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Research Article

Genetic Variability Studies for Economically Important Traits in Sunflower (*Helianthus Annuus* L.)

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Abstract

The research was conducted in the research area of Department of Plant Breeding and Genetics (PB&G), University of Agriculture Faisalabad (UAF), Pakistan during spring 2014. The triplicated research trial was laid out following randomized complete block design (RCBD). Fifteen lines of sunflower were studied for genetic variability and association of economic traits with seed yield. The data were recorded on quantitative traits i.e. days to 50% flowering (DFF), plant height (PH), number of leaves per plant (NOL), head diameter (HD), leaf area (LA), filled achene (FA), 100 achene weight (100AW), oil contents (OC), achene yield per plant (AY/P) and qualitative traits i.e. head angle at maturity (HA), achene color(AC). The recorded data were subjected to analysis of variance, correlation and path coefficient analysis. The accessions were highly significant for all traits under study. The accessions A-2.2 showed good performance for most of studied traits. The accession B-3.1 also show better performance followed by A-4.3 and A-7.10. Genotypic correlations are higher than phenotypic correlations. 100AW, NOL, LA and HD had positive and highly significant genotypic correlations with AY/P. Genotypic correlation of AY/P was significantly negative with PH, DFF and oil contents. LA, NOL, 100AWand OC showed direct positive effect on AY/P. DFF, PH, HD and FA had negative direct effect on AY/P.

Keywords: Variability; Correlation; Path coefficient; Quantitative; Quality related traits

Abbreviations: PB&G: Plant Breeding and Genetics; RCBD: Randomized Complete Block Design; PH: Plant Height; NOL: Number of Leaves; HD: Head Diameter; LA: Leaf Area; FA: Filled Achene; AW: Achene Weight; OC: Oil Contents; AY/P: Achene Yield per Plant; HA: Head Angle; AC: Achene Color

Introduction

Oil and fats are major part of human diet, important source of energy and also play role in carrying different vitamins in body. Due to the rapid growth in population of Pakistan, requirement of edible oil has also been raised. So a gap is produced between utilization and production in Pakistan. Although the country is making huge improvement in agriculture sector but still there exist extreme shortage of edible oil. During 2015-2016 Pakistan fulfilled 17% its requirement of edible oil by domestic oil and 83% by imported oil. Both conventional and non-conventional oilseed crops are important to fill the space between utilization and production. Sunflower (*Helianthus annuus* L.) belongs to non-conventional oilseed crops in Pakistan and has great ability to increase oil yield per hectare in Pakistan [1,2]. Sunflower being the 2nd most important oilseed crop of the world was introduced in Pakistan during 1960's. Sunflower is growing twice a year in Pakistan as a major edible oilseed crop. It is grown on 0.214 million acre with 0.92 million tons seed production and 0.035 oil production. Government of Pakistan 2015-2016 [3]. Sunflower seed contains 40-50% oil contents [4]. Sunflowers commercially available varieties contain 39 to 49% oil in their seeds.

The major part of oil comprises of unsaturated fatty acids (oleic acid 20% and linoleic acid 69%), with the remainder 11% are saturated fatty acids (palmitic and stearic fatty acids) Mirza [5]. Sunflower oil is considered as premium quality oil because of its taste, high smoke point, beam colour, good nutritional quality, elevated level of unsaturated fatty acids and lack of harmful/ unstable components like erusic acid and linolenic acid. It has the sturdy oxidative stability and alpha-tocopheroles are the source of vitamin E which is anti-inflammatory agent [6]. Variations are very precious for any breeding programs [7,8]. Genetic variations existing in the genotypes can be exploited efficiently as genetic resources in breeding programs [9] Success of breeding program rely upon the extent of variation present in a germplasm for yield and yield contributing traits [10]. Correlation analysis demonstrates the association of the economically important traits with achene yield. Path coefficient analysis facilitates the division of correlation coefficients into its direct and indirect effects of economic traits on achene yield [11]. It quantifies the association of different yield components and direct or indirect effects on seed yield [12, 13]. The ultimate objective of the sunflower breeders are to increase quantity and improve quality of the oil.

Materials and Methods

The research work was performed in the research fields of Department of Plant Breeding & Genetics, University of Agriculture Faisalabad, Pakistan. Fifteen accessions of sunflower were studied as listed in Table 1. The experiment was conducted in RCBD with three replications in spring 2014. Dibbler method was used for sowing of these accessions. Row to row distance was kept 0.75m and plant to plant 0.25m. Agronomic practices were kept constant during the experiment. The data was recorded on five randomly selected guarded plants per replication of each accession for DFF, PH, NOL, HD, LA, FA, AY/P, 100AW, OC and qualitative traits i.e. HA, AC. The recorded data were analyzed for variance following the method by Steel [14]. Correlation analysis proposed by Kwon [15] and path coefficient analysis by Dewey and Lu 1957 [16] were performed for determining the association among different morphological characters and their direct and indirect effects on seed yield.

Table 1: Sunflower accessions used in the present study.

Sr. No.	Name of accession	Sr. No.	Name of accession	Sr. No.	Name of accession
1	C-3.3.1	6	A-14.13	11	A-10.1.2
2	C-2.11	7	B-3.1	12	A-2.19
3	A-2.5	8	A-7.10	13	C-2.17.1
4	A-4.3	9	C-2.21	14	A-11.1.2
5	C-3.1	10	A-11.18	15	A-2.2

Results and Discussion

Genetic variability studies for quantitative and quality related traits

Presence of genetic variability is prerequisite for the development of new hybrids and varieties. ANOVA of different characters is presented in Table 2. Mean squares of different characters showed that accessions had noticeable differences for all the traits under study. The mean comparisons of accessions for different characters are presented in Table 3. DFF, PH,NOL, HD, LA, FA, AY/P, 100AW and OC ranges from 75-90 days, 158.17-182.56cm, 15-32 leaves, 7.76-15.94cm, 20.04-37.15cm^2, 497-677 achene, 20.29-38.96g, 1.50-6.58g and 41.20-34.33% respectively. Noticeable differences were present in the accessions and selection of various economic traits may be helpful in the development of new hybrid combinations.

Table 2: Mean squares of sunflower accessions for various plant characters.

SOV	DF	DFF	PH	NOL	HD	LA cm^2	FA	AY/P (g)	100 AW (g)	OC %
Accession	14	63.2**	44.81**	2.211*	1.995*	384.1**	6815.7**	68.99**	0.296*	9.14**
Replication	2	17.8667	22.7782	0.5368	0.1787	121.9	2585.77	9.006	0.232	0.76
Error	28	13.7952	17.7878	0.8016	0.5837	86.61	2910.93	16.7162	0.102	2.98

Table 3: Mean comparisons of sunflower accessions for various plant characters.

Accessions	DFF	PH	NOL	HD	LA cm^2	FA	AY/P (g)	100 AW (g)	OC %
A-2.2	87	171.69	30	15.94	32.61	661	33.07	5.7833	39.033
B-3.1	89	176.12	32	11.633	37.15	621	32.392	3.3473	39.933
A-7.10	89	165.81	23	13.353	36.32	632	30.662	6.5647	41.2
C-2.17.1	90	182.04	25	11.667	29.07	614	27.829	4.425	38.3
C-3.1	78	166.98	18	13.393	25.19	561	28.129	3.3103	37.8
A-14.13	81	168.1	17	15.44	27.97	642	23.011	4.3973	37.833

C-2.11	85	164.25	20	10.367	24.59	497	20.294	3.3253	37.967
A-2.5	90	182.56	19	10.453	23.81	588	25.051	2.0663	36.4
C-2.21	76	165.65	15	7.76	30.79	610	29.869	6.5843	38.2
A-11.18	80	169.91	21	9.007	22.7	582	26.571	1.84	35.967
A-10.1.2	81	164.46	16	10.193	24.04	602	22.132	5.456	36.2
A-2.19	85	168.75	19	8.433	25.3	566	21.977	1.5077	35.633
A-4.3	75	158.17	17	8.737	26.18	595	38.966	2.113	34.333
A-11.1.2	81	162.41	29	9.4	20.04	532	26.767	1.7937	37.1
C-3.3.1	75	162.75	18	10.753	22.1	677	26.531	2.5473	38.133

The observed results were in agreement with the results observed by different researchers [5,7,10,17-20]. Among studied accessions, A-2.2 showed good performance for NOL, HD, FA, 100AW, OC and AY/P. The accession B 3.1 showed good performance for NOL, LA, OC and AY/P. A-4.3 can be incorporate in breeding program to develop short duration, short stature high yielding hybrid. So, this breeding material can be used in breeding program for the development of short duration high yielding hybrids with short stature. Short heighted accessions may be helpful in the breeding of lodging resistant hybrids as lodging is one of the major issues of this crop. Accession A-7.10 has highest OC with good seed yield and 100AW. This accession may also be the source in production of high oil yielding hybrids.

Quality Determine Traits

Head angles of sunflower accessions are presented in the Figure 1. All the accessions showed different percentages of HA i.e. 135°, 180°, 45° and 225°. Most of the lines had three types of angles i.e. 180°, 135° and 45°. Only line A-14.13 had 180°and 135° head angle. But lines C-2.11, A-2 .5, A-4.3, B-3.1, A-7.10, A-10.1.2, A-11.1.2 and A-2.2 also showed head angle of 225°. The observed achene color for the accessions is presented in Figure 2. All the accessions possessed different percentages of achene color. All the accessions had maximum percentage of grey, black and light grey achene colour. Only line B-3.1 had black and grey achene colour. But accessions C-2.11, A-14.13, A-7.10, A-10.1.2, A-2.19 and C-2.17.1 showed a little percentage of white color achene.

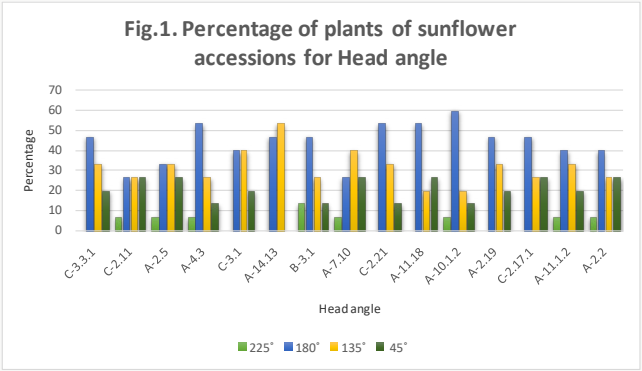

Figure 1: Percentage of plants sunflower accessions for head angle.

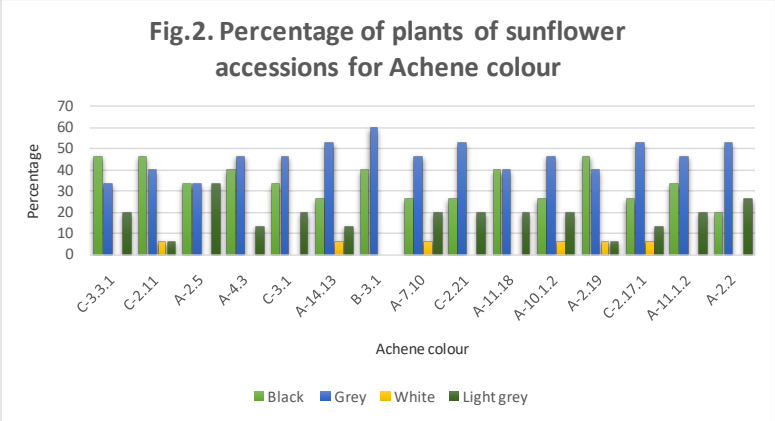

Figure 2: Percentage of plants sunflower accessions for Achene colour.

Correlation and path coefficient analysis

Genotypic and Phenotypic correlation coefficients among quantitative traits in 15 genotypes of sunflower are showed in Tables 4 & 5 respectively. Phenotypic correlation was lesser than the genotypic correlation. This showed that expressions of traits are mainly governed by the genetics of accessions and environment had little influence on them and selection can be fruitful for the improvement of breeding program [5,10,19,21-23]. Also discussed in their results that genotypic correlation is higher than the phenotypic correlation. 100AW (0.6879), NOL (0.501), LA (0.580) and HD (0.0603) had positive and highly significant genotypic correlations with AY/P. Genotypic (-0.634) and phenotypic (-0.45) correlation of AY/P was significantly negative with oil content. Phenotypic correlation coefficients of most of the traits were non-significant with AY/P. Genotypic correlations of DFF (-0.363), PH (-0.53) and FA (-0.527) were negative and highly significant with achene weight [5,12,23-32] also discussed the similar results in literature. Path analyses among quantitative traits are presented in Table 6. Results of correlation and path analysis can be helpful in the direct and indirect selection of valuable traits to improve the genetic potential of breeding material. Path analysis presented direct and indirect effects of different characters on AY/P.NOL, LA(0.083), 100AW(1.8979) and OC (1.5936) showed direct positive effect on AY/P [5, 33- 35]. Also discussed that 100AW showed positive direct effect on AY/P.

Table 4: Genotypic correlation coefficients of various characters among the sunflower accessions.

Variables	PH	HD	NOL	LA cm^2	FA	AY/P (g)	100 AW (g)	OC %
HD	-0.2681							
NOL	0.1149	0.4119						
LAcm2	-1.094	0.6707	0.1732					
FA	0.232*	-0.158*	0.886*	-0.099*				
AY/P (g)	-0.53**	0.0603*	0.501*	0.580*	-0.527**			
100 AW (g)	-0.647	0.0942*	0.346*	0.634*	*0.049	0.6879**		
OC%	-0.483*	-0.1357	0.1932	0.423*	0.0789*	-0.634*	1.0682*	
DFF	-0.1826	0.246	0.2838	-0.1567	0.1921	-0.363**	-0.5330*	0.5861*

Table 5: Phenotypic correlation coefficients of various characters among the sunflower accessions.

Variables	PH	HD	NOL	LA cm^2	NOA/H	FA	AY/P (g)	100 AW (g)	OC %
HD	-0.1948								
NOL	-0.1634	0.023							
LA cm2	-0.0853	0.295	0.1681						
NOA/H	-0.0493	0.064	0.5604	80.64					
FA	0.451**	-0.06	0.5609	-0.056	-0.2995				
AY/P (g)	-0.0258	-0.067	-0.036	0.252	0.2420*	-0.33*			
100 AW (g)	-0.0143	-0.168	-0.033	0.1306	0.0911	-0.49*	0.450**		
OC %	0.277*	-0.2	0.015	0.361	0.102*	0.1	-0.45*	0.98*	
DFF	-0.205	0.132	0.161	-0.04	0.1215	0.0256	-0.484	-0.25	0.371*

Table 6: Direct (bold diagonal) and indirect effects of various characters on achene yield per plant of sunflower accessions.

Variables	PH	HD	NOL	LA	FA	100AW(g)	OC %	DFF	rg
PH	-0.413	0.157	0.009	-3.9362	-0.013	-1.019	-1.8722	0.4852	0.1826
HD	0.1109	-0.589	0.034	1.4132	0.0091	2.414	0.2725	-0.3519	-0.246
NOL	-0.047	-0.242	0.083	1.3429	-0.05	0.955	-0.4229	-1.302	-0.2838
LA	0.2523	-0.395	0.031	1.8979	0.0057	1.105	0.0348	0.3025	0.1567
FA	-0.095	0.093	0.074	-0.3593	-0.057	-1.004	-0.1421	-1.9169	0.2921
100 AW(g)	0.2214	-0.035	0.042	2.0896	-0.03	2.904	-1.9905	-0.6535	0.3632
OC %	-0.267	0.055	-0.012	-2.2814	0.0028	1.3098	1.5936	0.9848	0.533
DFF	0.0841	-0.066	-0.034	-0.2328	-0.035	-0.3975	-1.8348	-0.1302	0.3383

Achene yield can be increased by considering these traits. DFF (-0.1302), PH(-0.413), HD(-0.589) and FA(-0.057) had negative direct effect on AY/P. PH showed positive indirect effects through HD, NOL and DFF. HD had positive indirect effect through PH(0.157), NOL(0.1109), LA(0.034), FA(1.4132), 100AW (0.0091) and OC(2.414) [18] also reported that HD had indirect positive effect on achene yield through 100AW. NOL had positive indirect effect through LA(1.3429) and 100AW(0.953) [5,7,36,37] also discussed the indirect effect of NOL on achene yield. LA showed positive indirect effects through PH (0.2523), NOL(0.031), FA(0.0057), 100AW(1.105), DFF(0.3025) and OC(0.0348). FA showed positive indirect effect through HD (0.093) and NOL (0.074). Hundred achene weights showed positive indirect effects through PH(0.2214), NOL(0.042) and LA(2.0896) [21,38,26] also reported that 100AWs had positive indirect effect through PH, LA and NOL. OC had positive indirect effects through HD(0.055), FA(0.0028), 100AW(1.3098) and DFF (0.9848). DFF had positive indirect effects through PH(0.0841). So a criterion may be developed for the selection of economic traits [39].

Conclusion

Significant genetic variability was present in the studied breeding material which may be exploited in hybridization programs to develop high seed and oil yielding, short duration and short stature hybrids of sunflower. Accessions A2.2, B-3.1, A 4.3 and A-7.10 showed best expression of economically important traits so they might be used in the future breeding programs for the improvement of achene yield. Correlation studies explained the direction of relationship between important traits. Direct and indirect association of PH, HD, NOL, LA, FA, 100AW and OC with AY/P recommended that these traits may be used as criteria for selection of sunflower types with good yield potential [40-42].

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