Genetic Diversity and Associations of Different Traits in Sunflower Varieties in Ethiopia

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Abstract

An experiment, consisting of twenty varieties from seven geographic origins of the world was conducted in Ethiopia to determine: the genetic diversity in sunflower cultivars so as to select parental stocks; and the associations among different traits so that major traits of importance could be identified.

Based on nine traits which were significantly ($P<0.01$) different, the genotypes were grouped into eight clusters. Cultivars in clusters II, III and VIII showed better performance for the majority of traits of interest; yield plant^{-1}, seeds head^{-1}, 1000-seed weight, harvest index, and oil yield ha^{-1}. Therefore, they should be considered for future breeding works.

The Mahalanobis's distance analysis showed that distance between clusters III and V was minimum (D^2=52.78) while distance between clusters VI and VII was maximum (D^2=1647.00), suggesting the existence of diversity amongst the populations. Therefore, parental lines can be selected and used for hybridization and sunflower improvement in Ethiopia. Maximum variations in the subsequent generations is expected if divergent classes could be crossed.

The correlation analysis revealed that seed yield was significantly associated with number and percentage of filled seeds head^{-1}, seed weight, harvest index, total above ground dry matter and stem diameter. The path analysis showed that seeds head^{-1} and seed weight bear the highest direct effects on yield. Hence, selection for these important traits will lead to the improvement of yield in sunflower.

Introduction

Sunflower (Helianthus annuus L) is one of the four leading world oil crops (FICK 1989) and among the eight important oilseeds in Ethiopia (HIRUY 1990, HAILE and MEKONEN 1993). Its acreage has increased steadily but its further expansion will depend on the crop's genetic potential for yield and oil content. To realize this breeding target, genetically diverse materials must be acquired and appropriate breeding methods should be employed. Under such circumstances, cluster and distance analyses are powerful tools to choose genetically diverse parents for desirable recombinations (ANAND and CHANDRA 1979, YADAVA and SINGH 1985, MARINKOVIC et al. 1992). In addition to the knowledge of diversity, a breeder should have to identify the most important traits based on the associations between yield and other traits.

In Ethiopia, though sunflower is one of the eight priority oilseeds, studies on genetic diversity and associations of different traits have not been thoroughly conducted. Therefore, this study was undertaken to determine: 1. genetic diversity in sunflower cultivars so as to select parental stocks; 2. associations among different traits so that major traits of importance could be identified.

Materials and methods

The experiment consisting of twenty sunflower varieties from seven different geographic origins of the world was conducted at Awasa (located at 7^0 04'N latitude and 38^0 31'E longitude) and Arsi-Negelle (located at 7^0 30'N latitude and 39^0 00 E longitude) Research Centers in Ethiopia. The experiment was laid out in randomized complete block design with 3 replications. Yield, growth and agronomic traits were measured on ten randomly selected plants from the middle 2 rows. All the parameters were statistically analyzed using MSTAT software. Nine parameters which were found to be highly significant (P<0.01) were further used to run cluster and distance analyses using SAS program. Correlation and path-coefficient analyses were computed according to DEWEY and LU (1959).

Results, discussions and conclusions

1. Genetic diversity

Simultaneous selection of parents based on a number of traits becomes more important when the aim is to improve complex quantitative traits such as seed yield. Hence, cluster and distance analyses were performed to form classes and measure distances. The twenty varieties included in the study were grouped into eight clusters (Table 1). Cluster I consisted of four varieties which possessed smaller total above ground dry matter and higher harvest indices (Table 2). Their seed yield plant^{-1} was lower and their importance to serve as parents for breeding works seem limited.

Cluster II consisted of three varieties which performed well in most of the traits of interest; seed yield plant^{-1}, seeds head^{-1}, harvest index and oil yield ha^{-1} (Table 2). These materials are therefore, considered valuable for future breeding works in Ethiopia. Cluster III consisted of 3 varieties which had higher oil content, seed yield plant^{-1}, harvest indices and heavier seed weight (Table 2). Though they possessed lower seeds head^{-1}, they could be considered as important sources for most of the traits.

Cluster IV consisted of 2 varieties. They are among the low oil yielders (Table 2) which made them less important as breeding materials. Cluster V is composed of 3 varieties (Table 1). This group possessed lower oil content and yield (Table 2). Cluster VI is composed of two varieties (Table 1). The varieties in this cluster showed poor performance for yield and yield components. Cluster VII consisted of two varieties (Table 1) which were known for their longer vegetative growth period and flowering. They possessed higher total above ground dry matter but lower harvest indices. Cluster VIII consisted of only 1 variety, HA 302. This promising variety was different from the groups and formed an independent class. Its performance showed that this line should be considered as parent.

Generally, genotypes from the same origin were grouped under different clusters, and vice versa. Therefore, it appeared that there were no relationships between geographic origins and diversity of the materials. Different authors (ANAND and CHANDRA 1979, YADAVA and SINGH 1985, MARINKOVIC et al. 1992) reported similar results.

Distance between clusters III and V was minimum followed by the distances between clusters II and V, II and III and I and VI. The maximum distance was found between clusters VI and VII. Distances between clusters I and VII and IV and VII were also large. Other clusters have smaller inter-class distances (Table 3). As maximum variations in the subsequent generations is expected from crosses that involve parents from the divergent classes, the crossing of parents selected from cluster VII with those from clusters I, IV and VI could produce desirable recombinants. Parents from cluster VI are also expected to produce segregants with moderate variations if they will be crossed with parents from clusters II, III, IV and V. Hybridization of parents selected from cluster VIII with parents from clusters I, IV, VI, VII could also produce progenies with desirable variations. On the other hand, crossing between clusters I and VI; II and V; III and V could not produce desirable recombinants since the inter-class distances between these groups were observed to be very small.

2. Associations

Correlation between yield and yield attributes: The results of the correlation analysis showed that there were significant associations between yield plant^{-1} and seeds head^{-1}, total above ground dry matter, seed weight, harvest index, percentage of filled seeds and stem diameter (Table 4). Similar results were reported earlier (MARINKOVIC 1992, HAILE and HAILU 1993).

Path-coefficient analysis: The results of path analysis revealed that seeds head^{-1} bear the highest direct effect on seed yield. Its indirect negative effects on yield were through 1000-seed weight, stem diameter and percentage of filled seeds (Table 5). The direct effect of seeds head^{-1} on yield was greater than its correlation coefficient with yield indicating its importance in influencing yield. Thousand seed weight had significant direct effects on seed yield. It exerted its indirect positive effects through harvest index, stem diameter and percentage of filled seeds. The correlation coefficient between seed weight and yield was lower than its direct effect on yield, because of its indirect negative effects through seeds head^{-1} and total above ground dry matter (Table 5). The present results are similar to the findings of different authors (PATHAK et al. 1983, SKORIC 1992, MARINKOVIC 1992, HAILE et al. 1995). Total above ground dry matter, harvest index, stem diameter and percentage of filled seeds bear insignificant direct effects on seed yield (Table 5).

In summary, the varieties belonging to clusters II, III and VIII showed better performance for oil and seed yields, and yield components. The Mahalanobis's distance analysis indicated the diversity of the materials and the possibility of selecting parental stocks from those materials for subsequent utilization in sunflower improvement program in Ethiopia. The results of the association analyses indicated that yield plant^{-1} was highly correlated with seeds head^{-1}, seed weight, percentage of filled seeds, harvest index, total dry matter and stem diameter of which seeds head^{-1} and seed weight are the major yield components. Therefore, selection program aimed at improving yield in sunflower should have to give a due emphasis to seeds head^{-1} and seed weight.

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Table 1. Clustering pattern of sunflower varieties and their respective origins

Cluster	Number of varieties	Varieties included in the Cluster and their origins
I	4	RO-1209 (Romania), Erika, Florem and Pag-SF-100A (All from Bulgaria)
II	3	NSH-2 (Yugoslavia), Edrine 87 (Bulgaria), RO-1198 (Romania)
III	3	HA 300 (USA), Pop-158 (USA), Carg-SF-400 (Canada)
IV	2	NSH-25 (Yugoslavia), NK-Sunbred 241 (Canada)
V	3	Hesa (USA), Argentario (Italy/ Argentina), Romsun 90 (Romania)
VI	2	Ch X Gene Pool-I (Russia), Cargill 207 (Canada)
VII	2	Improved Russian Black, Russian Black (Both from Russia)
VIII	1	HA 302 (USA)

Table 2. Mean of some quantitative traits of twenty sunflower varieties under different clusters

	Clusters							
Traits	I	II	III	IV	V	VI	VII	VIII
VP (days)	49.09	47.39	51.61	52.84	53.89	46.92	60.50	50.50
DFL (days)	70.88	69.94	76.55	78.42	78.39	66.50	91.67	76.17
FSPH (No.)	1098.84	1237.95	1093.89	1149.25	1086.17	995.17	1150.84	1086.50
TDMWT (g/plant)	186.59	201.99	204.06	194.13	207.25	198.75	281.33	237.75
HI (%)	34.20	36.30	34.40	29.30	31.20	35.40	23.50	33.80
SW (g)	58.04	58.98	64.00	52.09	58.83	58.97	56.78	66.00
SYPP (g/plant)	63.82	72.52	69.63	59.35	63.97	58.57	65.23	71.50
OC (%)	46.57	45.26	47.11	45.39	44.39	45.72	44.44	48.33
OY (kg/ha)	1579.00	1734.45	1742.66	1429.59	1498.22	1418.59	1541.34	1830.00

Note: VP=Vegetative Period, DFL=Days to Ray Flowering, FSPH=Number of Filled Seeds Per Head, TDMWT=Total Dry Matter Weight, HI=Harvest Index, SW=1000-Seed Weight, SYPP=Seed Yield Per Plant, OC=Oil Content, OY=Oil Yield

Table 3. Intra- and inter-class distances (D^2) among twenty sunflower varieties in eight clusters

CLUSTERS	I	II	III	IV	V	VI	VII	VIII
I	0	138.874	167.306	237.732	240.482	96.393	1090.000	473.693
II		0	83.391	154.014	76.213	449.330	701.506	238.337
III			0	280.728	52.780	468.739	649.397	122.103
IV				0	165.318	464.431	1049.000	631.603
V					0	575.825	542.406	190.904
VI						0	1647.000	928.442
VII							0	380.594
VIII								0

Table 4. Correlation coefficients between seed yield and some quantitative traits in twenty sunflower varieties

	SD	FSPH	PFS	TDMWT	HI	SW
FSPH	0.460**					
PFS	0.180	0.415**				
TDMWT	0.331**	0.517**	0.187			
HI	-0.092	0.116	0.115	-0.645**		
SW	-0.192*	-0.209*	-0.052	-0.060	0.421**	
SYPP	0.308**	0.802**	0.333**	0.451**	0.360**	0.406**

* and ** significant at P<0.05 and P<0.01, respectively.

Table 5. Direct (diagonal) and indirect effects of some quantitative traits on seed yield in sunflower

	SD	FSPH	PFS	TDMWT	HI	SW	COR. WITH SEED YIELD
SD	-0.005	0.381	-0.005	0.051	-0.013	-0.101	0.308
FSPH	-0.003	0.829	-0.012	0.080	0.017	-0.100	0.802
PFS	-0.001	0.344	-0.029	0.017	0.027	-0.033	0.333
TDMWT	-0.002	0.428	-0.005	0.155	-0.094	-0.032	0.451
HI	0.001	0.096	-0.003	-0.100	0.146	0.221	0.360
SW	0.001	-0.173	0.002	-0.009	0.062	0.525	0.406