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Diallel Analysis of some Quantitative Traits in Eight Inbred Lines of Maize and Gge Biplot Analysis for Elite Hybrids

Cross Mark

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ABSTRACT

An 8x8 half diallel analysis were performed at two planting dates to study the importance of types of combining ability (GCA and SCA) and its interaction with environment in F_1 of maize. Planting dates (D), crosses (Cr), GCA, SCA, CrxD, GCAxD, SCAxD were significant for all traits. GCA/SCA exceeded the unity for most traits. Non-additive seemed to be more prevalent for plant, ear heights and grain yield plant^{-1}. P8 gave significant positive ($\hat{g}_i$) effects for all studied traits. High SCA effects were exhibited by the crosses P1xP7, P1xP8, P2xP5, P3xP4, P3xP8, P4xP7, P4xP8 and P5xP6 for grain yield plant^{-1} across planting dates. Superiority of P2xP5 and P3xP8 over SC Hytech 2031 reached 13.84 and 6.16%, respectively. However, useful heterotic effects relative to SC 128 mean value were 21.14 and 10.22%, for the aforementioned crosses, respectively. P1xP8, P4xP8 and P5xP6 gave positive insignificant out-yielded than check hybrids. The five superior hybrids P2xP5 (G1), P3xP8 (G2), P5xP6 (G3), P1xP8 (G4) and P4xP8 (G5) along with SC10 (G6), SC 128 (G7) and SC Hytech 2031(G8) were evaluated in 2019 season at various environments using RCBD with 3 replicates to identify environments and suitable adapted maize hybrids. Stable genotypes are ranked descending for means of grain yield as follows: G1 > G8> G2> G7. G1, G8, and G2 were above average stability while genotypes G7 showed below average stability. Thus, G1 (P2xP5) and G2 (P3xP8) are promising crosses, and it's recommended to register as new varieties with high productivity and stability across environments.

Keywords: Combining ability, Diallel analysis, Maize, Gene action, GGE biplot.

INTRODUCTION

To improve any quantitative traits, we should know not only what proportion of the total variation among plants is a direct result to genetic differences but also the nature of genetic variation. Different procedures are available to estimate the inheritance of quantitative traits. The diallel cross system of common usage in this respect for its power and versatility. They are widely used applied simultaneously without restriction that the number of parental combinations, including or excluding parents. Thus, the techniques of analysis can be contrast on the basis of their return in terms of information produced (Ahmed *et al*., 2017 and El-Hosary 2014 a). The types of combining ability and superiority relative to check hybrid and their interaction across environments are essential in developing breeding strategies (Turkey *et al*., 2018).

Furthermore, the magnitude of genetic components for confirmed characters would rely fundamentally upon the environmental flexion's under which the breeding populations will be tested. When information on these points is available, the breeder can decide which of the numerous breeding procedures is most likely to succeed (El-Hosary 2014 a and El-Hosary *et al*., 2018).

The essential final stage in most applied plant breeding programs is the evaluation of promising hybrids over diversified environments (locations and seasons). Determines stability for elite crosses across various environmental conditions with the ultimate goal of improving some quantitative characters in maize is important to support and confirm the results of diallel analysis and estimate the interaction of genotypes across environment and determine the best variety for the best environment. As quantitative inherited trait, grain yield performance of a genotype often varies from one environment to another, leading to a significant genotype x environment (GxE) interaction which can severely limit gain of selecting superior genotypes. Understanding the interaction of those factors and how they affect grain yield is crucial for maintaining high yield (Fan *et al*., 2007 and Dehghani *et al*., 2009).

Using principal components model as multivariate analysis, graphical model have been extensively used including GGE biplot (Yan, 2001). This method give a set of functional graphs that visualize help the plant breeders to explore the interrelationships among studied environments, among tested genotypes and the association between genotypes and environments.

The main objectives of this study were to: 1) estimate type and relative amount of the genetic variance components and their interaction with planting dates, 2) estimate the relative superiority than two check varieties for grain yield plant^{-1} and 3) evaluate yield stability of the elite hybrids derived from diallel cross analysis along with three check hybrids in four locations under different planting date in each location.

MATERIALS AND METHODS

Eight inbred lines of white maize, Moshtohor P_1 (55), P_2 (351-4), P_3 (376), P_4 (321-9), P_5 (347-4), P_6 (334-1-A), P_7 (72-1) and P8 (333-4) with different yielding abilities were used in all diallel combinations without reciprocals giving a

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total of twenty eight crosses during 2017 season. The 28 crosses and two check hybrids (SC 128 and SC Hytech 2031) were evaluated in a randomized complete block design (RCBD) with three replicates in 2018 under two planting dates (16th May and 1st June) at the Agricultural Research and Experimental Station of the Faculty of Agriculture, Moshtohor in adjacent places. In both experiment, each plot consisted of two ridges of five meters length and 70 cm width. Hills were spaced at 25 cm with three kernels per hill on one side of the ridge. Dry method of planting was used in this concern. The seedlings were thinned to one plant per hill. The cultural practices were followed as usual for ordinary maize field in the area. Observations on 10 guarded plants in each plot were recorded to evaluate; plant height (cm), ear height (cm), days to maturity (day), No. of rows ear^{-1}, No. of kernels row^{-1}, 100-kernel weight (g), and grain yield plant^{-1} (g) which was adjusted at 15.5% grain moisture. The data obtained were subjected to genetical analysis of half diallel analysis as described by Griffing's (1956) method 4 model I. The combined analysis of the two experiments was carried out whenever homogeneity of mean squares was detected (Gomez and Gomez, 1984). The relative superiority expressed as the percentage deviation of the F_1 mean performance from the two check hybrids (SC 128 and SC hytech 2031).

All parents were planted in 1st August 2018 to recombine the proved hybrids which superior relative to check hybrids in the previous experiment and to obtain a sufficient amount of grains. The elite hybrids and three check hybrids (SC10, SC 128 and SC hytech 2031) were evaluated in eight trials *i.e.* four locations El Mansoura (El-Dakahlya) – Tala (El-Menofya) – Sids (Baneswif) – Moshtohor (EL-Qaluobya) under different planting date in each location of season 2019. The first planting date was 23, 22, 25 and 22 May and the second one was 13, 12, 15 and 15 Jun for the mention traits, respectively. In each trial the mention crosses were evaluated in a RCBS with three replicates. Each plot consisted of four ridges of 4 m length and 70 cm width. Hills were spaced at 25 cm apart with two grains per hill on one side of the ridge. Dry method of planting was used in this concern. The seedlings were thinned to one plant per hill. The cultural practices were followed as usual for ordinary maize field in the area. The grain yield plant^{-1} was recorded.

The GGE biplot (Genotype main effect plus Genotype by Environment interaction) analysis (Yan, 2001) was proposed to analyze the Multi-Environment Trial (MET) data using graphical presentation. GGE biplot depends on principal components analysis to interpret the two components of genotype (G) and genotype x environment (GxE) interaction, so it is termed as GGE biplot. The graphical presentation of biplot will be valid if the principal components 1 and2 (PC1 and PC 2) explained the largest part (at least 70%) of the two components being genotype (G) and GxE interaction (Yan *et al.,* 2007).

Although, GGE biplot analysis have the ability to generate graphics that allow visual presentation for MET data, but the GGE biplot graphs is highly preferable because they are easily to construct, more effective and more informative diagnostic tool for MET data as stated by Yan *et al.,* (2007) and Yan (2011). Accordingly, in the current work, it is use GGE biplot graph.

RESULTS AND DISCUSSION

The analysis of variance for crosses and combining ability of each and across planting date for all studied traits are illustrated in Table (1).

Table 1. Diallel analysis of traits studied for the 28 crosses among 8 inbred lines of maize evaluated at two planting dates.

S.O.V.	d.f.	Plant height	Ear height	Days to maturity	No of rows ear^{-1}	No of kernels row^{-1}	100-kernel weight	Grain yield plant-1
				The first planting date 16th May 2018				
Replication	2	189.71*	0.15	2.62	0.14	0.89	4.62**	33.66
Crosses	27	2907.93**	692.15**	151.60**	2.05**	27.35**	46.15**	1546.81**
Error	54	56.68	37.37	3.29	0.15	1.09	0.67	109.79
GCA	7	821.85**	74.14**	84.13**	1.09**	9.24**	20.12**	377.80**
SCA	20	1020.92**	285.52**	38.78**	0.54**	9.07**	13.73**	563.83**
Error	54	18.89	12.46	1.10	0.05	0.36	0.22	36.60
GCA/SCA		0.81	0.26	2.17	2.03	1.02	1.47	0.67
				The second planting date 1st Jun 2018				
Replication	2	6.40	20.06	2.05	0.05	8.31**	0.98	151.64*
Crosses	27	681.20**	595.73**	143.30**	1.75**	19.90**	24.29**	855.16**
Error	54	57.32	35.77	3.84	0.11	1.37	0.48	30.75
GCA	7	157.62**	147.31**	90.31**	1.06**	9.95**	14.38**	336.19**
SCA	20	251.37**	216.52**	32.88**	0.42**	5.48**	5.90**	267.16**
Error	54	19.11	11.92	1.28	0.04	0.46	0.16	10.25
GCA/SCA		0.63	0.68	2.75	2.55	1.82	2.44	1.26
				The combined analysis across the aforementioned planting dates				
Planting date (D.)	1	10588.65**	4388.34**	154.79**	6.53**	347.86**	622.80**	10460.91**
Rep. with D.	4	98.05	10.11	2.33	0.10	4.60**	2.80**	92.65
Crosses	27	2647.93**	1051.99**	228.31**	3.69**	32.41**	60.77**	2025.22**
Crosses x D	27	941.19**	235.89**	66.59**	0.12	14.84**	9.67**	376.75**
Error	108	57.00	36.57	3.57	0.13	1.23	0.57	70.27
GCA	7	586.16**	143.28**	145.14**	2.13**	15.06**	33.52**	592.17**
SCA	20	986.41**	423.25**	51.94**	0.91**	9.31**	15.61**	704.09**
GCA x D.	7	393.31**	78.17**	29.30**	0.03	4.12**	0.98**	121.81**
SCA x D.	20	285.88**	78.79**	19.71**	0.04	5.24**	4.01**	126.90**
Error	108	19.00	12.19	1.19	0.04	0.41	0.19	23.42
GCA/SCA		0.59	0.34	2.79	2.33	1.62	2.15	0.84
GCAxD./GCA		0.67	0.55	0.20	0.01	0.27	0.03	0.21
SCAxD./SCA		0.29	0.19	0.38	0.05	0.56	0.26	0.18

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**

Results revealed that highly significant mean squares due to hybrids were detected for all traits in both and across planting dates. That's because, presence of diversity in the parental material and sufficient amount of genetic variability adequate for further biometrical assessment. With the exceptional for No of rows ear^{-1}, significant hybrids by planting dates were detected. This might indicate that hybrids behave somewhat different from planting date to another. For the exceptional trait, insignificant interaction of hybrids with planting date were obtained, revealing that the response of the 28 hybrids may be similar ranked in both environment. The diallel crosses showing the highest and lowest means under each environment for each studied trait are presented in Table (2).

Table 2. The highest and lowest crosses for studied traits except grain yield plant-1, under early, late planting date and the combined across them.

Plant height (cm)						**Ear height (cm)**					
Early D		**Late D**		**combined**		**Early D**		**Late D**		**combined**	
P2 x P5	347.52	P2 x P5	286.55	P2 x P5	317.03	P5 x P6	172.48	P2 x P5	148.33	P2 x P5	153.17
P5 x P7	222.47	P2 x P4	225.94	P1 x P5	227.97	P1 x P5	103.30	P2 x P4	88.27	P2 x P4	97.13
Days to maturity						No of rows ear^{-1}					
Early D		Late D		Combined		Early D		Late D		combined	
P4 x P8	117.39	P2 x P6	117.59	P2 x P6	117.49	P5 x P6	14.62	P5 x P6	14.22	P5 x P6	14.42
P2 x P3	86.36	P1 x P5	89.70	P2 x P3	90.52	P4 x P6	11.33	P4 x P6	10.93	P4 x P6	11.13
No of kernel rows^{-1}						100-kernel weight (g)					
Early D		Late D		combined		Early D		Late D		combined	
P4 x P8	45.52	P3 x P4	39.93	P4 x P8	40.47	P2 x P5	38.52	P5 x P6	34.37	P5 x P6	35.97
P1 x P5	30.17	P5 x P6	29.85	P1 x P5	31.92	P1 x P5	23.12	P1 x P7	22.01	P1 x P5	22.63

The cross P2xP5 exhibited the highest values for plant height under both and across planting date also, showed the highest values for ear height under late planting date and combined data. The cross P5 x P6 gave the highest values for ear height at early planting date and the highest No of rows ear-1 at both and across environments and the heaviest 100-kernel weight at late planting date and the combined analysis. The lateness crosses were detected by crosses P4xP8, P2xP6 and P2xP6 at early, late planting date and combined across them, respectively. The desirable No of kernels row^{-1} were detected by the crosses P4xP8, P3xP4 and P4xP8, at early, late and combined analysis, respectively. The shortest hybrids were found in crosses P5xP7, P2xp4 and P1xp5 at early, late planting date and across them. While the lowest ear height were found by the crosses P1xP5 at early date and P2xP4 at late planting date and the combined analysis. The earliness hybrids were detected by cross P2xP3 at early planting date and combined analysis and P1xP5 at late planting date. The lowest values for No of rows ear^{-1} were showed by the cross p4xp6 at both and across the studied environments. The lowest values of No of kernels row^{-1} and 100-kernel weight were given by the cross P1xP5 at early planting date and the combined analysis, while the crosses P5xP6 and P1 xP7 showed the lowest values at late planting date

Mean performance values of F_1 crosses for the studied traits are presented in Table 3. For plant and ear heights, the crosses: P1xP4, P1xP5, P1xP6, P2xP4, P2xP6, P3xP5, P3xP6, P4xP6, P5xP6 and P6xP7 had the lowest values in both traits compared with check hybrids across the two environments. Short hybrids with low ear height are suitable for high density cultivation, respond to high nitrogen fertilization rates and resist lodging. On the other side, the three crosses P4xP7, P4xP8 and P5xP6 exhibited the highest values for plant high, Sometimes the tallest hybrid is desirable to obtain the highest vegetative mass used in the silage.

Seven F_1 hybrids (P1xP2, P1xP3, P1xP5, P1xP6, P1xP8, P2xP3 and P2xP4) tended to deviate towards earliness compared with check hybrids. Earliness if found in maize is favorable for escaping destructive injuries caused by borer like *Sesamia cretica ledi chilo simplex* But and *Pyrausta nubilialis*. Also, earliness in maturity could plants escapes from high temperatures at the end of the season to ensure good seed filling. These results are in agreement with those obtained by Hefny (2010), and Turkey *et al*., (2018).

The cross P5xP6 had the highest number of rows plant^{-1}compared with the check hybrids. Whereas five crosses (P1xP7, P1xP8, P3xP4, P3xP8 and P4xP8) did not differ significantly relative than SC 128. For 100-kernel weight; the cross P5xP6 expressed the highest values for this trait compared with the two check hybrids.

For grain yield plant^{-1}; three F_1 hybrids (P2xP5, P4xP8 and P5xP6) in the early planting date the two crosses (P2xP5 and P3xP8) at late planting date and the cross P2xP5 at the combined data showed the highest values and differ significantly relative than the check hybrids. Also, the three crosses P1xP8, P3xP4 and P5xP8 expressed high values for grain yield plant without significant differ than check hybrids. The high yield plant^{-1} of the P2xP5 could be attributed to its high No. of ears plant^{-1}. On the other hand, the high grain yield plant^{-1} of the three aforementioned F_1 hybrids could be attributed to the high values of one or more yield components and high No of ear plant^{-1}.

Superiority expressed as the percentage deviation of F_1 performance from SC 128 and SC hytech 2031 mean value for only grain yield plant-1 in each and across planting dates are given in table (4). The cross P2xP5, exhibited significantly heterotic effects in early planting date and the combined analysis. Three hybrids i.e. P2xP5, P4xP8 and P5xP6 in early planting date exhibited significantly heterotic effects which the relative superiority were 21.23, 17.69 and 18.87% compared with SC 128 and 16.79, 13.38 and 14.52 for SC hytech 2031 for the mention crosses, respectively.

Table 3. Average performance of the 28 crosses and two check hybrid SC 128 and Hytech 2031 for all studied traits at the combined analysis across the two planting dates and grain yield plant^{-1} at both and across environments.

cross	Plant height (cm)	Ear height (cm)	Days to maturity	No of rows ear^{-1}	No of kernels row^{-1}	100-kernel weight (g)	Grain weight plant^{-1} (g) Early planting date	late planting date	Combined.
P1 x P2	271.67	136.75	98.02	13.00	37.90	32.42	153.8	148.59	151.2
P1 x P3	266.99	126.77	100.90	12.71	37.84	32.42	151.2	147.34	149.27
P1 x P4	256.32	136.50	110.46	11.51	39.00	31.86	152.34	139.79	146.07
P1 x P5	227.97	103.31	103.50	13.25	31.92	29.63	128.78	119.9	124.34
P1 x P6	253.05	123.50	103.00	13.54	37.61	30.06	137.77	133.92	135.84
P1 x P7	278.93	136.92	111.74	13.30	40.27	33.29	172.52	141.68	157.1
P1 x P8	280.62	146.33	105.23	13.57	39.91	35.07	190.8	161.83	176.31
P2 x P3	283.57	127.18	90.52	12.76	37.74	31.7	156.32	147.53	151.92
P2 x P4	230.10	97.13	107.64	11.75	34.76	33.73	128.93	113.73	121.33
P2 x P5	317.03	153.17	113.86	13.05	37.81	39.35	212.12	196.37	204.24
P2 x P6	256.98	136.17	117.45	13.01	39.01	32.78	150.71	143.62	147.16
P2 x P7	271.51	145.43	110.51	12.13	38.36	36.48	158.32	150.43	154.37
P2 xP8	271.70	123.64	114.26	13.22	39.33	31.68	152.45	148.27	150.36
P3 x P4	283.70	136.30	111.50	13.71	39.99	36.14	168.46	157.2	162.83
P3 x P5	254.95	129.00	112.23	13.06	38.02	34.75	149.31	141.93	145.62
P3 x P6	245.75	113.05	112.44	12.64	32.60	39.39	141.04	131.83	136.44
P3 x P7	272.27	128.67	115.55	12.30	38.93	36.56	152.37	145.88	149.12
P3 x P8	277.56	133.67	113.70	13.37	39.76	38.43	186.23	178.67	182.45
P4 x P5	266.61	132.33	113.79	11.72	38.13	39.16	157.4	147.45	152.42
P4 x P6	258.09	120.65	113.71	11.13	35.30	36.59	147.69	132.58	140.14
P4 x P7	293.39	122.98	109.61	11.87	39.13	30.88	161.88	139.59	150.74
P4 x P8	289.43	132.57	112.53	13.60	40.47	36.27	205.93	138.58	172.26
P5 x P6	288.35	150.41	114.88	14.42	34.69	42.97	207.99	145.57	176.78
P5 x P7	228.29	117.50	115.37	11.83	33.02	35.2	133.71	121.67	127.69
P5 x P8	295.65	143.19	109.94	13.62	37.59	37.42	161.01	158.83	159.92
P6 x P7	247.50	112.09	110.03	12.28	39.09	33.7	133.36	124.68	129.02
P6 x P8	266.56	128.14	114.17	12.86	37.97	34.36	166.35	138.6	152.47
P7 x P8	273.23	120.70	116.93	12.67	37.80	34.68	155.2	136	145.6
SC128	274.00	148.00	111.00	13.40	41.10	37.71	179.3	154.2	166.25
SC 2031	282.00	162.00	120.00	12.40	34.80	41.7	182.4	162.1	172.25
LSD 5%	8.64	6.92	2.16	0.41	1.27	0.86	17.02	9.01	9.59
LSD 1%	11.43	9.16	2.86	0.54	1.68	1.14	22.57	11.94	12.69

Table 4. Relative superiority percentage relative to the two check hybrids SC 128 and SC hytech 2031 for grain yield plant-1 across the two planting dates.

Cross	Relative superiority % than SC 128 For grain yield plant-1			Relative superiority % than SC hytech 2031 For grain yield plant-1		
	Early planting date	Late planting date	Combined	Early planting date	Late planting date	Combined
P1 x P2	-12.10*	-3.64	-8.13**	-15.32**	-8.33**	-12.02**
P1 x P3	-13.59**	-4.45	-9.31**	-16.75**	-9.10**	-13.15**
P1 x P4	-12.94**	-9.34**	-11.25**	-16.12**	-13.76**	-15.01**
P1 x P5	-26.40*	-22.24**	-24.46**	-29.10**	-26.03**	-27.65**
P1 x P6	-21.26**	-13.15**	-17.47**	-24.15**	-17.39**	-20.96**
P1 x P7	-1.40	-8.12**	-4.55	-5.01	-12.60**	-8.59**
P1 x P8	9.04	4.94	7.12*	5.05	-0.17	2.59
P2 x P3	-10.66*	-4.32	-7.69*	-13.93**	-8.99**	-11.60**
P2 x P4	-26.32**	-26.24**	-26.28**	-29.02**	-29.84**	-29.40**
P2 x P5	21.23**	27.35**	24.09**	16.79**	21.14**	18.84**
P2 x P6	-13.87**	-6.86*	-10.59**	-17.02**	-11.40**	-14.37**
P2 x P7	-9.52	-2.45	-6.21*	-12.83**	-7.20*	-10.18**
P2 xP8	-12.87*	-3.85	-8.65**	-16.06**	-8.53**	-12.51**
P3 x P4	-3.73	1.95	-1.07	-7.25	-3.02	-5.26
P3 x P5	-14.67**	-7.96**	-11.52**	-17.79**	-12.44**	-15.27**
P3 x P6	-19.40**	-14.50**	-17.10**	-22.35**	-18.67**	-20.61**
P3 x P7	-12.92**	-5.39	-9.39**	-16.11**	-10.00**	-13.23**
P3 x P8	6.43	15.87**	10.85**	2.54	10.22**	6.16*
P4 x P5	-10.04*	-4.38	-7.39*	-13.34**	-9.04**	-11.31**
P4 x P6	-15.59**	-14.02**	-14.86**	-18.68**	-18.21**	-18.46**
P4 x P7	-7.48	-9.47**	-8.41**	-10.87*	-13.89**	-12.29**
P4 x P8	17.69**	-10.13**	4.66	13.38**	-14.51**	0.23
P5 x P6	18.87**	-5.60	7.41*	14.52**	-10.20**	2.86
P5 x P7	-23.58**	-21.10**	-22.42**	-26.38**	-24.94**	-25.70**
P5 x P8	-7.98	3.00	-2.84	-11.35*	-2.02	-6.95*
P6 x P7	-23.78**	-19.14**	-21.61**	-26.57**	-23.08**	-24.93**
P6 x P8	-4.93	-10.12**	-7.36*	-8.41	-14.50**	-11.28**
P7 x P8	-11.30*	-11.80**	-11.53**	-14.55**	-16.10**	-15.28**

*** and ** significant and high significant at 0.05 and 0.01 levels of probability, respectively.**

However, the two single crosses P2xP5 and P3xP8 out-yielded the two check hybrids at late planting date and combined analysis. The useful heterotic effects relative to SC 128 mean values were 27.35 and 15.87 at late planting date and 21.14 and 10.22% at the combined analysis, for the aforementioned crosses, respectively. However the relative superiority relative to SC hytech 2031 reached 21.14 and 10.22% at late planting date and 13.84 and 6.16% at the combined analysis, for the mention traits, respectively. Five, eleven and five crosses expressed insignificant different relative to SC 128 in early, late planting date and the combined analysis, respectively. However, five, three and five crosses showed insignificant different relative to SC hytech 2031. In addition, the crosses P1xP8 and P4xP8 in the combined across environments gave positive insignificant out-yielded the two check hybrids SC 128 and SC hytech 2031. Hence, it could be concluded that both crosses offer good possibility for improving grain yield of maize.

The variance associated with both types of combining ability (Table 1) i.e. general and specific were significant for all studied traits in both and across planting dates, revealing that both additive and non-additive types of gene action were involved in determining the performance of single- cross progeny. The genetic variance reported by El-Rouby *et al*., (1973) to be mostly due to additive type of gene action for earliness. The non-additive genetic variance was reported by, Osman *et al*., (2012), Zare *et al*.,(2011), Abdel-Moneam *et al.,(* 2014), El-Ghonemy (2015) and Kamara (2015) to be most prevalent for grain yield and most of its components. However other researchers Ibrahim (2012) and El-Hosary (2014 b) found that the additive play the major role in inheritance of grain yield. Mousa (2014) and El-Hosary and El-Fiki (2015) reported that both additive and non-additive effects were equal in expression of genetic variability for the yield and its components traits in maize. GCA mean squares were higher than those of SCA as indicated by the ratio GCA/SCA. This indicates that the largest part of the total genetic variability associated with these traits may be due to additive and additive by additive gene action types. Therefore, it is concluded that selection procedures based on the accumulation of additive effects should be very successful in improving each of studied traits. Vice versa ratio GCA/ SCA was less than unity for plant and ear heights in both and across planting date as well as grain yield plant-1 at early planting date and the combined analysis. Therefore, it could be concluded that the large portion of total genetic variability associated with these traits is due to non-additive gene action. The largest heterotic magnitude expressed by the previous traits as the deviation of particular F1 mean performance from the check hybrid. May strength the conclusion about the importance of non-additive gene effects in their inheritance.

Significant interaction of planting dates with both types of combining ability were detected for all the studied traits except, No of rows ear^{-1}, revealing that the magnitude of all types of gene action varied from planting date to another. On the contrary, insignificant interaction mean square was detected for the exception trait, revealing that all types of gene action did not appreciably fluctuate in magnitude from environment to other. It's fairly evident that the ratio for GCAxD/ GCA was higher than ratio of SCAxD/SCA for plant and ear heights and grain yield plant-1. These results indicated that the additive effect was more influenced by the environmental conditions than non-additive effects. For other traits, the ratio of SCAxD/SCA was higher than GCA xD/ GCA. These results indicated that the non-additive effects were more influenced by planting date than additive genetic effects. In the same trend, El-Gonemy (2015), reported that SCA was important in the inheritance of grain yield plant^{-1} and other agronomic traits. The magnitude of the interactions for SCA x sowing date (SD) was generally higher than for GCA x SD. This finding indicates non-additive type of gene action to be more affected by sowing date (SD) than additive and additive x additive types of gene action. This is in agreement with the findings of several investigators who reported that SCA is more sensitive to environmental changes than GCA (Gilbert 1958 and El-Badawy 2013).

General combining ability effects ($\hat{g}_i$) calculated for each parent (Table 5). These effects compare the average performance of each with the other one and facilitate the selection of parent for incorporation into or initiate the selection of lines for subsequent improvement. GCA effects ($\hat{g}_i$) estimated herein were found to differ significantly from zero. High positive values would be of interest under all traits in question except days to maturity as well as ear height where high negative effects would be useful from the breeder's point of view.

Table 5. Estimates of the relative GCA effects of parental inbred line for the studied traits across the two planting dates.

Parental lines	Plant height (cm)	Ear Height (cm)	Days to maturity	No of rows ear^{-1}	no of kernels row^{-1}	100-kernel weight (g)	Grain yield plant^{-1} (g)
p1	-6.90**	1.09	-6.33**	0.24**	0.16	-3.25**	-3.85**
p2	4.27**	2.66**	-3.10**	-0.09	0.24	-1.02**	2.89
p3	1.31	-1.48	-2.34**	0.18**	0.23	0.86**	2.40
p4	0.12	-4.17**	1.40**	-0.70**	0.55**	0.06	-2.91
p5	0.32	4.23**	2.12**	0.25**	-2.05**	2.38**	4.63**
p6	-10.11**	-3.25**	2.47**	0.07	-1.20**	0.93**	-7.57**
p7	-1.97	-3.20**	3.15**	-0.51**	0.52**	-0.58**	-8.27**
p8	12.97**	4.12**	2.65**	0.57**	1.56**	0.61**	12.69**
LSD5%(gi)	3.31	2.65	0.83	0.16	0.49	0.33	3.68
LSD1%(gi)	4.39	3.52	1.10	0.21	0.64	0.44	4.88
LSD5%(gi-gj)	5.01	4.01	1.25	0.24	0.74	0.50	5.56
LSD1%(gi-gj)	6.64	5.32	1.66	0.32	0.98	0.66	7.37

*** and ** significant differences from zero at 0.05 and 0.01 levels of probability, respectively.**

Significant negative ($\hat{g}_i$) effects were exhibited by P1 and P6 for plant height; P4, P6 and P7 for ear height; P1, P2 and P3 for days to maturity, while, the significant desirable ($\hat{g}_i$) effects were detected by P1, P3, P5 and P8 for No of rows ear-1; P4, P7 and P8 for No of kernels row-1; P3, P5, P6 and P8 for 100-kerenel weight and P5 and P8 for grain yield plant-1. The parental inbred line no 8 gave significant positive ($\hat{g}_i$) effects for all studied traits it ranked one for grain yield plant-1. Although, this parent give Significant positive ($\hat{g}_i$) effects for plant height, this indicates the strength of the green growth of crosses in which this parent enters. Its worth mentioning that the parental inbred line which possessed high ($\hat{g}_i$) for grain yield plant-1 might also be so for one or more of traits contributing to yield.

Estimates of specific combining ability ($\hat{s}_{ij}$) effects in the twenty eight for the studied traits across the two planting dates are presented in Table (6) the most desirable inter and intra-allelic interactions were exhibited by the hybrids P1xP5, P2xP4, P2xP8, P3xP6, P5xP7 and P6xP7 for both plant and ear heights, P1 x P2, P1 x P5, P1 x P6, P2 x P3, P4 x P7, P5 x P8 and P6 x P7for earliness; P1 x P6, P1 x P7, P3 x P4, P4 x P8 and P5 x P6 for No of rows ear^{-1}; P1 x P7, P2 x P5, P2 x P6, P3 x P4, P3 x P5, P4 x P5 and P6 x P7 for No of kernels row^{-1}, P1 x P2, P1 x P7, P1 x P8, P2 x P5, P2 x P7, P3 x P6, P3 x P7, P3 x P8, P4 x P5 and P5 x P6 for 100-kerenl weight; P1 x P7, P1 x P8, P2 x P5, P3 x P4, P3 x P8, P4 x P7, P4 x P8 and P5 x P6 for grain yield plant^{-1}. These crosses may be of prime importance in breeding programs whether towards hybrid maize production. If cross showing high specific combining ability involve only one good combiner such combinations would throw out desirable transgressive segregates providing that the additive genetic system present in the good combiner and complementary and epistatic effects present in the crosses act in the same direction to reduce undesirable plant characteristics and maximize the character in view. Therefore, the most previous crosses might be prime importance in breeding program for traditional breeding procedures.

Table 6. Specific combining ability effects for all traits studied across the two planting dates.

Cross	Plant height (cm)	Ear height (cm)	Days to maturity	No of rows ear^{-1}	no of kernels row^{-1}	100-kernel weight (g)	Grain yield plant^{-1} (g)
P1 x P2	6.17	3.92	-2.66**	0.08	-0.14	1.79**	0.27
P1 x P3	4.44	-1.92	-0.55	-0.48**	-0.19	-0.08	-1.17
P1 x P4	-5.03	10.51**	5.27**	-0.81**	0.65	0.15	0.94
P1 x P5	-33.59**	-31.09**	-2.41*	-0.01	-3.83**	-4.38**	-28.33**
P1 x P6	1.92	-3.42	-3.26**	0.46*	1.01	-2.52**	-4.63
P1 x P7	19.67**	9.95**	4.81**	0.80**	1.95**	2.22**	17.33**
P1 x P8	6.42	12.05**	-1.2	-0.02	0.55	2.81**	15.59**
P2 x P3	9.85**	-3.07	-14.17**	-0.11	-0.37	-3.03**	-5.26
P2 x P4	-42.42**	-30.43**	-0.77	-0.24	-3.67**	-0.21	-30.54**
P2 x P5	44.31**	17.20**	4.72**	0.11	1.98**	3.10**	44.83**
P2 x P6	-5.31	7.68*	7.96**	0.25	2.33**	-2.03**	-0.05
P2 x P7	1.08	16.90**	0.34	-0.04	-0.04	3.18**	7.86
P2 xP8	-13.67**	-12.21**	4.59**	-0.05	-0.1	-2.80**	-17.11**
P3 x P4	14.14**	12.88**	2.32*	1.44**	1.57**	0.32	11.45**
P3 x P5	-14.81**	-2.83	2.32*	-0.15	2.20**	-3.37**	-13.30**
P3 x P6	-13.58**	-11.29**	2.19*	-0.39*	-4.07**	2.71**	-10.29*
P3 x P7	4.8	4.28	4.62**	-0.15	0.53	1.38**	3.1
P3 x P8	-4.85	1.95	3.27**	-0.16	0.33	2.06**	15.47**
P4 x P5	-1.96	3.2	0.16	-0.61**	1.99**	1.83**	-1.18
P4 x P6	-0.05	-1	-0.28	-1.02**	-1.69**	0.7	-1.28
P4 x P7	27.11**	1.29	-5.05**	0.3	0.42	-3.50**	10.02*
P4 x P8	8.21*	3.55	-1.64	0.94**	0.72	0.7	10.59*
P5 x P6	30.01**	20.35**	0.17	1.32**	0.3	4.77**	27.83**
P5 x P7	-38.19**	-12.60**	-0.01	-0.68**	-3.09**	-1.49**	-20.56**
P5 x P8	14.23**	5.76	-4.95**	0.02	0.44	-0.45	-9.29*
P6 x P7	-8.55*	-10.53**	-5.71**	-0.05	2.13**	-1.55**	-7.04
P6 x P8	-4.43	-1.8	-1.07	-0.56**	-0.03	-2.08**	-4.54
P7 x P8	-5.9	-9.29**	1.01	-0.17	-1.91**	-0.24	-10.71*
LSD5%(sij)	7.33	5.87	1.83	0.35	1.08	0.73	8.14
LSD1%(sij)	9.72	7.78	2.43	0.46	1.43	0.97	10.79
LSD5%(sij-sik)	11.19	8.97	2.8	0.53	1.64	1.12	12.43
LSD1%(sij-sik)	14.85	11.89	3.71	0.71	2.18	1.49	16.48
LSD5%(sij-skL)	10.01	8.02	2.5	0.48	1.47	1	11.12
LSD1%(sij-skL)	13.28	10.64	3.32	0.63	1.95	1.33	14.74

*** and ** significant at 0.05 and 0.01 levels of probability, respectively.**

The results of combined analysis for grain yield plant-1 was significantly affected by environment which explain 32.11% of the total (G + E + GEI) variation, while genotype and genotype x environment interaction were significant accounted for 58.25% and 9.64% respectively (Table 7) and showed the effect of changes in environments on the yield performance of the genotypes evaluated. Sum of squares for environment cleared that the environments were variously with large difference among environmental means causing because of the variation in response of these crosses to change in environments.

Table 7. Combined analysis of variance for grain yield plant-1 of eight maize genotypes across eight environments at season of 2019.

Source	d.f.	s.s.	m.s.	SS%
Environments	7	28439	4063**	32.11%
Block	16	53	3	
Genotypes	7	51582	7369**	58.25%
Interactions	49	8537	174**	9.64%
IPCA 1	13	5701	439**	6.44%
IPCA 2	11	1177	107**	1.33%
Residuals	25	1659	66	
Error	112	626	6	

*** and ** significant at 0.05 and 0.01 levels of probability, respectively**

The GGE-biplot model account for 96.37% of the total variation of the standardized data contain of 86.89% and 9.48% variance attributable to the first (PC1) and second (PC2) principle component respectively. The relatively percentage (9.64%) of variance for GEI reflects the complexity of the relationship among genotypes and the environment.

Which–won–where or which–is–best for what analysis. Studying the which–won–where pattern of multi environment yield trails is important for the possible existence of different mega–environment in a region (Yan 2001). The polygon view a biplot is the best way to visualize the interaction patterns between genotypes and environments and to effectively interpret a biplot (Yan *et al.*, 2007). With respect to (Fig. 1) the rays divided the biplot into four sectors and the environments fail into one of them. A good feature of this view of GGE-biplot is that the top genotypes for each sector has higher yield than the others in all environments that all fall in the sector, (Yan and Rajcan 2002). Four genotypes i.e. no 1 , 8 , 2 and 7 located on the right of original points. These results revealed that these genotypes had high yield over grand mean. The genotype no 1 exhibited the high grain yield plant-1 and ranked the first genotypes in all environments (Table 8). This genotype recorded the highest average grain yield (large PC1 scores), but the genotypes 6, 4, 3 and 5 were below average (PC1 scores < 0) (Table 8). Genotypes located at the left of the plot origin were less responsive than the vertex genotypes. The biplot showed not only the average yield of genotype (PCA 1 effects), but also how it is achieved, (Kaya *et al*., 2002)

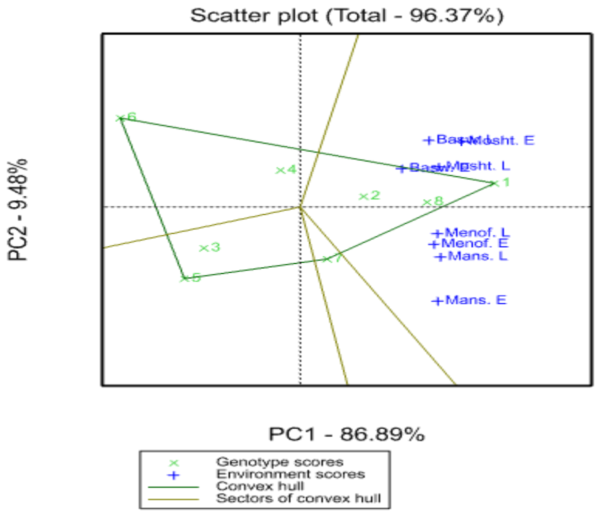

Fig. 1. Polygon view of the GGE-biplot for the which – one – where pattern for genotypes and environments.

Table 8. Genotype code and environments mean grain yield plant-1 of the eight maize genotypes tested across eight environments in season of 2019.

Code	Genotype	Mansoura		El-Menofya		Baneswif		Moshtohor		Mean
		23th May	13th Jun	22th May	12th Jun	25th May	15th Jun	22th May	12th Jun	
1	P2xP5	208.50	197.90	195.50	181.03	183.20	179.27	191.36	169.43	188.27
2	P3xP8	192.19	178.43	174.20	169.08	172.03	158.83	157.76	162.43	170.62
3	P5xP6	178.05	157.81	164.54	148.75	148.63	132.16	132.50	125.17	148.45
4	P1xP8	172.56	155.78	177.38	155.04	167.70	148.86	151.20	145.63	159.27
5	P4xP8	181.03	160.58	163.87	143.33	142.47	124.23	125.11	124.84	145.68
6	SC10	143.43	134.74	138.60	131.00	145.33	137.28	137.83	126.30	136.81
7	SC 128	198.76	174.50	176.67	171.67	159.00	144.48	152.81	143.98	165.23
8	SC Hytech 2031	198.58	180.51	196.67	180.67	167.53	164.54	176.35	165.86	178.84
MEAN		184.14	167.53	173.43	160.07	160.74	148.71	153.12	145.45	161.65

Fig 2. Illustrated that genotypes and environments in GGE biplot in the same plot. The angle between environments vectors provides information on the correlation between environments. An acute angle indicates positive correlation. But, a right angle indicates no correlation and the obtuse angle indicates negative correlation. Thus the fig 2 and Table 8 cleared that the positive correlations between Mansoura and Menofya environments were detected. Also, positive correlation between Moshtohor and Banesweuf environments was found. And vice versa, there were negative correlation between each of Masoura and Menofya environments and others.

As shown in Fig. (3), the percentage of total variation of the two-way interaction table that is explained by the first two principal components (PC1 and PC2) was 96.37 % indicating the goodness of fit and validity of the GGE biplot method. The straight line with a single arrow (abscissa) passes through the biplot origin is referred to as Average Environment Coordinate (AEC). The arrow direction points to higher mean performance for genotypes. The small circle that spotted on this line represents the average of environment PC1 and PC2 scores. It is defined by the average coordinates of all tested environments in the biplot. However, the line (ordinate) passes through the biplot origin and is perpendicular to the AEC line indicates to the stability proper. Thus, the genotype located closer to AEC line in the two directions had more stable yield and vice versa is right.

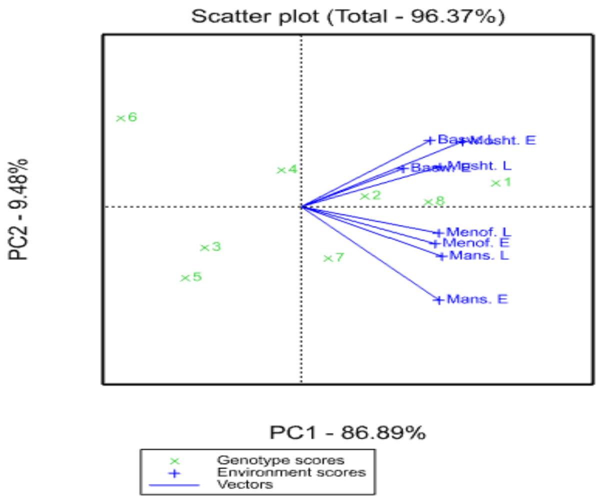

Fig. 2. Biplot of relationships among six environments

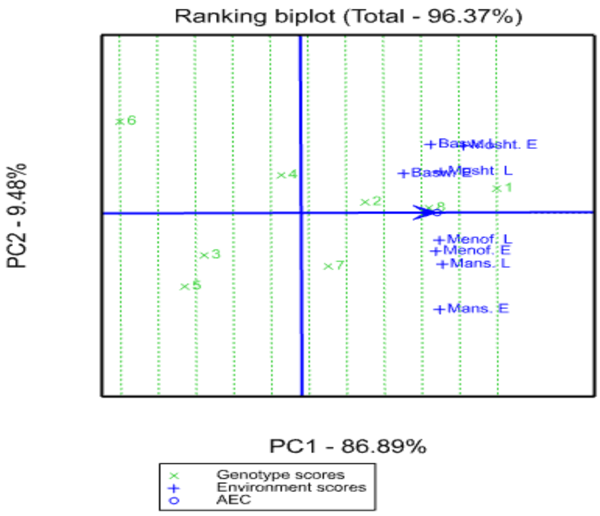

Fig. 3. The mean *vs.* stability view of the GGE biplot.

Consequently, the genotypes with above-average mean are descending ranked as follows: G1 > G8> G2> G7, whereas the remaining genotypes had below-average mean yield. Concerning the stable genotype regardless G1, G8, and G2 the high yield, the genotypes located very close to AEC line were reflecting their above average stability while genotypes G7 showed below average stability because it were slightly placed away from AEC abscissa .

In the conclusion, length of the average environment vector was sufficient to select genotypes based on yield mean performance. So, the genotypes 1 and 2 could be selected while the rest may be cancel. Also, a longer projection to the average environment all coordination (AEC) (Fig. 2). Regardless of the direction, represents a greater of the GEI genotypes which indicates that it is more variable and less stable across environments or vice versa. The current results are in a parallel line with those obtained with Dehghani *et al.*, (2006 and 2009), Often, GGE biplot graph is clear and easy to understandable when few genotypes and environments are used. While, if many genotypes and environments are used, the graph become so crowded that could be difficult to visualize and interpret.

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التحليل النصف تبادلى لبعض الصفات الكمية فى ثمانية سلالات من الذرة الشامية و تحليل الثبات بطريقة GGE BIPLOT للهجن المتفوقة

احمد على الحصرى

قسم المحاصيل – كلية الزراعة – جامعة بنها

تم إجراء التهجين النصف تبادلى بين ثمانية سلالات من الذرة الشامية وقيم الجيل الاول تحت ميعادى زراعه وذلك لتقدير القدرة على التالف (عامة و خاصة) و تفاعلهم مع البيئة. كان التباين الراجع الى ميعادى الزراعة و الهجن و القدرة العامة و الخاصة على التآلف و كذلك التفاعل مع البيئة معنويا لمعظم الصفات المدروسة. وجد أن التأثير الغير مضيف يلعب الدور الاكبر فى توريث صفات طول النبات و ارتفاع الكوز و محصول حبوب النبات. أظهر الأب الثامن قدرة تألف معنوية موجبة لكل الصفات المدروسة. كانت قيمة القدرة الخاصة للتآلف عالية فى الهجن 1X7, 1X8, 2X5, 3X4, 3X8, 4X7, 4X8 و5X6 لمحصول الحبوب للنبات فى التحليل التجميعى لمعادى الزراعة. كانت قوة الهجين ملحوظة لكل من الهجنين 2X5 و 3X8 فى التحليل التجميعي. حققت تلك الهجن تفوق عن هجين المقارنة هايتك 2031 يقدر ب 13.84 و 6.16% لكلا الهجينين على الترتي فى التحليل التجميعى. بينما كان التفوق عن صنف المقارنة فردى 128 يقدر ب 21.14 و 10.22% على الترتيب. تفوقت الهجن 1X8 , 4X 8 و6 X 5 فى التحليل التجميعى على اصناف المقارنة و لكن الزياده كانت غير معنوية. و لتقيم ثبات تلك الهجن المبشرة تم زراعتهم في ثمان بيئات مع ثلاث هجن مقارنه هم فردى 10, فردى 128 و هايتك 2031. و استخدم تصميم قطاعات كاملة العشوائية فى كل بيئة فى موسم 2019. و ذلك بغرض تعريف البيئات و الاصناف الثابته و ايضا تقدير التفاعل و معرفة أفضل الهجن لكل منطقة. أظهرت النتائج أن التركيب الوراثى 2X5 كان أفضل الهجن فى المحصول و الثبات عبر البيئات يتبعه الهجين الفردى هايتك 2031 ثم الهجين الفردى 3X8 و الهجين الفردى 128، بالاضافة الى محصولها العالى حيث تعدت المتوسط العام فى حين ان باقى الهجن كانت اقل من المتوسط العام للتجربة.