Genetic Variability and Heritability Studies in *Cuphea procumbens*

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The extent of variability, heritability and genetic advance for days to flowering, plant height, yield traits and yield were determined in 15 germplasm lines of *Cuphea procumbens*. Sufficient variability existed for number of branches/plant, yield/plant, number of fruits/plant and number of seeds/fruit indicating that selection for these traits between germplasm lines may be fruitful. Among 15 germplasm lines NBC 58, NBC61 and NBC 60 were found to be better for yield and yield traits. Heritability in broad sense was high for all the characters and ranged from 64.56 to 98.83%. High heritability coupled with high genetic advance and high coefficient of variability for yield/plant, number of fruits/plant, number of seeds/fruits and number of branches/plant indicates the governance of these characters by additive gene effects thereby implying that simple selection may be effective.

Key Words : *Cuphea procumbens*, Genetic Advance, Heritability, Medium-Chain Triglycerides, Variability

The genus *Cuphea,* consisting of herbaceous annuals and perennials, is the largest in the family Lythraceae having more than 260 species. The seed oil of *Cuphea* has unparallel diversity of fatty acid patterns that range from C_8-C_{18} with Medium-Chain Triglycerides (C_8-C_{14}) predominating, which is unique in plant kingdom (Graham, *et al.,* 1981; Hirsinger, 1985; Khanna and Singh, 1991). The Medium-Chain Triglycerids has wide applications in industries, medicine and nutrition and dietetics (Thompson, 1984; Knapp, 1990). *Cuphea* is native of sub-tropical Brazil and Mexico, and has been introduced in India for exploitation as oil seed crop (Singh *et al.,* 1998).

Preliminary investigation made at National Botanical Research Institute, Lucknow, India revealed that four species (*C. procumbens. C. lanceolata, C. viscosissima* and *C. wrightii)* are promising under Indian conditions. Among these *C. procumbens* was found to be the best. So the present study was conducted to study the genetic variability among *C. procumbens* germplasm lines and also to study the heritability and genetic advance of yield and yield contributing traits.

Materials and Methods

The exotic germplasm of *Cuphea procumbens* obtained from Unitied States Department of Agriculture (USDA), Plant Introduction Center, Ames, USA, were subjected to selection for pure lines and inbred lines during 1998-99. Among these the selfed seeds of 15 genotypes were raised in a randomized block design with three replications during 1999-2000, at National Botanical Research Institute, Lucknow, India, situated between 26^0 *40'N* latitude and 80^0 *45'E* longitude and at an altitude of 129 m above sea level. The rows were 3 m long while the spacing between the rows and within the rows were 65 cm and 30 cm respectively. Basal dose of NPK @ 45 kg, 40 kg and 40 kg per hectare was applied at the time of planting and remaining 45 kg of N was applied in two splits as top dressing. Ten plants were selected at random in each plot/replication and observations on days of flowering, plant height (cm), number of branches/plant, number of fruits/plant, number of seeds/fruits, test weight (g) and seed yield/plant (g) were taken.

The Analysis of Variance (ANOVA) for the design of experiment was performed according to Panse and Sukhatme (1967). The genotypic and phenotypic coefficient of variation and heritability in broad sense were computed according to method suggested by Johnson *et al.* (1955). Genetic advance was estimated according to Allard, 1960.

Results and Discussion

ANOVA for the design of experiment revealed that genotypes differed significantly for all the characters. Mean values, range and co-efficient of variation estimates reflected the presence of ample exploitable variability for all the characters under study (Table 1-3).

Mean performances of 15 germplasm lines for different characteristics (Table 1) revealed that days to flowering was variable between 76.75 (NBC 51) to 109.50 days (NBC 53) with an average of 84.76 $\pm$ 0.68 days. The low Genotypic Coefficient of Variation (GCV) (9.13%) for this character (Table 3) indicates that sufficient variability doesn't exist, so selection will not be effective.

Regarding plant height NBC55 was the shortest (39.75cm) and NBC 58 was the tallest (53.25 cm) among

Table 1. Mean values for days to flowering, plant height, yield traits and yield in different *C. procumbens* germplasm lines

Germplasm Lines	Days to Flowering	Plant Height (cm)	No. of Branches/ Plant	No. of Fruits/ Plant	No. of Seeds/ Fruit	Test Weight (g)	Seed Yield/ Plant (g)
NBC51	76.75	54.75	83.25	155.67	25.25	3.320	12.95
NBC52	82.00	46.50	74.25	163.67	19.50	3.910	12.50
NBC53	109.50	48.25	122.00	208.50	21.50	2.712	12.15
NBC54	82.00	50.50	109.75	202.50	15.75	3.020	9.61
NBC55	81.00	39.75	96.75	177.50	18.50	2.803	9.24
NBC56	82.00	52.75	52.75	146.13	23.75	3.144	10.85
NBC57	81.00	49.75	59.75	133.38	31.00	2.514	10.39
NBC58	82.50	53.25	123.00	197.50	29.25	3.026	17.40
NBC59	81.50	44.50	73.50	127.00	31.75	3.178	12.82
NBC60	87.50	41.25	78.25	125.50	31.75	2.860	15.23
NBC61	90.25	42.25	82.25	164.38	27.25	3.556	15.84
NBC62	90.50	47.75	58.00	121.88	27.25	2.712	8.95
NBC63	81.75	50.25	86.25	147.63	27.75	2.938	12.06
NBC64	82.25	50.75	63.25	102.50	27.00	2.874	7.95
NBC65	81.00	48.25	62.00	129.38	34.75	2.914	13.09
$\bar{x}$	84.76	47.43	81.66	153.53	26.12	3.098	12.06
SE	0.68	2.27	9.56	11.33	12.06	0.077	0.94
CV(%)	0.99	5.86	14.33	9.03	9.70	3.11	9.54
CD(5%)	1.41	4.65	19.58	23.21	4.24	0.16	1.92

the germplasm lines. The average was 47.43 ± 2.27 cm. GCV was low (7.91%) indicating lack of variability for this trait too (Table 3).

Among the yield traits number of branches/plant showed highest GCV (26.32%) followed by number of fruits/plant (20.17%), number of seeds/fruits (20.03%) and test weight (13.11%). The mean value for number of branches/plant ranged from 52.75 to 123.00 with an average of 81.66 ± 9.56. NBC58 (123.00) had the highest number of branches/plant followed by NBC53 (122.00) and NBC54 (109.75). The GCV is very high indicating the presence of rich exploitable variability for this character.

Among 15 germplasm lines NBC 65 had the highest number of seeds/fruit (34.75) and NBC53 had the highest number of fruits/plant (208.50). The magnitude of variability for both the characters are high, so selection for these characters between genotypes is effective. Maximum test weight was found in NBC52 (3.910 g), however the GCV for this trait is low indicating narrow variability.

The seed yield/plant ranged from 7.95 g to 17.40 g with an average of 12.06 ± 0.94. NBC58 had the highest yield/plant (17.40 g) followed by NBC61 (15.84 g) and NBC60 (15.23 g). The GCV for yield/ plant (21.47%) was high indicating existence of sufficient variability among germplasm lines. NBC58 that had the highest yield/plant also had the highest number of branches/plant. Other yield traits such as number of fruits/plant (197.50), numbers of seeds/fruit (29.25) and test weight (3.026 g) are also high for this germplasm line indicating the contribution of these characters towards yield. However the relationship between these characters and yield has to be further studied by correlation and path analysis.

Comparison of individual mean value of germplasm lines for seed yield/plant with arithmetic mean ($\bar{x}$12.06 ± 0.94 g) indicated 8 germplasm lines to be superior. Further test for significant difference among germplasm lines for seed yield/plant using CD (Table 2) revealed that NBC58 was on par with NBC61 and significantly different from other strains. NBC61 and NBC60 were on par with each other for this trait. Among 15 germplasm lines performance of three lines (NBC58, NBC61 and NBC60) in terms of yield was significantly better than other lines. So these three strains can be subjected for genetic improvement to be developed as varieties or can be used as parents in hybridization programmes. The coefficient of variation does not offer full scope to estimate the heritable variation. The relative proportion of heritable variation assessed with the help of heritability estimates and genetic advance expressed as percentage of mean are presented in Table 3.

Table 2. Comparison of mean seed yield/plant (g) of germplasm lines using Critial Difference (CD)

S.No.	Germplasm Lines	Seed Yield/ Plant (g)
1	NBC58	17.40
2	NBC61	15.84
3	NBC60	15.23
4	NBC65	13.09
5	NBC51	12.95
6	NBC59	12.82
7	NBC52	12.50
8	NBC53	12.15
9	NBC63	12.06
10	NBC56	10.85
11	NBC57	10.39
12	NBC54	9.61
13	NBC55	9.24
14	NBC62	8.95
15	NBC64	7.95
	$\bar{x}$	12.06
	CD (5%)	1.92

Note : Germplasm lines covered by same line are on par with each other

Heritability denotes the proportion of phenotypic variance that is due to genotypic control. This genotypic variance is important in crop improvement, since this component is transmitted to next generation. In general heritability was high for all the characters. Broad sense heritability was found to be maximum for days to flowering (98.83%) followed by test weight (94.56%) and yield/plant (83.49%). Plant height had lowest heritability (64.56%).

Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates alone (Singh and Narayanan, 1993). Johnson *et al.* (1995) pointed out that without genetic advance, the estimates of heritability would not be practically important in selection based on phenotypic appearance. Genetic advance among component traits were high for number of branches/ plant (47.62%), yield/plant (40.41%) and number of fruits/plant (37.92%). High heritability coupled with high genetic advance and high coefficient of variability for yield/plant, number of fruits/plant, number of seeds/fruit and number of brances/plant indicates that most likely

Table 3. Genetic parameters of different traits in *C. procumbens*

Plant Character	F Value	Range	Variance			Variability (%)		h^2 (%)	Genetic Advance (%)
			δ^2p	δ^2p	δ^2e	GCV	PCV		
Days to Flowering	253.00**	76.75-109.50	60.70	59.98	0.71	9.13	9.19	98.83	18.71
Plant Height (cm)	6.46**	39.75-53.25	21.85	14.10	7.74	7.91	9.85	64.56	13.10
No. of Branches/ Plant	11.11**	52.75-123.00	599.35	462.23	137.11	26.32	29.97	77.12	47.62
No. of Fruits/Plant	15.94**	102.50-208.50	1151.75	959.19	192.55	20.17	22.10	83.28	37.92
No. of Seeds/Fruit	13.79**	15.75-34.75	33.83	27.40	6.42	20.03	22.26	81.00	37.14
Test Weight (g)	54.11**	2.514-3.910	0.17	0.16	0.009	13.11	13.47	94.65	26.27
Seed Yield/ Plant (g)	16.17**	7.95-17.39	8.04	6.71	1.32	21.47	23.50	83.49	40.41

Note :
** Singnificant at 1% probability level.
δ^2p - Phenotypic Variance
δ^2g - Genotypic Variance
δ^2e - Environmental Variance
GCV - Genotypic Coefficient of Variation
PCG - Phenotypic Coefficient of Variation
h^2 - Heritability (Broad Sense)

heritability for these characters is due to additive gene effects and hence direct selection may be highly effective. Characters showing high heritability and low genetic advance indicate that these characters were governed by non-additive gene action (dominance and epistasis) and presence of gxe interaction. The heritability is being exhibited due to favourable influence of the environment rather than genotype and hence simple selection may not be rewarding. As such progeny of family testing is to be practiced for improvement of these traits. This implies that breeders can go for selection over several successive generations and locations following hybridization of desirable transgressive segregants. Test weight showed high heritability (94.65%) and moderately high advance (26.27%) and moderately high genetic advance (26.26%), so this trait can be included in the breeding system of component characters.

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