EVALUATION OF SINGLE AND THREE-WAY CROSS SUNFLOWER HYBRIDS FOR DROUGHT TOLERANCE

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Abstract

The objective of this study was to determine drought tolerance of single and three-way cross sunflower hybrids. Five single cross, and twenty-nine three-way hybrids along with Hysun 25 and two open-pollinated (OP) varieties, Record, and BOP1 were planted in a simple lattice design (6x6) under normal irrigation and stress conditions. Grain yield and agronomical characters were recorded under normal and stressed conditions for all genotypes. Stress tolerance index (STI) and stress susceptibility index (SSI) were used to select drought-tolerant genotypes with high yield. Combined analyses of variance for grain yield showed that 'Mehr' and (IL17 x CMS31) x R244 were the highest yielding genotypes. Calculating physiological indices showed that Mehr and (IL18 x CMS31) x R43 were the most drougth resistant genotypes using the stress susceptibility index (SSI). Based on the stress tolerance index (STI) Mehr and (IL17 x CMS31) x R244 were the most drought tolerant genotypes.

Introduction

Sunflower (*Helianthus annuus* L.) is one of the most important oil seed crops in Iran. It is well known that water deficit stress has a profound effect on the yield of sunflower (Muriel and Downess, 1974). Seed composition is also affected by drought. Water deficit during vegetative and reproductive growth stages reduces seed oil content (Hall et al., 1985). A number of regression techniques comparing yield to some kind of an environmental index as an independent variable have been developed to evaluate genotype adaptability. Fischer and Maurrer (1987) proposed a stress susceptibility index (SSI), whereas Fernandez (1992) used a stress tolerance index (STI) of genotype adaptability over a range of environments. Bochkovoy et al. (2000) concluded that three-way sunflower hybrids, whose yielding ability is the same as that of single cross hybrids, but have ecological stability, more profitable hybrid seed production, higher emergence of F1 seeds and their maternal forms, and a more effective and economic breeding scheme are the most preferable type of sunflower hybrids for Russia. The purpose of this present investigation was to compare grain yield of single and three-way cross hybrids under normal and drought-stressed conditions and to select the high-yielding drought-tolerant genotypes.

Materials and Methods

This research was conducted at the experimental field of the Seed and Plant Improvement Institute (SPII) in Karaj, Iran during 2001. Thirty-six sunflower genotypes (five single crosses, twenty-nine three-way hybrids and Hysun 25 in addition to two OP varieties, Record and BOP1) were planted in a simple lattice design (6x6) under normal irrigation and drought-stressed conditions. In one experiment, the normal regime of irrigation was applied, but in the other one, the genotypes were subjected to irrigation at only two stages: the first at germination and the second at the beginning of flowering. Growing period, plant height, head diameter, 1000-seed weight, oil content, grain and oil yield were used for ANOVA analyses.

Grain yield stress susceptibility index (SSI) (Fischer and Maurrer, 1987) and stress tolerance index (STI) (Fernandez, 1992) equations were used to evaluate genotype behavior under drought stress as follows:

$$SSI=[1-(Ys/Yp)]/SI \quad [1]$$

$$STI=[(Yp)(Ys)]/(Ydp)2 \quad [2]$$

Where Ys and Yp are grain yield in stress and normal conditions respectively, SI is the stress intensity and is estimated as: SI= [1-(Yds/Ydp)]; where Yds and Ydp are the mean grain yields of all genotypes evaluated under two conditions.

Results and Discussion

Combined Analysis of Variance. Combined analysis of variance for 1000-seed weight and oil content were highly significant ($P < 0.01$) under both normal and drought-stressed conditions (Table 1).

Table 1. Mean squares on the combined analysis of variance for yield and other traits.

S.O.V	DF	MEAN OF SQUARES					
		Plant height	Head diameter	Grain yield	1000-seed weight	Oil%	Oil yield
Environment	1	0.007ns	0ns	230.187**	16247.751**	3455.578*	63.429**
Error	2	2194.535	6.42	0.163	100.202	64.928	0.067
Genotypes	35	130.31ns	2.464ns	0.215ns	72.133**	28.299**	0.074ns
Genotypes x environment	35	61.736ns	0.831ns	0.179ns	33.443ns	11.079**	0.066*
Error							
pooled	50	85.3995	1.7275	0.145		4.7415	0.035
RCB design	70				27.641		
cv		9.78%	10.43%	17.62%	11.63%	4.90%	18.26%

However, differences for other characters were not significant for plants grown under normal

and water-stressed conditions. The highest oil content of 51.5% was obtained from the hybrid Mehr which had no significant difference in oil content compared to the check variety 'Record.' While the F-test for grain yield was not significant at the 0.05 probability level, it was significant at the 0.10 probability level. Using least significant difference (LSD) comparison of grain yield showed that (IL17 x CMS31) x R244, a three-way hybrid and Mehr single cross hybrid produced the highest grain yield under both normal and drought-stressed environments.

Stress Susceptibility Index (SSI). According to Fischer and Maurer (1979), a genotype with an SSI of less than one is considered a drought-tolerant genotype. According to the results (Table 2), the lowest SSI (0.81) was obtained in three-way hybrid (IL17 x CMS60/52) x R103. Three-way cross (IL18 x CMS31) x R43 and single cross hybrid Mehr showed 0.88, indicating the highest resistance to drought.

Table 2. Mean yield of genotypes in two different conditions, and their stress susceptibility index (SSI) and stress tolerance index (STI).

Genotypes	Grain yield t/ha		SSI	STI
	Normal	Stress		
IL3*CMS31*R-43	3.645	1.233	0.89	0.38
IL3*CMS31*R103	3.036	0.793	1.00	0.21
IL3*CMS31*43.2	3.229	0.687	1.06	0.19
IL3*CMS31*R244	3.275	0.909	0.98	0.25
IL3*CMS6052*R43	2.882	0.867	0.94	0.21
IL3*CMS60/52*R103	3.398	0.850	1.01	0.25
IL3*CMS6052*R232	3.317	0.793	1.03	0.22
IL3*CMS6052*R244	3.568	0.802	1.05	0.24
IL10*CMS31*R43	2.659	0.788	0.95	0.18
IL10*CMS31*R103	3.890	0.658	1.12	0.22
IL10*CM6052*R43	3.349	0.486	1.16	0.14
IL10*CMS6052*R103	3.300	0.880	0.99	0.25
IL10*CMS6052*R244	3.841	0.944	1.02	0.31
IL17*CMS31*R43	3.898	0.776	1.08	0.26
IL17*CMS31*R103	3.193	1.041	0.91	0.28
IL17*CMS31*R232	3.433	0.874	1.01	0.26
IL17*CMS31*R244	4.115	1.332	0.91	0.47
IL17*CMS6052*R43	3.214	0.799	1.02	0.22
IL17*CMS6052*R103	3.132	1.262	0.81	0.34
IL17*CMS6052*R232	3.059	0.972	0.92	0.25
IL17*CMS6052*R244	3.605	1.180	0.91	0.36
IL18*CMS31*R43	3.187	1.119	0.88	0.30
IL18*CMS31*R103	3.498	1.160	0.90	0.35
IL18*CMS31*R232	4.505	0.716	1.14	0.28
IL18*CMS31*R244	4.028	0.888	1.05	0.31
IL18*CMS6052*R43	3.687	0.915	1.02	0.29

IL18*CMS6052*R103	3.297	0.828	1.01	0.23
IL18*CMS6052*R232	3.593	0.707	1.09	0.22
CMS31*R43(Golshid)	3.589	0.979	0.98	0.30
CMS31*R244	3.521	0.623	1.11	0.19
Mehr	3.889	1.358	0.88	0.45
CMS60/52*R244	3.687	1.142	0.93	0.36
RECORD	2.760	0.879	0.92	0.21
Azargol	3.139	0.786	1.01	0.21
HYSUN25	2.959	0.568	1.09	0.14
BOP1	2.854	0.737	1.00	0.18

Stress Tolerance Index (STI). It has been suggested that Stress Tolerance Index (STI) and Stress Susceptibility Index (SSI) are appropriate physiological indices for evaluating and screening drought tolerance among genotypes (Fernandez, 1992). STI is found to be the best index of drought tolerance selection, but STI is the physiological drought index that is used to select drought-tolerance high-yielding genotypes. The preferred genotypes are those that have high yield and drought tolerant characteristics under both normal and drought-stressed conditions. In this study (IL17 x CMS31) x R244 three-way hybrid and single cross hybrid Mehr are high-yielding hybrids with drought tolerance characteristics (Table 3).

Table 3. Mean performance of genotypes for different traits in two experiments.

Genotypes	Plant height (cm)	Head diameter (cm)	Grain yield (t/ha)	1000-seed weight (gr)	Oil (%)	Oil yield t/ha
IL3*CMS31*R-43	102.3	13.04	2.439	52.53	45.40	1.149
IL3*CMS31*R103	93.5	12.75	1.915	43.27	39.00	0.797
IL3*CMS31*42.32	91.9	12.35	1.958	42.81	42.69	0.922
IL3*CMS31*R244	100.5	12.61	2.092	41.98	42.36	0.944
IL3*CMS6052*R43	108.6	13.71	1.875	46.32	45.28	0.925
IL3*CMS60/52*R103	98.2	13.37	2.124	42.84	38.84	0.900
IL3*CMS6052*R232	87.4	12.09	2.055	41.08	43.25	0.953
IL3*CMS6052*R244	100.6	12.20	2.185	40.66	45.13	1.068
IL10*CMS31*R43	98.1	12.45	1.724	49.35	46.96	0.874
IL10*CMS31*R103	95.2	12.36	2.274	44.25	42.70	1.070
IL10*CM6052*R43	91.7	11.76	1.918	42.76	46.61	1.020
IL10*CMS6052*R103	86.9	13.12	2.090	41.45	41.13	0.938
IL10*CMS6052*R244	96.1	13.77	2.393	43.74	47.10	1.177
IL17*CMS31*R43	86.0	12.28	2.337	49.78	45.71	1.156
IL17*CMS31*R103	93.0	12.88	2.117	45.85	41.18	0.899
IL17*CMS31*R232	89.8	13.04	2.154	39.38	45.54	1.025
IL17*CMS31*R244	93.4	11.99	2.724	46.66	42.78	1.187
IL17*CMS6052*R43	89.2	12.21	2.007	48.83	44.98	0.965

IL17*CMS6052*R103	89.1	12.69	2.197	45.91	42.84	0.963
IL17*CMS6052*R232	89.2	13.01	2.016	39.64	45.94	0.994
IL17*CMS6052*R244	97.7	12.70	2.393	40.44	46.29	1.201
IL18*CMS31*R43	92.0	12.42	2.153	47.40	46.51	1.060
IL18*CMS31*R103	97.4	13.16	2.329	43.26	42.45	1.068
IL18*CMS31*R232	87.5	13.03	2.611	48.72	45.05	1.319
IL18*CMS31*R244	96.4	13.54	2.458	43.46	45.81	1.164
IL18*CMS6052*R43	89.3	12.36	2.301	49.25	46.38	1.158
IL18*CMS6052*R103	97.1	12.80	2.063	38.92	42.30	0.905
IL18*CMS6052*R232	88.9	12.56	2.150	40.00	45.50	1.061
CMS31*R43(Golshid)	97.3	13.36	2.284	54.85	48.17	1.167
CMS31*R244	98.4	11.98	2.072	48.24	43.63	1.002
Mehr	91.3	11.33	2.624	50.74	51.50	1.365
CMS60/52*R244	91.9	11.74	2.415	45.18	47.33	1.185
RECORD	109.7	12.89	1.820	50.74	47.49	0.867
Azargol	92.4	11.15	1.963	52.31	43.89	0.905
HYSUN25	97.1	13.75	1.764	42.11	41.36	0.803
BOP1	97.7	11.36	1.796	42.34	39.54	0.729
LSD 0.05	13.12	1.87	0.541	7.41	3.09	0.266
LSD 0.01	17.50	2.49	0.721	9.84	4.12	0.354

Conclusions

Two experiments on sunflower under normal irrigation and drought-stressed conditions were carried out. It is concluded that despite some preconceptions, three-way cross hybrids of sunflower produced higher yields compared to single crosses. As these three-way cross hybrids include a combination of three inbred lines, they are well adapted to stressed conditions. Because much seed is obtained from three-way hybrids compared to a single cross in per unit area in seed multiplication programs, it seems that three-way hybrids should be used for grain production under both optimal and drought-stressed conditions in this country.

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