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Average heterosis of maize hybrids under terminal water stress at Moghan region

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ABSTRACT

To study effect of water deficit on morphological traits and average heterosis, three maize hybrids and their parental lines were evaluated under normal irrigation and water deficit after pollination using randomized complete block design with four replications at Agricultural and Natural Resources Research Center of Moghan during 2008. Combined analysis of variance revealed significant differences among genotypes for all the studied traits. However, genotype and irrigation interaction was not significant for most of the traits. The highest amount of heterosis for grain yield and yield components in both conditions was observed for single cross 704 (SC704) derived from a cross between MO17 and B73 inberd lines. The results show SC704 could be suitable hybrid for Moghan region as well as limited irrigation condition.

Key words: Grain yield, Heterosis, Maize, Water deficit

INTRODUCTION

Maize owes its importance and its high cultivation area to its adaptation ability to a wide variety of climatic conditions. That is why it is recognized as the main crop of temperate, hot-temperate, sub-tropical and humid zones [1] Water deficit can be viewed as the main natural limiting factor which reduces cultivation areas, particularly in world's arid and semi-arid zones. Limitation of water resources, improper distribution of annual rainfall and mismanagement of available sources can be taken as the cause of yield decrese in the above zones [2].

Campose et al. [3] conducting an experiment to find out maize resistance to drought concluded that maize is more sensitive to drought during flowering, style growth, and pollination periods. Heterosis (hybrid vigor) is defined as the size, growth, fertility and yield enhancement in progeny compared to parents. Heterosis, with the selection of proper parents, is used in different plants in a wide scale and in high yield hybrids. Nowadays, in developed countries, the most cultivation area is allocated to such plants as maize, sorghum, sunflower, and hybrid cultivars. Also, in developing countries, hybrids cultivation, due to their high yield, uniformity and hybrids reproducibility compared to free pollination varieties is on increase. At present, almost the whole maize cultivation area is devoted to hybrids varieties. Therefore, it seems that one of the ways to increase yield in most agronomic and horticultural plants, to produce food for the ever-increasing world's population, is the use of heterosis phenomenon and introducing hybrids varieties [4].

MATERIALS AND METHODS

This experiment was conducted in May, 2008 in Agricultural and Natural Resources Research Center of Ardabil situated in Moghan. After field preparation and fertilizer utilization based on soil experiment, implantation of genotypes, including three hybrids of SC700 (derived from $K_{74/1*}$ K_{18}), SC704 (derived from MO_{17}* B_{73}) and hybrid derived from $K_{74/1*}$ K_{19} accompanied by their parents in two favorite and limited irrigation conditions, conducted using of Randomized Complete Block Design with four replications. Favorite irrigation is carried out based on climate condition, crop requirement and local tradition. In the water deficit condition, irrigation was cut down from finished pollination stage (silk browning) until perfect physiological maturation. The experimental plot includes six lines measuring 75 centimeters in distance and 4 meters in length, computing 74000 bushes in each hectare. For the purpose of measuring of different traits, 10 bushes in each line and for the grain yield all the bushes were reviewed in plot.

Prior to combined variance analysis, uniformity variance trial was conducted (Bartlett's test). Then, combined variance analysis and comparing of means of the genotypes using the Duncan's test, at 0.05% level of probability was carried out. Rate of heterosis for the hybrids under study was estimated, in comparison with the parent's means and superior parent, using the following formula [5]:

(MPH): Heterosis percentage compared with the parents mean = $[(F_1\text{-MP})/MP] \times 100$
(HPH): Heterosis percentage compared with the superior parent= $[(F_1\text{-HP})/HP] \times 100$

RESULTS AND DISCUSSION

The results obtained from combined variance analysis in the normal and drought stress conditions by way of two different environments (Table 1), showed that between the different irrigation conditions, there was a significant difference among the all traits excluding number of kernel row, number of total leaves and ear leaf area at 0.01% level of probability. There was among the genotypes significant difference for all measured traits which was the sign of variability among the genotypes under study for this traits. There was significant interaction between genotype and irrigation conditions for grain yield, number of kernel per ear row, 1000-kernel weight, and ear length, was indication of dissimilar genotypes variations rate to the different humidity conditions for this traits. In the study of drought stress effect on maize genotypes by Farrokhi et al. [6], observed significant difference in grain yield, biological yield, number of grains per row, diameter ear, length ear and number of grains per ear.

Table 1.Combined analysis of variance for measured traits under normal irrigation and water deficit stress conditions

SV	DF	Grain yield	No. kernel rows	No. kernel /row	1000 kernel weight	No. total leaves	Ear length	Ear leaf area
Irrigation condition	1	73.09**	38^{ns}0.	417.99**	6724.00*	5.52^{ns}	76./34*	26.16^{ns}
Replication / condition	6	0.41	1.44	30.48	558.67	2.17	5.89	1979.13
genotype	7	64.88**	115.54**	726.78**	16504.00**	9.00**	81.15**	38293.42**
genotype× Irrigation condition	7	5.29**	1.86^{ns}	28.05**	2528.00**	0.55^{ns}	8.18**	547.77^{ns}
Error	42	0.24	1.46	7.30	687/81	0.77	1.61	1045.05
CV (%)		9.82	7.94	9.55	8.81	5.39	8.56	6.08

**, ** and ns significant at $p \leq 0.05$, $p \leq 0.01$ and non-significant, respectively*

Means comparison of the studied genotypes showed that in average irrigation conditions, three hybrids had high grain yield compared to parent lines. Among the lines under study, MO17 has the minimum yield, whereas the difference was non-existent between the remainder lines (Table 2).

Table 2. Means comparison of studied genotypes with the view of different traits under average of normal irrigation and water deficit conditions using Duncan test

Genotype	Grain yield (t/ha)	No. kernel rows	No. kernel/row	1000 kernel weight (gr)	No. total leaves	Ear length(cm)	Ear leaf area (cm^2)
SC700	7.96^{a}	18.06^{b}	39.09^{ab}	336.50^{ab}	16.73^{a}	18.05^{a}	606.00^{a}
SC704	8.63^{a}	15.08^{d}	42.40^{a}	313.00^{b}	16.50^{a}	18.98^{a}	575.65^{a}
K74/1×K19	8.37^{a}	17.13^{bc}	36.15^{b}	322.50^{ab}	16.52^{a}	18.55^{a}	588.31^{a}
B73	3.53^{b}	15.46^{cd}	24.85^{c}	249.50^{c}	17.33^{a}	12.55^{bc}	459.79^{c}
MO17	1.33^{c}	10.24^{e}	16.58^{e}	259.50^{c}	13.80^{b}	11.68^{c}	440.16^{c}
K18	3.58^{b}	12.01^{e}	20.47^{d}	359.00^{a}	16.10^{a}	12.77^{bc}	603.48^{a}
K74/1	3.38^{b}	21.79^{a}	23.73^{cd}	231.50^{c}	16.80^{a}	11.65^{c}	509.03^{b}
K19	3.21^{b}	11.90^{e}	23.06^{cd}	310.50^{b}	16.08^{a}	14.39^{b}	471.43^{bc}

Different letters in each column indicate significant differences at the5% probability level.

To investigate average heterosis for the measured traits, an orthogonal comparison is made of "hybrids versus lines". Mean comparison of hybrids versus parental lines showed that in the normal and water deficit conditions, the hybrids enjoyed higher grain yield than lines. In both conditions, in all measured traits excluding number of leaf, hybrids because of heterosis were recognized as superior to the lines (Tables 3 and 4).

Table 3. Means comparison of hybrids versus lines with the view of different traits under normal irrigation conditions

	Grain yield (t/ha)	No. kernel rows	No. kernel /row	1000 kernel weight (gr)	No. total leaves	Ear length(cm)	Ear leaf area (cm^2)
Hybrids	10.28 [a]	16.80 [a]	41.12 [a]	337.00 [a]	16.87 [a]	19.22 [a]	583.07 [a]
Lines	3.55 [b]	14.38 [b]	24.69 [b]	290.60 [b]	16.32 [a]	13.94 [b]	499.90 [b]

Different letters in each column indicate significant differences at the5% probability level

Table 4. Means comparison of hybrids versus lines with the view of different traits under water deficit conditions

	Grain yield (t/ha)	No. kernel rows	No. kernel /row	1000 kernel weight (gr)	No. total leaves	Ear length(cm)	Ear leaf area (cm^2)
Hybrids	6.36 [a]	16.72 [a]	37.31 [a]	311.00 [a]	16.30 [a]	17.83 [a]	596.90 [a]
Lines	2.46 [b]	14.18 [b]	18.79 [b]	273.40 [b]	15.72 [a]	11.28 [b]	493.65 [b]

Different letters in each column indicate significant differences at the5% probability level

In the study of hybrids, heterosis rate for the grain yield, it was revealed that in normal conditions, hybrid K74/1× K19 compared with superior parent and hybrid SC704 compared with mean parents had the highest percentage of heterosis (Table 5). Whereas in the water stress condition, the hybrid SC704 had the most percentage of heterosis compared with the superior parent and mean parents (Table 6). Contrary to two other hybrids, the hybrid SC704

Table5. Heterosis percent of the studied hybrids with respect to Mid Parent (MPH) and High Parent (HPH) for measured traits under normal irrigation conditions

	SC700		SC704		K74/1×k19		Total mean of hybrids	
	MPH	HPH	MPH	HPH	MPH	HPH	MPH	HPH
Grain yield	155.64	131.78	248.98	132.65	174.80	172.58	193.14	145.67
No. kernel rows	4.80	-16.22	12.79	-5.97	6.79	-18.58	8.13	-40.77
No. kernel /row	61.48	54.05	86.77	57.09	52.49	51.44	66.91	54.19
1000 kernel weight (gr)	19.52	-4.64	22.30	9.30	21.31	0.60	21.04	1.75
No. total leaves	2.99	2.08	7.59	-2.02	-1.97	-2.67	2.87	-0.87
Ear length(cm)	34.02	16.47	50.04	48.45	39.82	25.03	41.29	29.98
Ear leaf area (cm^2)	6.95	-2.10	27.62	24.65	16.32	12.55	16.96	11.70

Table6. Heterosis percent of the studied hybrids with respect to Mid Parent (MPH) and High Parent (HPH) for measured traits under water deficit conditions

	SC700		SC704		K74/1×k19		Total mean of hybrids	
	MPH	HPH	MPH	HPH	MPH	HPH	MPH	HPH
Grain yield	90.63	76.53	262.69	163.16	127.59	112.22	160.30	117.30
No. kernel rows	8.96	-18.04	21.84	1.04	-3.20	-24.15	9.20	-13.72
No. kernel /row	98.58	59.32	128.46	88.32	56.79	53.35	94.61	67.00
1000 kernel weight (gr)	8.54	-7.95	23.75	13.36	16.64	7.59	16.31	4.33
No. total leaves	0.31	-2.99	4.37	-7.51	3.10	-0.60	2.59	-3.70
Ear length(cm)	66.57	51.68	64.42	54.30	45.29	33.19	58.76	46.39
Ear leaf area (cm^2)	11.00	3.05	28.23	25.74	23.78	18.64	21.00	15.81

had the most heterosis rate for the grain yield in stress condition compared with favored irrigation condition (Tables 5 and 6). This is because of SC704 parent's hybrids low tolerance to stress water. So it should be stated that the parents of other two hybrids have the most tolerance for terminal stress water. Meta and Sarker [7] and Dehghanpur [8] have also reported the high heterosis for grain yield. In the study of heterosis and general and specific combining ability on average maturing maize germplasm of temperate and sub-tropical zones and of grain yield to the Mexican populations by Beck et al. [9], observed significant specific combining ability that has sign of heterosis for grain yield. Have been reported the similar results in study of genetic variance by Stuber et al. [10]. Sanvicente et al. [11], using the diallel analysis of 9 lines of maize observed that the general combining ability is significant for the all traits, whereas the specific combining ability was significant alone for the grain yield and plant length. Sparner et al. [12], obtained similar results by using diallel cross with 6 cultivars of maize.

Comparison of means of the studied hybrids showed that in the average condition the most number of kernel row went for the hybrids SC700 and K74/1× K19 as compared with the SC704 hybrid. Among the lines under study, line K74/1 has the most number of kernel rows even as compared with the hybrids (Table 2). The number of kernel row increases 8/13% and 9/20% in normal and stress conditions respectively for hybrids as compared with mean parents, whereas heterosis declines 40/77% and 13/72% for this trait as compared with the superior parent. The most relative

heterosis for this trait has been devoted to hybrid SC704 in both conditions. The hybrid SC704 as compared with the superior parent and mean parents and hybrid SC700 as compared with the mean parents have the most percentage of heterosis for the stress condition in comparison with the favorite irrigation (Tables 5 and 6).

In the average condition, hybrids had the most number of kernels per row as compared with the parental lines (Table 2). Ahmadi et al. [13] Chogan and Mosavat [14] concluded that in the hybrid SC704 high grain yield can be attributed to the most number of kernel per row. Based on the results obtained from this study and those of the other researchers, the number of kernel per row can be taken one of the most important yield components in the genotypes breeding and indirect selection for kernel yield increase. In the normal irrigation condition the rate of heterosis for the number of kernel per row for the hybrids under study was 66/91% and 54/19% respectively as compared with the mean parents and the superior parent. In the stress water condition this rate was 94/61% and 67% for the mean parents and the superior parent respectively. In terms of this trait in both irrigation conditions the hybrid SC704 had the most heterosis rate as compared with the mean parents and also with the superior parent of the other two hybrids (Tables 5 and 6). Findings Pal and Prodham [15], showed the non-additive genes effect on grain yield, number of grains per row and ear length.

Means comparison of the studied genotypes, showed that the hybrids SC700 and K74/1 × K19 and line K18 to have the most 1000-kernel weight (Table2). With the view of 1000-kernel weight in the both irrigation conditions the hybrids SC704 and K74/1 × K19 had the positive heterosis as compared with the parents mean and the superior parent. Whereas the hybrid SC700 had the positive heterosis just in comparison with the parents mean. In this regard, in all positions, the most heterosis belonged to hybrid SC704 (Tables 5 and 6).

CONCLUSION

Mean comparison of the genotypes showed that the hybrids had high value for the all traits excluding number of kernel row per ear as compared with parental lines. It is worth mentioning that in view of this trait just line K74/1 was superior from hybrids, whereas the rest of the lines valued less than hybrids. This is indicative of the importance should be given to the production of hybrid varieties in the present condition. In general, in terms of the grain yield and yield components, in both irrigation conditions hybrid SC704 had the most heterosis in comparison with other hybrids.

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