: Genotypic and phenotypic correlation between vegetative and flower yield parameters in different genotypes of carnation

Genotypes		1	2	3	4	5	6	7	8	9	10	11
1. Plant height (cm)	G	1	0.84**	0.67*	0.83**	0.83**	0.41	0.67*	0.88**	0.94**	0.87**	0.58
	P	1	0.70*	0.59	0.69*	0.76*	0.36	0.63*	0.73*	0.71*	0.85**	0.56
2. Plant spread (cm)	G		1	0.94**	0.61	0.81**	0.66*	0.75*	0.98**	1.06**	0.90**	0.75*
	P		1	0.79*	0.52	0.67*	0.55	0.64*	0.65*	0.67*	0.79*	0.65*
3. Number of branches	G			1	0.58	0.85**	0.64*	0.80**	0.90**	0.95**	0.89**	0.87**
	P			1	0.44	0.74*	0.56	0.73*	0.78**	0.76*	0.82**	0.77*
4. Nodes/stalk	G				1	0.91**	0.66*	0.24	0.84**	0.94**	0.79**	0.80**
	P				1	0.74*	0.59	0.24	0.54	0.55	0.70*	0.72*
5. Nodes/plant	G					1	0.64*	0.56	1.02**	1.10**	0.91**	0.90**
	P					1	0.59	0.45	0.85**	0.79**	0.85**	0.84**
6. Stem girth (mm)	G						1	0.09	0.61	0.64*	0.72*	0.82**
	P						1	0.12	0.55	0.56	0.66*	0.72*
7. Internodal length (cm)	G							1	0.71*	0.66*	0.66*	0.48
	P							1	0.59	0.54	0.64*	0.42
8. Number of leaves	G								1	0.99**	0.94**	0.94**
	P								1	0.96**	0.80**	0.72*
9. Leaf area (cm^2)	G									1	1.00	0.97**
	P									1	0.78*	0.65
10. Total dry matter (g/plant)	G										1.00	0.79**
	P										1.00	0.77
11. Flower yield/m^2	G											1.00
	P											1.00

****Significant @ 5 %, ** Significant @ 1 %***

Table 3: Genotypic and phenotypic correlation between qualitative and flower yield parameters in different genotypes of carnation

Genotypic		1	2	3	4	5	6	7	8	9
Length of flower stalk (cm)	G	1	0.23	0.63*	0.91**	1.04**	0.87**	0.77*	-0.11	0.32
	P	1	0.22	0.57	0.84**	0.81**	0.72*	0.75*	-0.11	0.32
Girth of flower stalk (mm)	G		1	0.11	0.25	0.29	0.65*	0.52	0.75*	0.67*
	P		1	0.05	0.17	0.25	0.56	0.48	0.64*	0.62
Flower bud diameter (cm)	G			1	0.78*	0.74*	0.62*	0.85**	0.12	0.32
	P			1	0.63	0.47	0.47	0.72*	0.09	0.28
Flower diameter (cm)	G				1	0.95**	0.90**	0.86**	0.02	0.42
	P				1	0.74*	0.72*	0.78*	0.02	0.41
Number of petals/flower	G					1	0.95**	0.94**	-0.21	0.27
	P					1	0.62*	0.68*	-0.16	0.11
Flower Length (cm)	G						1	0.84**	0.41	0.77*
	P						1	0.68*	0.35	0.59
Flower weight (cm)	G							1	0.14	0.46
	P							1	0.18	0.44
Vase life (days)	G								1	0.88

	P					1	0.75*
Flower yield/m^2	G						1
	P						1

Significant @ 5 %, ** Significant @ 1 %

Table.4: Genotypic and phenotypic correlation between flowering and flower yield parameters in different genotypes of carnation

Genotypic		1	2	3	4	5
Days taken to bud initiation	G	1	0.99**	-0.63	0.97**	-0.83
	P	1	0.98**	-0.61	0.95**	-0.81
Days taken to flower opening	G		1	-0.67	0.99**	-0.85
	P		1	-0.66	0.93**	-0.81
Duration of flowering (days)	G			1	-0.64	0.94**
	P			1	-0.64	0.91**
Days taken for peak flowering	G				1	-0.85
	P				1	-0.8
Flower yield/m^2	G					1
	P					1

Significant @ 5 %, ** Significant @ 1 %

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