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Studies on genetic variability in gaillardia *(Gaillardia pulchella* Foug.) genotypes

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Abstract: Genetic variability and heritability studies involving eight genotypes of gaillardia *(Gaillardia pulchella* Foug.) indicated that there were highly significant differences between the genotypes for most of characters studied. The analysis of variance revealed that highly significant differences among genotypes for all the characters studied. The phenotypic coefficients of variations (PCV) were higher than genotypic coefficient of variation (GCV) for all the characters studied. However higher PCV and GCV estimates were found for number of branches per plant, number of leaves per plant, flower yield per hectare and seed yield per plant. Estimates of high heritability with high genetic advance over per cent mean for growth characters were observed for plant height, number of branches per plant, number of leaves per plant, leaf area and chlorophyll content. And for flowering traits, it was recorded in duration of flowering, days taken for seed setting, indicating the possible role of additive gene action.

key words: Genetic advance, Genetic variability, Gaillardia, Heritability

Introduction

Gaillardia pulchella Foug. is a herbaceous annual or short-lived perennial (Helen *et al.,* 2007), belongs to the family of Asteraceae with basic chromosomes number of X=18 and 2n=36 (Srivastava and Kandpal, 2006). Out of twenty species available in the genus *Gaillardia*, only *Gaillardia pulchella* is annual and *Gaillardia aristata*, is a perennial are in cultivation (Anon, 1950). It is native to Florida and western United States (Anon, 2007). The generic name of gaillardia was proposed in honor of Gaillard de Marentonneauin 18_{th} century, a French supporter of botany (Bailey, 1929). Flowers are small and numerous; born in solitary, usually showy heads which is stated as capitulam with 4 to 6 cm in diameter. Individual flowers in a capitulam are called florets which range from one to ten according to cultivars or genotypes. As a member of Asteraceae it has both ray and disc florets which are pistillate and hermaphrodite, respectively in nature. Flower has a long hairy stalk and single, semi- double and double types with single or multicolored heads (Cox and Klett, 1984). The crop produces flowers in a wide range of colors such as yellow, orange, cream, scarlet, bronze, brick-red and red and can be grown all around the year (Shreedhar, 1993). Nowadays, gaillardia has gained importance for its profuse and long duration flowering habit. It is one of the hardiest annuals that can be grown in a variety of soils and under varied climatic conditions it tolerates temperature as low as -1°C. Gaillardia can withstand fairly high salinity and 50 per cent of yield could be obtained even at 8.7 ds/m salinity level and this can be tried as a new flower crop for saline soils (Khimani, 1991). Present investigations were carried out to assess eight gaillardia genotypes for morphological, flowering, yield and quality parameters to select suitable accession for further exploitation.

Material and Methods

The present experiment was carried out at experimental block of Department of Floriculture and Landscape Architecture, College of Horticulture, Mudigere during the period from October 2014 to April 2015 to study the genetic variability, heritability and genetic advance in eight gaillardia genotypes. The experiment was laid out in randomized complete block design (RCBD) with three replications. Details of the genotypes used in study were given in table-1.

Forty five old seedlings were transplanted in ridges and furrow after irrigation and other cultural practices are followed as per standard recommendations (Anon., 2008). Observations were recorded on five randomly tagged plants from each genotypes of each replication avoiding border plants. Observations were recorded on various parameters and analyzed statiscally. Analysis of variance was carried out as per the procedure given by Panse and Sukhatme (1967) using the mean values of random plant in each replication from all treatments. Genotypic and phenotypic coefficients of variation were estimated according to Burton and Devane (1953) based on estimate of genotypic and phenotypic variance.

Results and Discussion

Analysis of variance of all the eight genotypes revealed highly significant variation among the genotypes for most of the characters studied. This suggested the presence of wide range of variability for different characters among the genotypes which can be exploited through selection. The mean performance of the

Table-1: Details of the genotypes used in study were

Genotypes	Type	Colour
T_1: Arabhavi Gaillardia Collection-1 (AGC-1)	Double	Yellow
T_2: Arabhavi Gaillardia Collection-2 (AGC-2)	Double	Reddish centre with outer yellow
T_3: Dharwad Gaillardia Collection-1 (DGC-1)	Double	Bright yellow
T_4: Dharwad Gaillardia Collection-2 (DGC-2)	Double	Red tinged with yellow
T_5: Sarpan Gaillardia Collection-1 (SGC-1)	Double	Bright red
T_6: Sarpan Gaillardia Collection-2 (SGC-2)	Double	Bright pink
T_7: Sarpan Gaillardia Collection-3 (SGC-3)	Double	Bright yellow
T_8: Sarpan Gaillardia Collection-4 (SGC-4)	Double	Yellow tinged with red

Table-2: Mean performance of *Gaillardia pulchella* Foug. genotypes for growth parameters, flower quality and seed yield

Genotype	Growth parameters						Flower quality					Seed yield per plant (g)
	Plant height (cm)	No. of branches /plant	Days taken for appea-rance of first flower	Days taken for 50 % flowering	Flowering duration (days)	Days taken for full bloom	Diameter of Flower (cm)	Individual flower weight (g)	No. of flowers /plant	Flower yield /plant (g)	Vase life (days)	
T_1	52.60	13.83	59.00	92.00	136.67	5.00	3.52	3.27	131.60	344.68	6.27	11.17
T_2	57.50	14.13	49.00	81.67	128.33	5.33	3.18	3.05	99.40	271.62	6.20	12.91
T_3	45.29	10.53	55.33	95.33	119.67	5.33	3.18	3.11	94.87	270.61	6.04	9.27
T_4	58.38	14.17	48.00	78.00	146.67	4.67	3.15	3.07	115.27	348.94	7.06	13.41
T_5	38.47	13.40	55.67	86.00	125.33	5.00	2.85	2.96	111.27	279.09	6.09	10.02
T_6	49.37	12.80	51.00	85.67	126.67	4.33	2.99	2.93	129.33	334.39	6.63	9.08
T_7	54.28	11.47	53.67	87.33	140.33	6.33	3.73	3.60	98.07	296.79	6.39	17.12
T_8	48.59	13.00	53.00	87.67	139.67	4.67	3.33	3.09	121.27	339.11	6.46	12.76
S. Em±	0.94	0.30	1.74	3.16	2.85	0.37	0.11	0.04	0.71	7.26	0.16	0.41
CD@5%	2.86	1.00	5.29	9.58	8.66	1.11	0.35	0.12	2.17	22.06	0.49	1.26

Table-3: Analysis of variance for growth characters in gaillardia genotypes

Character	Mean sum of square		
	Replic-ationd f = 2	Geno-typesd f = 7	Errord f = 14
Plant height (cm) at 30 DAT	1.40	33.55*	0.70
Plant height (cm) at 60 DAT	1.54	119.06*	1.84
Plant height (cm) at 90 DAT	1.58	131.32*	2.66
Plant spread (E-W) (cm) at 30 DAT	3.61	3.05	4.07
Plant spread (E-W) (cm) at 60 DAT	3.38	43.58*	1.78
Plant spread (E-W) (cm) at 90 DAT	2.00	74.33*	1.34
Plant spread (N-S) (cm) at 30 DAT	0.17	10.96*	1.11
Plant spread (N-S) (cm) at 60 DAT	0.34	44.41*	2.49
Plant spread (N-S) (cm) at 90 DAT	0.42	60.89*	2.54
Number of branches/plant at 30 DAT	2.28	4.45	3.74
Number of branches/plant at 60 DAT	0.40	9.13*	0.37
Number of branches/plant at 90 DAT	0.21	5.10*	0.28
Number of leaves/plant at 30 DAT	2.33	175.45*	1.36
Number of leaves/plant at 60 DAT	2.94	10610.17*	37.85
Number of leaves/plant at 90 DAT	408.07	34576.49*	65.95
Leaf length at 30 DAT	0.60	7.22*	0.54
Leaf length at 60 DAT	1.89	8.00*	0.89
Leaf length at 90 DAT	0.16	3.45*	0.11
Stem girth (cm) at 30 DAT	0.71	0.98	0.87
Stem girth (cm) at 60 DAT	1.84	2.06	1.48
Stem girth (cm) at 90 DAT	2.33	9.01*	0.99
Leaf area (cm^2)	4294.78	2871816.58*	14447.16
Chlorophyll 'a'(mg/g)	0.53	10.00*	0.15
Chlorophyll 'b'(mg/g)	0.13	2.25*	0.13
Total Chlorophyll (mg/g)	10.51	24.49*	2.29
Dry weight of plant (g) at 30 DAT	1.84	41.88*	0.97
Dry weight of plant (g) at 60 DAT	0.79	23.09*	1.05
Dry weight of plant (g) at 90 DAT	3.85	35.60*	0.97

* Significant at 0.05 probability levels,DAT- Days After Transplanting, E-W- East to West direction, N-S- North to South direction

Table -4: Analysis of variance for flowering, yield and quality character in gaillardia genotypes.

Character	Mean sum of square		
	Replic-ationd f = 2	Geno-typesd f = 7	Errord f = 14
(a) Flowering parameters			
Days taken for appearance of first flower	11.16	40.26*	9.11
Days taken for 50 percent flowering (days)	71.16	88.51*	29.92
Duration of flowering (days)	17.54	255.78*	24.44
Days taken for full bloom (days)	0.16	1.11*	0.40
Days taken for seed setting (days)	72.04	147.88*	11.04
(b) Yield parameters			
Number of flower/plant	1.67	610.68*	1.52
Number of flowers/plot	84909.92	2431121.21*	33224.53
Flowers yield (g/plant)	172.67	3562.90*	158.70
Flowers yield (t/ha)	0.98	25.64*	0.71
Seed yield (g/plant)	1.01	21.51*	0.51
Seed yield (kg/ha)	15505.61	77457.01*	6544.46
(c) Quality parameters			
Flower diameter (cm)	0.10	0.23*	0.03
Number of whorls/flower	0.041	0.95*	0.18
Stalk length (cm)	0.06	22.76*	3.44
Individual flower weight(g)	0.01	0.13*	0.005
Shelf life (hrs)	0.16	9.00*	0.47
Vase life (days)	0.02	0.33*	0.07

* Significant at 0.05 probability levels

varieties (Table-2) showed that the genotype DGC-2 (58.38 cm) recorded higher plant height over all other genotypes of gaillardia whereas, genotype SGC-4 recorded lower plant height (45.29 cm). The number of branches per plant was maximum in genotype DGC-2 (14.17). The days taken for appearance of first flower (48.00), days taken for 50 per cent flowering (78.00) and flowering duration (146.67 days) was minimum in genotype DGC-2. The genotype SGC-2 took minimum days for full bloom (4.33). Highest flower diameter was recorded in genotype SGC-2. Individual flower weight (3.60 g) was maximum in genotype SGC-1. The maximum number of flowers per plant (131.60) was found in DGC-1. The maximum flower yield per plant was recorded in the genotype DGC-2 (348.94 g) and it was on par with genotypes DGC-1 (344.68 g), AGC-2 (339.11 g) and SGC-2 (334.39 g), whereas, the genotype SGC-4 recorded minimum flower yield per plant (270.61 g). Genotype SGC-1 recorded significantly maximum seed yield per plant (17.12 g) while, it was minimum in genotype SGC-2 (9.08 g/ plant). The maximum vase life was recorded in the genotype DGC-2 (7.06 days) and it was statiscally on par with SGC-2 (6.63 days) whereas genotype SGC-4 had minimum vase life (6.04 days).

The mean performance of the varieties showed that the maximum plant height, number of branches per plant, minimum days taken for appearance of first flower, days taken for 50 per cent flowering, maximum flowering duration and flower yield per plant and vase life of flowers were recorded in genotype DGC-2. Similar trend was also made by Panwar *et al*. (2013) in marigold. Among the flowering characters, minimum days taken for full bloom were

Table-5: Estimates of mean, range, components of variance, heritability, genetic advance and genetic advance mean for growth, flowering (days), yield and quality parameters in gaillardia genotypes

Character	Mean±S.Em	Range	GV	PV	GCV (%)	PCV (%)	h^2 (%)	GA	GAM (%)
(a) Growth parameters									
Plant height (cm) at 30 DAT	14.83±0.48	10.47-18.96	10.95	11.65	22.3	23.01	94	6.6	44.53
Plant height (cm) at 60 DAT	32.76±0.79	22.94-42.60	39.07	40.92	19.07	19.52	95	12.58	38.4
Plant height (cm) at 90 DAT	50.56±0.94	38.47-58.38	42.88	45.54	12.95	13.34	94	13.09	25.89
Plant spread (E-W) (cm) at 30 DAT	13.37±1.17	11.94-15.28	-0.34	3.73	4.36	14.45	91	0.36	2.72
Plant spread (E-W) (cm) at 60 DAT	34.68±0.77	29.56-41.38	13.93	15.72	10.76	11.43	88	7.24	20.87
Plant spread (E-W) (cm) at 90 DAT	45.98±0.67	39.47-53.28	24.33	25.67	10.72	11.01	94	9.89	21.51
Plant spread (N-S) (cm) at 30 DAT	14.38±0.61	10.53-16.02	3.28	4.4	12.6	14.58	74	3.22	22.42
Plant spread (N-S)(cm) at 60 DAT	34.29±0.91	28.64-41.96	13.97	16.46	10.89	11.83	84	7.09	20.67
Plant spread (N-S) (cm) at 90DAT	45.50±0.92	38.44-51.35	19.45	21.99	9.69	10.3	88	8.54	18.77
Number of branches/plant (30 DAT)	1.76±1.12	0.80-4.66	0.23	3.89	27.55	112.97	59	0.24	13.84
Number of branches/plant (60 DAT)	8.28±0.35	6.07-11.33	2.91	3.29	20.62	21.91	88	3.13	39.97
Number of branches/plant (90 DAT)	12.91±0.30	10.53-14.16	1.6	1.89	9.81	10.65	84	2.4	23.88
Number of leaves/plant (30 DAT)	27.58±0.68	18.00-42.86	58.02	59.39	27.61	27.94	97	15.51	56.23
Number of leaves/plant (60 DAT)	268.00±3.55	201.33-368.46	3524.1	3561.96	22.15	22.26	98	121.63	45.38
Number of leaves/plant (90 DAT)	412.60±4.68	330.23-642.40	11503.5	11569.5	25.99	26.06	99	220.31	53.39
Leaf length (cm) at 30 DAT	12.71±0.43	10.88-14.92	2.22	2.77	11.73	13.1	80	2.75	21.66
Leaf length (cm) at 60 DAT	14.32±0.55	11.90-16.68	2.37	3.26	10.75	12.61	72	2.7	18.88
Leaf length (cm) at 90 DAT	8.13±0.20	7.02-10.18	1.11	1.23	12.95	13.63	90	2.06	25.36
Stem girth (mm) at 30 DAT	9.31±0.54	8.59-10.00	0.03	0.91	2.07	10.24	41	0.08	0.86
Stem girth (mm) at 60 DAT	14.09±0.70	12.86-15.34	0.19	1.67	3.1	9.19	11	0.3	2.16
Stem girth (mm) at 90 DAT	20.74±0.58	17.74-22.85	2.67	3.66	7.87	9.22	72	2.87	13.85
Leaf area (cm^2/plant)	4512.03±69.40	3453.85-6046.68	952457	966904	21.63	21.79	98	1995.35	44.22
Chlorophyll 'a'(mg/g)	6.77±0.23	4.96-9.35	3.28	3.43	26.75	27.38	95	3.64	53.85
Chlorophyll 'b'(mg/g)	3.46±0.21	2.41-4.72	0.7	0.84	24.27	26.49	83	1.58	45.81
Total Chlorophyll(mg/g)	9.67±0.86	6.17-13.18	7.73	10.02	28.75	32.75	77	5.03	52.02
Dry weight of plant (g)(30 DAT)	14.05±0.57	9.06-19.60	13.63	14.61	26.27	27.19	93	7.34	52.28
Dry weight of plant (g)(60 DAT)	21.96±0.59	19.16-26.42	7.34	8.4	12.33	13.19	87	5.21	23.76
Dry weight of plant (g)(90 DAT)	35.82±0.57	32.02-40.64	11.54	12.51	9.48	9.87	92	6.72	18.76
(b) Flowering parameters (days)									
Days taken for first flowering	53.08±1.74	48.00-59.00	10.38	19.5	6.07	8.319	53	4.84	9.12
Days taken for 50 percent flowering	86.71±3.16	78.00-95.33	19.53	49.45	5.09	8.11	39	5.72	6.59
Duration of flowering	132.92±2.85	119.66-146.66	77.11	101.56	6.6	7.58	75	15.76	15.19
Days taken for full bloom	5.08±0.37	4.33-6.33	0.23	0.64	9.59	15.77	37	0.61	12.03
Days taken for seed setting	61.42±1.92	52.66-71.67	45.61	56.65	10.99	12.25	80	12.48	20.32
(c) Yield parameters									
Number of flowers/plant	112.63±0.71	94.86-131.60	203.05	204.58	12.65	12.69	99	29.24	25.96
Number of flowers/plot	6093.45±105.23	5115.60-7899.73	799299	832523	14.67	14.97	96	1804.58	29.61
Flower yield (g/plant)	310.65±7.26	270.60-348.94	1134.73	1293.43	10.84	11.57	87	64.99	20.92
Flower yield (t/ha)	18.28±0.48	14.21-22.16	8.3	9.02	15.76	16.42	92	5.69	31.15
Seed yield (g/plant)	11.96±0.41	9.08-17.12	7	7.51	22.1	22.9	93	5.26	43.95
Seed yield (kg/ha)	718.06±46.71	544.79-1027.19	23637.5	30182	21.41	24.19	78	280.28	39.03
(d) Quality parameters									
Flower diameter (cm)	3.24±0.11	2.85-3.72	0.06	0.1	7.93	10.02	62	0.41	12.93
Number of whorls/flower	7.16±0.25	6.33-8.00	0.25	0.44	7.05	9.26	58	0.79	11.08
Stalk length (cm)	26.79±1.07	21.80-31.09	6.44	9.88	9.47	11.73	65	4.22	15.74
Individual flower weight(g)	3.13±0.04	2.92-3.59	0.04	0.04	6.67	7.06	89	0.4	12.99
Shelf life of flowers (hours)	11.51±0.40	9.90-14.43	2.84	3.31	14.62	15.81	85	3.21	27.92
Vase life of flowers (days)	6.39±0.16	6.04-7.06	0.08	0.16	4.56	6.29	53	0.43	6.82

GV-Genotypic Variance: **PV**- Phenotypic Variance: **GCV**- Genotypic Coefficient of Variation: **PCV**- Phenotypic Coefficient of Variation: **h^2**- heritability: **GA**- Genetic Advance: **GAM**- Genetic Advance Mean

recorded in genotype SGC-2. The maximum seed yield both per plant and per hectare was higher in genotype SGC-1. Similar results were obtained by Singh and Singh (2010) in marigold and in dahlia by Vikas *et al.* (2011).

Table-5 represents data on range, mean, coefficients of variation, heritability and genetic advance as percentage of mean of the all characters under study. From these tables, it can be concluded that the difference among genotypic variance and phenotypic variance

was very less for most of traits studied indicating the fact that these characters are not much influenced by environmental factors. This also suggests that presence of sufficient genetic variability, which can be exploited by practicing pureline selection. Range of variations was observed for all the traits in the present study indicating the presence of sufficient amount of variation among the genotypes (Panwar *et al*., 2013). The range in the values reflect the amount of phenotypic variability, which is not very reliable since it includes genotypic, environmental and genotype × environmental interaction components and does not reveal the character showing higher degree of variability. Further, the phenotype of the crop is influenced by additive gene effect (heritable), dominance (non-heritable) and epistatis (non-allelic interaction). Hence, it becomes necessary to split the observed variability into phenotypic coefficients of variability (PCV) and genotypic coefficients of variability (GCV), which ultimately indicates the extent of variability existing for various traits. However, even this does not give a true picture about the extent of inheritance of the character. The effectiveness of selection for any character does not depend on the amount of variability alone but also with estimates of heritability. Therefore, the heritability (h^2) of a character can be relied upon, as it enables them to decide the extent of selection pressure to be applied under particular environment, which separates out the environmental influence from the total variability.

Estimates of phenotypic variance (PV) were higher compared to genotypic variance (GV) for all the characters, indicating the role of environmental factors for the expression of these characters. Less difference was observed for genotypic and phenotypic variance for most of the characters studied, which indicates the fact that these characters are not much influenced by environmental factors. This also suggests the presence of sufficient variability, which can be exploited by practicing selection based on phenotype for growth parameters. Phenotypic coefficient of variation (PCV) was higher than those of genotypic coefficient of variation (GCV) for the characters under study and is in agreement with the result of Singh and Singh (2010) and Pal and Kumar (2010) in marigold and in dahlia by Vikas *et al*. (2011). In this study, phenotypic and genotypic coefficient of variations were high for number of branches per plant, number of leaves per plant, flower yield per hectare and seed yield per plant. It was least for vase life. Similar results were obtained by Anuja and Jahnavi (2012), Singh and Singh (2010) and Panwar *et al*. (2013) in marigold and in chrysanthemum by Baskaran *et al.* (2010).

The genotypic coefficient of variation alone does not provide reliable information about the assessment of variation that is heritable and therefore, estimation of heritability becomes imperative. Heritability (broad sense) estimates ranged from 11.00 % for stem girth at 90 days after transplanting to 99.00 % for number of leaves (90 DAT) and flowers produced per plant. The high value of heritability (>70%) was observed for most of traits studied except plant spread (30 DAT), number of branches per plant (30 DAT), stem girth (30 and 90 DAT), days taken for first and 50 percent flowering and time taken for full bloom which revealed that these traits were most influenced by environmental changes suggesting that the selection based on phenotype would not be effective for these traits. Similar findings were reported in marigold by Panwar *et al*. (2013) and Mathew *et al.* (2005) and in dahlia by Vikas *et al*. (2011).

In present study, estimates of high heritability with high genetic advance over per cent mean (GAM) for growth characters were observed for plant height, number of branches per plant, number of leaves per plant, leaf area and chlorophyll content. And for flowering traits, it was recorded in duration of flowering, days taken for seed setting, indicating the possible role of additive gene action. Similarly, for yield and quality parameters high genetic advance over per cent mean (GAM) was observed for number of flowers per plant and plot, flower and seed yield both per plant and hectare, stalk length and shelf life of flowers. The results are in conformity to those observed for number flowers per plant by Anop *et al., (*2011) in gerbera and for flower yield in marigold by Mathew *et al.* (2005) and Misra *et al*. (2013) for average flower weight in chrysanthemum.

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