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Direct indirect effect and correlation coefficients among flower diameter and its component characters in carnation (*Dianthus caryophyllus* L.)

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Abstract
The experiment was conducted on "Direct indirect effect and correlation coefficients among flower diameter and its component characters in Carnation (*Dianthus caryophyllus* L.)" on at polyhouse, Horticulture research centre, Sardar Vallabhbhai Patel University of Agriculture & Technology Meerut in 2018-19. At phenotypic level, flower diameter exhibited significant and positive correlation with flower duration (0.51%) followed by leaf pair/stem (0.385). while negative and significant association with days taken to bud opening. Plant height showed significant and positive convolution with stem length (0.968) and stem length displayed positive and significant correlation with leaf pair/stem (0.636). The highest positive direct effect on lower diameter was exerted by flower duration (0.443) followed by days taken to bud appearance (0.331), plant height (0.092) and stem length (0.008) while the negative direct effect on flower diameter by days taken to bud opening (-0.316) and leaf pair/stem.

Keywords: Path coefficient analysis, correlation coefficients diameter and component characters

Introduction
Carnation (*Dianthus caryophyllus* Linn.) is one of the most important commercial cut flowers in the global florist trade and ranks within the top ten cut flowers of the world. Carnation is a member of the family Caryophyllaceae has 88 genera and 1750 species. The name carnation is derived from the latin term *"Carnatio"* meaning freshness and good luck. Caryophyllous means pink refers to the colour of blooms of the original species. Carnation crop grow well in sunny environment at mild temperature. Carnation plant is one of the world's most important cut flowers due to perpetual flowering; in several countries they rank second next to rose (Pant, 2016) and carnation is known for single and multi-color cultivars.

It is a semi hardy herbaceous perennial with thick, narrow, linear and succulent leaves. Leaf blades are simple, entire, linear, glaucous, arranged in pairs, keeled and five nerved and their colour varies from green to grey- blue or purple. The stems are hardy, shiny and have one to three angles with tumid joints. Each stem produces a terminal flower and hence inflorescence is generally a terminal cyme, sometimes racemiform. Flowers are bisexual and occasionally unisexual. The flower colour varies from white to pink or purple in colour. When grown in gardens, flowers grow between 6 and 8.5 cm in diameter. Some disbudded greenhouse grown plants for exhibition have flowers of up to 10 cm diameter. Petals are broad with frilled margins and calyx is cylindrical with bracts at the base. The stamens can occur in one or two whorls, in equal number or twice the number of the petals. The fruit is in the form of a capsule and contains many small seeds. The fruit ripens within five weeks of pollination. The fruits contain an average of 40 seeds. On maturity the tubular capsule opens from top and releases the seeds.

It is essential for plant breeders to estimate the type of variation available in a collection of germplasm. Also, available information on variability and correlation among traits in carnation is very scanty. Hence, the aim of the present investigation was to ascertain the nature and extent of correlation present in vegetative and flowering character in twenty five genotypes of carnation, and, to identify elite genotype to be used in hybridization programmes to bring about desired improvement in cut-flower yield in this crop.

Material and Methods

The present investigation was conducted at Horticultural research center Sardar Vallabhbhai Patel University of Agriculture & Technology Meerut, India during 2016-17. The experimental material for the present investigation comprised 25 varieties which were produced from source as given in Table 1. The experiment was laid out in completely randomized design under polyhouse conditions. The potting mixture was prepared by equal portion of soil leaf mould sand before transplanting of rooted cutting. Rooted cuttings were transplanted into pot during Ist week of October during 2016-17 under polyhouse condition. Plant were watered after transplanting by using water cane. Routine operations like hoeing, weeding and spraying of insecticides and fungicides were done when required. Single pinching was done at 6 node stage manually after a 4 week and 2-4 healthy lateral shoots were allow to grow. Staking was done by wooden stick. Observations were recorded on three randomly tagged plants from each genotype in each replication. The mean value of 3 plants in each replication were utilized for statistically analysis. Path co-efficient analysis was done as suggested by Dewey and Lu (1959) [1] to partition the simple correlation co-efficient into direct and indirect effects.

Results and Discussion

Estimates of correlation coefficients

The phenotypic and genotypic correlation coefficients computed between the seven characters under study in table 1 (a) and table 1 (b) respectively.

At phenotypic level, flower diameter exhibited significant and positive correlation with flower duration (0.51%) followed by leaf pair/stem (0.385). while negative and significant association with days taken to bud opening.

Table 1(a): Estimates of genotypic (g) correlation coefficients among different character in carnation

Characters	Plant height (cm)	Stem Length (cm)	Leaf pair/Stem	Days taken to bud appearance	Days taken to bud opening	Flower duration (day)	Flower Diameter (cm.)
Plant height (cm)	1.000	0.965**	0.647**	-0.268*	-0.199	0.421**	0.235*
Stem Length (cm)			0.636**	-0.290*	-0.167	0.448**	0.227*
Leaf pair/Stem				0.016	-0.233*	0.634**	0.385**
Days taken to bud appearance					0.640**	-0.105	0.054
Days taken to bud opening						-0.288*	-0.243*
Flower duration (day)							0.517**
Flower Diameter (cm.)							1.000

*, ** significant at 5% and 1% level, respectively

Table 1(b): Estimates of phenotypic (P) correlation coefficients among different character in carnation

Characters	Plant height (cm)	Stem Length (cm)	Leaf pair/Stem	Days taken to bud appearance	Days taken to bud opening	Flower duration (day)	Flower Diameter (cm.)
Plant height (cm)	1.000	1.005**	0.665**	-0.284*	-0.209	0.439**	0.242*
Stem Length (cm)			0.657**	-0.290*	-0.186	0.457**	0.249*
Leaf pair/Stem				0.025	-0.231*	0.636**	0.399**
Days taken to bud appearance					0.672**	-0.100	0.037
Days taken to bud opening						-0.283*	-0.236*
Flower duration (day)							0.548**
Flower Diameter (cm.)							1.000

*, ** significant at 5% and 1% level, respectively

Plant height showed significant and positive convolution with stem length (0.968) followed by leaf pair/stem length (0.647) and flower duration (0.421) while negative and significant correlation were observed with day taken to bud appearance (-0.268). Stem length displayed positive and significant correlation with leaf pair/stem (0.636) followed by flower duration (0.448), while negative and significant correlation with days taken to bud appearance (-0.290) leaf pair/stem showed positive and significant correlation with flower duration (0.634). Days taken to bud appearance showed positive and significant correlation with bays to bud opening (0.640). Days taken to bud opening showed negative and significant correlation with flower duration (-0.288).

The estimate of genotypic correlation coefficients table 1(a) between seven characters showed clear parallelism in direction with their corresponding phenotypic correlation coefficients 1(b). The genotypic correlation was in general, higher in magnitude than the corresponding correlations at phenotypic level.

Path-coefficient analysis

The path coefficient analysis were carried out by using phenotypic as well as genotypic correlation coefficients between seven characters to resolve direct and indirect effects of different characters on grain yield per plant. The direct and indirect effects of different characters on flower diameter at phenotypic level were presented in table 2 (a).

The highest positive direct effect on lower diameter was exerted by flower duration (0.443) followed by days taken to bud appearance (0.331), plant height (0.092) and stem length (0.008) while the negative direct effect on flower diameter by days taken to bud opening (-0.316) and leaf pair/stem.

Table 2(a): Estimates of direct and indirect effects for various traits towards flower diameter in carnation at phenotypic level

Characters	Plant height (cm)	Stem Length (cm)	Leaf pair/Stem	Days taken to bud appearance	Days taken to bud opening	Flower duration (day)	Flower Diameter (cm.)
Plant height (cm)	0.092	0.008	-0.026	-0.089	0.063	0.187	0.235*
Stem Length (cm)	0.089	0.008	-0.025	-0.096	0.053	0.199	0.227*
Leaf pair/ Stem	0.060	0.005	-0.040	0.005	0.074	0.281	0.385**

Days taken to bud appearance	-0.025	-0.002	-0.001	0.331	-0.202	-0.047	0.054
Days taken to bud opening	-0.018	-0.001	0.009	0.212	-0.316	-0.128	-0.243*
Flower duration (day)	0.039	0.004	-0.025	-0.035	0.091	0.443	0.517**

*, ** significant at 5% and 1% level, respectively

Table 2(b): Estimates of direct and indirect effects for various traits towards flower diameter in carnation at genotypic level

Characters	Plant height (cm)	Stem Length (cm)	Leaf pair/Stem	Days taken to bud appearance	Days taken to bud opening	Flower duration (day)	Flower Diameter (cm.)
Plant height (cm)	0.534	-0.453	-0.034	-0.084	0.058	0.221	0.242*
Stem Length (cm)	0.537	-0.450	-0.034	-0.085	0.051	0.230	0.249*
Leaf pair/ Stem	0.355	-0.296	-0.052	0.007	0.064	0.320	0.399**
Days taken to bud appearance	-0.152	0.130	-0.001	0.295	-0.185	-0.050	0.037
Days taken to bud opening	-0.111	0.084	0.012	0.198	-0.276	-0.142	-0.236*
Flower duration (day)	0.235	-0.206	-0.033	-0.029	0.078	0.503	0.548**

*, ** significant at 5% and 1% level, respectively

Plant height exhibited indirect positive effect on flower diameter via flower duration (0.187) followed by days taken to bud opening (0.063) and stem length. Stem length by flower duration (0.199) followed by plant height (0.089) and days taken to bud opening (0.053). leaf pair/stem by flower duration ((0.281) followed by days taken to bud opening (0.074), plant height (0.060), stem length (0.005) and days taken to bud appearance (0.005). days taken to bud opening by days taken to bud appearance (0.212) and leaf pair/stem (0.009). flower duration by days taken to bud opening (.0.091) followed by plant height (0.039) and stem length (0.004).

The direct and indirect effect of different characters on flower dreamily at genotypic level is presented in table 4.16 (b). The highest pair have direct effect on flower diameter was exerted by plant height (0.534) followed by flower duration (0.503) and days taken to bud appearance (0.295) while negative direct effect showed by stem length (-0.450) followed by days taken to bud opening (-0.276) and leaf pair/stem (-0.025). Plant height exhibited highest positive indirect effect on flower diameter via flower duration (0.221) followed by days taken to bud opening (0.058) while negative direct effect by stem length (-0.453) followed by days taken to bud appearance (-0.084) and leaf pair/stem (-0.034). Stem length by plant height (0.537), flower duration (0.230) and days taken to bud opening (0.051) while negative indirect effect by days taken of bud appearance (-0.085). And leaf pair/stem. Leaf pair/stem via plant height (0.355), followed by flower duration (0.320), days taken to bud opening (0.064) and days taken to bud appearance (0.004) while Negative indirect effect via stem length (-0.296). Days taken to bud appearance via stem length (0.130) while negative indirect effect via days taken to bud opening (-0.185) followed by plant height (-0.152), flower duration (-0.050) and leaf pair/stem (0.001). Days taken to bud opening via days taken to bud appearance (0.198) followed by stem length (0.084) and leaf pair/stem (0.012) while negative indirect effect via flower duration (-0.142) and plant height (-0.111). Flower duration via plant height (0.235) and days taken to bud opening (0.078) while negative indirect effect via stem length (-0.206) followed by leaf pair/stem (-0.033) and days taken to bud appearance (-0.029)

In the present study, phenotypic and genotypic correlations were computed between seven characters. The flower diameter exhibited a very strong positive association with flower duration followed by leaf pair/stem, stem length and plant height while negative and significant association with days taken to bud opening. Thus, flower duration, leaf pair/stem, stem length and plant height emerged as most important associates of flower diameter in carnation. However, flower diameter had strong negative association at genotypic and phenotypic levels with days taken to bud opening. The strong positive associations flower diameter with flower duration followed by leaf pair/stem, stem length and plant height while negative and significant association with days taken to bud opening are agreement with earlier findings of Johnson *et al.* (1955) [4], (Misra *et al.* 2003) [6], Karuppaiah *et al.* (2009) [3], Tarannum and Hemla Naik, B. (2013), and Prakash *et al.* (2018) [9].

Leaf pair per stem exhibited strong positive association at phenotypic as well as genotypic levels with flower duration. Similarly, stem length showed very strong positive association leaf pair per stem and flower duration at both levels. The positive association at both levels was also recorded between stem length, leaf pair per stem and flower duration had very strong positive association at both levels with plant height. The existence of positive association at both levels between different yield components as mentioned above augers well for getting correlated response to their improvement during selection. The genotypic correlation coefficients between different characters were generally similar in nature to the corresponding phenotypic correlation coefficients in this experimentation. However, the genotypic correlations were greater in magnitude than their corresponding phenotypic correlations. Similar results have been reported in rice by various workers (Karuppaiah *et al.* (2009) [3], Gaidhani *et al.* (2016) [2] and Raghupathi *et al.* (2019) [12].

Path-coefficient analysis is a tool to partition the observed correlation coefficient into direct and indirect effects of diameter components on flower diameter to provide clear picture of character associations for formulating efficient selection strategy. Path analysis differs from simple correlations that it points out the causes and their relative importance, whereas the latter measures simply the mutual association ignoring the causation.

In the present study, the path-coefficient analysis was carried out at phenotypic (Table 4.5) as well as genotypic (Table 4.6) levels. At phenotypic as well as genotypic levels, flower duration exhibited very high positive direct effect on flower diameter, followed by days taken to bud appearance, plant height and stem length. The high direct effect of flower duration possessing highly significant positive association with flower diameter highlighted the importance of this trait for carnation improvement. Dewey and Lu (1959) [1], Singh and Katiyar (2001) [14], (Sanyat and Gupta, 2003) [6], Misra *et al.* (2003) [6]., Karuppaiah *et al.* (2009) [3] and Raghupathi *et al.* (2019) [12] have also found high direct contribution of

flower duration, days taken to bud appearance, plant height and stem length on flower diameter. Thus, flower duration followed by days taken to bud appearance emerged as most important direct contributor towards the flower diameter. Direct effects of remaining characters on flower diameter were too low to be considered important.

Positive indirect effects were showed via flower duration, days taken to bud opening and stem length by plant height on flower diameter phenotypic level as well as genotypic level. In contrast days to days taken to bud appearance, showed considerable negative indirect effects on flower diameter via plant height. The complexity arising due to contrasting negative indirect effect with positive indirect effect in case of biological yield per plant renders true role of biological yield per plant as indirect yield contributor complex in nature. On the basis of path-coefficient analysis at phenotypic level and genotypic level the remaining estimates of indirect effects not discussed above were too low to be considered of any consequence. The high order positive direct and indirect contribution of flower duration was also recorded by Wrigth (1921), Sanyat and Gupta (2003) [6], Misra *et al.* (2003) [6], Martolia (2006) [5], and Prakash *et al.* (2018) [9].

Thus, the maximum direct effect of flower duration corroborates the findings of Karuppaiah *et al.* (2009) [3] and Raghupathi *et al.* (2019) [12]. The negligible residual factor on grain yield suggested that no other major yield components were left over.

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