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Vipul K Baraiya
Department of Genetics and Plant Breeding, N. M. College of Agriculture, N.A.U., Navsari, Gujarat, India

PK Jagtap
Niger Research Station, N.A.U, Vanarasi, Vansda, Navsari, Gujarat, India

Himalay R Patel
Department of Genetics and Plant Breeding, N. M. College of Agriculture, N.A.U., Navsari, Gujarat, India

Correspondence
Vipul K Baraiya
Department of Genetics and Plant Breeding, N. M. College of Agriculture, N.A.U., Navsari, Gujarat, India

Genetic variability, heritability and genetic advance for seed yield in sunflower (*Helianthus annus* L.)

Vipul K Baraiya, PK Jagtap and Himalay R Patel

Abstract
A field experiment had been conducted to obtain information on genetic variability, heritability and genetic advance for seed yield and associated characters under irrigated conditions by using forty eight diverse genotypes. The analysis of variance revealed the significant differences among the genotypes for all the traits indicating presence of sufficient variability among the genotypes for various traits. High estimate of genotypic and phenotypic coefficient of variation were observed for leaf area, head diameter, oil content, seeds per head, filled seeds per head and seed yield per plant.While, high heritability coupled with high genetic advance observed for stem girth, leaf area, head diameter, oil content, plant height, 100 seed weight, seeds per head, filled seeds per head, harvest index and seed yield per plant indicated that selection may be effective for improving these characters.

Keywords: sunflower, variability, broad sense heritability, genetic advance

Introduction
In the agricultural economy of India, oilseeds are important next to food grains. Sunflower is one of the important oilseed crops after Groundnut, Rapeseed-Mustard and Soybean. It is an important crop for production of healthy edible oil for cardiac problems due to which sunflower oil has great demand in commence. Breeding programmes aim at development of cultivars with high yield and yield components. The seed yield of sunflower (*Helianthus annuus* L.) is a complex character, which is highly influenced by environmental variations. Information on nature and magnitude of variability present in a population due to genetic and non genetic causes is an important prerequisite for systematic breeding programme.
India is one of the major oilseed producing countries in the world with an area of 285.25 lakh ha and an annual production of 328.77 lakh tonnes. In India, sunflower crop is grown in 6.91 lakh ha and a production of 5.47 lakh tonnes with a productivity of 791 kg ha^{-1}compared to the world's average productivity of 1749 kg ha^{-1} (Anonymous, 2014) [2].
The development of an effective plant breeding program is dependent upon the existence of genetic variability. Hence, an insight into the magnitude of variability present in a cross combinations is an indirect indication of genetic variability present in crop species.
The heritability estimates aid in determining the relative amount of heritable portion in variation and thus help plant breeder in selecting the elite inbreds from a diverse population. Heritability estimates along with genetic advance are normally more helpful in predicting the gain under selection than heritability estimates alone. Therefore the present study was undertaken to study the genetic variability, heritability and genetic advance in forty eight genotypes of sunflower.

Material and Methods
The experiment was conducted with forty eight diverse genotypes under irrigated condition during *rabi* 2017-18 at Niger Research Station, Navsari Agricultural University, Vanarasi, Navsari (Gujarat). The material was grown in a randomized block design with three replications. The seeds were sown at 60 cm between rows and 30 cm between plants within the row. The experiment was laid out with one row of 3.6 cm length of each genotype surrounded by two guard rows to avoid damage and border effects. Normal crop raised following all recommended cultural practices and plant protection measures. Five competitive plants from each replication were selected at random and observations were recorded on thirteen characters

viz., days to 50% flowering, days to maturity, plant height (cm), head diameter (cm), stem girth (cm), number of leaves per plant, leaf area (cm^2), seeds per head, filled seeds per head, 100 seed weight (g), oil content (%), harvest index (%) and seed yield per plant (g).

The observations on days to 50% flowering were recorded on plot basis. The mean over replication of each character was subjected to statistical analysis. The estimate of genotypic and phenotypic coefficient of variation was calculated according to Burton (1952) [3], heritability in broad sense and expected genetic advance as per the procedure of Allard (1960) [1].

Results and Discussion

The results obtained under the present investigation are presented in Table 1 and 2. Analysis of variance revealed significant differences among the genotypes for all the characters. A wide range of variability was exhibited by most of the traits under study (Table 1). The wide range of variation noticed in all the characters would offer scope of selection for improvement of desirable types. The highest genotypic coefficient of variation was observed for seed yield per plant (36.03%) followed by oil content (30.28%), seeds per head (30.03%), head diameter (28.14%), filled seeds per head (27.36%) and leaf area (22.11%) while it was moderate forharvest index (16.79%), 100 seed weight (14.12%) and stem girth (13.16%). The characters *viz*., number of leaves per plant (9.92%), days to 50 percent flowering (5.72%) and days to maturity (2.75%) expressed low degree of genotypic and phenotypic coefficients of variation. The presence of high GCV for seed yield per plant, oil content, seeds per head, head diameter, filled seeds per head and leaf area suggested the possibility of improving and fixing these characters through effective selection. The higher estimates of heritability were observed foroil content (98.58%) followed by filled seeds per head (91.92%), seeds per head (91.73%), seed yield per plant (91.26%), 100 seed weight (89.03%), head diameter (88.74%), leaf area (78.88%), harvest index (76.63%), stem girth (72.86%), plant height (69.33%) and days to 50 percent flowering (71.94%).The moderate value of heritability was noticed in number of leaves per plant (57.23%) and days to maturity (56.15%).

The high estimate of genetic advance (% of mean) was observed for the seed yield per plant (70.91%) followed by oil content (61.95%), seeds per head (59.26%), head diameter (54.61%), filled seeds per head (54.05%), leaf area (40.45%), harvest index (30.28%), 100 seed weight (27.45%), stem girth (23.15%) and plant height (22.90%). The genetic advance (% of Mean) was moderate number of leaves per plant (15.46%). It was low for days to 50 percent flowering (10.00%) and days to maturity (4.25%).

High heritability was associated with high genetic advance (% of mean) for stem girth, leaf area, head diameter, oil content, plant height, 100 seed weight, seeds per head, filled seeds per head, harvest index and seed yield per plant, while high heritability coupled with moderate genetic advance (% of mean) was observed for days to 50 percent flowering. Moderate heritability along with low genetic advance (% of mean) was expressed by remaining characters.

The highest value of GCV was observed for leaf area, head diameter, oil content, seeds per head, filled seeds per head and seed yield per plant. High magnitude of GCV indicated the presence of wide variation for the characters under studied to allow further improvement by selection of the individual trait. High estimates of GCV in sunflower have been also reported by Shinde *et al*. (1983) [13], Teckleword *et al.* (1999) [16], Ravi (2001) [10], Reddy and Reddy (2006) [11], Seneviratne *et al*. (2003) [12], Dutta (2013) [4] and Supriya *et al*. (2016) [15].

High heritability were exhibited by stem girth, leaf area, head diameter, oil content, plant height, 100 seed weight, seeds per head, filled seeds per head, harvest index and seed yield per plantIndicating the additive gene action and hence, selection would be effective. Similar results were reported by Sultana *et al.* (2005) [14], Reddy and Reddy (2006) [11], Khan *et al.* (2007) [7], Janamma *et al.* (2008) [5], Kalukhe *et al.* (2010) [6] and Supriya *et al.* (2016) [15] for these characters.

High estimates of genetic advance expressed as percentage of mean in sunflower have also been reported earlier for seeds yield per plant, oil content, seeds per head, head diameter, filled seeds per head, leaf area, 100 seed weight and plant height by Sultana *et al.* (2005) [14], Reddy and Reddy (2006) [11], Khan *et al.* (2007) [7], Janamma *et al*.(2008) [5], Kalukhe *et al.* (2010) [6], Supriya *et al.* (2016) [15].

Table 1: Analysis of variance (Mean sum of Square) for different characters in sunflower

Source of Variation	d.f.	Days to 50 % flowering	Days to maturity	No. of leaves per plant	Stem girth (cm)	Leaf area (cm^2)	Head diameter (cm)	Oil content (%)
Replication	2	1.562	5.673	7.357	0.424	545.404	1.843	0.926
Genotype	47	53.147**	47.219**	28.665**	1.835**	2298.690**	36.193**	204.820**
Error	94	6.115	9.751	5.717	0.202	188.309	1.468	0.977
Source of Variation	**d.f.**	**Plant height (cm)**	**100 seed weight (g)**	**Seeds per Head**	**Filled seeds per head**	**Harvest index (%)**	**Seed yield per plant (g)**	
Replication	2	2	0.013	441.465	441.465	0.019	13.007	
Genotype	47	47	1.777**	188171.517**	188171.517**	1.010**	247.342**	
Error	94	94	0.070	5487.231	5487.231	0.093	7.651	

Table 2: Mean, range, variability parameter, heritability and genetic advance as percent mean for different characters in sunflower

Parameters	Mean	Range	σ^2_g	σ^2_p	σ^2_e	GCV %	PCV %	Heritability (%)	Genetic Advance (% Mean)
Days to 50% flowering	69	57-75	15.677	21.793	6.115	5.726	6.751	71.94	10.00
Days to maturity	128	117-135	12.489	22.241	9.751	2.757	3.679	56.15	4.256
No. of leaves per plant	27.87	22.83-34.26	7.649	13.366	5.717	9.920	13.114	57.23	15.460
Stem girth (cm)	5.60	4.08-7.42	0.544	0.747	0.202	13.166	15.424	72.86	23.150
Leaf area (cm^2)	119.95	54.72-179.45	703.460	891.769	188.309	22.110	24.894	78.88	40.454
Head diameter (cm)	12.08	6.31-17.77	11.574	13.043	1.469	28.146	29.879	88.74	54.618
Oil content (%)	27.21	15.90-43.97	67.947	68.924	0.977	30.289	30.506	98.58	61.952
Plant height (cm)	142.25	106.67-193.66	362.205	522.473	160.268	13.353	16.037	69.33	22.903
100 seed weight (g)	5.34	4.09-6.93	0.569	0.639	0.070	14.122	14.967	89.03	27.451

Seeds per head	821.51	256.00-1327.00	60894.762	66381.993	5487.231	30.038	31.362	91.73	59.266
Filled seeds per head	775.28	234.00-1166.66	45018.417	48976.667	3958.249	27.367	28.545	91.92	54.050
Harvest index (%)	32.92	22.33-43.00	0.003	0.004	0.0009	16.794	19.185	76.63	30.284
Seed yield per plant (g)	24.80	8.98-42.13	79.897	87.548	7.651	36.035	37.721	91.26	70.914

Where, σ^2_g, σ^2_p and σ^2_e are the genotypic, phenotypic and environmental variance, respectively GCV% and PCV% are genotypic and phenotypic coefficient of variation, respectively GA (% of mean) is genetic advanced expressed as percent of mean

Conclusion

From the foregoing discussion it could be concluded that the most important yield attributing traits *viz.*, filled seeds per head, seeds per head, seed yield per plant, 100 seed weight and head diameter are under the influence of additive gene action and can be improved by simple selection method, while leaves per plant and days to maturity are under the influence of non-additive gene action and can be improved through heterosis breeding.

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