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Combining ability and gene effects for earliness, yield and its components in maize (*zea mays* l.) under optimal irrigation and water stress conditions

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Abstract

Two field experiments were performed during, 2012 and 2013 summer seasons at the Experimental Farm, Fac. of Agric., (El-Khattara), Zagazig University. A half diallel crosses among seven inbred lines of yellow maize i.e. 105 (P_1), 50 (P_2), 126 (P_3), 35 (P_4), 78 (P_5), 85 (P_6) and 125 (P_7) were evaluated for earliness, yield and its components under optimal irrigation (4000 m3) and drought stress (2400 m3) conditions. Highly significant mean squares of both general (GCA) and specific (SCA) combining abilities variances were detected for all traits under both conditions. The ratio of σ2 GCA/σ2 SCA was more than unity, indicating that GCA variance was more important than SCA ones in the inheritance of these traits, except grain yield under both conditions and ASI under drought one only. Therefore, dominance genetic variance was the predominant type controlling grain yield and ASI under drought stress condition and the additive one was the predominant type controlling the remaining traits under both conditions. The inbred lines P_2, P_3, P_4 and P_5 exhibited negative and significant GCA effects for earliness characters (days to 50% tasselling and days to 50% silking) under both conditions and P_4 for ASI under drought stress one, therefore, these inbred lines were the best combiners for earliness characters under drought stress. Significant positive GCA effects were recorded in inbred lines P_2, P_3 and P_6 for ear leaf area; P6 for ear length; P_4 and P_6 for number of rows/ear; P_2 and P_4 for number of grains/row; P1 and P3 for 100-grain weight and P4 for grain yield (ard./fad.) under both conditions. Additive (D) and dominance (H1 and H2) genetic variances were significant for earliness characters, ASI, plant height, ear leaf area and number of rows/ear under both conditions and for ear length and100-grain weight under optimal irrigation one only, suggesting the involvement of additive and dominance gene actions in the genetics of these characters. Highly narrow sense heritability estimates (> 70 %) were recorded for earliness characters, ear leaf area and number of rows/ear under both conditions, therefore phenotypic selection must be used to improve these traits. Whereas, it ranged from (30-70 %) for plant height, ear length, number of grains/row and 100-grain weight, moreover, it was low (< 30%) for ASI and grain yield (ard./fad.) under both conditions, therefore recurrent selection must be used to improve these traits.

Key wards: maize, optimal irrigation, drought stress, combining ability and gene effects.

Introduction

Maize is one of principal cereal crops in Egypt and all over the world. It is used as feed for cattle and poultry. Also, it is considered as a main component in several important industries such as corn oil, starch, fructose sugar and other products. In the last period, maize is used for human feed in Egypt by mixing 20% with wheat flour in bread making to lessen wheat imports by 2.4 million tons annually and save hard currency.

Potential expansion of maize area is just possible in Egyptian deserts, but the soil in these areas is sandy with low water holding capacity and thus exposes maize plants to water stress. Such drought stress causes great decreases in grain yield.

Edmeades (2013) reported that the yield differential between well-watered crop potential yield and water-limited yield is often large, but as a rough rule of thumb 20-25% of this differential could be excluded by genetic improvement in drought tolerance and a moreover 20-25% by used of water-conserving agronomic practices. Significant maize yield decreases from drought are predicted to increase with world climate vary as temperatures increase and rainfall allocation variations in key conventional production lands (**Campos *et al.*, 2004**).

Drought-tolerance genotypes produce more yield with minimal water than drought-sensitive ones **(Ramirez-Vallejo and Kelly, 1998). Heisey and Edmeades (1999)** reported that 20-25% of the world maize area is influenced by drought.

Determining drought-tolerant genotypes for great efficient water use is needed to reduction the negative effects correlated with water stress under sandy soils conditions (**Barnabás *et al.*, 2008; Gleick and Palaniappan, 2010 and Colak *et al.*, 2015**). Therefore, improving maize for water stress tolerance is becoming a great challenge in relation of climate variations and limited irrigation water.

A major effect of drought stress in maize is a delay in silking, resulting in an increase in the anthesis-silking interval (ASI), which is an important cause of yield failure.

When water stress synchronizes with the 7–10 days interval before flowering, ear develop will slow great than tassel one and there is a lateness in silk emergence relative to pollen shed, giving increasing in the period between anther shoot and silk exposure. This anthesis-silking interval (ASI) is appeared to be highly associated with grain yield, especially kernel number and ear number per plant (**Sari-Gorla *et al.*, 1999**) and (**Edmeades, 2013**).

Diallel analysis system is one of important techniques used to estimate combining ability which supports the breeders in selecting desirable parents and crosses with maximum potential of gene exploitation for to identifying the most promising inbred lines to be involved in maize single crosses programs. **Ofori *et al*. (2015) and Zeleke (2015)** reported that combining ability was important in the genetics of yield and most of its attributing traits. (**Okasha *et al*., 2014; Mousa 2014; Al-Falahy, 2015)** and **Ofori *et al.* (2015)** obtained significant additive effect for only grain yield whilst non-significant GCA and SCA effects were identified for earliness traits. Significant mean squares through GCA and SCA for days to maturity and GCA for grain yield were detected. However, GCA/SCA ratio showed that additive gene effects were more important than dominance ones in the genetics of grain yield kg/ha **(Zeleke 2015)**. **Ertiro *et al.* (2017)** mentioned that indirect selection to minimize ASI is been an effective approach for selecting genotypes with improved synchronization of male and female flowering under stress.

Therefore, this investigation aimed to estimate combining ability and gene effects for earliness, yield and its attributes traits under optimal irrigation and drought stress conditions and to determine superior hybrids to develop the yielding ability in maize breeding program under drought stress.

Materials and Methods

In the present study, two field experiments were carried out during two summer growing seasons, viz, 2012 and 2013 at Zagazig Agriculture Research Station (El-Khattara, which the soil is sandy), Egypt. In 2012, summer growing season, 7 yellow inbred lines named 105 (P_1), 50 (P_2), 126 (P_3), 35 (P_4), 78 (P_5), 85 (P_6) and 125 (P_7). (These lines were originated from subtropical yellow genetic stock populations and Composite 21, and produced by the Maize Dep., Field Crops Res. Inst., ARC, Giza, Egypt and improved by Agronomy Dep., Fac. of Agric., Zagazig University).The studied inbred lines were grown and crossed to obtain 21 F_1's crosses in a half diallel fashion excluding reciprocals. In 2013, summer growing season, two field experiments were carried out under two water irrigation treatments i.e. optimal irrigation (4000 m^3) and drought stress (2500 m^3). The plot size was 3 m by 4 m. The field was irrigated using drip irrigation system. Each plot has three drip lines space one m apart with drippers spaced 0.35 m apart within the line and each dripper. In May 20, genotypes were planted on both sides of the drip line. Each irrigation strip had a control valve and pressure measure to retain the running pressure at 1 bar and sender flow rate of 4 Liters/h. The targeted irrigation water amount for each optimal irrigation and drought stress was measured using a flow meter. Irrigation was initiated two days before planting with average of 1 hour every day until 30 days age for both conditions, 1.5 hour every 2 days and 1 hour every 3 days from 30 days age to the end of growing season for optimal irrigation and drought stress, respectively. Before seeding, each experiment received 31 kg P_2O_5 and 50 kg K_2O/faddan. Nitrogen fertilizer was applied at the rate of 120 kg N / faddan and splitted in equal doses with irrigation until flowering.

Collected data:

The following data were recorded on ten guarded and competitive plants from each replicate for parents and their F_1 crosses: earliness characters (days to 50% tasselling, days to 50% silking), anethsis-silking interval (ASI), plant height, ear leaf area, ear length, number of rows/ear, number of grains/row, 100-grain weight, whereas grain yield (ard./fad.) was recorded from the middle two rows in each plot (2 m^2) under both conditions.

Statistical analysis:

The collected data were statistically analyzed using conventional two way analysis of variance according to **Steel *et al.* (1997).** Genotype mean squares were spiltted into its main components.

General (GCA) and specific (SCA) combining abilities were evaluated using model1, method 2 for parents and their F_1 crosses **(Griffing, 1956**). The components of genetic variance; additive, dominance and their derived parameters were evaluated using diallel biometrical approach outlined by **Hayman (1954a& b)**. Narrow sense heritability was estimated depend on **Mather and Jinks (1982)**

Results and Discussion

Mean performance

Data presented in Tables (1 and 2) showed mean squares of the all traits under the study for parents and their F1 crosses under optimal irrigation and drought stress conditions.

Table 1. Mean squares for days to 50% tasselling, days to 50% silking, ASI, plant height and ear leaf area under optimal irrigation and drought conditions**.**

S.O.V	d.f	Days to50% tasselling		Days to 50% silking		ASI		Plant height (cm)		Ear leaf area (cm^2)	
		Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought
Genotypes	**27**	37.3**	40.6**	49.07**	54.65**	4.21**	4.18**	1459.93**	1469.68**	22502.63**	21290.16**
Parent	**6**	65.9**	69.8**	86.16**	88.98**	6.05**	6.44**	2598.33**	2562.21**	33128.24**	20234.03**
F1	**20**	25.1**	26.2**	31.82**	34.19**	3.35**	3.12**	437.72**	439.90**	19009.42**	15949.10**
P,*vs*,F$_1$	**1**	109.4**	154.0**	171.68**	258.04**	10.32**	12.0**	15073.81**	15510.04**	28613.21**	134448.11**
GCA	**6**	139.4**	145.3**	179.25**	185.96**	7.02**	3.16**	3865.40**	3823.83**	90245.68**	61413.28**
SCA	**21**	8.11**	10.7**	11.88**	17.14**	3.41**	4.48**	772.66**	797.07**	3147.48**	9826.41**
Error	**54**	1.57	1.74	1.16	2.61	0.62	1.01	15.77	38.50	116.26	126.30
GCA/SCA		**17.18**	**13.59**	**15.1**	**10.85**	**2.05**	**0.71**	**5.01**	**4.79**	**28.67**	**6.24**

*,** Significant at 0.05 and 0.01

Table 2. Mean squares for ear length, number of rows/ear, number of grains /row, 100-grain weight and grain yield under optimal irrigation and drought conditions.

S.O.V	d.f	Ear length (cm)		Number of rows/ear		Number of grains/row		100-grain weight (gm)		Grain yield (ard./fad.)	
		Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought
Genotypes	**27**	6.91**	6.31**	4.12**	4.08**	88.37**	100.87**	44.09**	58.63**	57.13**	42.19**
Parent	**6**	5.62**	5.25**	3.02**	3.59**	15.02**	24.43**	16.13**	20.48**	5.39*	3.22*
F1	**20**	5.71**	6.09**	3.78**	3.85**	76.51**	92.84**	46.19**	60.89**	37.82**	26.15**
P,*vs*,F$_1$	**1**	38.81**	17.13**	17.50**	11.57**	765.46**	720.14**	169.75**	242.41**	753.86**	596.81**
GCA	**6**	19.75**	9.93**	13.28**	13.55**	202.95**	216.98**	95.09**	123.57**	28.22**	21.70**
SCA	**21**	3.25**	5.28**	1.50**	1.37*	55.63*	67.70**	29.51**	40.08**	65.39**	48.05**
Error	**54**	2.15	1.48	0.58	1.02	1.83	6.54	1.30	3.42	0.97	1.65
GCA/SCA		**6.08**	**1.88**	**8.85**	**9.89**	**3.65**	**3.2**	**3.22**	**3.08**	**0.43**	**0.45**

*,** Significant at 0.05 and 0.01

It is noticeable that mean squares due to maize genotypes, parents and their F_1 crosses were highly significant for all traits under both conditions. These results provide evidence for the presence of adequate amount of genetic variability valid for further biometrical assessments.

Parents versus crosses mean squares as indicated to average heterosis were found to be highly significant also for all studied traits under both optimal irrigation and drought stress conditions. In this connection, significant and great value of genetic variability between parents and their F1 crosses were detected for earliness, yield and its components by **Al-Naggar *et al.* (2016a)** which confirmed the obtained results in the current study.

Highly significant mean squares of both general (GCA) and specific (SCA) combining abilities variances were detected for all traits under both conditions. The ratio of σ2 GCA/σ2 SCA was more than unity, indicating that GCA variance was more important than SCA one in the genetics of these traits, except grain yield under both conditions and ASI under drought one only. Therefore, dominance genetic variance was the predominant type controlling grain yield and ASI under drought stress condition and the additive one was the predominant type controlling the remaining traits under both conditions. The abovementioned results are in agreement with **Okasha *et al.* (2014)** who found that GCA mean squares were higher in its magnitude than the corresponding SCA ones for grain yield and ASI.

Mean performance of earliness, ASI, plant height and ear leaf area under both optimal irrigation and drought conditions (Table 3) showed significant differences between the tested seven maize inbred lines and their F1 crosses under both conditions, suggesting that the studied genotypes differed in genes governed these characters.

Table 3. Mean performance of seven maize parents and their F_1 crosses for days to 50% tasselling, days to 50% silking, ASI, plant height and ear leaf area under optimal irrigation and drought conditions.

Genotypes	Days to 50% tasselling		Days to 50% silking		ASI		Plant height (cm)		Ear leaf area (cm^2)	
	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought
P_1	73.0	71.7	77.0	75.0	4.0	3.3	170.0	168.7	546.18	416.9
P_2	62.7	61.7	66.0	64.0	3.3	2.3	192.0	190.0	697.44	525.2
P_3	62.3	61.0	65.7	64.0	3.3	3.0	255.0	251.7	635.32	511.4
P_4	62.0	61.0	65.0	63.7	3.0	2.7	193.0	182.7	480.20	399.0
P_5	68.3	67.7	75.3	74.3	7.0	6.7	174.0	171.0	446.61	340.7
P_6	59.0	57.3	63.3	61.7	5.3	4.3	212.7	208.7	724.63	567.8
P_7	64.0	62.0	68.0	65.3	4.0	3.3	180.0	177.3	584.36	510.1
$P_1 \times P_2$	65.0	63.0	68.3	66.3	3.3	3.3	216.3	214.7	655.29	562.4
$P_1 \times P_3$	64.0	63.0	68.0	66.3	4.0	3.3	240.3	238.7	624.59	511.1
$P_1 \times P_4$	63.7	62.0	69.7	66.7	6.0	4.7	219.3	216.7	540.24	405.2
$P_1 \times P_5$	69.7	66.7	72.0	68.7	2.3	2.0	209.7	207.3	487.52	476.0
$P_1 \times P_6$	64.3	61.7	68.7	65.7	4.3	4.0	225.0	221.7	732.40	618.5
$P_1 \times P_7$	66.3	64.3	70.3	67.7	4.0	3.3	211.0	208.0	561.52	546.2
$P_2 \times P_3$	60.0	58.7	63.0	61.0	3.0	2.3	243.7	240.3	660.08	594.3
$P_2 \times P_4$	59.7	58.3	61.3	60.3	1.7	2.0	224.7	220.7	643.65	570.5
$P_2 \times P_5$	62.0	60.7	66.0	63.7	4.0	3.0	218.3	215.7	637.72	554.5
$P_2 \times P_6$	60.0	58.0	62.7	59.3	2.7	1.3	233.3	230.0	783.41	732.4
$P_2 \times P_7$	59.7	57.3	62.0	62.7	2.3	5.3	219.3	215.7	655.42	573.3
$P_3 \times P_4$	58.3	57.0	60.0	57.3	1.7	1.3	243.0	239.7	622.50	516.3
$P_3 \times P_5$	62.0	60.7	65.0	63.3	3.0	2.7	240.7	237.3	573.41	513.3
$P_3 \times P_6$	58.3	55.7	62.0	59.0	3.7	3.3	249.7	246.0	742.59	669.3
$P_3 \times P_7$	61.0	59.7	64.0	62.3	3.0	2.7	242.0	239.3	637.33	507.1
$P_4 \times P_5$	60.7	60.3	65.7	63.3	5.0	3.0	219.3	216.0	525.42	472.6
$P_4 \times P_6$	57.7	53.7	61.7	55.7	4.0	2.0	235.0	230.7	693.25	605.5
$P_4 \times P_7$	61.3	59.7	65.0	62.0	3.7	2.3	221.7	217.3	547.33	546.2
$P_5 \times P_6$	61.0	60.0	65.3	62.7	4.3	2.7	225.3	220.7	643.11	601.5
$P_5 \times P_7$	62.3	61.3	66.3	63.7	4.0	2.3	212.3	207.3	538.30	534.2
$P_6 \times P_7$	61.7	59.7	64.7	61.3	3.0	1.7	229.7	225.3	734.21	643.5
L.S.D $_{0.05}$	1.15	1.21	0.98	1.48	0.72	0.92	3.63	5.67	9.86	10.28

On the basis of mean of number of days to tasselling, the inbred lines could be split into three groups. The early group (59 – 62.3 day) and (57.3 – 61) included P_3, P_4 and P_6, the medium group (>62.7 – 64 day) and (61 – 61.7) included P_2 and P_7 and the latest one (> 64 day) and (> 61.7 day) included P_1 and P_5 inbred lines under optimal irrigation and drought stress, respectively.

Moreover, the F_1 crosses differed significantly for days to tasselling, and could be split also, into three groups. The early group (57.7 – 61.7 day) and (53.7 – 59.7) which included $P_2×P_4$, $P_2×P_3$, $P_2×P_6$, $P_2×P_7$, $P_3×P_4$, $P_3×P_6$, $P_3×P_7$, $P_4×P_5$, $P_4×P_6$, $P_4×P_7$ and P_5xP_6crosses. The medium group (62 –65 day) and (60.7–63) included P_1xP_2, $P_1×P_3$, $P_1×P_4$, $P_1×P_6$, $P_2×P_5$, $P_3×P_5$ and $P_5×P_7$ crosses, whereas the latest one (> 65 day) and (> 63 day) included P_1xP_5, P_1xP_7 and P_3xP_4 crosses under optimal irrigation and drought stress, respectively.

Also, on the basis of mean of number of days to days to silking, the inbred lines could be divided into three groups i.e. The early group (63.3–66 day) and (61.7–64) included P_2, P_3, P_4 and P_6, the medium group (68 day) and (65) included P_7 and the latest one (> 68 day) and (> 65 day) included P_1 and P_5 inbred lines under optimal irrigation and drought stress, respectively.

Like wise, the F1 crosses differed significantly for days to tasselling, and could be spilt also, into three groups. The early group (61.7– 63 day) and (55.7 – 61) which included P2×P3, P2×P4, P2xP6, P2×P7, P3×P4, P3×P6 and P4×P6 crosses. The medium group (64 –66 day) and (62 – 63) included P2×P5, P3×P5, P3×P7, P4×P5, P4×P7, P5×P6 and P6×P7 crosses, whereas the latest one (> 66 day) and (> 63 day) included P1×P2, P1×P3, P1×P4, P1×P5, P1×P6 and P1×P7 crosses under optimal irrigation and drought stress, respectively

It is important to note that the parental maize inbreds P_3, P_4 and their F1 crosses $P_2×P_3$, $P_2×P_4$, $P_3×P_4$, $P_3×P_6$, $P_3×P_7$, $P_4×P_5$, $P_4×P_6$ and $P_4×P_7$ were the earliest genotypes. The foregoing crosses displayed high levels of earliness and shared in one or two common earlier parent. Hereby, earliness genes were transmitted from the parents to the F1 progeny. This result agrees with the concept that earliness is more heritable character (**Okasha *et al.*, 2014**).

Based on mean of anthesis-silking interval (ASI), the inbred lines P_2, P_3 and P_4 and F_1 crosses $P_1×P_6$, $P_2×P_3$, $P_2×P_4$, $P_2×P_6$, $P_2×P_7$, $P_3×P_4$,$P_3×P_5$, $P_3×P_6$and $P_6×P_7$ had the lowest anthesis-silking interval among the all genotypes under both conditions.

Concerning plant height, the parental inbred lines P_1, P_2,P_4 and P_7 and the F_1 crosses $P_1×P_2$, $P_1×P_4$, $P_1×P_5$, $P_1×P_7$, $P_2×P_5$, $P_2×P_7$, $P_4×P_5$ and $P_5×P_7$were the shortest genotypes under both conditions.

For ear leaf area, the maize inbred lines P_2, P_3 and P_6 and F1 crosses, $P_1×P_6$, $P_2×P_3$, $P_2×P_6$, $P_2×P_7$, $P_3×P_5$, $P_3×P_6$, $P_4×P_6$ and $P_6×P_7$ exhibited the highest mean values of ear leaf area under both conditions.

Data presented in Table (4) showed mean performance of grain yield (ard./fad.) and its components under optimal irrigation and drought stress conditions. Significant differences were recorded between the tested seven maize inbred lines and their F_1 crosses under both optimal irrigation and drought stress conditions, suggesting that the studied genotypes differed in genes governed these characters. For ear length maize inbred lines P_3, P_6 and P_7 exhibited the highest mean values of ear length, whereas maize inbred line P_5 was the lowest one among the studied inbred lines under both conditions. For F_1 crosses, $P_1× P_3$, $P_2× P_3$, $P_2× P_6$, $P_3× P_4$, $P_3× P_5$, $P_3× P_6$, $P_3× P_7$, $P_5× P_6$ and $P_6× P_7$ crosses had the longest ears. However, P_2 x P_5 and P_4 x P_5 had the shortest ears among the studied F_1 crosses under both conditions.

For grain yield and its components, results showed that the highest values of grain yield/fad. were exhibited by the maize inbred lines P_2, P_3, P_4 and P_7; inbred lines P_2, P_4, P_6 and P_7 for number of rows/ear; inbred lines P_1, P_2, P_3 and P_4 for number of grains/row and inbred lines P_1, P_5, P_6 and P_7 for 100-grain weight under both conditions.

Concerning F_1 crosses, the $P_1× P_5$, $P_2× P_3$, $P_2× P_4$, $P_2× P_6$, $P_3× P_4$, $P_4× P_5$, $P_4× P_6$, $P_5× P_6$ and $P_6 × P_7$ produced the highest values of grain yield/fad., number of rows/ear, number of grains/row and 100-grain weight among the studied F_1 crosses. On the other side, maize single crosses $P_1× P_4$and $P_2× P_7$showed the lowest values of grain yield and its components under the two conditions. The remaining single crosses exhibited different magnitudes of grain yield and its contributing characters between this ranges. In this connection, significant and highly significant differences among maize genotypes were recorded for grain yield, number of rows/ear, number of grains/row and 100-grain weight by **Al-Naggar *et al.* (2016b)**.

Generally the mean performance of the studied inbred lines and their F_1 crosses for yield and its contributing characters was higher under optimal irrigation condition compared with drought stress one.

Table 4. Mean performance of seven maize parents and their F_1 crosses for ear length, number of rows/ear, number of grains /row, 100-grain weight and grain yield under optimal irrigation and drought conditions**.**

Genotypes	Ear length (cm)		Number of rows/ear		Number of grains /row		100-grain weight (gm)		Grain yield (ard./fad.)	
	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought
P_1	15.4	11.3	12.5	12.7	27.5	24.0	22.562	20.229	9.718	8.292
P_2	14.5	12.0	13.7	14.0	29.3	28.0	19.536	17.203	12.514	10.214
P_3	16.4	14.4	13.3	13.2	28.0	26.0	21.712	18.712	11.045	9.079
P_4	13.5	11.2	14.6	14.8	31.0	29.0	17.218	13.552	11.370	9.370
P_5	12.5	12.6	12.0	12.0	24.5	22.0	23.127	21.080	8.770	7.047
P_6	15.8	14.2	14.7	15.0	27.0	23.0	23.930	19.794	9.047	7.885
P_7	15.2	13.5	14.0	14.0	25.2	22.0	22.103	20.437	10.525	8.770
$P_1 \times P_2$	15.0	12.6	14.0	14.3	35.9	37.0	27.419	23.552	15.459	12.336
$P_1 \times P_3$	18.7	14.4	13.5	13.9	32.8	35.0	31.228	30.228	14.836	11.458
$P_1 \times P_4$	16.4	14.3	14.3	14.5	42.3	40.0	25.503	22.336	13.725	11.227
$P_1 \times P_5$	16.0	13.3	12.0	12.0	29.3	25.0	24.558	22.458	19.355	15.813
$P_1 \times P_6$	16.5	16.1	15.5	15.7	30.1	28.0	26.143	25.277	14.007	11.408
$P_1 \times P_7$	15.8	11.4	14.0	13.7	31.1	30.0	25.975	25.641	15.460	13.353
$P_2 \times P_3$	17.8	13.7	14.0	14.2	36.3	42.0	27.689	27.355	18.346	15.709
$P_2 \times P_4$	15.2	13.8	15.3	15.3	45.1	43.0	17.476	16.309	20.445	16.514
$P_2 \times P_5$	14.4	14.0	14.0	14.1	33.2	27.0	21.593	19.459	14.596	13.459
$P_2 \times P_6$	16.5	15.4	16.0	15.9	35.0	31.0	23.663	21.463	21.843	18.918
$P_2 \times P_7$	14.9	13.8	14.0	14.0	34.3	35.0	22.887	18.753	11.209	10.140
$P_3 \times P_4$	17.6	15.2	14.5	14.6	44.0	33.0	27.805	26.639	24.685	21.796
$P_3 \times P_5$	17.3	10.5	13.3	13.3	30.5	26.0	27.759	25.492	15.487	14.219
$P_3 \times P_6$	19.4	16.3	15.8	15.5	32.7	28.0	30.645	29.312	14.541	13.439
$P_3 \times P_7$	17.4	12.5	14.1	13.7	30.8	32.0	29.918	27.585	15.672	14.492
$P_4 \times P_5$	13.7	13.0	14.2	13.3	37.2	27.0	19.547	14.408	23.562	19.277
$P_4 \times P_6$	16.2	13.6	16.7	16.0	39.4	36.0	21.827	19.694	20.514	17.312
$P_4 \times P_7$	15.7	12.7	15.5	15.5	38.3	30.0	22.306	21.639	15.975	13.639
$P_5 \times P_6$	16.6	14.9	15.2	15.3	29.0	26.0	17.31441	14.381	16.658	14.641
$P_5 \times P_7$	15.6	13.2	14.0	13.5	28.2	25.0	23.374	20.707	16.673	14.728
$P_6 \times P_7$	16.4	14.5	16.3	16.7	29.0	28.0	24.880	22.713	21.202	17.355
$L.S.D_{0.05}$	1.34	1.11	0.76	0.92	1.24	2.34	1.04	1.69	0.92	1.18

General and specific combining abilities

General combining ability (GCA) effects for all studied characters under optimal irrigation and drought conditions are shown in Tables (5 and 6). The results showed that the inbred lines P_2, P_3, P_4 and P_5 exhibited negative and significant GCA effects for earliness characters under both conditions and P_4 for ASI under drought stress one, therefore, these inbred lines were the best general combiners for earliness characters under drought stress and could be involved in maize breeding program to improve earliness. Also, significant negative GCA effects were obtained for earliness characters by **Ofori *et al.* (2015).**

In continuous, significant negative GCA effects were obtained for plant height by inbred lines P_1, P_2, P_5 and P_7 under both conditions and inbred line P_4 under drought stress only.

On the other side, significant positive GCA effects were recorded in inbred lines P_2, P_3 and P_6 for ear leaf area; P_6 for ear length; P_4 and P_6 for number of rows/ear; P_2 and P_4 for number of grains/row; P_1 and P_3 for 100-grain weight and P_4 for grain yield (ard./fad.) under both conditions. Hereby, these inbred lines were the best general combiners and possessed more desired genes for increasing yield and its attributes under the studied environments. Thus, hybrid breeding program involving these inbred lines in single, triple or double crosses may be useful for building high yielding hybrids. In this connection, **Al-Naggar *et al.* (2016c)** found positive significant GCA effects for ear length, number of grains / row, 100 grain weight and grain yield.

Specific combining ability (SCA) effects for all studied characters are shown in Tables (7 and 8). The results showed significant negative SCA effects for days to 50% tasselling in single crosses $P_1 \times P_4$, $P_2 \times P_7$, $P_4 \times P_6$ and $P_5 \times P_7$ under the two conditions; single crosses $P_1 \times P_3$ and $P_4 \times P_5$ under optimal irrigation condition and single crosses $P_2 \times P_5$, $P_3 \times P_6$ and $P_4 \times P_6$ under drought stress one.

Meanwhile, significant negative SCA effects were recorded for days to silking in single crosses $P_1 \times P_5$, $P_3 \times P_4$, $P_3 \times P_5$ and $P_5 \times P_7$ under both conditions; single crosses $P_2 \times P_4$, $P_2 \times P_7$, $P_4 \times P_5$ and $P_5 \times P_6$ under optimal irrigation condition and single crosses P_2 x P_5 and P_4x P_6 under drought stress one. Moreover, significant negative SCA effects were detected for ASI in single crosses $P_1\times P_5$, $P_3\times P_4$ and $P_6\times P_7$ under both conditions; single cross $P_2\times P_4$ under optimal irrigation condition and single crosses $P_2\times P_6$ and $P_5\times P_7$ under drought stress one. In this connection significant negative SCA effects were obtained for days to tasselling, days to silking and ASI by **Al-Naggar *et al.* (2016b)**.

Significant positive SCA effects were recorded in single crosses $P_1\times P_2$, $P_1\times P_6$, $P_2\times P_4$, $P_2\times P_5$, $P_2\times P_6$, $P_3\times P_4$, $P_3\times P_6$, $P_4\times P_5$, $P_4\times P_6$ and $P_6\times P_7$ for ear leaf area; single crosses $P_1\times P_4$, $P_1\times P_6$ and $P_3\times P_6$ for ear length; single crosses $P_1\times P_2$, $P_1\times P_4$, $P_2\times P_3$, $P_2\times P_4$, $P_2\times P_7$ and $P_4\times P_6$ for number of grains /row; single crosses $P_1\times P_3$, $P_2\times P_3$, $P_3\times P_4$, $P_3\times P_5$, $P_3\times P_6$ and $P_3\times P_7$for 100-grain weight and single crosses $P_1\times P_5$, $P_1\times P_7$, $P_2\times P_3$, $P_2\times P_4$, $P_2\times P_6$, $P_3\times P_4$, $P_3\times P_5$, $P_4\times P_6$, $P_5\times P_6$ and $P_6\times P_7$ for grain yield (ard./fad.), under both conditions and single cross, P_6 x P_7 for number of rows/ear under drought stress only. These single crosses could be used to breed high yielding maize hybrids. In this connection, significant positive SCA effects were obtained for ear length, number of rows / ear, number of grains / row and 100 grain weight by **Ofori *et al.* (2015) and Zeleke (2015)** and for grain yield by **Mousa (2014) and Al-Falahy (2015)**.

Components of variances and heritability

Components of genetic variance and their derived parameters for all studied characters under optimal irrigation and drought stress conditions are presented in Tables (9 and 10).

The results showed that additive (D) and non-additive (H1 and H2) genetic variances were significant for earliness, ASI, plant height, ear leaf area and number of rows/ear under both conditions and for ear length and100-grain weight under optimal irrigation one only, suggesting the involvement of additive and dominance gene action in the genetics of these traits. In this respect both additive and dominance gene effects were involved in the genetic control of earliness, ASI, plant height, ear leaf area and number of rows/ear **(Al-Naggar *et al.*, 2016c)**.

Dominance (H1 and H2) genetic variances were significant for number of grains /row and grain yield (ard./fad.) under both conditions and for ear length and100-grain weight under drought stress one only.

The additive component (D) was great than dominance (H1and H2) once for earliness, plant height, ear leaf area and number of rows/ear, whereas, the dominance (H1and H2) components was greater than additive (D) one for the remaining traits under both conditions.

Significant positive (F) value was found for plant height under both conditions and ASI under drought stress one only, indicating that increasing alleles which exhibited dominance effects were more frequent than recessive ones in the parental populations. Whereas, it was negative and significant for ear leaf area and number of rows/ear under both conditions and for ear length under optimal one only, indicating that decreasing alleles were more frequent in the parental genotypes.

The sum of dominant alleles in heterozygous phase over all loci, as indicated by (h^2), was significant and positive for all characters under both conditions, showing that dominant genes governing these characters was mainly due to heterozygosity loci.

The environmental variance was significant for days to 50% tasselling, ASI, plant height, ear length and number of rows/ear under both conditions and days to 50% silking under drought stress only, indicating that these characters was more influenced by environmental conditions.

The average degree of dominance $(H_1/D)^{0.5}$ was minimal than unity for earliness and plant height under both conditions and for ear leaf area under optimal irrigation condition and number of rows/ear under drought one, showing the importance of additive gene action in the gene expression of these characters. Whereas, it was more than unity for the remaining traits, showing the importance of dominance gene action in the gene expression of these traits.

The value of $[H_2 / 4H_1]$ was minimal than its maximum value (0.25) for all characters, showing unequal distribution of both positive and negative alleles among the studied inbred lines in these characters.

Proportion of [KD/KR] was more than unity for all characters except ear leaf area, number of rows/ear and number of grains/row under both conditions and ear length under optimal irrigation one, suggesting that dominant genes were more frequent than recessive ones in the genetic makeup of the studied inbred lines.

Highly narrow sense heritability estimates (> 70 %) were recorded for earliness characters, ear leaf area and number of rows/ear under the two conditions, therefore phenotypic selection must be used to improve these traits. Whereas, it ranged from 30 to70 % for plant height, ear length, number of grains/row and 100-grain weight, moreover, it was low (< 30%) for ASI and grain yield (ard./fad.) under the two conditions, therefore recurrent selection must be used to improve these traits. In this connection, similar conclusions were reported by **Al-Naggar *et al.* (2016c) and Ali (2016)** for the above-mentioned characters.

Table 5. General combining ability (GCA) effects for days to 50% tasselling, days to 50% silking, ASI, plant height and ear leaf area under optimal irrigation and drought conditions.

Genotypes	Days to 50% tasselling		Days to 50% silking		ASI		Plant height (cm)		Ear leaf area (cm^2)	
	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought
P_1	4.33**	4.138**	4.65**	4.529**	0.286*	0.360*	-10.81**	-9.646**	-29.38**	-37.73**
P_2	-0.93**	-0.83**	-1.53**	-1.03**	-0.64**	-0.233	-2.143**	-1.571	52.461**	38.332**
P_3	-1.31**	-1.12**	-1.76**	-1.47**	-0.49**	-0.270	23.376**	23.725**	19.21**	4.593*
P_4	-1.63**	-1.53**	-1.76**	-1.99**	-0.159	-0.381*	-1.106	-2.757**	-47.28**	-42.06**
P_5	1.59**	2.03**	2.43**	2.603**	0.804**	0.545**	-9.476**	-9.423**	-73.29**	-51.06**
P_6	-2.11**	-2.60**	-1.9**	-2.62**	0.360**	-0.048	7.153**	6.725**	91.1**	79.27**
P_7	0.037	-0.085	-0.090	-0.026	-0.159	0.026	-6.995**	-7.053**	-12.83**	8.65**
S.E.(gi-gj)	0.214	0.225	0.184	0.276	0.135	0.172	0.678	1.06	1.84	1.92

*,** Significant at 0.05 and 0.01

Table 6. General combining ability (GCA) effects for ear length, Number of rows/ear, number of grains /row, 100-grain weight and grain yield under optimal irrigation and drought conditions.

Genotypes	Ear length (cm)		Number of rows/ear		Number of grains /row		100-grain weight (gm)		Grain yield (ard./fad.)	
	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought
P1	0.203	-0.380	-0.69**	-0.568**	-0.61**	0.397	1.623**	1.855**	-1.41**	-1.56**
P2	-0.516*	-0.080	0.008	0.162	1.828**	3.508**	-1.28**	-1.33**	0.222	0.139
P3	1.492**	0.376	-0.299*	-0.312	0.117	0.952*	3.014**	3.420**	0.081	0.335
P4	-0.66**	-0.350	0.564**	0.469**	5.139**	3.063*	-2.49**	-2.79**	1.858**	1.361**
P5	-1.0**	-0.447*	-0.87**	-0.983**	-2.84**	-4.38**	-1.22**	-1.58**	-0.117	-0.003
P6	0.632*	1.216**	1.134**	1.173**	-1.43**	-1.83**	0.110	-0.093	0.215	0.288
P7	-0.153	-0.335	0.153	0.058	-2.21**	-1.714**	0.245	0.517	-0.854**	-0.556*
S.E.(gi-gj)	0.25	0.21	0.13	0.172	0.231	0.437	0.195	0.316	0.169	0.220

*, ** Significant at 0.05 and 0.01

Table7. Specific combining ability (SCA) effects days to 50% tasselling, days to 50% silking, ASI, plant height and ear leaf area optimal irrigation and drought conditions**.**

Genotypes	Days to 50% tasselling		Days to 50% silking		ASI		Plant height (cm)		Ear leaf area (cm^2)	
	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought
P_1×P_2	-0.91	-1.157	-0.93	-0.991	0.009	0.194	9.417**	9.491**	12.421*	25.2**
P_1×P_3	-1.54*	-0.861	-1.04	-0.546	0.528	0.231	7.898**	8.194*	14.972**	7.63
P_1×P_4	-1.54*	-1.45*	0.630	0.306	2.194**	1.676**	11.380**	12.68**	-2.896**	-51.6**
P_1×P_5	1.241	-0.343	-1.22*	-2.29*	-2.435**	-1.92**	10.083**	10.009**	-29.61**	28.19**
P_1×P_6	-0.39	-0.713	-0.19	-0.065	0.009	0.676	8.787**	8.194*	50.884**	40.36**
P_1×P_7	-0.54	-0.565	-0.37	-0.657	0.194	-0.065	8.935**	8.306*	-16.06**	38.66**
P_2×P_3	-0.28	-0.231	0.148	-0.324	0.454	-0.176	2.565	1.787	-31.37**	14.75*
P_2×P_4	-0.28	-0.157	-1.52**	-0.472	-1.213**	-0.398	8.046**	8.602**	18.681**	37.65**
P_2×P_5	-1.167	-1.380*	-1.037	-1.73*	0.157	-0.324	10.083**	10.269**	38.756**	30.63**
P_2×P_6	0.537	0.583	0.01	-0.843	-0.731	-1.398**	8.454**	8.454**	20.056**	78.21**
P_2×P_7	-1.95**	-2.60**	-2.53**	-0.102	-0.546	2.528**	8.602**	7.898*	-4.002	-10.31
P_3×P_4	-1.241	-1.194	-2.63**	-3.03**	-1.361**	-1.028*	0.861	2.306	30.789**	17.18**
P_3×P_5	-0.796	-1.083	-1.82**	-1.62*	-0.991*	-0.620	6.898**	6.639*	7.706	23.12**
P_3×P_6	-0.759	-1.454*	-0.444	-0.731	0.120	0.639	-0.731	-0.843	12.497*	48.82**
P_3×P_7	-0.241	0.028	-0.296	0.009	-0.028	-0.102	5.750**	6.269	11.166*	-42.7**
P_4×P_5	-1.81**	-1.009	-1.15*	-1.102	0.676	-0.176	10.046**	11.787**	26.204**	29.09**
P_4×P_6	-1.093	-3.05**	-0.778	-3.55**	0.120	-0.583	9.083**	10.306**	29.639**	31.63**
P_4×P_7	0.426	0.435	0.704	0.194	0.306	-0.324	9.898**	10.750**	-12.349*	42.96**
P_5×P_6	-0.981	-0.269	-1.3*	-1.139	-0.509	-0.843	7.787**	6.972*	5.504	36.64**
P_5×P_7	-1.81**	-1.454*	-2.15**	-2.73**	-0.324	-1.250*	8.935**	7.417*	4.633	39.99**
P_6×P_7	1.241	1.509*	0.556	0.157	-0.880*	-1.324*	9.639**	9.269*	36.149**	18.99**
S.E. (sij)	**0.656**	**0.691**	**0.563**	**0.847**	**0.414**	**0.527**	**2.079**	**3.25**	**5.645**	**5.88**

*,** Significant at 0.05 and 0.01

Table 8. Specific combining ability (SCA) effects for ear length, number of rows/ear, number of grains /row, 100-grain weight and grain yield under optimal irrigation and drought conditions**.**

Genotypes	Ear length (cm)		Number of rows/ear		Number of grains /row		100-grain weight (gm)		Grain yield (ard./fad.)	
	Optimal irrigation	**Drought**	**Optimal irrigation**	**Drought**	**Optimal irrigation**	**Drought**	**Optimal irrigation**	**Drought**	**Optimal irrigation**	**Drought**
1×2	-0.588	-0.484	0.359	0.430	1.937**	3.167*	3.161**	1.369	1.026*	0.479
1×3	1.105	0.927	0.200	0.470	0.515	3.722**	2.673**	3.297**	0.544	-0.595
1×4	0.919	1.486*	0.137	0.256	4.993**	6.611**	2.455**	1.617	-2.34**	-1.85**
1× 5	0.864	0.649	-0.76	-0.759	0.004	-0.944	0.233	0.524	5.262**	4.098**
1×6	-0.269	1.719**	0.733	0.752	-0.641	-0.500	0.492	1.857	-0.418	-0.598
1×7	-0.151	-1.395*	0.215	-0.133	1.170	1.389	0.189	1.612	2.104**	2.192**
2×3	0.856	-0.073	-0.033	0.393	1.574*	7.611**	2.040**	3.608**	2.427**	1.95**
2×4	0.405	0.753	0.437	0.644	5.352**	6.500**	-2.67**	-1.227	2.749**	1.733**
2×5	-0.018	1.016	0.537	0.256	1.430*	-2.056	0.173	0.708	-1.125*	0.041
2×6	0.449	0.753	0.533	-0.530	1.885**	-0.611	0.918	1.227	5.790**	5.210**
2×7	-0.366	0.738	-0.485	0.393	1.963**	3.278*	0.007	-2.092*	-3.78**	-2.72**
3×4	0.797	1.697	-0.122	0.100	5.996**	-0.944	3.367**	4.354**	7.13**	6.818**
3×5	0.842	-2.94**	0.178	0.319	0.507	-0.500	2.043**	1.992*	-0.093	0.604
3×6	1.308	1.164**	0.607	0.296	1.230	-1.056	3.603**	4.327**	-1.37**	-0.465
3×7	0.127	-1.051	-0.044	-0.356	0.141	2.833*	2.742**	1.991*	0.829	1.431*
4×5	-0.610	0.319	0.215	-0.463	2.185**	-1.611	-0.661	-2.88**	6.206**	4.636**
4×6	0.256	-0.810	0.644	0.048	2.941**	4.833**	0.293	0.921	2.826**	2.381**
4×7	0.542	-0.158	0.459	0.630	2.585**	-1.278	0.637	2.257*	-0.645	-0.448
5×6	1.001	0.619	0.611	0.833	0.485	2.278	-5.52**	-5.61**	0.945	1.074
5×7	0.786	0.438	0.393	0.115	0.463	1.167	0.427	0.110	2.028**	2.006**
6×7	-0.014	0.108	0.722	1.126*	-0.115	1.611	0.607	0.631	6.225**	4.342*
S. E. (sij)	**0.77**	**0.64**	**0.399**	**0.529**	**0.71**	**1.339**	**0.597**	**0.968**	**0.517**	**0.673**

*,** Significant at 0.05 and 0.01

Table 9. Components of genetic variance and derived parameters for days to 50% tasselling, days to 50% silking, ASI, plant height and ear leaf area under optimal irrigation and drought conditions.

Genetic components	Days to 50% tasselling		Days to 50% silking		ASI		Plant height (cm)		Ear leaf area (cm2)	
	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought
D	21.1**±0.3	22.3**±0.5	28.3**±0.6	28.32**±0.9	1.81**±0.6	1.82**±0.5	860.7**±23.6	836.0**±26.1	11004.2**±136.9	6695.7**±352
H1	6.08**±0.7	7.75**±1.2	11.1**±1.5	13.6**±2.1	4.2*±1.34	5.71**±1.2	633.9**±53.5	621.1**±59.1	3795.7**±310.7	10392.7**±799
H2	5.80**±0.7	7.78**±1.2	9.5**±1.45	11.98**±2.1	3.5**±1.34	4.20**±1.2	586.5**±53.0	581.1**±59.0	2955.2**±310.4	8479.7**±798
F	1.19±0.7	1.33±1.4	3.7±1.60	2.81±2.28	1.63±1.5	3.04*±1.3	409.4**±58.7	385.0**±64.8	-2371.7**±340.9	-1580.9**±877
h2	20.0**±0.5	28.3**±0.9	31.8**±1.0	47.49**±1.5	1.82±0.94	2.08**±0.8	2810.0**±37.0	2885.0**±41.3	5320.1**±217.4	25062.5**±559
E	0.83**±0.1	0.99**±0.2	0.42±0.23	1.35**±0.32	0.21±0.21	0.33±0.2	5.38**±8.0	18.1*±9.2	38.51±48.41	48.97±124.55
derived parameters										
H1/D	0.54	0.59	0.63	0.69	1.52	1.77	0.86	0.86	0.59	1.25
H2/4H1	0.24	0.25	0.21	0.22	0.21	0.18	0.23	0.23	0.19	0.20
KD/KR	1.11	1.11	1.23	1.15	1.84	2.79	1.77	1.73	0.69	0.83
h2/H2	3.45	3.63	3.36	3.97	0.53	0.49	4.79	4.96	1.80	2.96
$h_{(n.s)}$	81.64	78.06	82.46	75.75	29.38	9.15	62.12	60.04	90.14	70.14

*,** Significant at 0.05 and 0.01

Table 10. Components of genetic variance and derived parameters for ear length, Number of rows/ear, number of grains /row, 100-grain weight and grain yield under optimal irrigationand drought conditions**.**

Genetic components	Ear length (cm)		Number of rows/ear		Number of grains /row		100-grain weight (gm)		Grain yield (ard./fad.)	
	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought	Optimal irrigation	Drought
D	1.17**±0.2	1.169±0.81	0.82**±0.06	0.86**±0.1	4.387±4.26	5.92±9.11	4.95*±2.32	5.63±3.48	1.475±3.70	0.527±3.16
H1	1.84**±0.45	5.91**±1.85	1.28**±0.13	0.8**±0.3	62.12**±9.7	73.9**±20.7	42.9**±5.26	56.7**±7.9	69.41**±8.40	49.29**±7.18
H2	1.49**±0.45	4.68*±1.84	0.95**±0.13	0.7**±0.3	43.72**±9.7	58.8**±20.7	26.4**±5.26	33.97**±7.9	63.14**±8.39	44.37**±7.17
F	-1.69**±0.5	0.81±2.03	-1.2**±0.14	-1.3**±0.32	-18.45±10.6	-21.04±22.7	1.22±5.78	1.89±8.7	1.53±9.21	0.59±7.88
h2	6.90**±0.31	2.91*±1.29	3.17**±0.09	2.0**±0.2	142.5**±6.8	133.3**±14.5	31.5**±3.68	44.65**±5.6	140.5**±5.87	111.09**±5.02
E	0.70**±0.07	0.58±0.29*	0.19**±0.02	0.33**±0.04	0.62±1.51	2.23±3.22	0.43±0.82	1.19±1.23	0.32±1.31	0.55±1.12
derived parameters										
H1/D	1.25	2.25	1.25	0.96	3.76	3.53	2.94	3.17	6.86	9.67
H2/4H1	0.20	0.20	0.19	0.22	0.18	0.20	0.15	0.15	0.23	0.23
KD/KR	0.27	1.36	0.28	0.14	0.28	0.33	1.09	1.11	1.16	1.12
h2/H2	4.64	0.62	3.33	2.87	3.26	2.27	1.19	1.31	2.23	2.50
$h_{(n.s)}$	59.95	31.24	72.93	68.65	64.09	55.42	58.91	57.76	16.16	17.24

*,** Significant at 0.05 and 0.01

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القدرة على الأئتلاف والتأثير الجينى للتبكير والمحصول ومكوناتة فى الذرة الشامية تحت ظروف الرى الأمثل والإجهاد المائى

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أقيمت تجربتان حقليتان خلال الموسمين الصيفيين 2012 و2013 بمحطة بحوث كلية الزراعة (بالخطارة) جامعة الزقازيق. تم تقييم سبع سلالت من الذرة الصفراء(105 (P_1), 50 (P_2), 126 (P_3), 35 (P_4), 78 (P_5), 85 (P_6) and 125 (P_7 لصفات التبكير والمحصول ومكوناته تحت ظروف الرى الأمثل (4000 م^3) وإجهاد الجفاف (2400 م^3). أشارت النتائج الى أن تباين كل من القدرة العامة والخاصة على الأئتلاف عالى المعنوية لجميع الصفات تحت الدراسة تحت ظروف كل من الرى الأمثل والجفاف.كانت النسبة بين تباين القدرة العامة والقدرة الخاصة على الأئتلاف أكبر من الوحدة لجميع الصفات ، فيما عدا صفة محصول الحبوب تحت ظروف كل من الرى الأمثل والجفاف وصفة الفترة بين خروج النورة المذكرة والنورة المؤنثة تحت ظروف الجفاف فقط مشيراَ الى أهمية الفعل الجينى السيادى فى وراثة هاتين الصفتين وأهمية الفعل الجينى المضيف فى وراثة باقى الصفات. سجلت السلالاتP_2،P_3 ، P_4 و P_5قدرة عامة على الأئتلاف سالبة ومعنوية لصفات التبكير تحت ظروف كل من الرى الأمثل والجفاف،أيضاَ سجلت السلالة P_4 قدرة عامة على الأئتلاف سالبة ومعنوية لصفة الفترة بين خروج النورة المذكرة والنورة المؤنثة تحت ظروف الجفاف فقط . على الجانب الآخر، سجلت السلالات P_2،P_3 وP_6 قدرة عامة على الأئتلاف موجبة ومعنوية لصفة مساحة ورقة الكوز ، السلالةP_6 لصفة طول الكوز ، السلالات P_4 وP_6 لصفة عدد السطور / الكوز، السلالات P_2 وP_4 لصفة عدد الحبوب / السطر، السلالات P_1 وP_3 لصفة وزن 100 حبة و السلالة P_4 لصفة محصول الحبوب (أردب / فدان). كان تباين الفعل الجينى المضيف والسيادى معنوياَ لصفات التبكير، الفترة بين خروج النورة المذكرة والنورة المؤنثة، ارتفاع النبات، مساحة ورقة الكوز وعدد السطور /الكوز تحت ظروف كل من الرى الأمثل والجفاف ، طول الكوز ووزن 100 حبة تحت ظروف الرى الأمثل فقط. كانت كفاءة التوريث فى المعنى الضيق مرتفعة (أعلى من 70%) لصفات التبكير، مساحة ورقة الكوز وعدد السطور /الكوز تحت ظروف كل من الرى الأمثل والجفاف، بينماتراوحت (من 30 – 70%) لصفات ارتفاع النبات، طول الكوز، عدد الحبوب /السطر و وزن 100 حبة، فى حين كانت منخفضة (أقل من 30%) لصفات الفترة بين خروج النورة المذكرة والنورة المؤنثة و محصول الحبوب (أردب/فدان) تحت ظروف كل من الرى الأمثل والجفاف.