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Line X Tester Analysis of Agro-Physiological Traits in Sunflower under Water Deficit Condition

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Abstract*:To assess the effect of water deficit on some traits of sunflower, 16 hybrids derived from line × tester cross of four lines and four testers were evaluated under normal irrigation and water deficit at flowering stage using randomized complete blocks design with three replications at two separate experiments. The measured traits were head diameter, grain yield/plant, 100 grain weight, Chlorophyll index and leaf temperature. Combined analysis of variance revealed significant differences between normal irrigation and water stress treatment for all the traits except 100 grain weight. Genetic analyses estimated the degree of dominance for different traits in the range of 1.69 and 2.24 in the both normal and water deficit conditions suggesting the importance of dominance gene effect in controlling the studied traits compared with additive gene effect. The estimated heritability for leaf temperature and chlorophyll index was higher compared with the agronomic traits. AGK46 line with significant and positive general combining ability (GCA) for Chlorophyll index and significant and negative GCA for leaf temperature was detected as promising line. Based on all trait's SCA, RGK26 × AGK30 and RGK25 × AGK2 were identified as promising crosses in normal and water deficit conditions, respectively.*

Keywords: *General combining ability (GCA), Specific combining ability (SCA), Heritability, Sunflower*

1. Introduction

Drought stress is the most important factor of abiotic stresses (Boyer, 1982). Many aspects of metabolism and plant growth can be affected by water deficit condition (Simova-Stoilova *et al.*, 2008). Stone *et al.* (2001) reported that the lack of moisture during the flowering stage until the end of flowering have the most negative impact on hybrid's performance. Significant reduction on yield and yield components of sunflowers under water deficit condition has been reported also by other researchers (Freres *et al.*, 1986; Neelima, 2007; Soleimanzadeh *et al.*, 2010). It was reported that the highest yield loss in sunflower was observed when drought stress was occurred during developmental phase of flowering to grain filling period.

Line × tester analysis provides information about general combining ability (GCA) and specific combining ability (SCA) of parents, as well as estimating the different types of gene effects. Hladny *et al.*, (2011) reported that the role of non-additive effects in genetic control of sunflower's number of grain per head and 100 grain weight were more important than additive effects. Also, in other reports, for grain weight, grain yield, plant height and head diameter of sunflower, more important non-additive effect than additive one have been obtained (Ortis *et al*., 2007). Gvozdenovic *et al.*, (2005) by estimating of variance components for plant height and head diameter in sunflower showed that the non-additive genetic variance components play an important role in heredity of these traits.

The objective of this study was to evaluate genetic control of some agronomic and physiological traits, including chlorophyll content and leaf temperature in four sunflower cytoplasmic male sterile lines and four restorer of fertility testers and their 16 hybrids under normal irrigation and water deficit conditions.

2. Materials and Methods

2.1 Plant Materials and Experimental Design

The plant materials used in this study consisted of 16 sunflower hybrids and their eight parents (4 lines and 4 testers), which kindly provided by the Research Center for Agriculture and Natural Resources of Khoy, West Azerbaijan, Iran (Table 1). Field experiments were carried out in 2015 cropping season at the University of Tabriz Agricultural Research Station, located 12 km East of Tabriz with the height of 1360 meters above sea level. Line × tester experiment was performed in two separate randomized complete blocks designs (with three replications), one at normal irrigation and another at water deficit condition. Water deficit was applied during flowering period R4 or start of flowering stage for about 21 days non irrigation (late June in the region).

2.2 Studied Traits

Some agronomic and physiological traits including head diameter, 100 grai weight, grain yield/plant, leaf temperature and chlorophyll index were measured in 10 randomly selected samples. Leaf temperature were measured at physiological maturity stage using infrared thermometer TES 1327, equipped with a laser beam between 13:30 and 15 pm in 10 leaves randomly selected from the top of the canopy (at water deficit period). Chlorophyll index was measured by using chlorophyll meter SPAD-502 (Minollta) at three points of two leaves of 10 plants.

2.3 Data Analyses

Data collected from two separate experiments were first exposed to normality test of residuals and homogeneity of variance. Combined analysis of variance was performed to examine the significance of various sources of variation. In addition, data were subject to line×tester analysis (Singh and Chaudhury, 2001) to estimate GCA and SCA as well as their respective variance components and heritability.

3. Result and Discussion

Combined analysis of variance revealed significant differences between normal irrigation and water deficit condition for all the traits except 100 grain weight. Line × tester interaction was significant for all the studied traits. Line × tester × condition interaction was also significant for all the traits except 100 grain weight. Line × condition interaction was significant for leaf temperature, grain yield/plant and chlorophyll index. Condition × tester interaction was significant for head diameter, grain yield/plant and chlorophyll index (Table 2).

Due to significant interactions between experimental conditions and parental lines, genetic analysis was performed, separately for tow irrigation conditions. Estimates of GCA and SCA variance, components of genetic variance, $\sigma^2_{SCA}/\sigma^2_{GCA}$ ratio, degree of dominance and board and narrow sense heritability are shown in Tables 3 and 4 for normal irrigation and water deficit stress, respectively. In water deficit conditions, the degree of dominant was more than 1 for all of the traits whereas $\sigma^2_{SCA}/\sigma^2_{GCA}$ ratio was less than 1 (Table 3) indicating the importance of dominance gene effect in controlling these traits. This was true for normal irrigation condition as well. This result is consistent with the Hladni *et al*. (2011) report whereas opposite to Sharma *et al*. (2003). Broad sense heritability (h^2_b) estimates, varied from 0.41 to 0.86 under water deficit condition and from 0.50 to 0.85 under normal irrigation . However, in both conditions, narrow sense heritability (h^2_n) were as much more less than (h^2_b) values. Heritability values for the Chlorophyll index was somewhat higher than those of agronomic traits.

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General combining ability (GCA) values for lines and testers are presented in Table 5 under water deficit condition. AGK30 line had the highest GCA for head diameter in both conditions, whereas AGK46 line showed the highest GCA for 100 grain weight in normal condition(data are not shown) and AGK30 for this trait under water deficit condition. AGK2 and AGK30 had the highest positive GCA for grain yield/plant at both conditions. The highest GCA for chlorophyll was estimated in AGK46 at both conditions. Also this line showed the highest negative GCA for leaf temperature under normal irrigation. Higher leaf temperature could interrupt photosynthesis activities and decrease plant yield (Farooq *et al*., 2009); therefore, the negative values of GCA for this trait will be suitable. Among the testers, RGK21 showed positive and significant GCA for 100 grain weight, and RGK25 for chlorophyll index under normal irrigation. Under water deficit stress, RGK26 showed positive and significant GCA for head diameter.

Significant SCA were obtained for all the traits excepted chlorophyll index under both conditions (data are not shown) . Under water deficit condition, RGK26 × AGK30 cross showed positive and significant SCA for head diameter, 100 grain weight and chlorophyll index. In normal condition, positive and significant SCAs for head diameter, grain yield/plant and chlorophyll index was estimated for RGK25 × AGK2 cross.

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TABLE I: Nomenclature of sunflower testers, lines and hybrids.

Number	Name	Hybrid Number	Hybrid Name	Hybrid Number	Hybrid Name
tester 1	RGK15	1	RGK15×AGK2	9	RGK25×AGK2
tester 2	RGK21	2	RGK15×AGK30	10	RGK25×AGK30
tester 3	RGK25	3	RGK15×AGK46	11	RGK25×AGK46
tester 4	RGK26	4	RGK15×AGK330	12	RGK25×AGK330
line 1	AGK2	5	RGK21×AGK2	13	RGK26×AGK2
line 2	AGK30	6	RGK21×AGK30	14	RGK26×AGK30
line 3	AGK46	7	RGK21×AGK46	15	RGK26×AGK46
line 4	AGK330	8	RGK21×AGK330	16	RGK26×AGK330

TABLE II: Combined analysis of variance for line × tester design in sunflower in normal and water deficit conditions.

Sources of variation	Degrees of freedom	Head diameter	100 grain weight	Yield per plant	Leaf temperature	SPAD
Condition	1	32203.68**	10.49ns	18215.34**	24.04**	162.912**
Block/Cond.	4	152.49	1.21	61.771	25.30	70.51
Line	3	2227.44**	1.32	2274.69**	3.020*	268.40**
Tester	3	385.09**	5.159**	674.32**	1.870	35.85**
Line × condition	9	593.62**	4.246**	178.41**	1.923*	90.25**
Line × condition	3	155.60	1.66	162.86*	6.660**	38.25**
Tester × condition	3	344.08*	2.45	492.85**	1.510	40.63**
Line × tester × cond.	9	462.25**	1.523	591.69**	2.279**	19.21**
Erorr	60	84.94	1.017	42.36	0.777	5.210
CV		7.2	15.62	25.24	7.14	5.9

* and ** : significant at probability level of 5% and 1%, respectively.

TABLE III. Estimation of genetic variance components, dominance degree and heritability in line × tester crossing sunflower in normal condition

	Head diameter	100 grain weight	Yield per plant	Leaf temperature	SPAD
GCA variance for lines	76.06	0.025	70.94	0.330	20.23
GCA variance for testers	1.103	0.207	32.32	0.024	1.683
SCA variance	138.26	0.582	148.65	0.335	20.77
Additive variance of line	152.12	0.0515	141.89	0.66	40.4
Additive variance of tester	2.206	0.414	64.64	0.048	3.366
Average additive variance	77.163	0.232	103.265	0.384	21.883
Dominance variance	138.26	0.582	148.65	0.335	49.88
Phenotypic variance	305.328	1.625	442.074	1.423	20.77
$\sigma^2_{SCA}/\sigma^2_{GCA}$ of lines	0.558	0.042	0.447	0.985	0.974
$\sigma^2_{SCA}/\sigma^2_{GCA}$ of testers	0.007	0.355	0.217	0.071	0.081
Degree of dominance	1.89	2.239	1.69	1.320	1.377
Broad sense heritability	0.70	0.50	0.56	0.50	0.85
Narrow sense heritability	0.25	0.14	0.23	0.26	0.43

GCA= general combining ability
SCA= specific combining ability
σ^2= variance component

TABLE IV. Estimation of genetic variance components, dominance degree and heritability in line × tester crossing sunflower in water deficit conditions

	Head diameter	100 grain weight	Yield per plant	Leaf temperature	SPAD
GCA variance for lines	59.078	0.065	81.79	0.316	4.46
GCA variance for testers	54.505	0.258	9.915	0.059	3.83
SCA variance	63.173	1.477	114.46	0.547	12.27
Additive variance of line	118.156	0.13	163.59	0.632	8.926
Additive variance of tester	109.01	0.516	19.83	0.118	7.66
Average additive variance	118.58	0.323	91.712	0.375	8.293
Dominance variance	63.173	1.477	114.46	0.547	12.27
Phenotypic variance	434.76	3.02	307.08	1.773	23.65
$\sigma^2_{SCA}/\sigma^2_{GCA}$ of lines	1.78	0.044	0.714	0.577	0.363
$\sigma^2_{SCA}/\sigma^2_{GCA}$ of testers	1.64	0.174	0.086	0.107	0.312
Degree of dominance	1.076	3.03	1.561	1.70	1.720
Broad sense heritability	0.41	0.59	0.67	0.52	0.86
Narrow sense heritability	0.27	0.10	0.29	0.21	0.35

GCA= general combining ability
SCA= specific combining ability
σ^2= variance component

TABLE V. General combining ability values of sunflower lines and testers under water deficit condition

	Head diameter	100 grain weight	Yield / plant	Leaf temperature	SPAD
AGK2	-0.275*	-0.165	4.814	-0.057	-1.916*
AGK30	11.589**	0.381	8.106*	-0.405	-0.728
AGK46	-14.22**	0.029	-11.145**	1.115**	3.149**
AGK330	2.906	-0.245	-1.750	-0.653	-0.560
SE(GCA)	2.582	0.319	3.542	0.266	0.507
SE(gi-gi)	3.651	0.451	5.010	0.377	0.718
RGK15	-3.719	0.295	-3.778	-0.205	0.951
RGK21	1.749	0.504	3.800	-0.240	1.106
RGK25	-7.312*	-0.113	-4.869	0.164	0.754
RGK26	9.282*	-0.686	4.872	0.281	-2.812*
SE(GCA)	2.582	0.319	3.542	0.266	0.507
SE(gi-gi)	3.651	0.451	5.010	0.377	0.718