RESEARCH PAPER

Genetic variability study for yield and associated quantitative characters in mutant genotypes of *Dianthus caryophyllus* L.

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Abstract

The present study was conducted to evaluate the nine *Dianthus* genotypes, including normal and mutagen treated, to assess the magnitude of variability and to pick up the heritable component of variation present in the quantitative traits. The analysis of variance revealed highly significant (P< 0.05 or 0.01) differences for all the characters studied, indicating the presence of substantial genetic variability. The phenotypic co-efficient of variation (PCV) was higher than genotypic co-efficient of variation (GCV) for all the characters studied, this shows the influence of the environmental effect on the characters. Highest GCV and PCV were noticed for total branches per plant and lowest for total no. of flowers per plant along with plant height (cm) at 50% flowering phase and flower diameter (cm) only in PCV. Broad sense heritability ranged from 33.33 (Days to seed germination) to 95.30 (Plant height at 50% flowering phase) per cent. Total leaves and branches showed high, plant height, days to branching and seeds per inflorescence showed moderate and flower per plant showed low genetic gain. Thus, these traits may serve as an effective selection parameter during breeding programme for crop improvement.

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Introduction

Dianthus caryophyllus, commonly known as Carnation, is a popular cut-flower as per its floricultural impact throughout the world. A high agronomic demand related to yield or production was noticed for this Caryophyllaceous member. Inducible mutation by chemical or physical agents can produce the development of *Dianthus* cultivars with more desirable floral characteristics and higher productivity (Roychowdhury and Tah, 2011; Roychowdhury, 2011). The knowledge of the extent to which the desirable characters are heritable is a prerequisite for any crop improvement programme, especially for mutation breeding. For this purpose, inducible mutation is a suitable source of producing variation through mutation breeding procedure (Domingo *et al.*, 2007) which can produce several improved mutant varieties with high demanding economic values (Din *et al.*, 2004). Various quantitative traits with agro-economical value like seed weight, number of branches, leaves, flowers, leaf area, etc., are very much complex in nature because they confirm polygenic inheritance and greatly influenced by minute fluctuation of environmental components. Genetic improvement of any crop is largely depending on the magnitude of several genetic parameters like analysis of variance of each mean value, phenotypic and genotypic variances, phenotypic and genotypic coefficient of variation (PCV and GCV), broad sense heritability and genetic gain on which the breeding methods are formulated for its further improvement. Analysis on genetic variability reveals about the presence of variation in their genetic constitution, and it is of outmost important as it provides the basis for effective selection. Wide spectrum of genetic variability has been induced in *Dianthus caryophyllus* using both physical and chemical mutagens in order to utilize it in floricultural improvement and inheritance studies (Patil, 1966; Ashri, 1970; Gowda *et al.*, 1996). The extent of variability is measured by genotypic coefficient of variance (GCV) and phenotypic coefficient of variance (PCV) which provide informations about relative amount of variation in different characters. Hence, to have a thorough comprehensive idea, it is necessary to have and analytical assessment of quantitative traits. Since heritability is also influenced by environmental factors, the information on heritability alone may not help in pin pointing characters enforcing selection. Nevertheless, the heritability estimates in conjunction with the predicted genetic gain will be more reliable (Johnson *et al.*, 1955). Heritability gives the information on the magnitude of inheritance of quantitative traits i.e. polygenic inheritance, while genetic gain will be helpful in formulating suitable selection procedures. Hence, the present study in *Dianthus* cultivar has been undertaken to study the available extent of genetic variation and the magnitude of heritability of several common quantitative characters and the maximum possible amount of genetic gain expected to occur during the selection programme for crop improvement.

Materials and methods

The present study comprises of nine genotypes including normal (Control) and mutant of experimental plant material (*Dianthus caryophyllus* L.) after mutagenic treatment. Pure line seeds of this *Dianthus* variety were treated with three commonly used chemical mutagens namely Ethyl methane sulphonate (EMS), Sodium Azide (SA) and Colchicine (Col) with the concentrations of 0.1%, 0.4% and 0.7% (w/v) for each mutagen according to Roychowdhury (2011). The mutagen treated seeds were sown for raising first mutant (M_1) generation and were maintained at Crop Research Farm (latitude 23.53° N, 22.56° S and longitude 83.25° E, 86° W), Botany Department, The University of Burdwan, West Bengal, India, during winter season (2009 to 2010). This sowing process followed Randomized Block Design (RBD) layout with three replications for each genotypes/treatments. Each genotype was sown in three rows of 5 m length plot and 20 cm apart by adopting the spacing of 20 x 20 cm. Normal

recommended cultural practices and plant protection measures were followed. The data were recorded on five randomly selected plants from each replication for quantitative traits studied like days to seed germination, plant height (cm) at 50% flowering phase, days to branching, total number of branches per plant, total leaves per plant, leaf area (cm2), total no. of flower per plant, diameter of flower (cm), seeds per inflorescence and weight (g) of 1000 seeds. These all data were analyzed statistically. For the analysis of genetic parameters, we consider the analysis of variance of each mean value, phenotypic and genotypic variances, phenotypic and genotypic coefficient of variation (PCV and GCV), broad sense heritability and genetic gain. Mean values were subjected to analysis of variance (ANOVA) to test the significance for each traits after Panse and Sukhatme (1957, 1967). Phenotypic and genotypic variances were estimated according to Lush (1940). The genotypic and phenotypic coefficients of variation (GCV and PCV) were worked out according to the method advocated by Singh and Chaudhary (1985). Heritability in broad sense was worked out as per the methodology given by Allard (1960). Expected genetic gain (GG) of the genotypes and its per cent of mean at 5% intensity of selection pressure (2.06 after Kang et al., 1983) were calculated according to Singh and Chaudhary (1985).

Results and discussion

In this investigation, all 10 studied quantitative characters showed significant differences in the mean sum of squares due to genotypes or treatments (Table 1) which indicate that the nine genotypes of *Dianthus* cultivar including the control and mutagen treated ones were genetically divergent. So, there is a huge scope for selection of promising mutant lines with different metrical traits from the present gene pool. The presence of wide range of variability might be due to diverse source of materials after mutation taken as well as environmental influence affecting the phenotypes. The calculated value of variance ratio was significant at 5% level in case of days to seed germination, leaf area and weight of 1000 seeds; other characters showed significant at 1% level of significance. The significant critical difference (CD) value indicates that *Dianthus* cultivar was no doubt suitable in the location where prevailing agro-climatic factors provided plantation of crop was in proper time. Higher the CD value indicates higher the stability in that climate. Here, total leaves per plant shows higher CD value (4.49), days to branching and seeds/inflorescence show moderate (2.74 and 2.64, respectively) and weight of 1000 seeds represents lower CD value (0.21).

The estimation on genetic parameters like genotypic ($\sigma^2 g$) and phenotypic ($\sigma^2 p$) variance, genotypic (GCV) and phenotypic (PCV) coefficient of variation, broad sense heritability (h^2_{bs}) and genetic gain (GG) of the population of *Dianthus* genotype under study is given in Table 2. A wide range of variation was observed among different genotypes or treatments with regard to different characters. The range of mean within the character was generally in equilibrium for most characters except for total leaves per plant, total number of flower per plant and no. of seeds per inflorescence.

The maximum genotypic and phenotypic variation were obtained for total leaves per plant and plant height (cm) at 50% flowering phase, while moderate variation was observed for days to branching, seeds per inflorescence and total no. of flower per plant. This indicated that the environment did not influence these characters very much. Values of phenotypic and genotypic variance were very much close for weight (g) of 1000 seeds and total no. of branches per plant. The character with almost equal value of phenotypic and genotypic variance can be considered stable. Low level of genotypic and phenotypic variance for days to seed germination, leaf area (cm²), flower diameter (cm) which also shows negative value for genotypic variance and 1000 seed weight (g) is indicative of stable nature

of these characters. Similar findings were reported by   Ganesan *et al*. (1994) and Rao *et al*. (1996).

Table 1. Analysis of variance for 10 quantitative characters in 9 genotypes of *Dianthus caryophyllus* including normal control and mutant ones grown at Crop Research Farm, Burdwan University, during winter (2009-2010). Mean sum square (MSS) of replications, treatments and error along with critical difference (CD) and coefficient of variation (CV) were calculated for each studied characters. 'df' denotes degree of freedom.

Source	df	Quantitative characters studied									
		Days to seed germination	Plant height (cm) at 50% flowering phase	Days to branching	Total no. of branches / plant	Total leaves/ plant	Leaf area (cm²)	Total no. of flower/ plant	Diameter of flower (cm)	Seeds/ inflorescence	Weight (g) of 1000 seeds
Replication	2	0.15	0.286	1.148	1.78	0.704	0.04	3.37	0.02	1.037	0.001
Treatment	8	0.37*	32.69**	13.75**	3.171**	105.12**	0.69*	10.62**	0.106**	70.79**	0.026*
Error	16	0.148	0.528	1.315	0.359	3.537	0.258	1.287	0.03	3.62	0.015
Coefficient of Variation (CV)		8.926	1.437	6.686	12.535	3.132	13.262	3.119	4.214	10.01	7.953
Critical Difference (CD)		0.66	1.73	2.74	1.43	4.49	0.88	1.96	0.41	2.64	0.21

* and ** sign indicate the significant at probability 5% and 1% level of significance, respectively.

Table 2. Component of genetic parameters for 10 quantitative characters among nine *Dianthus caryophyllus* genotypes.

Quantitative Characters	Mean (X)	Range		Components of Variance			GCV	PCV	h^2_{bs} %	GG	GG as % of mean
		Max	Min	σ^2g	σ^2p	σ^2e					
Days to seed germination	4.31	5.01	4.13	0.074	0.222	0.148	0.235	0.406	33.33	0.185	4.29
Plant height (cm) at 50% flowering phase	50.57	55.1	45.6	10.723	11.251	0.528	0.239	0.246	95.30	6.43	12.72
Days to branching	17.15	22.6	13.21	4.148	5.463	1.315	0.439	0.505	75.93	3.186	18.58
Total no. of branches/plant	4.78	7.4	3.51	0.937	1.296	0.359	0.750	0.882	72.30	1.441	30.15
Total leaves/plant	60.04	85.91	34.34	33.861	37.398	3.537	0.359	0.377	90.54	10.852	18.07
Leaf area (cm²)	3.83	4.86	2.82	0.144	0.402	0.258	0.367	0.613	35.82	0.28	7.31
Total no. of flower/plant	36.37	43	25.4	3.111	4.398	1.287	0.179	0.214	70.74	2.57	7.06
Diameter of flower (cm)	4.11	4.6	3.5	-0.07	0.029	0.099	---	0.154	-241.37	---	---
Seeds/inflorescence	19	27.6	12.32	3.972	5.562	1.59	0.561	0.638	71.41	2.932	15.43
Weight (g) of 1000 seeds	1.54	1.82	1.25	0.011	0.026	0.0147	0.253	0.388	42.30	0.092	5.97

Legends:

σ^2g = genotypic variance, σ^2p = phenotypic variance, σ^2e = environmental variance, GCV = genotypic coefficient of variance, PCV = phenotypic coefficient of variance, h^2_{bs} = broad sense heritability, GG = genetic gain.

In general, phenotypic coefficient of variation (PCV) was higher in magnitude than the genotypic coefficient of variation (GCV) for all the characters studied, the close resemblance between the corresponding estimates of both PCV and GCV in almost all the characters suggested that the environment had little effect in those characters expression (Ranjan Jalgaonkar et al., 1990). The GCV provides a measure to compare genetic variability present in various quantitative characters. The highest value of it was recorded for total branches per plant, moderate for days to branching and seeds per inflorescence and lowest for total flowers per plant. Flower diameter (cm) showed no GCV because genotypic variance was negative. The higher value clearly indicated high degree of genotypic variability in these quantitative traits in *Dianthus caryophyllus*. PCV which measure total relative variation was highest for total branches per plant, moderate for seeds per inflorescence, leaf area, days to branching and seed germination, lowest for flower diameter (cm), total no. of flowers per plant and plant height (cm) at 50% flowering phase. Similar result was reported for plant height (cm) Pathania *et al.* (1988). High values of GCV suggest better improvement scope for these traits by selection. However, the estimation of heritable variation with the help of genetic coefficient of variation alone may be misleading. Burton (1951, 1952) suggested that the genetic coefficient of variation together with heritability estimates gave the better picture of the extent of heritable variation.

Heritability (h^2) and genetic gain (GG) estimates were interpreted as low, medium and high as per the classification of Johnson *et al.* (1955a). Broad sense heritability (h^2_{bs}) ranged from 33.33 (Days to seed germination) to 95.30 (Plant height at 50% flowering phase) per cent. High heritability was recorded for plant height at 50% flowering phase (95.3%) and total leaves per plant (90.54%), moderate heritability for days to branching (75.93%), total branches per plant (72.3%), seeds per inflorescence (71.41%) and total

flowers per plant (70.74%), lowest for days to seed germination (33.33%) and leaf area (35.82%). Flower diameter showed negative value due to its genotypic variance. High heritability combined with high genetic gain as per cent of mean was observed for total leaves per plant and total no. of branches per plant. This indicates the lesser influence of environment in expression of these characters and prevalence of additive gene action in their inheritance, hence amenable for simple selection. High heritability with moderate genetic gain as per cent of mean was recorded for plant height at 50% flowering, days to branching and seeds per inflorescence indicating that these characters were governed by additive gene interaction. High heritability coupled with low genetic gain as per cent of mean was recorded for total flowers per plant indicating non-additive gene action for these traits.

The knowledge on heritability of traits is helpful to decide the selection procedure to be followed to improve the trait in a situation. Higher estimates of heritability with genetic gain as per cent of mean was observed for total leaves per plant and total no. of branches per plant indicating the presence of additive gene action and so selection can be easily done for these traits. The trait which expressed high heritability and low genetic gain showed non additive gene interaction, hence heterosis breeding would be recommended for that trait.

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