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Genetic Analysis of Water Stress Tolerance Attributes in F1 Maize Diallel Crosses

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Abstract

A half diallel set of crosses involving 10 inbred lines of maize along with commercial hybrid ARCGH 128 were evaluated at two different irrigation treatment during two season 2019 and 2020 using RCBD design with three replications at two locations (Minia and Assuit governorates), to determine combining ability and gene action for grain yield and its components. the most superior crosses for the economic traits were detected in L1 X L2 for leaf proline content, ear weight and number of rows/ear, L1 X L8 for number of ear /plot and number of rows/ear, L4 X L9 for Days to tasseling and Days to silking, L3 X L8 for Leaf angle, leaf rolling, number of kernels/ear, number of rows/ear and number of kernels/row and L3 X L10 for days to tasseling, days to silking,leaf rolling, relative water content (RWC %), kernel fresh weight, number of rows/ear and yield. Highly significant and larger in magnitude values of dominance (H1 and H2) components were found to be at the significant level at (5%) for all studied characters which confirmed their importance in the expression of these characters. However (D) dominance component was reached to the significant level only for the normal irrigation treatment for the leaf angel at both locations, all irrigation treatment for leaf proline content at both locations, normal irrigation treatment for number of kernel/row at Assuit location and all irrigation treatment for 100 kernel weight and number of ear/plot at both locations. The (F) component was significant and positive for all irrigation treatment for leaf proline content at both location, normal irrigation treatment for number of kernel/row at Assuit location, all irrigation treatments for 100 kernel weight at both location, stress irrigation treatment for number of ear/plot at Minia location. Significant differences of environmental variance (E) components were recorded for all irrigation treatment for leaf rolling at Assuit location, all irrigation treatment for ear weight at Minia location and all irrigation treatment for number of rows/ear and number of ear/plot at both locations. Dominance component of variance (H1 and H2) were significant and/or highly significant for all studied traits and (H1) was greater than (H2) in F1 indicating that positive and negative alleles at loci of these trait were not in proportional equal for parents. The estimator (h2) were refers to the dominance effect overall heterozygous loci was significant for all studied traits except days to tasseling for normal irrigation treatment at both locations, stress irrigation treatment for leaf angel at Minia location, all irrigation treatment for leaf rolling at both locations, normal irrigation treatment for ear weight/kg/plot at both locations and for stress irrigation treatment for number of rows/ear at Minia location. Average degree of dominance (H1/D) 0.5 was more than unity for all traits, these finding indicated the involved of an over dominance expression for all characters. However the over dominance observed in such character may not be an index of true over dominance could be based due to linkage epistasis or both together. Since the ratio of dominance (KD) recessive (KR) alleles was more than one for all the studied characters, these indicates a preponderance of dominant gene in the parents for the characters. The value of K (h2/H2, which stands for the number of groups of genes that exhibit dominance for each character) was <1 for all the studied characters for normal irrigation treatment at Assuit location and all irrigation treatment at Minia location and all irrigation treatment at Minia location for number of rows/ear and 100 kernel weight/gm. This suggested that just one group of genes showed dominance governed all of them while this parameter could be underestimated, when the dominance effects of all genes was not concerned with equivalent, size and distribution, where the distribution of genes was correlated, or complementary gene interactions occur. Heritability values in bored sense (h2b) were relatively low for all characters. However, heritability in narrow sense (h2n) was high scored values more 50% except leaf rolling for stress irrigation treatment at Minia location (0.48%) these results confirmed that the environmental effects constitute a major portion of the total phenotypic variation in these characters.

Key words: Maize, Drought stress, Hayman, graphical analysis**.**

Introduction

Maize (Zea mays L.) is considered the most widely cultivated and dominate food crops in the world. It is grown throughout various environments in the world. This crop can be used for human consumption or livestock feed and as a raw material for industrial products. It is grown on more than 160 million hectares in the world, with annual production of more than 1017 million mega-grams in 2103 (**FAO, 2013**). Increasing maize production to narrow the gap between production and consumption is vital in Egypt.

Considerable variations in maize productivity in different parts of Egypt should be reduced to attain a projected high productivity. This could be achieved through diversification of maize breeding programs and developing new set of maize varieties.

Water stress affects 45% of the world's crops and arable lands. It is a major constraint in maize production and the most negative factor causing yield reduction in semiarid regions (**El-Hosary et al., 2013; Umar et al 2014**). Maize growth and yield affected by soil moisture regime caused yield deterioration, especially if water deficit occurs during the flowering or reproductive phase (**Lucia et al., 2021**)

Drought avoidance includes mechanisms which reduce water loss from plant or keep water absorption. Drought tolerance is the ability of plant to resist low water supply by enhancing tissue water potentials (**El-Hosary et al., 2013)**. Therefore, a main objective in maize plant breeding programs is improving drought resistant genotypes. The ideal maize genotype should be high yielding under all environmental conditions. However as genetic effects are not independent of environmental effects, most genotypes may differ by environmental changes (**Banziger et al., 2000; El-Hosary et al., 2011**).

Considerable importance is now being given to interaction of genotypes with a wide range of soil water stress in maize breeding programs. Therefore, great attention should be paid to select drought tolerant maize genotypes combined with high yielding properties under different drought environments, which could be achieved by testing maize genotypes continuously across different drought environments.

Combining ability is a concept developed to help the breeder in selection of parental stocks appropriate to the designed breeding procedure (**Basbag et al., 2007**). Parents of the best potentiality to transmit high yielding ability or improved earliness and drought tolerance traits to their progeny of new combinations, are those exhibiting the highest values for specific combining ability (SCA) effects. Whereas, combinations of the highest values for SCA demonstrate exploition of heterosis concept. The utility of diallel cross design in investigating the genotypic by environmental interactions has been considered by **Allard, (1956) and Allard and Bradshaw, (1964)**.

The aim of this study was to identify gene action controlling the inheritance of studied traits, to estimate the magnitude of combining ability (GCA and SCA) in the first generation and to enhance yield potentiality and resistance to drought stress of maize genotypes.

Materials And Methods

This study reported here in was carried out at environmental research and studied Institute (ESRI), University of Sadat City, and the crosses season was done in private land at Minia governorate during successive season 2019, and the F1 was evaluated at two locations in Minia and Assuit governorates during successive season 2020. One commercial hybrid ARC-GH 128 and ten inbred lines were used in this study and these inbred lines were obtained from Agriculture Research Center (ARC).

In the first summer season 2019, seeds of the ten inbred lines were split sown on 1th May and 8th to avoided differences in flowering time and secure enough hybrids seed at special location at Menia governorate. All possible cross combinations without reciprocals were made between 10 inbred lines by hand method giving a total of 45 genotype in the season 2019 will be evaluated in the second season.

In the second summer season 2020 the two experiments were conducted at two locations under two independent experiments, (normal irrigation) (irrigation every 12 days) and water-stress irrigation every 21 days. Planting dates was 15th June 2020 in Menia locations and the second location in 20th June 2020 at Assuit location.

The ten inbred lines, 45 F1 and the commercial single cross ARC-GH321 **(Table 1)** were separately grown randomly in randomized complete block design (RCBD) with three replications. The experiment wee fertilized by organic maters before planting and a rate of 120 unit of N/feddan split in three dosses before the first three irrigations. All other agricultural practice were done as normally practiced in the two locations. Plots were two ridges 10 m long and the spacing between ridges and hills were 70 and 25 cm, respectively. To adjust the plant stand, two kernels were planted/hill on one side of the ridge then seedlings were later thinned to one plant/hill.

The other cultural practices were followed as usual for ordinary maize field in the area. Mean data were calculated after recorded measurements on 15 plants chosen at random from each plot for parents, F_1 crosses and ARC-GH128, except days to 50% silking where the mean of plot was used. The following traits were measured at flowering stage; leaf proline content (mg g^{-1}) determined according to protocol of **Bates et al. (1973)** as a physiological indicator of plant status under the implemented water stress treatments.

Table 1. Name and Pedigree of the studied inbred lines maize genotypes.

Inbred line number	Pedigree	Origin
Check variety	ARC-GH-128	
P1	G-308A-S.C.U1202	Egypt
P2	RG-5 g.s (sanjuan × ci 64) (S.C.14)	Egypt
P3	RG-8 g.s (sanjuan × ci 56) (S.C.14)	Egypt
P4	G-221 D White composite (S.C.16)	Egypt
P5	G-241 A Ellis 19S1	Egypt
P6	RG-15 g.s (syn.Laposta × Ci64)	Egypt
P7	RG-9 g.s (sanjuan × ci 55) (S.C.12)	Egypt
P8	G-308A-S.C.U1232	Egypt
P9	RG-17 g.s (syn.Laposta × Ci45)	Egypt
P10	G-201 D White composite (S.C.11)	Egypt

Characters studied

Agronomic characters

1. Days to tasseling
2. Days to silking
3. Plant height (cm)
4. Ear height (cm)
5. Leaf Angel
6. Leaf rolling
7. Leaf proline content (mg)
8. Relative water content (RWC %)

Yield and yield component:

9. Ear weight /plot (Kg)
10. Kernel FW/plot (kg)

11. No. of row/ear
12. No. of kernel/row
13. Number of kernels/ear
14. 100 kernel weight
15. No. of ear/plot
16. Drought susceptibility index.
17. Feddan yield/kg.

Hayman's approach: The data obtained herein were further subjected to diallel cross analysis described by **Hayman (1954)**, to obtain more information's about the genetic behavior of the traits under study.

This technique was used to obtain the following statistics:

The covariance between the parents and their offspring in the r the array (Wr).

The variance of the r the array (Vr).

The variance of the parents (volo).

The covariance between the parents and the mean of F1 offspring (volo1).

The mean-variance of arrays (v1l1).

The variance of the array means (v0l1).

The square of the difference between the mean of the parents and the mean of the n2 progeny (ML1 – ML0) 2. These statistics were used to estimate the following components of genetic variation and their related genetic ratios.

Data Analysis. Data were analyzed using the Hayman approach as followed (Singh & Chaudhary 1979) analysis of variance, variance and covariance estimation, the establishment of the graph Wr-Vr, variance component estimation as well as the other parameters and the most dominant and recessive parents. From the data analysis we obtained: (i) variations due to additive effect (D); (ii) the mean of 'Fr' over the arrays (F), Fr is the covariance of additives and non-additive effects in single array; (iii) components of variation due to the dominance effect of the genes (H1); (iv) calculations to predict the proportion of positive and negative genes in the parents (H2); (v) the dominance effects (as the algebraic sum over all loci in

Statistical analysis of Morley-Jones and Hayman performed by MSTAT-C version 1.42, SPSS ver 17 and Dial 98 statistical packages to estimate genetic parameters.

Result and Discussion

The most desirable and/or highest mean performance for all crosses in all trait studied under the two locations and the two irrigation treatments and their combined data were defined. It was defined for days to tasseling (45.7 day to tassel) for crosses (L3 X L10 and L4 X L9) for stress irrigation treatments at Assuit location. Also days to silking was (48.3 day to silk) for crosses (L3 X L10 and L4 X L9) for stress irrigation treatments at Assuit and Minia locations. These two traits days to tasseling and days to silking are consider as desirable character from breeder point of view because it make plant avoid the drought stress, mature early and decrease irrigation. While plant height (plant height) was (370.3cm) for crosses (L1 X L9) for normal irrigation treatments at Assuit location **(Table 2)**. These character is consider as desirable character from breeder point of view because long plant height increase the silage production. It defined for ear height (ear height) was (111.3cm) for crosses (L2 X L6) for stress irrigation treatments at Assuit location. This character is consider as desirable character from breeder point of view because low ear height prevent plant from lodging and harvest easier. Also leaf angel was (3.3) for crosses (L3 X L6 ,L3 X L8 and L8 X L9) for normal irrigation treatments at Assuit and Minia locations. This character is consider as desirable character from breeder point of view because it prevent water loss by transpiration and increase the population in area unit. While leaf rolling was (3.7) for crosses (L3 X L8, L3 X L10 and L8 X L9) for all irrigation treatment and their combined analysis data at both locations and for crosses (L3 X L9 and L4 X L6) for normal irrigation treatments at both locations .While Leaf Proline content was (30.3) for cross (L1 X L2) for normal irrigation treatments at Minia locations. Also for relative water content (RWC %) was (30.2%) for cross (L3 X L10) for normal irrigation treatments at Minia locations. Also number of DSI was (0.3) for crosses (L4 X L7) at Assuit location. Regard to ear weight/kg/plot was (10.0kg) for cross (L1 X L2) for normal irrigation treatments at Assuit locations. Also kernel fresh weight was (5.3kg) for cross (L3 X L10) for normal irrigation treatments at Minia locations. Regard to number of rows/ear was (15.3 row/ear) for crosses (L1 X L2, L3 X L6, L3 X L8, L3 X L9 and L4 X L65) for all irrigation treatment and their combined analysis data at both locations, and for crosses (L1 X L7 and L1 X L8) for normal irrigation treatment at both locations, and for crosses (L3 X L10) for normal and stress irrigation treatments and their combined analysis data at Assuit locations and for Minia stress irrigation treatment, and for (L7 X L10) for normal irrigation treatments at Assuit location and finally for cross (L8 X L9) for stress irrigation treatments at Assuit location and for Minia normal and stress irrigation treatment and their combined analysis data. Also number of kernel/row was (40.7 kernel/row) for crosses (L3 X L6 and L3 X L8) for normal irrigation treatments at Assuit location. Regard to 100 kernel weight was (40.8gm) for crosses (L2 X L10 and L4 X L6) for normal irrigation treatments at Minia location. Also for number of ears/plot was (46.3 ear/plot) for cross (L1 X L8) for normal irrigation treatments at Assuit location. And for number of kernel/ear was (622.7 kernels/ear) for crosses (L3 X L6 and L3 X L8) for normal irrigation treatments at Assuit location. And for feddan yield was (6580.8 kg) for cross (L3 X L10) for normal irrigation treatments at Assuit location.

Table 2. Mean performance of characters studied for F1 crosses studied under two different irrigation treatment at two locations

Genotype	Plant height				Ear height			
	Asuit		Menia		Asuit		Menia	
	N	S	N	S	N	S	N	S
1*2	310.7	310.7	324.3	312.3	176.3	151.3	156.7	148.7
1*3	315.7	300.7	320.3	307.3	172.7	152.7	167.7	149.3
1*4	310.7	290.7	312.3	295.3	163.3	148.0	156.7	138.0
1*5	310.3	285.3	292.7	286.0	151.7	126.7	141.7	127.3
1*6	315.7	300.7	328.3	312.3	162.0	137.0	151.7	138.0
1*7	300.3	285.3	294.0	281.3	153.0	123.0	140.7	130.7
1*8	310.7	300.7	317.3	309.7	162.7	142.7	163.3	150.3
1*9	370.3	250.3	269.7	258.7	151.7	126.7	141.7	130.7
1*10	300.3	274.3	291.7	271.3	151.3	131.3	151.7	139.7
2*3	290.3	260.3	271.0	260.3	141.7	116.7	129.0	126.3
2*4	310.3	295.3	301.7	293.7	171.7	141.7	158.3	151.0
2*5	300.3	300.3	324.0	307.0	172.0	152.0	175.3	162.7
2*6	270.7	250.7	281.7	263.0	151.3	111.3	141.3	121.7
2*7	300.3	290.3	311.7	293.7	156.7	141.7	161.7	144.3
2*8	290.7	280.7	303.3	289.3	162.3	142.3	157.7	142.7
2*9	270.3	260.3	275.7	263.0	132.7	112.7	135.7	117.7
2*10	290.7	260.7	295.3	278.3	163.0	133.0	151.7	133.3
3*4	330.3	310.3	323.3	311.0	162.0	142.0	155.3	148.3
3*5	280.7	270.7	289.7	274.3	161.7	141.7	155.7	141.7
3*6	290.7	280.7	306.7	291.3	162.7	147.7	163.0	151.7
3*7	280.7	275.7	292.7	277.3	157.3	132.3	152.0	138.7
3*8	280.7	270.7	274.7	260.0	141.7	111.7	131.7	121.7
3*9	280.7	275.7	292.0	272.3	142.0	122.0	149.3	128.7
3*10	300.7	300.7	311.7	300.3	158.0	148.0	162.3	150.3
4*5	300.7	295.7	311.7	300.7	152.7	132.7	148.3	138.0
4*6	290.3	260.3	281.7	263.7	141.7	111.7	130.3	117.0
4*7	280.3	280.3	291.7	272.0	146.7	116.7	140.7	124.3
4*8	280.7	272.7	289.0	273.0	151.3	136.3	157.0	137.7
4*9	300.3	280.3	311.7	300.0	152.3	127.3	143.3	130.0
4*10	300.7	300.7	319.7	303.7	152.7	142.7	162.7	147.7

5*6	280.3	280.3	291.7	274.3	148.0	123.0	144.7	126.7
5*7	280.7	270.7	281.0	269.3	147.0	127.0	143.3	129.0
5*8	310.3	300.3	322.7	305.7	161.7	151.7	171.7	155.7
5*9	320.7	300.7	331.7	314.3	167.7	152.7	171.3	161.3
5*10	310.3	290.3	301.7	288.3	168.0	143.0	162.0	149.0
6*7	280.7	280.7	284.7	273.3	168.0	153.0	172.7	160.0
6*8	300.3	290.3	306.7	288.7	158.0	123.0	147.3	130.3
6*9	300.7	310.7	311.7	297.0	142.0	127.0	136.7	125.3
6*10	300.3	290.3	301.7	293.0	143.0	118.0	130.3	122.7
7*8	320.7	300.7	323.7	307.7	152.7	142.7	160.7	146.7
7*9	275.3	240.3	271.7	253.0	142.3	112.3	138.3	118.7
7*10	300.7	260.7	302.7	297.3	146.3	131.3	152.0	135.0
8*9	320.3	310.3	323.7	312.3	151.7	131.7	148.3	133.7
8*10	320.7	310.7	331.7	311.7	152.0	137.0	157.7	141.3
9*10	330.7	300.7	334.7	313.3	152.0	142.0	162.3	143.0
LSD 5%	2.3	2.3	4.7	4.0	1.6	1.6	3.8	4.3
LSD%1	3.0	3.0	6.2	5.3	2.1	2.1	5.0	5.6

Continued

Days to tasseling				Days to silking			
Asuit		Menia		Asuit		Menia	
N	S	N	S	N	S	N	S
55.3	50.7	57.7	54.7	56.7	51.3	58.7	55.3
50.3	48.3	51.3	51.7	52.3	50.0	53.3	51.7
57.3	53.7	58.3	55.7	56.3	53.0	58.7	54.7
58.3	55.7	59.3	59.7	60.7	59.3	61.3	58.7
51.7	50.7	54.3	55.7	54.7	52.7	56.3	55.3
50.3	46.7	51.3	49.3	52.7	49.7	53.7	49.7
51.3	49.3	52.7	52.3	52.3	49.7	54.7	51.7
50.7	48.3	52.3	51.3	53.7	49.3	54.7	51.3
60.3	57.3	62.7	60.3	61.7	57.3	63.3	60.3
55.7	54.3	57.3	56.7	56.3	54.7	58.7	57.0
53.3	51.7	53.7	54.3	52.7	54.3	55.3	54.3
57.3	55.3	57.3	56.7	56.7	54.7	58.7	56.3
60.7	59.3	61.7	61.3	61.3	59.7	63.7	60.7
50.3	49.7	51.7	52.7	51.3	50.3	53.7	52.3
54.3	52.3	55.7	55.3	54.3	51.7	57.3	54.3
59.7	57.7	61.7	61.7	60.3	59.7	63.7	61.7
55.3	51.7	57.3	55.3	55.3	53.7	58.7	54.7
50.3	47.3	51.7	50.7	50.7	49.7	53.3	50.3
56.3	54.7	58.3	58.3	57.3	56.7	60.7	57.7
60.7	55.7	61.7	60.3	60.7	59.7	63.3	59.7
59.3	55.3	60.7	57.7	59.7	55.3	61.7	57.7
58.3	53.7	58.7	56.3	59.3	55.3	60.3	56.7
52.3	46.3	53.3	50.7	54.7	49.3	55.3	50.7
50.7	45.7	51.3	48.7	53.3	48.3	53.3	48.7
58.3	54.7	59.3	58.3	59.7	55.3	61.3	58.7
54.3	51.7	55.7	55.7	55.7	51.7	57.3	55.3
57.7	55.3	58.7	58.0	59.7	56.3	60.3	57.7
56.3	54.3	58.3	58.7	59.3	57.3	60.7	58.7
50.3	45.7	51.7	48.3	52.7	56.3	53.7	48.3
57.3	54.3	58.3	57.7	59.3	54.3	60.3	57.7
50.3	46.3	52.3	51.7	52.3	49.3	54.7	51.7
56.7	53.3	58.3	57.3	59.3	54.3	60.3	56.7

62.7	57.3	63.3	57.7	62.3	55.3	63.3	57.7
53.3	48.7	54.3	51.3	55.7	49.3	56.3	51.7
59.7	57.3	60.7	60.7	61.7	58.7	62.3	59.7
58.7	53.3	59.3	56.3	60.7	54.3	61.7	55.7
52.7	49.3	53.7	51.7	55.3	49.3	55.3	51.7
56.7	52.3	57.3	53.7	58.3	50.7	58.7	52.7
56.7	52.3	57.7	53.7	57.7	51.3	58.3	53.7
57.7	54.7	59.3	58.7	59.7	55.3	61.3	58.7
52.7	47.7	54.7	51.7	54.3	49.3	56.3	51.7
54.7	50.3	57.3	53.3	56.3	50.3	58.3	53.7
54.7	49.7	55.7	54.3	57.7	52.3	58.7	54.7
60.3	52.7	60.7	57.3	60.7	55.3	62.3	57.7
53.3	51.7	55.3	54.3	55.3	52.3	57.7	54.7
1.0	1.4	0.6	0.5	1.2	1.3	0.5	0.9
1.3	1.9	0.8	0.7	1.6	1.7	0.6	1.2

Continued

Leaf_Angel				Leaf_Rolling			
Asuit		Menia		Asuit		Menia	
N	S	N	S	N	S	N	S
5.3	7.3	4.3	6.7	2.7	2.3	2.7	2.3
5.3	7.3	4.3	6.7	1.3	2.7	1.3	2.7
6.7	5.3	7.3	5.3	1.3	2.3	1.7	2.3
5.3	5.3	4.7	5.0	1.3	1.7	1.3	2.3
6.7	5.3	7.3	5.3	1.3	1.7	1.3	2.3
7.7	7.3	8.3	7.3	1.7	1.7	2.3	2.3
7.3	7.3	6.7	6.7	1.3	2.7	1.3	2.7
8.7	7.3	8.7	6.7	1.3	1.7	1.3	2.3
7.3	7.3	6.7	6.7	1.7	1.7	1.7	2.3
8.7	8.7	8.7	8.7	1.7	1.7	1.7	2.3
8.7	8.7	9.3	9.3	2.3	2.3	1.7	2.3
8.7	8.7	8.7	8.7	2.3	2.7	2.3	2.7
7.3	7.3	7.3	7.3	1.3	2.7	1.3	2.7
7.3	7.3	7.3	7.3	1.3	2.3	1.3	2.3
7.3	7.3	7.3	7.3	1.3	2.3	1.3	1.7
7.3	7.3	7.3	7.3	1.7	2.3	1.7	1.7
8.7	8.7	8.7	8.7	2.7	3.3	2.7	2.7
8.7	8.7	9.3	9.3	2.3	3.3	2.3	2.7
8.7	8.7	8.7	8.7	2.7	3.3	2.7	2.7
3.3	5.3	3.3	5.3	2.7	3.3	2.7	2.7
6.7	5.3	7.3	5.3	2.3	3.3	2.3	2.7
3.3	5.3	3.3	5.3	3.7	3.7	3.7	3.7
5.3	5.3	4.7	5.3	3.7	3.3	3.7	2.7
5.3	5.3	4.7	5.3	3.7	3.7	3.7	3.7
6.7	5.3	6.7	5.3	2.3	2.3	2.3	2.3
5.3	5.3	4.7	5.3	3.7	2.7	3.7	2.7
6.7	6.7	6.7	6.7	2.3	1.7	2.3	2.3
8.0	6.7	8.7	6.7	2.7	1.7	2.7	2.3
8.0	6.7	9.3	7.3	1.7	2.3	2.3	2.7
6.7	6.3	7.3	6.7	1.3	1.7	1.3	2.3
5.3	5.3	5.3	5.3	1.7	2.7	1.7	2.7
6.7	5.3	7.3	5.0	1.7	2.7	2.3	2.7

6.7	5.3	7.3	5.3	1.3	1.7	1.3	2.3
6.7	6.7	7.3	6.7	1.3	1.7	1.3	2.3
8.7	6.7	9.3	7.3	1.7	2.7	1.7	2.7
8.7	6.7	8.7	6.7	1.7	2.7	2.3	2.7
8.7	6.7	9.3	7.3	1.7	2.7	2.3	2.7
8.7	6.7	9.3	7.3	1.3	2.3	1.0	2.3
7.3	6.7	7.3	6.7	1.7	3.3	2.3	2.7
7.3	6.7	7.3	7.3	1.3	3.3	1.3	2.7
8.7	6.7	8.7	6.7	2.7	3.3	2.7	2.7
7.3	6.7	6.7	6.7	2.7	3.3	2.7	2.7
3.3	5.3	3.3	5.3	3.7	3.7	3.7	3.7
8.7	8.7	8.7	8.7	1.7	2.3	2.3	2.7
6.7	7.3	7.3	6.7	1.3	1.7	1.3	2.3
1.1	0.9	0.8	0.8	0.9	1.0	0.9	0.9
1.4	1.2	1.1	1.1	1.2	1.3	1.2	1.2

Continued

Leaf_Prolin_content				RWC%			
Asuit		Menia		Asuit		Menia	
N	S	N	S	N	S	N	S
27.9	25.6	30.3	28.1	23.4	21.1	25.8	23.5
27.6	24.2	28.9	25.6	18.8	15.4	20.1	16.8
23.4	21.2	24.9	22.6	20.7	18.4	22.2	19.9
21.4	17.8	23.3	20.1	18.8	15.6	21.1	17.9
20.9	18.9	23.9	21.9	18.6	16.6	21.6	19.6
14.1	11.2	16.3	13.4	19.7	16.8	21.9	19.0
21.6	19.3	23.3	20.6	21.3	18.7	22.6	20.0
26.1	22.6	27.5	24.4	24.2	20.9	25.4	22.3
13.4	11.8	15.9	14.3	19.1	17.6	21.6	20.0
21.4	19.5	23.3	21.5	24.6	22.7	26.5	24.6
15.7	13.4	18.2	15.9	22.2	19.9	24.6	22.3
24.0	20.7	25.3	22.0	21.9	18.5	23.2	19.9
21.1	18.8	22.6	20.3	20.1	17.8	21.6	19.3
20.7	17.8	23.3	20.1	23.3	20.1	25.6	22.4
14.2	12.2	17.2	15.2	24.6	22.6	27.6	25.6
22.2	19.3	24.4	21.5	20.1	17.2	22.3	19.4
20.7	18.3	22.3	19.6	24.3	21.7	25.6	23.0
18.9	15.7	20.2	17.1	20.2	17.1	21.6	18.5
16.7	15.4	19.5	17.9	22.1	20.6	24.6	23.0
17.1	15.3	19.1	17.2	27.9	26.2	29.8	27.9
19.6	17.3	22.0	19.8	17.9	15.6	20.3	18.0
20.3	16.9	21.6	18.3	27.4	24.2	28.7	25.4
23.9	21.6	25.3	23.1	25.7	23.4	27.2	24.9
23.9	20.8	26.3	23.1	27.9	24.7	30.2	27.0
26.3	24.3	29.3	27.3	18.3	16.3	21.3	19.3
18.1	15.2	20.3	17.4	26.6	23.7	28.8	25.9
18.9	16.3	20.2	17.6	19.9	17.3	21.2	18.6
18.9	15.7	20.2	17.1	19.2	16.1	20.6	17.5
20.7	19.2	23.2	21.6	19.7	18.2	22.2	20.6
17.3	15.5	19.3	17.4	22.7	20.8	24.6	22.7
23.8	21.5	26.2	24.0	24.1	21.8	26.5	24.2

22.9	19.6	24.3	20.9	20.3	16.9	21.6	18.3
21.8	19.6	23.3	21.0	18.4	16.1	19.9	17.6
26.8	23.7	29.3	26.0	17.5	14.3	19.8	16.6
16.3	14.3	19.3	17.3	19.2	17.2	22.2	20.2
16.8	14.1	19.2	16.3	22.4	19.5	24.6	21.7
28.0	25.3	29.3	26.6	20.2	17.6	21.5	18.9
21.7	18.9	23.4	20.2	20.2	17.1	21.6	18.5
17.9	16.3	20.4	18.8	20.2	18.5	22.5	20.9
17.3	15.5	19.3	17.4	18.2	16.3	20.1	18.2
13.8	11.6	16.3	14.0	14.5	12.2	16.9	14.6
20.9	17.5	22.2	18.9	15.5	12.1	16.8	13.5
17.9	15.6	19.4	17.1	24.9	22.7	26.5	24.2
13.9	10.8	16.3	13.1	17.5	14.3	19.8	16.6
13.3	11.3	16.2	14.3	17.1	15.1	20.1	18.1
0.5	0.5	0.8	0.8	0.3	0.3	0.4	0.4
0.7	0.7	1.0	1.0	0.4	0.4	0.6	0.6

Continued

Ear weight /plot (Kg)				kernel FW/plot			
Asuit		Menia		Asuit		Menia	
N	S	N	S	N	S	N	S
10.1	6.7	10.0	7.7	4.5	3.4	4.8	2.6
7.8	4.3	9.7	6.2	3.5	2.3	4.0	3.2
8.1	5.6	9.4	6.9	3.4	2.9	3.9	3.0
5.6	3.2	7.4	5.0	2.9	2.1	3.5	2.1
6.2	3.1	7.9	4.8	3.1	2.0	3.6	2.5
6.2	3.1	7.3	4.4	3.1	2.1	3.5	2.3
8.2	5.8	9.9	7.5	3.5	3.1	4.1	3.1
6.8	4.1	8.1	5.4	2.9	2.2	3.3	2.7
6.2	4.1	7.7	5.6	2.8	2.4	3.3	2.6
6.1	3.0	7.1	3.9	3.0	2.0	3.3	2.4
6.7	4.4	8.4	6.1	2.9	2.5	3.4	3.0
6.3	3.2	8.3	5.2	2.7	2.0	3.4	2.6
5.3	2.3	6.6	3.2	3.1	1.8	3.5	1.8
6.5	3.0	8.2	4.7	2.8	1.9	3.4	2.2
7.7	5.2	9.3	6.8	3.3	2.8	3.8	3.0
7.9	5.5	9.2	6.8	3.3	2.9	3.8	3.2
4.9	1.8	6.6	3.5	3.1	1.6	3.6	2.2
6.8	3.9	8.1	5.2	2.9	2.3	3.3	2.5
6.3	3.9	7.9	5.5	3.2	2.4	3.7	2.8
9.6	6.9	10.0	7.9	4.6	3.2	5.0	3.4
5.6	3.5	7.2	5.1	3.0	2.2	3.5	2.5
9.2	6.0	10.2	7.0	4.6	3.1	4.9	3.1
9.4	7.1	10.1	7.2	4.3	3.4	4.6	3.5
11.0	7.9	10.1	7.2	5.0	3.6	5.3	4.0
7.8	4.4	9.5	6.1	3.4	2.6	3.9	3.0
9.3	5.8	10.0	6.8	4.5	2.8	4.8	3.3
3.9	1.4	5.5	3.0	2.5	1.5	3.1	1.8
4.3	2.1	5.7	3.3	2.8	1.7	3.2	2.0
5.2	2.1	6.8	3.7	2.8	1.7	3.3	1.8
3.9	1.9	4.9	2.0	2.8	1.3	3.0	1.7
4.7	2.3	6.4	4.0	2.5	1.9	3.1	2.1
7.1	4.4	9.0	6.3	3.1	2.5	3.7	2.9
8.2	6.1	9.5	7.4	3.5	3.1	3.9	3.2

6.9	3.7	8.6	5.4	2.9	2.3	3.5	2.6
6.1	3.7	7.6	5.3	3.0	2.2	3.5	3.0
7.2	4.1	8.5	5.4	3.0	2.3	3.5	2.8
6.9	3.5	8.5	5.1	2.9	2.3	3.5	2.5
5.9	2.4	7.2	3.7	2.8	1.7	3.3	2.2
6.2	3.5	7.5	5.0	2.9	2.2	3.4	2.9
8.6	6.2	9.6	7.2	3.6	3.1	3.9	3.2
5.2	2.1	6.8	3.7	2.7	1.7	3.3	2.1
3.8	2.3	5.8	2.9	2.1	1.3	2.7	2.0
9.3	6.9	10.1	7.0	3.9	3.4	4.2	3.4
7.8	5.1	9.5	6.8	3.3	2.6	3.9	3.1
8.2	5.9	9.7	7.6	3.4	3.0	4.0	3.0
0.4	0.4	0.6	0.6	0.4	0.4	0.5	0.5
0.5	0.5	0.8	0.8	0.5	0.6	0.6	0.6

Continued

No_of Row/Ear				No_of Kernel/Row			
Asuit		Menia		Asuit		Menia	
N	S	N	S	N	S	N	S
15.3	15.3	15.3	15.3	35.7	30.3	38.3	32.0
12.7	12.7	12.7	12.7	35.3	28.7	37.7	29.7
13.3	12.7	13.3	12.7	33.7	29.0	34.7	27.7
13.3	13.3	13.3	13.3	34.7	24.3	31.3	24.7
13.3	13.3	13.3	14.7	33.7	25.7	33.7	25.7
15.3	13.3	15.3	14.7	36.7	26.3	33.0	28.0
15.3	14.7	15.3	14.7	33.3	25.7	35.7	28.3
14.7	14.7	13.3	14.7	35.3	26.7	34.3	27.3
14.7	12.7	13.3	12.7	32.3	25.3	31.7	24.3
12.7	12.7	12.7	12.7	31.7	25.7	32.3	24.7
14.7	12.7	14.7	12.7	31.7	23.3	31.7	22.3
14.7	14.7	13.3	13.3	33.7	24.7	32.3	24.7
14.7	12.7	13.3	12.7	36.3	25.3	33.3	26.3
14.0	12.7	14.7	12.7	37.7	25.7	35.0	27.7
12.7	12.7	12.7	12.7	33.7	25.3	33.7	25.7
12.7	12.7	12.7	12.7	31.7	26.7	34.7	27.3
12.7	12.7	12.7	12.7	34.3	25.3	34.3	26.3
14.7	12.7	14.7	12.7	31.7	25.7	34.3	26.3
14.7	12.7	13.3	12.7	31.3	26.3	31.3	26.3
15.3	15.3	15.3	15.3	40.7	38.7	38.7	37.3
12.7	12.7	12.7	12.7	30.7	22.7	31.7	22.3
15.3	15.3	15.3	15.3	40.7	33.7	35.7	38.3
15.3	15.3	15.3	15.3	39.7	35.7	39.3	36.7
15.3	15.3	14.7	15.3	37.7	33.7	38.3	35.0
12.7	12.7	12.7	12.7	30.3	29.3	35.3	29.7
15.3	15.3	15.3	15.3	39.7	34.7	38.7	38.3
13.3	12.7	13.3	12.7	34.7	26.3	33.7	27.3
13.3	12.7	14.7	12.7	34.7	25.3	30.7	24.3
14.7	14.7	14.7	13.3	31.3	24.7	30.3	23.7
12.7	12.7	12.7	12.7	30.7	26.7	33.3	29.3
12.7	12.7	12.7	12.7	28.3	26.3	31.7	24.7
13.3	14.7	14.7	13.3	31.7	31.7	36.7	30.7
14.7	12.7	13.3	12.7	34.3	34.3	36.0	30.7
14.7	12.7	12.7	12.7	36.3	31.3	37.0	31.3

12.7	12.7	12.7	12.7	30.7	25.7	33.7	28.3
12.7	12.7	12.7	12.7	32.3	26.3	33.0	24.7
13.3	14.7	14.7	13.3	30.3	25.3	33.3	24.3
13.3	12.7	13.3	12.7	30.7	22.7	31.3	24.7
13.3	12.7	14.7	12.7	31.7	22.7	30.3	25.0
12.7	12.7	12.7	12.7	30.3	23.3	29.3	23.0
12.7	12.7	12.7	12.7	27.7	20.7	26.0	21.3
15.3	12.7	12.7	12.7	30.3	24.3	30.3	25.7
13.3	15.3	15.3	15.3	39.7	35.7	38.7	36.3
12.7	14.7	12.7	13.3	31.7	24.3	31.3	24.3
12.7	12.7	12.7	12.7	30.7	24.7	31.7	26.3
1.8	1.8	1.9	1.8	0.9	1.1	1.8	2.1
2.4	2.4	2.4	2.4	1.2	1.4	2.4	2.7

Continued

100_Kernel_Weight/gm				No_of Ears/plot			
Asuit		Menia		Asuit		Menia	
N	S	N	S	N	S	N	S
33.0	32.2	33.5	32.5	43.7	42.7	43.7	42.7
30.2	29.6	27.6	26.9	44.7	44.0	42.7	43.3
33.4	32.5	34.3	33.9	43.3	43.3	42.7	42.7
32.7	31.8	34.7	34.3	42.7	42.7	41.7	41.7
30.0	29.7	28.4	27.5	42.3	42.7	41.7	41.3
34.6	34.2	36.5	35.7	45.7	43.7	45.7	43.7
26.0	25.4	27.3	26.6	46.3	45.3	45.7	44.7
30.2	29.7	32.2	31.6	42.3	42.3	42.3	42.3
30.3	30.0	32.3	31.3	42.3	42.7	41.7	42.3
28.7	28.1	26.3	25.4	41.7	41.3	40.3	40.7
34.2	33.6	34.3	33.7	42.7	42.7	42.7	42.7
30.2	29.8	28.3	27.9	41.3	40.3	40.7	39.7
29.3	28.5	28.6	28.2	42.7	41.7	42.7	41.7
33.6	32.9	31.7	30.7	43.7	42.0	42.3	41.3
31.6	30.6	28.7	27.9	43.0	42.3	42.7	42.3
33.0	32.1	36.9	36.2	43.3	42.7	42.7	42.3
30.2	29.9	40.8	40.2	43.0	41.7	42.3	41.7
32.7	32.3	33.5	32.5	42.3	40.3	41.7	39.7
34.6	33.9	34.3	33.4	44.7	43.0	44.7	42.3
30.2	29.7	28.4	27.8	42.3	41.3	42.3	41.3
30.3	30.0	27.3	26.9	42.7	41.0	42.7	41.7
28.7	28.1	32.3	32.0	42.3	41.3	42.3	41.3
34.2	33.6	34.3	33.4	43.7	41.3	42.3	40.7
30.2	29.8	28.6	27.8	43.7	42.0	43.7	41.3
33.6	32.8	28.7	28.0	44.0	42.0	43.3	41.3
31.7	31.0	40.8	40.2	44.7	42.3	44.7	42.3
33.4	32.5	27.6	26.6	44.3	39.7	43.7	38.7
30.0	29.1	34.7	33.7	43.3	40.7	42.7	40.3
26.0	25.7	36.5	35.8	43.7	42.3	42.3	41.7
29.3	29.0	32.2	31.7	44.3	42.3	43.7	41.7
31.6	30.9	26.3	26.0	44.7	43.0	43.3	42.3
30.2	29.7	28.3	27.4	44.7	42.7	44.7	42.7
34.6	34.2	31.7	30.9	43.7	41.7	42.3	40.7
30.3	29.8	36.9	36.2	43.0	42.3	42.3	42.3
28.7	28.0	34.3	33.7	44.3	42.7	43.7	41.3
30.2	29.8	32.3	31.3	41.3	41.3	40.7	40.7

33.6	32.8	28.7	27.7	41.3	41.3	41.3	41.3
31.7	31.0	34.7	34.0	40.7	41.0	40.7	40.3
30.0	29.0	26.3	25.9	40.3	39.7	39.7	39.0
29.3	28.4	36.9	36.6	40.7	40.7	40.7	40.7
30.2	29.9	34.3	33.4	40.7	40.3	40.0	39.7
30.3	30.0	32.3	31.6	41.3	41.3	41.3	41.3
30.2	29.6	28.7	28.0	44.3	42.7	43.7	41.3
33.6	33.1	34.7	34.1	42.3	41.7	41.7	40.7
29.3	29.0	26.3	25.3	42.3	41.7	42.3	41.7
0.5	0.4	0.3	0.3	1.4	2.5	1.6	2.0
0.7	0.5	0.4	0.4	1.9	3.3	2.1	2.6

Continued

No_of Kernels/ Ear				Yield/feddan				DSI	
Asuit		Menia		Asuit		Menia		Asuit	Menia
N	S	N	S	N	S	N	S		
547.3	464.7	586.7	488.0	6072.3	4032.3	6006.0	4638.3	0.7	0.8
448.0	362.7	479.3	376.0	4666.8	2566.8	5830.8	3730.8	0.6	0.6
450.0	368.0	462.0	351.3	4835.4	3335.4	5627.4	4127.4	0.7	0.7
461.3	324.0	417.3	329.3	3363.0	1923.0	4407.0	2967.0	0.6	0.7
449.3	342.7	448.0	376.7	3722.1	1862.1	4712.1	2852.1	0.5	0.6
560.7	350.0	504.7	410.7	3703.4	1841.1	4373.1	2633.1	0.5	0.6
511.3	375.3	546.0	416.0	4924.5	3484.5	5932.5	4492.5	0.7	0.8
519.3	392.7	456.7	400.0	4059.6	2439.6	4881.6	3261.6	0.6	0.7
474.0	320.7	421.3	309.3	3720.3	2460.3	4644.3	3384.3	0.7	0.7
402.0	326.0	408.7	313.3	3665.4	1797.6	4271.4	2351.4	0.5	0.6
463.3	294.7	464.7	283.3	4033.2	2653.2	5017.2	3637.2	0.7	0.7
494.7	361.3	430.7	329.3	3785.4	1925.4	4949.4	3089.4	0.5	0.6
532.7	320.7	446.0	333.3	3174.3	1370.1	3966.3	1926.3	0.4	0.5
527.3	326.0	514.7	350.7	3871.5	1771.5	4915.5	2815.5	0.5	0.6
426.0	322.0	428.0	324.7	4603.5	3103.5	5593.5	4093.5	0.7	0.7
402.0	338.7	439.3	346.7	4733.7	3293.7	5525.7	4085.7	0.7	0.7
434.7	320.7	434.0	333.3	2924.4	1064.4	3932.4	2072.4	0.4	0.5
465.3	324.7	504.0	334.0	4059.6	2319.6	4881.6	3141.6	0.6	0.6
460.7	334.7	418.0	332.7	3788.1	2348.1	4712.1	3272.1	0.6	0.7
622.7	592.0	592.0	572.0	5733.3	4113.3	6000.0	4719.3	0.7	0.8
389.3	286.7	401.3	282.7	3355.2	2095.2	4339.2	3079.2	0.6	0.7
622.7	514.7	546.0	587.3	5496.0	3576.0	6102.0	4182.0	0.7	0.7
609.3	545.3	602.7	562.0	5665.5	4285.5	6060.0	4320.0	0.8	0.7
576.7	516.7	561.3	536.0	6580.8	4720.8	6060.0	4320.0	0.7	0.7
384.0	372.0	448.0	375.3	4705.2	2665.2	5695.2	3655.2	0.6	0.6
608.7	532.0	592.0	586.7	5597.7	3497.7	6000.0	4103.7	0.6	0.7
460.7	333.3	449.3	345.3	2314.2	814.2	3322.2	1822.2	0.3	0.5
462.7	322.0	450.7	309.3	2568.0	1268.0	3390.0	1950.0	0.5	0.6
460.7	362.7	443.3	314.7	3144.0	1284.0	4068.0	2208.0	0.4	0.5
389.3	338.7	423.3	370.7	2343.3	1140.0	2949.3	1209.3	0.5	0.4
359.3	334.0	401.3	312.7	2846.7	1406.7	3830.7	2390.7	0.5	0.6
421.3	464.0	538.0	409.3	4260.0	2640.0	5424.0	3804.0	0.6	0.7
503.3	436.0	480.0	388.7	4903.2	3643.2	5695.2	4435.2	0.7	0.8
532.7	396.0	468.0	396.7	4108.8	2188.8	5152.8	3232.8	0.5	0.6
389.3	326.0	426.7	358.7	3683.5	2206.5	4576.5	3196.5	0.6	0.7
411.3	332.7	416.0	313.3	4293.0	2433.0	5085.0	3225.0	0.6	0.6
404.7	372.0	488.7	324.7	4110.9	2070.9	5118.9	3078.9	0.5	0.6
409.3	286.7	418.7	313.3	3517.2	1417.2	4339.2	2239.2	0.4	0.5
421.3	286.7	445.3	316.7	3715.8	2084.7	4508.7	3008.7	0.6	0.7
384.0	296.7	372.0	290.7	5157.0	3717.0	5763.0	4323.0	0.7	0.8
351.3	261.3	330.0	270.0	3117.9	1257.9	4101.9	2241.9	0.4	0.5
464.7	308.7	384.0	325.3	2293.8	1380.0	3457.8	1717.8	0.6	0.5

528.0	546.0	592.0	556.0	5597.7	4157.7	6060.0	4200.0	0.7	0.7
402.0	356.0	396.0	324.7	4651.2	3031.2	5695.2	4075.2	0.7	0.7
388.0	313.3	401.3	334.0	4890.6	3546.9	5796.9	4536.9	0.7	0.8
63.2	48.5	63.0	54.9	226.8	258.3	284.5	284.5	0.1	0.0
82.8	63.6	82.6	72.0	297.4	338.7	373.1	373.1	0.1	0.1

Hayman numerical method

Genetic components and heritability, **Hayman (1954)** suggested certain assumptions that need to be fulfilled for valid diallel analysis. These include homozygous parents, diploid segregation, no reciprocal differences, no genotype environmental interaction, no epistasis, no multiple alleles and uncorrelated gene distribution. Failure of anyone or any combinations of the assumptions invalidates to some degree the conclusion obtained by means of analysis.

The data obtained here were subjected to the genetical analysis of half diallel table as described by **Hayman (1954)**. The mean values of each cross were used to estimate the different genetic components of variation $\hat{D}$, $\hat{F}$, $\hat{H}1$, $\hat{H}2$, $\hat{h}2$, $\hat{E}$ as defined by

Hayman (1954). The different genetic components of variation and their portions for all traits studied at the two different fertilizer levels are given in Table (3).

Table 3. Component of variation and other statics for traits studied under the two irrigation treatments at two locations (Hayman method)

	Plant height	Ear height						
	ASSUIT	MINIA	ASSUIT		MINIA			
	N	S	N	S	N	S	N	S
E	15.68	15.68	4.57	4.07	5.01	5.05	3.63	4.46
D	15.68	68.79	66.81	68.83	14.72	31.17	47.39	30.87
F	424.29	112.48	109.86	134.02	48.6	51.54	82.35	53.7
H1	6738.15**	6470.12**	6361.74**	6529.88**	1312.76**	1168.48**	1345.51**	1336.40**
H2	6312.49**	6338.96**	6230.70**	6380.00**	1241.81**	1103.38**	1275.32**	1273.85**
h^2	42452.33**	42262.97**	41131.60**	42239.75**	7522.02**	4349.78**	6172.46**	6228.87**
S^2	126893	28860.26	27238.9	26881.86	2697.46	1539.51	2523.81	1514.25
(H1/D)^0.5	5.87	9.7	9.76	9.74	9.44	6.12	5.33	6.58
H2/4H1	0.23	0.24	0.24	0.24	0.24	0.24	0.24	0.24
KD/KR	1.45	1.18	1.18	1.22	1.42	1.31	1.39	1.3
h^2/H2	6.73	6.67	6.6	6.62	6.06	3.94	4.84	4.89
h^2 (n.s)	0.06	0.03	0.03	0.03	0.06	0.07	0.05	0.06
H^2 (b.s)	0.99	0.99	1	1	0.98	0.98	0.99	0.99

Continued

Days to tasseling				Days to silking				Leaf angl			
ASSUIT		MINIA		ASSUIT		MINIA		ASSUIT		MINIA	
N	S	N	S	N	S	N	S	N	S	N	S
0.23	0.35	0.27	0.29	0.23	0.26	0.26	0.14	0.14	0.11	0.11	0.10
1.55	0.96	2.89	3.04	1.77	2.23	2.02	2.6	2.45**	0.53	3.28**	0.94
3.18	1.96	6.2	4.31	3.03	3.86	3.81	2.61	2.73	0.51	4.37	1.47
46.75**	47**	47.78**	47.24**	41.27**	45.44**	42.29**	43.33**	9.67**	4.45**	14.08**	5.86**
41.49**	41.61**	41.46**	41.91**	36.77**	41.38**	37.75**	39.50**	8.42**	3.63**	11.74**	4.53**
2.43	5.96*	4.92	12.19**	13.66**	18**	15.33**	10.10**	5.97**	1.34*	5.72**	1.1
3.21	4.32	5.31	6.57	1.57	8.53	2.73	5.27	0.51	0.27	0.9	0.41
5.49	7	4.07	3.94	4.83	4.51	4.58	4.08	1.99	2.9	2.07	2.5
0.22	0.22	0.22	0.22	0.22	0.23	0.22	0.23	0.22	0.2	0.21	0.19
1.46	1.34	1.72	1.44	1.43	1.47	1.52	1.28	1.78	1.4	1.95	1.91
0.06	0.14	0.12	0.29	0.37	0.43	0.41	0.26	0.71	0.37	0.49	0.24
0.15	0.17	0.12	0.16	0.15	0.1	0.12	0.16	0.18	0.29	0.17	0.25
0.98	0.97	0.98	0.98	0.98	0.98	0.98	0.99	0.95	0.92	0.97	0.94

Continued

Leaf rolling				Leaf proline content/mg				RWC%			
ASSUIT		MINIA		ASSUIT		MINIA		ASSUIT		MINIA	
N	S	N	S	N	S	N	S	N	S	N	S
0.11*	0.12**	0.11	0.11	0.13	0.15	0.54	0.54	0.21	0.21	0.76	0.76
0.19	0.1	0.2	0.06	30.41**	30.68**	29.16**	29.73**	2.09	2.4	1.08	1.58
0.17	-0.07	0.14	-0.04	61.55**	62.11**	59.16**	59.81**	2.29	4.19	1.88	3.81
1.84**	1.09**	1.79**	0.20**	105.23**	100.36**	97.59**	93.97**	41.02**	44.08**	39.94**	43.76**
1.57**	0.94**	1.59**	0.20**	68.29**	63.39**	61.86**	58.10**	34.54**	35.75**	33.55**	35.68**
0.01	0.1	0.03	0.04	23.57**	24.36**	24.85**	24.65**	48.52**	48.02**	48.22**	47.95**
0.03	0.01	0.04	0.001	47.45	35.05	37.69	29.16	12.75	13.56	13.19	12.68
3.11	3.3	2.99	1.83	1.86	1.81	1.83	1.78	4.43	4.29	6.08	5.26
0.21	0.22	0.22	0.25	0.16	0.16	0.16	0.15	0.21	0.2	0.21	0.2
1.34	0.81	1.26	0.69	3.39	3.54	3.49	3.61	1.28	1.51	1.33	1.59
0.01	0.11	0.02	0.2	0.35	0.38	0.4	0.42	1.4	1.34	1.44	1.34
0.22	0.31	0.2	0.24	0.14	0.15	0.15	0.16	0.26	0.26	0.23	0.23
0.83	0.77	0.83	0.48	0.99	0.99	0.97	0.97	0.98	0.98	0.94	0.94

Continued

Ear Weight kg-plot				Kernal Fw				No row ear			
ASSUIT		MINIA		ASSUIT		MINIA		ASSUIT		MINIA	
N	S	N	S	N	S	N	S	N	S	N	S
0.17	0.17	0.77*	0.78**	0.15	0.14	0.16	0.16	0.44**	0.44**	0.44**	0.44**
1.58	0.5	1	1.31	0.54	0.37	0.58	0.54	-0.32	-0.34	-0.32	-0.34
-0.12	0.2	-0.44	1.69	-0.01	0.14	0.45	0.62	-0.53	-0.57	-0.71	-0.57
10.12**	11.75**	7.34**	8.90**	11.11**	10.61**	8.26**	9.31**	3.44**	3.25**	2.88**	2.65**
9.4**	10.29**	7.01**	7.36**	10.15**	9.45**	7.31**	8.13**	3.52**	3.2**	2.93**	2.45**

2.52	11.52**	1.95	6.43**	13.21**	11.48**	11.04**	9.82**	2.4**	0.9*	1.76**	0.59
1.13	0.63	1.25	0.48	0.39	0.45	0.29	0.31	0.02	0.08	0.06	0.13
2.53	4.85	2.71	2.61	4.54	5.35	3.77	4.15	0	0	0	0
0.23	0.22	0.24	0.21	0.23	0.22	0.22	0.22	0.26	0.25	0.25	0.23
0.97	1.09	0.85	1.66	1	1.07	1.23	1.32	0	0	0	
0.27	1.12	0.28	0.87	1.3	1.21	1.51	1.21	0.68	0.28	0.6	0.24
0.32	0.24	0.26	0.18	0.22	0.22	0.21	0.2	0.05	0.1	0.13	0.17
0.95	0.95	0.77	0.76	0.96	0.96	0.94	0.94	0.68	0.68	0.67	0.65

Continued

No of Kernals/row				100-Kernel weight/gm				No of ears/plot			
ASSUIT		MINIA		ASSUIT		MINIA		ASSUIT		MINIA	
N	S	N	S	N	S	N	S	N	S	N	S
0.58	0.53	0.78	0.68	0.14	0.13	0.19	0.13	0.36*	0.82**	0.47**	0.52**
29.05**	5.14	5.99	10.01	20.32**	22.91**	23.87**	24.18**	1.75**	4.09**	1.64**	3.14**
56.94**	8.09	9.86	19.43	35.88**	39.87**	43.00**	42.86**	1.65	5.1**	1.73	2.93*
94.48**	117.43**	95.39**	146.46**	48.29**	49.45**	90.31**	90.80**	10.87**	12.84**	10.53**	9.80**
64**	107.86**	88.81**	131.46**	31.84**	31.57**	67.57**	68.46**	9.94**	10.65**	9.71**	8.82**
136.37**	440.25**	486.95**	518.68**	65.05**	61.53**	52.88**	53.62**	37.24**	65.75**	32.93**	44.88**
42.51	78	20.74	146.8	20.25	18.64	28.4	29.2	0.21	0.46	0.21	0.22
1.8	4.78	3.99	3.83	1.54	1.47	1.95	1.94	2.49	1.77	2.53	1.77
0.17	0.23	0.23	0.22	0.16	0.16	0.19	0.19	0.23	0.21	0.23	0.23
3.38	1.39	1.52	1.68	3.68	3.91	2.72	2.69	1.47	2.09	1.53	1.72
2.13	4.08	5.48	3.95	2.04	1.95	0.78	0.78	3.75	6.17	3.39	5.09
0.07	0.11	0.06	0.08	0.05	0.05	0.1	0.1	0.15	0.14	0.11	0.18
0.97	0.98	0.97	0.98	0.98	0.98	0.99	0.99	0.89	0.8	0.86	0.84

Continued

No of Kernels/ear			
ASSUIT		MINIA	
N	S	N	S
615.64	632.08	551.11	400.49
3884.59	1320.92	450.08	1458.22
8634.27	34345.4**	1329.11	3746.06
29993.58**	31292.27**	29468.20**	42102.32**
24025.6**	91231.39**	27301.38**	37467.09**
43766.44**	103579.6**	112080.21**	103754.60**
3927318	20122280.09	3365590.34	20122455.09
2.78	7.37	8.09	5.37
0.20	0.23	0.23	0.22
2.33	1.33	1.45	1.63
1.82	0.00	4.11	2.77
0.08	0.13	0.08	0.11
0.91	0.96	0.93	0.96

Continued

Feddan yield/kg				DSI	
ASSUIT		MINIA		ASSUIT	MINIA
N	S	N	S		
52643.16	52643.16	56207.83	56207.83	0.0012	0.0005
195704.44	208464.44	210192.17	197432.17	0.0058	0.0052
-2793.70	-63171.14	165137.07	225514.51	0.0105	0.0097
4001989.51**	3624642.13**	2976690.67**	3354038.05**	0.0551	0.0370
3655539.98**	3362728.44**	2636160.24**	2928971.78**	0.0445	0.0290
4755098.66**	5195536.2**	3975222.47**	3534784.93**	0.0524	0.0182
50374675638.92	47681666564.68	37090338103.24	39783347177.48	0.0000	0.0000
4.52	4.16	3.76	4.12	3.08	2.67
0.23	0.23	0.22	0.22	0.20	0.20
1.00	0.91	1.23	1.32	1.84	2.08
1.30	1.60	1.51	1.21	0.00	0.00
0.22	0.23	0.21	0.20	0.19	0.18
0.96	0.96	0.94	0.94	0.00	0.00

D: Component of variance due to additive effects; H1: Component of variance due to dominance effects; H2: dominance effects indicating the symmetry of positive and negative effects of (U) proportion of homozygous parents; h2: dominance effect, estimated as the algebraic sum over all loci in heterozygous phase in all crosses; E: environmental or non-heritable components of variance; H1/D: average degree of dominance over all loci; KD/KR: ratio of total number of dominant to recessive genes in all parents.

The separating of the total genetic variance to its parts via additive and dominance gene effects for the studied characters showed in **(Table 3)**. The results showed dominance (H1 and H2) components were found to be at the significant level at (5%) for all studied character which confirmed their importance in the expression of these characters **(Table 3)**. However (D) component was reached to the significant level only for the normal irrigation treatment for the leaf angel at both locations. All irrigation treatment for leaf proline content at both location, normal irrigation treatment for number of kernel/row at Assuit location and all irrigation treatment for 100 kernel weight and number of ear/plot at both locations.

The (F) component was significant and positive for all irrigation treatment for leaf proline content at both location, normal irrigation treatment for number of kernel/row at Assuit location, all irrigation treatment for 100 kernel weight at both location, stress irrigation treatment for number of ear/plot at Minia location.

Significant differences of environmental variance (E) components were recorded for all irrigation treatment for leaf rolling at Assuit location, all irrigation treatment for ear weight at Minia location and all irrigation treatment for number of rows/ear and number of ear/plot at both locations.

Dominance component of variance (H1 and H2) were significant and/or highly significant for all studied traits and (H1) was greater than (H2) in F1 indicating that positive and negative alleles at loci of these trait were not in proportional equal for parents.

The estimator (h2) were refers to the dominance effect overall heterozygous loci was significant for all studied traits except days to tasseling for normal irrigation treatment at both locations, stress irrigation treatment for leaf angel at Minia location, all irrigation treatment for leaf rolling at both locations, normal irrigation treatment for ear weight/plot at both locations and for stress irrigation treatment for number of rows/ear at Minia location.

Average degree of dominance (H1/D) 0.5 was more than unity for all traits, these finding indicated the involved of an over dominance expression for all characters. However the over dominance observed in such character may not be an index of true over dominance could be based due to linkage epistasis or both together **(Comstock and Robinson, 1952)**.

The gene frequency among maize inbred lines estimated by means of (H2/4H1) indicated a symmetrical distribution of genes with positive and negative effect for plant height for normal irrigation treatment at Minia location, all irrigation treatment for ear height at both location, stress irrigation treatment for leaf rolling at Minia location, normal irrigation treatment for ear weight/plot at Minia location, stress irrigation treatment for number of rows/ear at Assuit location and normal irrigation treatment at Minia location for number of rows/ear.

The distribution seemed to be nearly symmetrical for normal irrigation treatment for plant height at Assuit location, stress irrigation treatment for days to silking at both locations, normal irrigation treatment for ear weight/kg/plot and kernel fw at Assuit location, stress irrigation treatment for number of rows/ear at Minia location, normal and stress irrigation treatment for number of kernel/row at both locations, normal irrigation treatment at Assuit location and for all irrigation treatment at Minia for number of ears/plot and finally for all irrigation treatment for number of kernel/ear at both locations.

Since the ratio of dominance (KD) recessive (KR) alleles was more than one for all the studied characters, these indicates a preponderance of dominant gene in the parents for the characters.

The value of K (h2/H2, which stands for the number of groups of genes that exhibit dominance for each character) was <1 for all the studied characters days to tasseling, days to silking, leaf angel, leaf rolling, leaf proline content and ear weight/plot for normal irrigation treatment at Assuit location and all irrigation treatment at Minia location and all irrigation treatment at Minia location for number of rows/ear and 100 kernel weight. This suggested that just one group of genes showed dominance governed all of them while this parameter could be underestimated, when the dominance effects of all genes was not concerned with equivalent, size and distribution, where the distribution of genes was correlated **(Jinks, 1954)**, or complementary gene interactions occur **(Mather and Jinks, 1971)**.

Heritability values in bored sense (h2b) were relatively low for all characters However, heritability in narrow sense (h2n) was high scored values more 50% except leaf rolling for stress irrigation treatment at Minia location (0.48%) these results confirmed that the environmental effects constitute a major portion of the total phenotypic variation in these characters.

Graphical analysis:

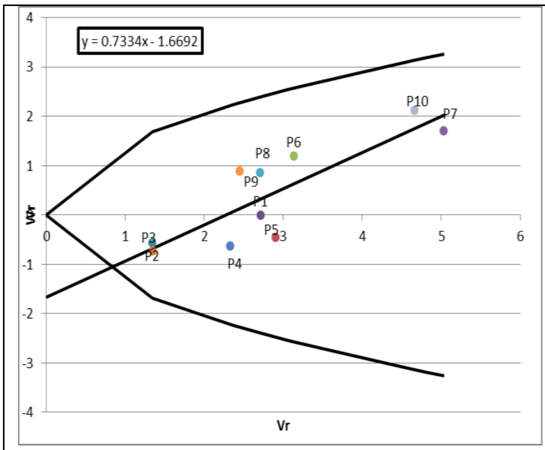
The graph of Wr on Vr prospectively provides information on three points. First, it supplies a test of the adequacy of the model; in the absence of non–allelic interaction and with the independent distribution of the genes among the parents, Wr is related to Vr by straight regression line of unit slope.

Second, a measure of the average level of dominance is provided by the departure from the origin of the point where the regression line cuts Wr axis Finally, dispersion of parent, around the regression line indicates the distribution of dominance and recessive genes among the parents, i.e.,

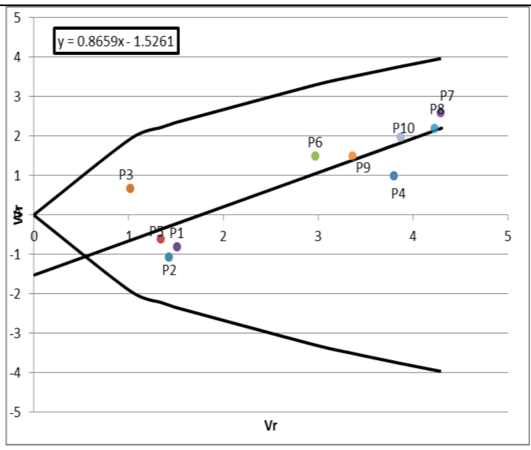
The points nearest the origin are for the arrays derived from parents with most dominant genes, while the parents far from the origin are for arrays derived from parents with most recessive genes. Also, graphical analysis was conducted to assess the genetic relationship among the parents.

The graphical analysis of Feddan yield is given in Figure 1 (A, B, C and D). The Wr on Vr regression lines were found to be shifted to the right of unit slope line and cut Wr axis below the origin point for all irrigation treatment at both locations, revealing the existence of over-dominance controlling this character. The dispersion of the parents around the regression line indicated that inbred line (P6, P9 and P10) is far from the origin and therefore have more recessive genes at all irrigation treatment at both location. P1, P6 and P9 is far from the origin and therefore have more recessive genes at normal irrigation treatment at Minia location and (P6 and P8) is far from the origin and therefore have more recessive genes at stress irrigation treatment at Minia location. Most of the dominant genes for number of feddan yield were distributed in inbred lines (P3) for all irrigation treatment at both location being at the lower end of the regression line.

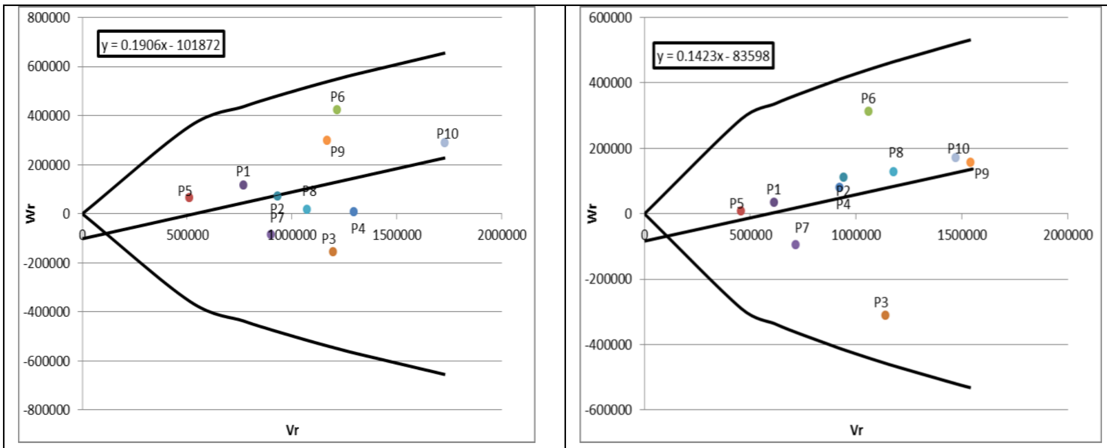
Wr/vr graphs for all irrigation treatment at both locations:



A



B



C D

Fig. 1. The graphical analysis of Feddan yield is given in (A, B, C and D).

Conclusion

The most desirable and/or highest mean performance for all crosses in all trait studied under the two locations and the two irrigation treatments and their combined data were defined. The (F) component was significant and positive for all irrigation treatment for leaf proline content at both location, normal irrigation treatment for number of kernel/row at Assuit location, all irrigation treatments for 100 kernel weight at both location, stress irrigation treatment for number of ear/plot at Minia location. The dispersion of the parents around the regression line indicated that inbred line (P6, P9 and P10) is far from the origin and therefore have more recessive genes at all irrigation treatment at both location. P1, P6 and P9 is far from the origin and therefore have more recessive genes at normal irrigation treatment at Minia location and (P6 and P8) is far from the origin and therefore have more recessive genes at stress irrigation treatment at Minia location

References

Allard, R.W. 1956. The analysis of genetic-environmental interaction by means of diallel crosses. Genetics 41, 305–318.

Allard, R.W., Bradshaw, A.D. 1964. Implications of genotype-environmental interactions in applied plant breeding. Crop Sci. 4, 503–508.

Barrs, H.D., Weatherley, P.E., 1962. A re-examination of the relative turgidity technique for estimating water deficits in leaves. Aust. J. Biol. Sci. 15, 413–428.

Basbag, S., Ekinci, R. Gencer, O. 2007. Combining ability and heterosis for earliness characters in line x tester population of *Gossypium hirsutum* L. Hereditas 144, 185–190.

Bates, L.S., Waldren, R. P., Teare, I.D. 1973. Rapid determination of free proline for water-stress studies. Plant Soil 39, 205–207.

Banziger, M., Edmeades, G.O., Beck, D., Bellon, M. 2000. Breeding for Water Stress and N Stress Tolerance in Maize: From Theory to Practice. CIMMYT, Mexico, D.F., Mexico**.**

El-Hosary, A.A.A., Sedhom, A.S., and EL-Badawy, M.E.L.M. 2011. Genetic and Biotechnological Studies for Important Traits in Maize. LAP Lambert Academic Publishing, ISBN 978-3-8454-4108-5, paperback, 280 Pages http://www.bod.com/index.php?id=3435&objk_id=570116

Hosary A.A., El-Badawy, M.E., Abdallah, T.A.E., El-Hosary, A.A.A., Abou Hussen, I.A. 2013. Evaluation of diallel maize crosses for physiological and chemical traits under drought stress. The 8th Plant Breeding International Conf. 14-15 May. Special Issue. Egypt. J. Plant Breed. 17(2), 357–374.

FAO 2015. FAO Statistics Devision. Food and Agriculture Organization (FAO) of the United Nations, Roma, Italy

Gomez, K.N., Gomez, A.A. 1984. Statistical Procedures for Agricultural Research. John. Wiley and Sons. Inc., New York, 2nd ed.

Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing systems. Austr. J. of Biol. Sci. 9, 463–493.

Hayman, B.I. 1954.The theory and analysis of diallel crosses. Genetics 39, 789–809.

Lucia, O., Ida, D., Chiara, C., Eugenio, C., Mauro, M. 2021. Yield Performance and Physiological Response of a Maize Early Hybrid Grown in Tunnel and Open Air under Different Water Regimes. Sustainability 13, 11251.

Mather, K., Jinks, J.L. 1971. Biometrical Genetics. (2nd ed.), Chapman and Hall Ltd. London.

Jinks, J.L. 1954. The analysis of continuous varation in a diallel cross of *Nicotiana reustica* varieties. Genetics 39, 767–788.

Monje, O.A., Bugbee, B. 1992. Inherent limitations of nondestructive chlorophyll meters. A comparison of two types of meters. Hort. Sci. 27, 69–71.

Umar U.U., Ado, S.G., Aba, D.A., Bugaje, S.M. 2014. Estimates of combining ability and gene action in maize (*Zea mays* L.) under water stress and non-stress conditions. Glob. J. Biol. Agric. Health-care 4 (25), 247–253.