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ESTIMATION OF GENETIC PARAMETERS FOR YIELD AND YIELD COMPONENTS IN SUNFLOWER UNDER NORMAL AND STRESS WATER DEFICIT

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Abstract

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The description of a suitable breeding strategy in drought prone environments is an important function for sunflower breeders. To achieve this function, dependable information on heritability and gene effects on yield and related traits under these conditions is necessary. Thirty sunflower hybrids were produced by line × tester cross of six male-sterile and five restorer lines. hybrids were evaluated in three levels of irrigation as follows: non-stressed plots irrigated at regular intervals (W_1), mild water stress (W_2), from the beginning of button stage (R_4) to seed filling initiation ($R_{6),}$ and severe water stress (W_3) started from the beginning of button stage (R_4) to physiological maturity. Based on observations, plant height**,** stem diameter, number of seed were controlled by additive effects under irrigation conditions. Head diameter, plant height, stem diameter, 1000-seed weight, number of seed and yield were controlled by additive effects under mild stressed conditions. Under severe stress conditions, however, head diameter, plant height, stem diameter, number of seeds were controlled by additive effects, plant height and stem diameter were controlled by both additive and dominant effects and Seed yield was mainly influenced by dominant effects. Yield correlated positively with head diameter and plant height, 1000-seed weight and number of seeds. According to heritability and correlation between traits, under drought stressed conditions in breeding programs, number of seed, head diameter and plant height can be reliable criteria for selection of tolerant genotypes with higher yields.

Key words: sunflower, drought stress, line × tester, gene action, heritability

Introduction

Sunflower (*Helianthus annuus* L.) is one of the most main oil crops that widely grown on many parts of the world (Hu et al., 2010). The importance of hybrid cultivars in sunflower has increased recently because of their higher seed yield com-pared with cross-pollinated varieties in many countries in the world. Hybrids of sunflower are more stable, highly self-fertile, with high yield performance, and more uni-form at maturity (Kaya and Atakisi, 2004).

Drought stress is reported to cause reduction plant height and decrease seed yield. The amount of water available to the crop is consequently a key factor in determining yield, and the opportunity and modality of irrigation must be determined precisely in local conditions (Ozturk et al., 2008).

Knowledge of genetic parameters is essential for understanding of any crop improvement breeding programs (Arshad et al., 2007). The sunflower genotypes subjected to progressive drought at each growth stage of sunflower, as often happens in field conditions, presented a large variation and gene actions in terms of water status maintenance Pourmohammad et al. (2014). Traits which have the highest dominant effects on environment alteration of plant for maximizing production are phenological related traits. (Golparvar et al., 2013).

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Seed number has the largest direct influence on seed yield (Skoric, 1974; Marinkovic, 1987; Dusanic, 1998).

Bajaj et al. (1997) observed the additive gene effects were important in the inheritance of days to maturity, 1000-seed weight and oil content while seed yield per plant was predominantly under the control of non-additive gene effect.

Hussain et al. (1998) and Radhika et al. (1999) found that SCA variances were higher than GCA variances for 1000-seed weight, seeds head and seed yield which were, generally controlled by non-additive gene action. This is known mainly because of interaction between genotype and environment especially under stress (Sharma et al., 2002).

Tahir et al. (2002) also concluded that seed yield mainly depends upon 1000 seed.

Weight, number of filled seed per plant and seed filling percentage, and that this information can be used as as selection criteria to improve seed yield.

The non-additive gene actions were more effective for plant height head diameter seeds per head 1000 seed weight seed yield characters (Karasu et al., 2010).

Seed yield was mainly governed by dominant effects and plant height and oil content were controlled by additive effects (Ghaffari et al., 2012).

Indirect selection in primer breeding generations according traits with higher heritability than yield is one of the important breeding strategies. Then, knowing heredity way and genetic control of various traits is very important in breeding plans.

Sunflower seed yield is a complex trait with polygenetic base that is highly influenced by the environment (Skoric et al., 2007). Then it seems that studying the heredity way of trait and choosing appropriate breeding strategy for each environment is necessary and producing new cultivars which are flexible to various environments is one of the major goals of breeders.

A significant correlation was found between seed yield with head diameter, Darvishzade et al. (2011) and yield with total number of seeds per head, and also found between head diameter and total number of seeds per head. (Hlandi et al., 2006).

It seems that heritability of traits, general and specific combining abilities of cultivars, heterosis of traits, and way of genes action and the other genetic parameters are changed by change in environmental condition and then it is necessary to propose appropriate strategies for improving every trait indifferent environments So, the aims of this study were comparing mode of inheritance and gene action in genetic control of agronomical traits sunflower hybrids under drought stress condition.

Materials and Methods

30 F_1 hybrids developed by crossing 6 cytoplasmic male sterile (cms) female lines (B110, B147, B221, B329, B343 and B355) to five male restorer lines (R19, R26, R46, R50 and R56) were used in this study. These hybrids were made from 2010 plantings in the Khoy Field Station, Khoy, Iran and evaluated in line × tester fashion. The 30 hybrids obtained in 2010 were planted at three levels of irrigation in the University of Tabriz Agricultural Research Fields-Iran in May 2011, 2012. The research station situated at the altitude of 1360 meters and 46°,17′ longitude and 38°,5′ latitude. In the spring and summer cultivation average precipitation was 271.3 mm and average temperature was 10°C.

The seeds of F_1 generation were planted in the sunflower research area under irrigated and drought stress conditions in a sandy loam soil. Treatments were allocated in split plot fashion based on randomized complete block design with three replications. Each genotype was sown in one individual row of 3 m length and distance between rows of 60 cm and the seeds were planted at 30 cm intervals. Two seeds of sunflower were planted in each hole by hand and thinned to single plant at seedling stage. Different water levels were developed by irrigating the non-stressed plots at regular intervals (W_1) while two levels of drought were developed by mild water stress, from the beginning of button stage (R_4) (Schneiter and Miller, 1981) to start seed filling ($R_{6), (W2}$) and applying a severe water stress which started from the beginning of button stage (R_4) to physiological maturity (W_3). Weeds were controlled manually, diseases were considered absent. Data were recorded on plant height (cm), head diameter (cm), stem diameter (cm), 1000-seed weight (g), number of seeds per head, seed yield (kg/ha).

Analysis of variance for combining ability was done according to the line x tester method, in which estimates of GCA variances and SCA variances were obtained as suggested by Singh and Chaudhary (1977).

$$\hat{\sigma}^2_{GCA} = \text{Cov HS} =$$

$$\hat{\sigma}^2_{GCA}(T) = \frac{MST - MSE}{rl}$$

$$\hat{\sigma}^2_{GCA}(L) = \frac{MSL - MSE}{rt}$$

$$\hat{\sigma}^2_{GCA}(LT) = \frac{MSLT - MSE}{r}$$

$$F = 1 \quad \hat{\sigma}^2_{GCA} = \left[\frac{1+F}{4}\right]\sigma^2_A$$

$$\rightarrow \quad \hat{\sigma}^2_{GCA} = \left[\frac{1+F}{2}\right]^2\sigma^2_D$$

$$F = 1 \rightarrow \quad \hat{\sigma}^2_D = \sigma^2_{SCA}$$

$$\hat{h}^2_B = \frac{\sigma^2_G}{\sigma^2_G + \frac{\sigma^2_E}{r}}$$

$$\hat{h}^2_N = \frac{\sigma^2_A}{\sigma^2_A + \sigma^2_D + \frac{\sigma^2_E}{r}}$$

Statistical analysis was performed by MSTAT-C ver. 1.42 and SPSS ver. 17 software. Data for hybrids subjected to Line × Tester analysis (Singh and Chaudhury, 1995) to estimate general combining ability (GCA). The method described by Kempthorne (1957) was adopted for combining ability analyses.

Results and Discussion

Since different levels of irrigation in all traits, line and tester effect for all traits interaction between line × water levels and tester × water levels for number of traits were significant, we performed a further line × tester analysis for different irrigation levels (Table 2). As we know significant line or tester effects indicate the importance of additive effects and if line × tester effect is significant it indicates that non-additive effects control the concerned traits (Singh and Chaudhary, 1995).

Here, in normal irrigation level (w_1) line or tester is significant ($p < 0.01$). As a result, head diameter (cm), stem diameter (cm), number of seeds per head. Were under control of additive effect and in this condition, line × tester effects were significant for stem diameter, so the was under control of both additive and dominant effects. and In mild water stressed level (w_2), line and tester are also significant ($p < 0.01$), therefore, plant height, head diameter, stem diameter, 1000-seed weight, number of seeds per head, seed yield, were controlled by additive effects and In this condition, line × tester effects were significant for stem diameter, so the was under control of both additive and dominant effects.

In severe stress condition (w_3), however, line or tester effects were significant ($p < 0.01$) for, plant height, stem diameter, number of seeds per head. So they were under control of additive effects. In this condition, line or tester and line × tester effect were significant for, plant height, stem diameter and yield. So they were under control of both additive and dominant effects. For yield, however, line and tester were not significant; therefore, it was controlled by dominant effects (Table 2).

Table 1

Analysis of variance of line × tester in sunflower for head diameter (HD), plant height (PH), stem diameter (SD), 1000-seed weight (SW), number of seeds per head (NS) and yield (Y) at the different levels of irrigation

a

Source of variation	df	MS								
		HD (cm)			PH (cm)			SD (cm)		
		W_1	W_2	W_3	W_1	W_2	W_3	W_1	W_2	W_3
Repeat(R)	2	54.628**	604.455^{ns}	32.511**	773.75**	4242.8**	1211.6**	8.705*	13.182**	6.926**
Line(L)	5	13.221^{ns}	25.644**	8.454*	1065.8**	1228.1**	740.28**	0.531**	0.603**	0.2^{ns}
Tester(T)	4	6.454^{ns}	4.468^{ns}	1.84^{ns}	613.85**	239.34^{ns}	331.18*	4.855**	14.418^{ns}	20.527**
L × T	20	6.569^{ns}	3.473^{ns}	3.55^{ns}	78.184^{ns}	123^{ns}	208.33*	1.594**	1.771**	2.419*
Erorr	58	7.362	2.434	2.596	71.223	108.32	103.38	2.219	2.078	1.327

NS – not significant, * is significant at 0.05, ** significant at 0.01 probability level; normal irrigation (W_1), mild water stress (W_2), severe water stress (W_3)

b

Source of variation	df	MS								
		SW (gr)			NS			Y (g/ha)		
		W_1	W_2	W_3	W_1	W_2	W_3	W_1	W_2	W_3
Repeat(R)	2	2.979**	0.97*	290.87^{ns}	3855117**	35983.8^{ns}	106257**	1997.9**	228.33^{ns}	629.18**
Line(L)	5	0.395^{ns}	1.005**	270.02^{ns}	97121**	144578.5**	84300.8**	313.98^{ns}	358.87*	87.11^{ns}
Tester(T)	4	0.716^{ns}	0.818*	268.46^{ns}	6631.12^{ns}	49889.4^{ns}	36878.94^{ns}	53.25^{ns}	214.59^{ns}	57.32^{ns}
L × T	20	0.175^{ns}	0.302^{ns}	275.07^{ns}	23249.7^{ns}	13146.12^{ns}	34052.06*	89.04^{ns}	56.68^{ns}	137.53*
(R)×(LT)	58	0.33	0.292	270.94	26800	35531.97	19304.64	138.85	122.88	63.59

ns – not significant, * is significant at 0.05, ** significant at 0.01 probability level; normal irrigation (W_1), mild water stress (W_2), severe water stress (W_3)

Table 2
Parameters of genetic head diameter (HD), plant height (PH), stem diameter (SD), 1000-seed weight (SW), number of seeds per head (NS) and yield (Y)

Variance	HD (cm)	PH (cm)	SD (cm)	SW (g)	NS	Y (g/ha)
GCA variance (line)	2.095	164.21	0.236	0.023	1602	28.93
GCA variance (tester)	0.059	38.528	0	0.0255	1376	1.793
SCA variance	0.283	34.28	0	0.033	491.08	5.921
Average additive variance	3.261	304.85	0.2261	0.0723	26288	46.445
Dominance variance	0.283	34.28	0	0.033	491.08	5.921
${}^{2}{}_{GCA} / \sigma^{2}_{SCA}$ (line)σ	7.387	4.79	0	0.691	32.63	4.88
${}^{2}{}_{GCA} / \sigma^{2}_{SCA}$ (tester)σ	0.21	1.123	2.922	0.757	2.803	0.302
Board sense heritability (%)	61.81	87.05	18.34	36.74	67.61	51.13
Narrow sense heritability (%)	59.24	82.41	19.69	29.81	66.99	48.07
C.V (%)	15.44	8.06	11.08	11.07	23.1	27.57

One important note from Table 2 is that under w_3, plant height and stem diameter in addition to additive effect, were controlled by dominant gene effect, while yield was under control of dominant gene effect. This implies that these lines possess favorable alleles with additive effects develop these traits. This could be due to high variability in experimental conditions or similarities of genetic sources used for development of these lines.

The line GCA/SCA variance ratio expression of plant height, head diameter, number of seeds per head, seed yield and tester GCA/SCA variance ratio for plant height, stem diameter and number of seeds per head was greater than 1, which indicates additive genes have higher effect than non-additive genes the main role in the inheritance of this trait, whereas, when the line GCA/SCA variance ratio is lower than it 1 indicates the non-additive effects (dominant or epistatic) are more effective in the inheritance of stem diameter and1000-seed weight traits (Table 2). Joksimovic et al. (2000), Gvozdenovic et al. (2005) and Ciric et al. (2012) had similar results with contribution of non-additive component in plant height.

Correlations between traits were estimated and are given in Table 3. Correlations between head diameter, plant height, 1000-seed weight, number of seeds per head for yield. The direction of correlation was positive for relative water content and yield. Therefore, selection for one of these traits should be accompanied by the associated traits, and this would provide the opportunity to exert multi-traits selection in sunflower breeding programs. By calculation of simple correlation coefficients, highly significant positive correlation was determined between seed yield and 1000 seed weight (Table 1). These results are in agreement with the studies of (Tahir et al., 2002), (Dusanic et al., 2004), (Yasin and Singh, 2010) and (Radik et al, 2013).

Conclusions

Although in normal condition, line × tester showed that additive effects had a greater contribution than dominance ef-

Table 3
Correlation between traits i.e. head diameter (HD), plant height (PH), stem diameter (SD), 1000-seed weight (SW) and number of seeds per head (NS) and yield (Y)

Traits	HD	PH	SD	SW	NS	Y
HD		0.425**	0.018ns	0.73**	0.723**	0.841**
PH			0.027ns	0.257**	0.463**	0.434**
SD				-0.454ns	0.087ns	0.051ns
SW					0.455**	0.719**
NS						0.928**
Y						

ns – not significant, * significant at 0.05, ** significant at 0.01 probability level fects for number of grains per spike, these considers showed that dominance effects had a greater share in controlling this trait under drought condition. Therefore, in non-stress condition where the additive gene action was present the selection in early generation possibly successful however, in drought condition selection may be deferred to later segregating generations.

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