African Crop Science Journal, Vol. 19, No. 3, pp. 183 - 188
ISSN 1021-9730/2011 $4.00
Printed in Uganda.

EVALUATION OF GENETIC PARAMETERS FOR AGRO-METRICAL CHARACTERS IN CARNATION GENOTYPES

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(Received 29 July, 2011; accepted 26 September, 2011)

ABSTRACT

Carnation *(Dianthus caryophyllus)* is a worldwide reputed cut-flower crop. The objective of the study was to estimate various genetic parameters like critical difference (CD), phenotypic and genotypic variance, phenotypic and genotypic coefficient of variation (PCV and GCV), broad sense heritability and genetic gain, etc. of *Dianthus* genotypes in order to assess the magnitude of variability for various agro-metrical characters.The study revealed highly significant differences for all the studied characters, indicating the presence of substantial genetic variability. The phenotypic coefficient of variation(PCV) was higher than its corresponding genotypic counterpart (GCV) for all characters studied. The highest GCV and PCV were evident in total branches per plant; and their lowest values for total number of flowers per plant along with plant height taken at 50% flowering phase. Broad sense heritability ranged from 33.33 (days to seed germination) to 95.30 (plant height at 50% flowering) per cent. Flowers per plant showed low genetic gain; hence, heterosis breeding would be recommended. These characters may serve as effective selection parameter in breeding programme for crop improvement.

Key Words: *Dianthus caryophyllus*, genetic gain, mutation breeding

RÉSUMÉ

La Carnation *(Dianthus caryophyllus)* est une cut-flower crop mondialement reconnue. L'objectif de cette étude était d'estimer divers paramètres génotyipiques et phénotypiques des génotypes de *Dianthus* genotypes pour évaluer l'ampleur de variabilité de divers caractères agro-métriques. L'étude a révélé de différences significativement élevées pour tous les caractères étudiés, indiquant ainsi la présence d'une variabilité génétique substancielle. Le coefficient de variabilité phénotypique (PCV) était plus élevé que son homologue génoyipique correspondant (GCV) pour tous les caractères étudiés. Les GCV et PCV les plus élevés étaient évident dans le total de branches par plant; et leurs valeurs les plus basses pour le total du nombre de fleurs par plat ainsi que la hauteur de plants à 50 % de la phase de floraison. L'héritabilité au sens large variait de 33.33 (Nombre de jours à la germination de grains), à 95.30 (hauteur de plants à 50% de la floraison) pour cent. Le nombre de fleurs par plant a montré une gain génétique basse; ainsi, l'amélioration de l'héterosis pourrait être recommendée. Ces caractères pourraient server comme sélection efficace des paramètres dans le programme d'amélioration des cultures.

Mots Clés: *Dianthus caryophyllus*, gain génétique, l'amélioration mutation

INTRODUCTION

Carnation *(Dianthus caryophyllus)* is a popular cut-flower throughout the world. Inducible mutation by chemical or physical agents can accelerate the *Dianthus* cultivars with more desirable floral characteristics and higher productivity (Roychowdhury and Tah, 2011a). 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 for producing variation through mutation breeding (Domingo *et al*., 2007).

Various agro-metrical traits like seed weight, number of branches, leaves, flowers and leaf area are very complex in nature because they confirm polygenic inheritance and are greatly influenced by minute fluctuation of environmental components.

Genetic improvement of any crop is largely dependent on the magnitude of several genetic parameters like 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 its presence and is of utmost importance as it provides the basis for effective selection. Wide spectrum genetic variability has been induced in *Dianthus caryophyllus* using both physical and chemical mutagens (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 provides information about the relative amount of variation in different characters. Hence, to obtain a comprehensive idea, it is necessary to undertake an 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. However, heritability estimates in conjunction with the predicted genetic gain will be more reliable (Johnson *et al*., 1955).

This study was undertaken to assess the extent of genetic variation and the magnitude of heritability of several common agro-metrical characters and the maximum possible amount of genetic gain expected to occur in *Dianthus* cultivar during selection for crop improvement.

MATERIALS AND METHODS

The study comprised of nine genotypes, including a normal (control) and mutant of *Dianthus caryophyllus* L. after mutagenic treatment. Pure line seeds of *Dianthus* 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 (Roychowdhury and Tah, 2011b). The mutagen-treated seeds were sown for raising first the mutant (M_1) generation and were maintained at the Crop Research Farm (latitude 23.53^{o}N, 22.56^o S and longitude 83.25^o E, 86^o W), Botany Department, The University of Burdwan, West Bengal in India, during winter season.The sowing process followed a randomised block design with three replications for each treatment.

Each genotype was sown in three rows of 5 m length and spacing of 20 cm x 20 cm. Data were recorded on five randomly selected plants from each replication for plant height at 50% flowering phase, days to branching, total number of branches per plant, total leaves per plant, leaf area, number of flowers per plant, diameter of flower, seeds per inflorescence and weight of 1000 seeds.

For statistical analysis of genetic parameters, we considered 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 as per Panse and Sukhatme (1967). Phenotypic and genotypic variances were estimated according to Lush (1940). The genotypic and phenotypic coefficients of variation (GCV and PCV) were computed according to the method advocated by Singh and Chaudhary (1985). Heritability in broad sense was determined according to 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 Sing and Chaudhary (1985).

RESULTS AND DISCUSSION

All the studied agro-metrical characters showed significant differences ($P<0.05$) among genotypes(Table 1), indicating that the nine genotypes of *Dianthus* cultivar, including the control and mutagen-treated were genetically divergent. Thus, there is a huge scope for selection of promising mutant lines with different agro-metrical traits from the present gene pool. The presence of a wide range of variability might be due to diverse sources of the materials after mutation induction, as well as environmental influence affecting the phenotypes.

The calculated value of variance ratio was significant ($P<0.05$) in case of days to seed germination, leaf area and weight of 1000 seeds. It also reveals that the value of coefficient of variation (CV) ranges from 1.437 for plant height at 50% flowering to 13.262 for leaf area.The significant critical difference (CD) values indicate that *Dianthus* cultivar was suitable for the location where prevailing environmental effects were favourable. The higher CD value indicates higher stability in that environment. Here, total leaves per plant showed higher CD value (4.49), days to branching and seeds per inflorescence show moderate (2.74 and 2.64, respectively) and weight of 1000 seeds represents lower CD value, i.e. 0.21 (Roychowdhury, 2011).The estimation of genotypic (σ^2g) and phenotypic (σ^2p) variance, genotypic (GCV) and phenotypic (PCV) coefficient of variation, broad sense heritability (h^2_{bs}) and genetic gain (GG) of the *Dianthus* genotypes is given in Table 2. A wide range of variation was observed with regard to different traits. The differences among maximum and minimum values of all characters were high in total leaves per plant (51.57), total flowers per plant (17.6) and number of seeds per inflorescence (15.28). The other characters showed non-significant differences.

The maximum genotypic and phenotypic variations were obtained for total leaves per plant and plant height at 50% flowering; while moderate variation was observed for days to branching, seeds per inflorescence and total flower per plant. This indicated that the environment did not significantly ($P<0.05$) influence these characters. There was a very close difference between phenotypic and genotypic variance for weight of 1000 seeds (0.015) and total number of branches per plant (0.359). The character with almost equal value of phenotypic

TABLE 1. Analysis of variance for agronomic characters in treatments of *Dianthus caryophyllus* including control and mutant genotypes

Source	df	Agronomical characters studied									
		Days to seed germination	Plant height (cm) at 50% flowering phase	Days to branching	Total number of branches/ plant	Total leaves/ plant	Leaf area (cm^2)	Total number of flower/ plant (cm)	Diameter of flower	Seeds/ inflores-cence	Weight (g) of 1000 seed
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*	32.698*	13.759*	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

*Sign indicates the significant at probability 5% level of significance

TABLE 2. Component of genetic parameters for 10 agro-metrical characters among nine *Dianthus caryophyllus* treatments

Agro-metrical traits	Mean (X)	Range		Components of variance			GCV	PCV	h^2_{bs} %	GG	GG as % of mean
		Max	Min	$\sigma^2 g$	$\sigma^2 p$	$\sigma^2 e$					
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 (cm^2)	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

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

and genotypic variance can be considered stable, based on Yadav *et al.* (2010). Lower values of genotypic and phenotypic variance were noticed in days to seed germination, leaf area, flower diameter and 1000 seed weight, which is indicative of the stable nature of these characters. Flower diameter showed negative value (-0.07) for genotypic variance. Similar findings were reported by Rao *et al.* (1996).

In general, the phenotypic coefficient of variation (PCV) was higher than its genotypic counterpart (GCV) for all the characters studied (Table 2). This resemblance between PCV and GCV in almost all the characters suggests that the environment had little effect on those characters' expression and was consistent with Jalgaonkar *et al.*'s. (1990) observation. The GCV provides a measure for comparing genetic variability in various metrical characters. The highest GCV value was recorded for total branches per plant (0.75), moderate for days to branching (0.439), and seeds per inflorescence (0.561); and the lowest for total flowers per plant (0.179). Flower diameter showed no GCV because genotypic variance was negative. The higher value (0.75 for total branches per plant) clearly indicated a high degree of genotypic variability in the examined traits in *Dianthus caryophyllus*. PCV which measures total relative variation was the highest for total branches per plant (0.882); moderate for seeds per inflorescence (0.638), leaf area (0.613), days to branching (0.505) and seed germination (0.406); the lowest for flower diameter (0.154), total number of flowers per plant (0.214) and plant height (0.246). Similar results were reported for plant height by Pathania *et al.* (1988). High values of GCV suggested better improvement for selection of traits. However, the estimation of heritable variation with the help of genetic coefficient of variation alone may be misleading. Burton (1952) suggested that the genetic coefficient of variation together with heritability estimates gave a 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.* (1955). Broad sense heritability ranged from 33.33% for days to seed germination to 95.30% for plant height at 50% flowering. High heritability was recorded for plant height (95.3%) and total leaves per plant (90.54%). Moderate values were obtained for days to branching (75.93%), total branches per plant (72.3%), seeds per inflorescence (71.41%) and total flowers per plant (70.74%). The lowest heritability values were obtained for days to seed germination (33.33%) and leaf area (35.82%).

Flower diameter showed a negative value due to its genotypic variance. High heritability combined with high genetic gain was observed for total leaves per plant and total number of branches per plant. This indicates less influence of environment in expression of these characters; and prevalence of additive gene action in their inheritance (Panse, 1957). Hence, these metrical traits require simple selection in breeding programmes. High heritability with moderate genetic gain was recorded for plant height, days to branching and seeds per inflorescence. This indicated that the characters were governed by additive gene interaction. High heritability coupled with low genetic gain was recorded for total flowers per plant indicating non-additive gene action.

The knowledge on heritability of traits is helpful in deciding the selection procedure to improve the trait given. Higher estimates of heritability with genetic gain as per cent of mean was observed for total leaves per plant and total number 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.

REFERENCES

Allard, R. W. 1960. Principles of plant breeding. New York, John Wiley and Sons. pp. 89-98.

Ashri, A. 1970. A dominant mutation with variable penetrance and expressivity induced by diethyl sulfate in peanuts, *Arachis hypogaea* L. *Mutation Research* 9:473-480.

Burton, G. W. 1952. Quantitative inheritance in grasses. *6th International Grassland Congress* 1:277-283.

Domingo, C., Andres, F. and Talon, M. 2007. Rice cv. Bahia mutagenised population: A new resource for rice breeding in the Mediterranean basin. *Spanish Journal of Agricultural Research* 5:341-347.

Gowda, M. V. C., Nadaf, H. L. and Sheshagiri, R. 1996. The role of mutation in intraspecific differentiation of groundnut (*Arachis hypogaea* L.). *Euphytica* 90:105-113.

Jagaonkar, R., Jamadagni, B. M. and Salvi, M. J. 1990. Genetic variability and correlation studies in turmeric. *Indian Cocoa, Arecanut and Spices Journal* XIV (1):20-22.

Johnson, H. W., Robinson, H. F. and Comstock, R. E. 1955. Estimation of genetic and environmental variability in soybean. *Agronomy Journal* 47:314-318.

Kang, M.S., Mille, J.D. and Tai, P.Y. P. 1983. Genetic and phenotypic path analysis and heritability in sugarcane. *Crop Science* 23: 643-647.

Lush, J.L. 1940. Intra-sire correlation and regression of offspring on dams as a method of estimating heritability of characters. *Proceedings of American Society for Animal Production* 33:293-301.

Panse, V.G. 1957. Genetics of quantitative characters in relation to plant breeding. *Indian journal of Genetics and Plant Breeding* 17: 318-328.

Panse, V.G. and Sukhatme, P.V. 1967. Statistical Methods for Agricultural Workers. 2nd Edition, ICAR publication, New Delhi. 381p.

Pathania, N., Singh, M. and Arya, P.S. 1988. Genetic evaluation of some economic traits in turmeric (*Curcuma longa* L.). *Himachal Journal of Agricultural Research* 14 (1):38-43.

Rao, T.P., Gomathinayagam, P. and Soundrapandian, S. 1996. Genetic variability and character association studies in semi-dry rice. *Madras Agricultural Journal* 83(3):185-188.

Roychowdhury, R. 2011. Effect of Chemical Mutagens on Carnation (*Dianthus caryophyllus* L.): A Mutation Breeding Approach. Lambert Academic Publishing, Germany. 15 p.

Roychowdhury, R. and Tah, J. 2011a. Mutation breeding in *Dianthus caryophyllus* for economic traits. *Electronic Journal of Plant Breeding* 2(2):282-286.

Roychowdhury, R. and Tah, J. 2011b. Assessment of chemical mutagenic effects in mutation breeding programme for M_1 generation of Carnation (*Dianthus caryophyllus*). *Research in Plant Biology* 1(4):23-32.

Singh, R.K. and Chaudhary, B.D. 1985. Biometrical Methods in Quantitative Genetic Analysis. Kalyani Publishers, Ludhiana, India. 318p.

Yadav, P., Rangare, N.R., Anurag, P.J. and Chaurasia, A.K. 2010. Quantitative analysis of Rice (*Oryza sativa* L.) in Allahabad agro-climate zone. *Journal of Rice Research* 3(1): 16-18.