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HORTICULTURE

Morphological Variation and Genetic Diversity in Carnation (*Dianthus caryophyllus* L.) Using Agro-morphic Traits

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ABSTRACT

The objective of the study was to assess the morphological variation and genetic divergence among carnation accessions based on agro-morphic traits. Analysis of variance indicated significant difference among the genotypes for different agro-morphological traits. The cultivar Rebra had maximum plant height, stem length, leaf pair per stem while earlier bud appearance was found in cultivar Tabor. Maximum days took to bud appearance exhibited by cultivar Niva. The minimum days taken to bud opening were observed in Irene and maximum days took to bud opening found in cv. Baltico. The maximum flower duration was recorded in cv. Irene and the minimum flower duration exhibited by cv. Kazhrela. Cultivar Rebra produced larger flower while, cv. Jureno gave smaller flower. On the basis of D^2 analysis, the 25 genotypes could be grouped into 3 clusters. Cluster II accommodated highest number of 11 genotypes, followed by, cluster I with having 10 genotypes and cluster III contained 4 genotypes only. The maximum inter-cluster distance was observed between cluster III and I followed by, cluster III and II) and minimum inter-cluster distance showed between cluster II and I. As far as the cluster means are concerned, genotypes consisted in cluster II had highest mean value of plant height, stem length, flower duration and flower diameter while some genotypes showed higher mean value for the characters like earlier bud emergence in cluster II and cluster I. Therefore, a hybridization programme may be initiated involving the genotypes belonging to diverse clusters with high mean for almost all the component characters.

Highlights

- Cultivar Rebra had maximum plant height, stem length, leaf pair per stem while earlier bud emerged by cv. Tabor and maximum days took to bud appearance noted with cv. Niva.
- Cultivar Irene showed maximum flower duration and minimum flower duration exhibited by cv. Kazhrela. Cultivar Rebra produced larger flower while, cv. Jureno gave smaller flower.
- D^2 analysis revealed 3 clusters among the genotypes. Cluster II contained maximum number of 11 genotypes, followed by cluster I with 10 genotypes and cluster III having 4 genotypes only.
- As far as the cluster means value, some genotypes consisted in cluster II had highest mean value of plant height, stem length, flower duration and flower diameter while some genotypes showed higher mean value for the characters like earlier bud emergence in cluster II and cluster I.

Keywords: *Dianthus caryophyllus* Linn, D^2 analysis, carnation, genetic divergence, agro-morphic traits

Carnation is one of the most popular crops in India. It is commercial cultivated in states like Himachal Pradesh, Uttarakhand, West Bengal, Maharashtra, Tamil Nadu, Kashmir and Karnataka. Himachal Pradesh where it offers a tremendous scope for its cultivation due to varied climatic regions. It has been observed that due to its excellent keeping

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quality, wide range of forms, colures and ability to withstand long distance transportation and remarkable ability to rehydrate after continuous shipping, carnation is preferred by growers in several flower exporting countries. Pant, (2016) reported that among the flowering plants, carnation plant is one of the world's most important cut flowers due to perpetual flowering. In several countries, carnation having second rank next to rose.

Carnation (*Dianthus caryophyllus* Linn.) is a member of the family Caryophyllaceae has 88 genera and 1750 species. The *Dianthus* species are adapted to the cooler alpine regions including Europe and Asia and are also found in the Mediterranean coastal regions. Genetically carnations are generally diploids (2n=30), though tetraploid forms (4n= 60) have also been identified. Triploid carnations were produced for commercial purpose and majority of cultivated carnations are diploid. The family Caryophyllaceae consists of 80 genera and 2000 species which are either annual or perennial and most of them occur in the northern hemisphere.

Moreover, knowledge of morphological variation is essential for selection based improvement as it indicates the transmissibility of a character into future generations. It is also important to study the performance of existing cultivars for their superior desirable characters (Archana *et al.* 2007). Hence, it becomes very much necessary to study the agro-morphological variation of genotypes. Assessment of agro-morphological variation among the germplasm accessions is necessary in order to provide information for plant breeding programs (Lin 1991; Kumar 2015 a, b). Several researchers reported the use of agro-morphological traits in the characterization of germplasm diversity in horticultural crops (Baliyan *et al.* 2014; Kumar 2015; Giri *et al.* 2019). Genetic diversity plays an important role in plant breeding because hybrids between lines of diverse origin, generally, display a greater heterosis than those between closely related parents. Therefore, present investigation was undertaken to analyze agro-morphological variation and genetic diversity in carnation genotypes and also grouping of these genotypes based on their clustering pattern which further aids the breeder in selection of divergent genotypes in crop.

MATERIALS AND METHODS

The present investigation was conducted at polyhouse in the Department of Horticulture, Sardar Vallabhbhai Patel University of Agriculture & Technology, and Meerut-250110 (U.P.) during the year 2016-17. The experimental material consisted 25 genotypes for the study (Table 1).

Table 1: Name of genotypes with collection centre

Sl. No.	Cultivars	Colour	Source of procurement
1	Dark Randevous	Purplish pink with dark pink stripes	Department of FLS, UHF, Nauni, Solan
2	Rebra	Red	,,
3	Irene	White	,,
4	Sunrise	Yellow	,,
5	Kazhrela	Red	,,
6	Jureno	Pink	,,
7	Tikar	Dark Yellow	,,
8	Golern	Pink	,,
9	IIHRP-1	Red	,,
10	Lavender Lace	Purple	,,
11	Niva	White	,,
12	Baltico	White	,,
13	Farida	Light yellow with dark pink strips	,,
14	Narman	Red	,,
15	Pirandello	Red	,,
16	Harvey	Yellow	,,
17	Gaudina	Red	,,
18	Kelios	Red	,,
19	Yellow Star	Yellow	,,
20	Tabour	Light purple with dark purple strips	,, ,,
21	Domingo	White	,,
22	Liberty	Yellow	,,
23	Eskimo	Red	,,
24	White Bedding	White	,,
25	Happy Golern	White	

The experiment was laid out in randomized block design (RBD) and replicated thrice. The rooted cuttings were planted on the raised beds of 1 m width with spacing of 20 × 15 cm. Uniform package of practices was followed throughout the cropping season to grow a successful crop. The following observations were recorded on 3 randomly selected plants of each cultivar under each replication and the mean values for different characters were

subjected to statistical analysis. Seven characters were taken for the study *viz*., plant height (cm), stem length (cm), leaf pairs per stem, flower characters, days to flower bud formation, days to flower bud opening, duration of flowering (days) and flower diameter (cm). The mean values of the genotypes in each replication for quantitative and qualitative characters were used for statistical analysis (Table 2). The data were processed with the help of the software programme SPAR-1 (Doshi and Gupta, 1991). The genetic diversity among the 25 genotypes of carnation was assessed by using D^2 Mahalanobis statistic (Mahalanobis, 1936)]. The grouping of accessions was done using Tocher's method described by (Rao 1952).

RESULTS AND DISCUSSION

A total of 25 Carnation genotypes were evaluated for growth and flowering traits during the year 2018. Analysis of variance (Table 2) indicates highly significant differences among the genotypes for the characters viz: plant height, stem length, leaf pair/ stem, days taken to bud appearance, days taken to bud opening, flower duration and flower diameter.

The data given in (Table 3) clearly indicates that genotypes used in the study showed significant differences among the qualitative and quantitative traits. The cultivar Rebra had maximum plant height (70.11 cm) followed by, Irene (69.12 cm), Farida (68.19 cm) and cv. Kazherela showed minimum plant height (50.53 cm). Highest stem length was recorded in cv. Rebra (66.85) followed by lrene (65.85 cm) and Tabor (64.27 cm) while the lowest stem length was found in cv. Kazherela (45.68 cm). The cv. Rebra resulted in maximum leaf pair/stem (14.13) followed by, White Bedding (13.64 leaf pair/stem), Dark Rendevores (13.56 leaf pair/stem) and the lowest leaf pair/stem (8.13) produced by Kazherela.

Table 2: Analysis of variance for 7 characters in parents of carnation

Source of variation	d.f.	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.)
Replication	2	0.265	0.020	0.005	0.530	0.109	0.003	0.003
Treatment	24	99.009**	100.773**	7.516**	474.768**	425.502**	4.938**	0.447**
Error	48	0.921	0.857	0.033	3.396	5.137	0.031	0.007

Table 3: Mean performance for parents of carnation genotypes for growth and flowering parameters.

Sl. No.	Genotypes	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.)
1	Baltico	65.10	61.20	11.33	128.21	158.04	10.00	5.19
2	Dark Rendevous	61.25	57.32	13.56	108.13	133.02	11.84	5.34
3	Domingo	57.03	53.44	11.25	118.06	138.01	12.44	4.80
4	Eskimo	56.42	52.30	9.75	120.24	139.03	10.87	5.10
5	Farida	68.19	61.55	12.54	95.10	119.02	11.00	5.25
6	Gaudina	56.34	51.62	10.27	111.12	133.20	11.00	5.69
7	Golern	66.16	61.80	12.65	127.03	144.23	9.98	5.38
8	Happy golern	65.42	60.26	12.58	130.19	130.10	10.00	5.30
9	Harvey	64.77	59.93	12.65	110.04	133.07	10.00	5.20
10	IIHRP-1	54.31	50.20	9.78	119.13	139.11	9.87	5.44
11	Irene	69.12	65.85	13.43	94.06	108.12	13.15	5.70
12	Jureno	58.37	54.28	12.45	100.35	122.04	8.83	4.48
13	Kazhrela	50.53	45.68	8.13	123.11	141.38	8.60	4.68
14	Kelios	55.28	51.57	11.26	120.19	135.12	10.00	5.20
15	Liberty	53.61	49.57	11.17	115.22	135.21	11.23	5.32
16	Lavender lace	65.43	62.36	9.38	93.14	154.23	9.20	4.50
17	Narman	59.78	54.85	12.65	117.04	136.48	12.00	5.00

18	Niva	60.41	56.49	11.35	134.52	154.68	10.00	4.70
19	Pirandello	51.22	47.18	10.57	125.26	147.52	10.00	5.68
20	Rebra	70.11	66.85	14.13	121.12	140.31	13.00	5.90
21	Sunrise	57.18	53.26	9.87	107.11	131.23	9.67	4.78
22	Tabor	67.20	64.27	11.54	91.17	115.07	12.00	5.54
23	Tikar	63.30	58.62	11.40	120.20	137.40	11.00	4.80
24	White Bedding	62.11	57.85	13.64	131.10	142.30	12.00	5.30
25	Yellow Star	56.12	51.63	8.97	107.08	122.10	9.00	5.10
	Mean	60.59	56.40	11.45	114.71	135.60	10.67	5.18
	Range	50.00	45.68	8.13	91.00	108.00	8.60	4.48
		70.00	66.85	14.13	134.00	158.00	13.15	5.90
	SE(d)	0.78	0.76	0.15	1.51	1.85	0.14	0.07
	C.D.	1.58	1.53	0.30	3.03	3.73	0.29	0.14
	C.V.	1.59	1.64	1.58	1.61	1.67	1.65	1.62

Table 4: Clustering pattern of 25 genotypes of carnation on the basis of non-hierarchical Euclidean cluster analysis

Clusters	No of genotypes	Name of genotypes
I	10	Sunrise, Jureno, Lavender Lace, Baltico, Farida, Narma, Pirandello, Yellow Star, Domingo, Happy Golern
II	11	Dark Randevous, Rebra, Irene, Tikar, Golern, IIHRP-1, Harvey, Gaudina, Kelios, Eskimo, White Bedding
III	4	Kazhrela, Niva, Tabour, Liberty

Variation in growth characters among the genotypes might be due to the genetic constitution of individual plant. Similar variations in agro-morphic traits have been reported by various workers i.e. (Kumar *et al.* 2007; Kumar *et al.* 2014; Kumar 2015; Sirohi *et al.* 2017 and Prakash *et al.* 2018) in different flowering crops. Flowering parameters also showed significant differences among the genotypes (Table 3). The earlier bud appearance (91.17) was found in cv. Tabor, followed by, Lavender lace (93.14 days) and Farida (93.10 days) while, maximum days took to bud appearance (134.52) recorded with cv. Niva. The minimum days taken to bud opening were found in cv. Irene (108.12) followed by, Tabor (115.07 days) and Farida (119.02 days) while, maximum days took for bud opening (158.04 days) registered with cv. Baltico. The longer flower duration (13.15 days) was recorded in cv. Irene followed by, Rebra (13.00 days), Domingo (12.44 days) and shorter flower duration (8.60 days) exhibited by cv. Kazhrela. Cultivar Rebra produced larger flower (5.90 cm) followed by Irene (5.70 cm) and Gaudina (5.69 cm) while, cv. Jureno gave smaller flower (4.48 cm). The variation in flower attributing traits might be due to hereditary traits of different genotypes. It might also be due to the genetic makeup of the varieties and their interaction with prevailing genotype and environment. Similar findings have also been reported by Baliyan *et al*. (2014), Kumar *et al.* (2016) and Prakash *et al.* (2017) in chrysanthemum Kumar *et al*. (2007) and Kumar (2015b) in gladiolus (Kumar 2015 b and Kaushik *et al*. 2016) in garlic.

In present study, Non-hierarchical Euclidean cluster analysis helped in grouping of 25 genotypes into 3 distinct non-overlapping clusters (Table 4). Cluster II accommodated highest number of 11 genotypes, followed by cluster I with having 10 genotypes and cluster III had only 4 genotypes. Similar results were also reported by Baliyan *et al*. (2014), Kumar *et al.* (2016) and Prakash *et al.* (2017) in chrysanthemum, Kumar et al (2014) in gladiolus and Gupta *et al*. (2017) in pea. The intra-cluster and inter-cluster distance (Table 5) revealed that inter-cluster distance values were greater than the intra-cluster values. The maximum inter-cluster distance was observed between cluster III and I (4.682), followed by cluster III and II (3.391) and minimum inter-cluster distance was recorded between cluster II and I (2.459) indicating the resemblance among the genotypes of this group for all characters studied. Thus, the crossing between the genotypes belonging to cluster pairs separated by very high inter-

Table 5: Average intra and inter-cluster distances for 3 clusters in carnation

Clusters	I	II	III
I	1.787		
II	2.459	**1.931**	
III	4.682	3.391	**1.814**

Table 6: Cluster means values for 7 characters in carnation

Clusters		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.)
I	**Mean**	54.65	50.73	10.22	114.70	134.40	9.91	5.15
	S.Em.±	2.65	2.66	1.23	8.15	7.93	0.92	0.41
II	**Mean**	62.46	58.56	12.04	119.64	141.73	10.77	5.05
	S.Em.±	2.91	2.88	1.24	12.31	9.64	1.12	0.30
III	**Mean**	68.50	64.63	12.91	100.25	120.50	12.29	5.60
	S.Em.±	1.29	2.31	1.12	13.94	13.77	1.00	0.27

cluster distances, may be helpful to get desirable transgressive segregants. The lowest inter-cluster distance between demonstrated by cluster II and I which indicates that genotypes belong to these clusters pairs were genetically close to each other. The crosses between genotypes belonging to clusters separated by low inter-cluster distances are unlikely to throw promising recombinants in the segregating generations. Arunachalam (1981) also stated that genotypes belonging to the cluster with maximum inter cluster distance are genetically more divergent. Therefore, it is suggested that selection of genotypes based upon large cluster distances from all the clusters may lead to favorable broad spectrum of genetic variation for flower yield improvement. Similar results had also been suggested by Baliyan *et al*. (2014) in chrysanthemum. As far as the cluster means are concerned, different clusters have higher mean values for different traits indicating that few of the cluster contained genotypes with most of the desirable characters (Table 6). The genotypes accommodated in cluster II had highest mean value of plant height, stem length, flower duration and flower diameter while some genotypes showed their higher mean value for the characters like earlier bud emergence in cluster II and I however, bud opening exhibited by some genotypes in cluster II and III (Table 6). Therefore, a hybridization programme may be initiated involving the genotypes belonging to diverse clusters with high mean for desirable and qualitative traits. Therefore, based on D^2 analysis, yield contributing characters showed higher value under clusters mean performance need to be given more weightage, while selecting parents for improvement. Giri *et al*. (2019) also observed similar findings when worked on marigold.

Keeping in view the above aspects, the genotypes 'Rebra and Irne from cluster II cultivar Tabor from cluster III and Lavender Lace from cluster I respectively found deserve and to be considered as potent parents for further utilization in carnation improvement programme.

CONCLUSION

The wide spectrum of variation was observed in carnation germplasm for growth and flowering traits. Cultivar Rebra gave maximum plant height (70.11cm), stem length (66.85 cm), leaf pairs per stem (14.13), flower diameter (5.90 cm) while, flower duration (13.15 days) observed in cv. Irene. Cultivar Tabor emerged earlier bud appearance (91.17) and minimum days took to bud opening were found in cv. Irene (108.12). Divergence analysis of twenty five genotypes of carnation was grouped in to 3 different clusters. Cluster II contained highest number of (11 genotypes) followed by, cluster I with 10 genotypes and cluster III had minimum 4 genotypes. The maximum inter-cluster distance was observed between cluster III and I (4.682), followed by cluster III and II (3.391) and minimum inter-cluster distance was recorded between cluster II and I (2.459). Cluster mean values of different cluster showed differences among the characters. Therefore, crosses between members of clusters having high cluster means for important characters coupled with high inter-cluster distance between them are

likely to be more rewarding. Clustering pattern in this situation exhibited considerable differences which indicated that it would be logical to examine genetic divergence in this environment individually for genetically reliable information.

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