J. Plant Production, Mansoura Univ., Vol. 5 (9): 1523-1532, 2014

USING STATISTICAL METHODS TO EVALUATE SOME INBRED LINES OF MAIZE UNDER DIFFERENT SOWING DATE

Hoda E.A. Ibrahim[1] and M.M.M Hassan [2]
1- Center Lab. For Design and Stat. Anal. Res., ARC, Giza. Egypt.
2- Field crops Res. Institute, ARC and Giza. Egypt.

ABSTRACT

GGE biplot analysis is an effective method which is based on the principal component analysis (PCA) in order to fully evaluate multi environmental yield trials (METs). Additive main effects and multiplicative interaction (AMMI) is an alternative method for assessing phenotypic stability and adaptability. In this research, data of 16 maize inbred lines were used to perform AMMI and GGE biplot analysis. These inbred lines were evaluated under four sowing dates during two successive summer seasons of 2012 and 2013. Inbred line by sowing dates table was used for performing the analysis. Based on both mean grain yield and yield stability, inbred lines Giza 603, Sids 34, Giza 629 and Giza 628 proved to be superior and also had greater mean performance among the test inbred lines. Graphic analysis was used to identify the most suitable inbred lines for each tested sowing date. Inbred lines Sids 34, Giza 629, Gemmeiza 1021, Sids 7, Giza 612, Giza 628, Giza 603, Gemmeiza 1004 and Giza 602 were identified as suitable in all sowing dates. The AMMI analysis identified the best sowing date as second sowing date D2 which had the highest PCA1 and the best 1PCA2 values. The GGE biplot graphics revealed four sowing dates were clustered into two groups in all cases Group one included sowing date 1 and 2 Group two included sowing date 3 and 4, inbred line Giza 603the best performer in all inbred lines, followed by Sids 34, Giza 629 and Giza 628.

Inbred lines Giza 603, Sids 34, Giza 628, had the highest yield stability into the best sowing dates. Thus sowing date 1 and 4 are the most discriminative sowing dates. . This inbred lines intervention in the production of many commercial hybrids.

Keywords: maize, GGE biplot, AMMI, PCA, G × E interaction, sowing dates.

INTRODUCTION

Maize (Zea mays L.), one of the major field crops in Egypt. Phenotype is a combination of genotype (G), environment (E) and genotype × environment interaction (G × E). G × E usually complicates the process of selecting superior genotypes**.**

Consequently, multi-environment trials (METs) are widely used by plant breeders for evaluating the relative performance of genotypes over the target environments (Delacy *et al.,* 1996). Additive main effects and multiplicative interaction (AMMI,Gauch, 1992) method is commonly used to analyze MET data and have also been applied in G×E interaction studies in maize and other crops (Bertoia *et al*., 2006; Lee *et al*., 2003; Ades and Garnier-Géré, 1997; Wu and Matheson, 2005; Butrón *et al*., 2004).

The GGE biplot analysis of these data showed that ideal test environments could discriminate superior performing maize from poor ones, and identified four-environments in the target areas. GGE biplot analysis was recently developed to simultaneously use some of the functions of these methods. In phenotypic variation, E explains most of the variation, and G and G × E are usually small (Yan, 2002). However, only G and G × E interaction are relevant to cultivar evaluation, particularly when G × E interaction is determined as repeatable (Hammer and Cooper, 1996). Hence, Yan *et al.* (2000) deliberately put the two together and referred to the combination as GGE. following the proposal of Gabriel (1971), the biplot technique was also used to display the GGE of MET data, and is referred to as a GGE biplot (Yan, 2001; Yan *et al*., 2000).The GGE biplot is in fact a data visualization tool that graphically displays G × E interaction in a two way table (Yan *et al.,* 2000). The GGE biplot is an effective tool for the following applications1. Genotype evaluation (mean performance and stability), and 2. Environmental evaluation (to discriminate among genotypes in target environments). GGE biplot analysis is increasingly being used in G × E interaction studies in plant breeding research (Butron *et al.,* 2004; Dehghani *et al.*, 2006; Kaya *et al.,* 2006; Samonte *et al*., 2005; Yan and Tinker, 2005). AMMI is a multivariate technique for assessing\the phenotypic stability and adaptability of genotypes (Pacheco and Vencovsky, 2005). This method partitions the overall variation into G, E and G × E. The data structure that AMMI and GGE biplot analyses require is a two-way data matrix, such as number of genotypes tested in a number of environments. The experiment may or may not be replicated. These analyses combine two statistical procedures: analysis of variance (ANOVA) and principal component analysis (PCA) (Gauch, 2006). The purpose of this research was to apply GGE biplot and AMMI techniques to study the patterns of G×E interaction in maize; to graphically display means, adaptability and stability of maize inbred lines and to identify suitable inbred lines for each sowing date.

MATERIALS AND METHODS

Sixteen maize inbred lines Table 1 were evaluated in four sowing date during two seasons of 2012 and 2013 using a randomized complete block design (RCBD) with four replications at Sakha Research Station, Kafr, El-Sheikh Governorate. The four sowing date were1st May (D1), 15th May (D2), 1st Jun (D3), and 15th Jun (D4). The same 16 inbred lines were used in each sowing date. All agronomic practices were carried out as recommended. Each plot consisted of two rows, 80 cm in width, 6 m in length and 20 cm between hills, all plants are harvested for grain yield and adjusted to 15.5% moisture, and Bartlet's test of homogeneity of variances and least significant difference test at 5% level of probability was used to compare means. The ANOVA and Graphic analysis (GGE biplot) was performed using GGE biplot software (Yan, 2001). AMMI and GGE biplot methods were used to study the G, E and G × E effects on grain yield. These methods have been described in detail by Gabriel (1971), Yan *et al.* (2001), Yan (2002), Yan and Hunt (2002), Yan and Kang (2003) and Gauch (1992 and 2006).

Table 1: The codes and names of maize inbred lines

Inbred lines codes	Inbred lines names	Inbred lines codes	Inbred lines names
Gm 2	Gemmeiza 2	Gz 602	Giza 602
Gm 4	Gemmeiza 4	Gz 603	Giza 603
Sd 7	Sids7	Gz 612	Giza 612
Gm 18	Gemmeiza 18	Gz 628	Giza 628
Gm 21	Gemmeiza 21	GZ 629	Giza 629
Gm 27	Gemmeiza 27	Gm 1002	Gemmeiza 1002
Sd 34	Sids 34	Gm 1004	Gemmeiza 1004
Sd 63	Sids 63	Gm 1021	Gemmeiza 1021

RESULTS AND DISCUSSION

Regarding to interaction effects data in Table 2 showed that interaction between sowing dates and maize inbred had highly significant effects on all studied traits in both seasons. Gz 603, Sd 34 and Gz 629 inbred had highest grain yield in both seasons under the 2nd sowing date. Whereas, these inbred recorded 26.09, 21.01, and 20.09 ardab/fed, respectively in the 1st season and 28.59, 23.51 and 20.79 ardab/fed, respectively in the 2nd season under the second sowing date for yield.

Table 2:Comparative yield performance of maize (Zea mays L.) inbred lines at different sowing dates during 2012 and 2013 seasons.

Inbred lines	sowing dates 2012											
	No of days to 50% tasseling				No of days to 50% silking				Plant height			
	1st MAY	15th MAY	1st JUN	15th JUN	1st MAY	15th MAY	1st JUN	15th JUN	1st MAY	15th MAY	1st JUN	15th JUN
GM 2	80.25	74.00	72.50	69.25	79.00	73.50	73.00	69.25	199.75	133.75	111.50	96.00
GM 4	72.25	66.00	68.00	67.25	73.25	67.00	69.00	68.00	214.75	214.25	164.750	141.00
Sd 7	72.25	69.00	70.50	70.25	72.00	70.75	71.50	70.50	257.75	255.00	178.25	191.50
GM 18	76.00	70.50	72.00	69.50	77.25	71.75	73.75	70.25	185.75	185.00	132.75	124.25
GM 21	74.00	66.00	66.75	68.25	74.25	67.50	68.25	69.25	201.00	206.00	163.50	155.00
GM 27	76.00	69.50	74.50	72.25	77.25	71.00	76.50	72.75	216.50	217.75	172.50	170.00
Sd 34	71.50	65.75	68.25	67.00	72.25	67.00	69.25	67.75	231.50	236.50	188.50	192.75
Sd 63	76.25	69.75	72.50	71.00	75.50	71.75	74.25	71.50	205.25	193.75	177.00	139.00
Gz 602	72.75	68.00	69.25	69.25	73.25	69.00	69.50	69.75	253.00	279.00	195.00	210.00
Gz 603	72.25	66.50	70.50	69.00	72.50	66.75	71.50	69.25	261.25	255.75	190.25	222.75
Gz 612	71.50	67.75	70.00	65.00	71.75	66.25	71.25	66.25	264.00	270.75	210.75	224.00
Gz 628	72.50	66.50	68.25	68.25	72.25	66.50	69.50	68.00	211.25	204.75	152.25	153.25
Gz 629	70.50	65.00	66.00	65.25	70.75	65.50	67.75	67.50	199.75	209.25	152.75	134.00
Gm 1002	69.25	63.00	64.25	65.25	69.25	63.75	66.75	66.25	209.00	216.50	163.25	164.25
Gm 1004	72.25	67.25	69.00	69.00	72.00	68.5	69.25	69.25	208.25	201.25	163.25	150.25
Gm 1021	71.75	65.25	65.75	64.00	71.25	65.25	65.50	64.00	238.25	228.50	167.50	164.75
L. S. D	3.02				3.1				22.58			

Continue

Inbred	Ear height				Ear				Yield			
	1st MAY	15th MAY	1st JUN	15th JUN	1st MAY	15th MAY	1st JUN	15th JUN	1st MAY	15th MAY	1st JUN	15th JUN
GM 2	105.25	99.75	67.25	61.00	8.00	7.00	2.75	3.75	1.98	2.16	0.835	1.17
GM 4	111.75	114.75	92.75	65.75	34.50	37.25	34.75	28.00	8.66	10.46	8.27	6.01
Sd 7	147.00	139.50	108.00	96.50	59.25	54.25	36.50	29.00	17.46	15.98	10.4	7.88
GM 18	115.25	116.75	85.75	73.50	42.75	51.75	24.25	30.25	6.88	10.56	3.96	5.72
GM 21	107.75	111.75	99.00	80.75	35.75	47.75	43.25	38.25	7.44	11.71	7.62	6.68
GM 27	129.25	125.50	105.75	104.25	55.00	47.25	47.50	39.00	8.26	13.22	7.62	5.33
Sd 34	132.75	132.00	104.25	94.75	49.50	55.5	50.75	44.25	18.93	21.01	16.80	12.91
Sd 63	122.00	124.75	100.50	98.00	41.75	48.25	38.25	26.50	11.47	13.12	9.49	3.86
Gz 602	140.00	149.25	103.75	98.25	52.75	51.00	51.50	48.50	9.61	14.2	12.51	15.11
Gz 603	147.50	143.75	116.25	117.50	63.25	79.25	47.00	49.25	18.16	26.09	13.81	13.77
Gz 612	141.00	140.00	109.50	105.75	60.25	59.00	49.50	43.25	13.68	15.75	11.96	10.6
Gz 628	124.75	118.75	95.75	91.50	46.25	63.25	48.50	40.75	10.98	19.73	12.34	8.44
Gz 629	114.75	112.25	92.75	71.75	46.00	54.00	50.25	33.00	17.55	20.09	12.45	7.84
Gm 1002	114.00	114.75	98.75	81.00	34.50	29.75	34.25	37.75	6.11	7.21	5.75	6.88
Gm 1004	122.75	112.75	98.50	79.75	48.00	48.5	39.75	28.75	15.29	16.21	12.17	8.24
Gm 1021	131.25	119.25	96.00	84.25	43.50	44.5	43.25	38.25	13.98	13.69	10.07	6.68
L .S. D	16.46				11.94				3.18			

Continue

Inbred	sowing dates 2013											
	No of days to 50% tasseling				No of days to 50% silking				Plant height			
	1st MAY	15th MAY	1st JUN	15th JUN	1st MAY	15th MAY	1st JUN	15th JUN	1st MAY	15th MAY	1st JUN	15th JUN
GM 2	75.250	78.750	68.000	64.750	75.500	79.500	67.750	65.750	152.750	166.500	188.25	136.250
GM 4	71.500	70.500	61.250	61.250	71.750	72.250	61.750	63.750	197.250	191.500	190.000	192.500
Sd 7	68.500	72.750	63.250	64.000	71.750	73.000	62.750	64.750	233.25	240.500	228.750	217.000
GM 18	73.500	75.750	67.000	65.750	74.250	78.750	67.500	65.500	184.250	193.750	178.250	159.750
GM 21	71.000	70.500	61.500	63.50	71.500	73.750	63.250	64.250	188.250	189.750	222.500	181.250
GM 27	73.25	75.250	67.000	66.500	73.750	78.000	67.250	67.000	235.500	221.750	208.500	209.250
Sd 34	71.000	72.000	62.750	62.750	71.75	73.000	62.750	64.500	232.250	238.750	232.500	221.750
Sd 63	73.00	76.50	67.500	63.750	73.500	77.000	66.00	65.250	188.250	205.00	193.500	168.000
Gz 602	73.250	74.750	65.000	65.250	73.750	74.750	65.500	65.500	239.500	258.250	263.250	247.750
Gz 603	70.500	72.500	63.250	64.000	70.500	72.500	63.500	65.250	259.000	258.75	241.500	213.250
Gz 612	70.250	71.750	62.500	63.500	70.500	72.250	62.500	65.750	259.250	251.750	241.000	226.000
Gz 628	71.250	72.50	63.500	63.000	71.750	73.000	62.500	63.000	190.000	212.00	194.500	181.250
Gz 629	70.500	71.000	60.750	59.50	71.000	71.250	60.750	60.250	200.750	208.250	211.250	176.750
Gm 1002	68.500	68.750	59.750	59.500	68.500	69.000	59.750	60.250	238.000	187.500	225.000	209.000
Gm 1004	71.750	72.250	62.750	61.250	73.000	74.500	62.000	61.500	213.750	219.500	195.000	183.750
Gm 1021	70.250	70.500	60.750	60.000	71.000	70.750	60.250	60.250	214.000	228.250	226.000	197.500
L .S. D	2.16				1.8				26.57			

Continue

Inbred	Ear height				Ear				Yield			
	1st MAY	15th MAY	1st JUN	15th JUN	1st MAY	15th MAY	1st JUN	15th JUN	1st MAY	15th MAY	1st JUN	15th JUN
GM 2	105.25	99.75	67.25	61.00	97.750	93.25	113.5	85.0	13.43	5.58	4.28	5.77
GM 4	111.75	114.75	92.75	65.75	105.25	94.25	97.50	100.5	10.89	7.22	12.9	5.24
Sd 7	147.00	139.50	108.00	96.50	131.25	115.5	122.8	111.8	19.34	12.72	17.66	9.15
GM 18	115.25	116.75	85.75	73.50	111.0	101.5	107.0	101.0	8.41	7.97	8.51	5.79
GM 21	107.75	111.75	99.00	80.75	104.25	91.75	127.5	103.8	8.95	8.99	11.35	5.74
GM 27	129.25	125.50	105.75	104.25	136.0	116.8	120.8	116.8	11.23	9.49	11.44	3.68
Sd 34	132.75	132.00	104.25	94.75	134.50	121.3	136.5	132.3	24.23	23.51	21.73	12.64
Sd 63	122.00	124.75	100.50	98.00	107.5	110.3	117.3	105.5	14.89	13.88	11.09	5.04
Gz 602	140.00	149.25	103.75	98.25	133.50	124.0	143.3	134.3	16.21	10.16	17.68	10.06
Gz 603	147.50	143.75	116.25	117.50	150.5	144.3	147.5	129.5	17.41	28.59	23.69	14.32
Gz 612	141.00	140.00	109.50	105.75	134.75	128.5	129.8	107.3	21.84	11.48	15.92	5.03
Gz 628	124.75	118.75	95.75	91.50	116.25	117.0	113.3	111.3	19.27	16.58	15.71	11.5
Gz 629	114.75	112.25	92.75	71.75	108.25	111.3	123.8	98.75	18.26	20.79	16.59	12.03
Gm 1002	114.00	114.75	98.75	81.00	139.25	88.75	125.3	116.3	7.44	9.68	10.49	5.02
Gm 1004	122.75	112.75	98.50	79.75	112.50	101.5	116.3	101.3	15.56	9.98	15.44	10.95
Gm 1021	131.25	119.25	96.00	84.25	112.25	115.3	131.0	112.3	23.09	17.23	16.82	6.92
L .S. D	20.83				10.59				3.15			

The ANOVA for grain yield using the AMMI method is presented in Tables 3, 4 and 5 for 2012 and 2013 seasons and the average of the two seasons, respectively. There were significant differences among the inbred lines (G), sowing dates (D) and G × D interaction. Significant G ×D interaction explain 1 1.45%, 12.69% and 9.01% of the total sum of squares for 2012 and 2013 and the two-year average, respectively.

Table 3: Analysis of variance for grain yield of 16 maize inbred lines in four sowing dates during the 2012 cropping season

S.O.V	Df	SS	MS	P > F	% of Total
Inbred lines (G)	15	4320	288.0**	< 0.00000	54.41
Planting dates (D)	3	1485	494.9**	< 0.00000	18.71
DXG	45	909	20.2**	< 0.00000	11.45
IPC1	17	589	34.6**	< 0.00000	7.42
IPC2	15	242	16.1**	< 0.00002	3.05
Residual	13	78	6.0		
Error	180	813	4.5		10.24
Total	255	7939	31.1		

Table 4: Analysis of variance for grain yield of 16 maize inbred lines in four sowing dates during the 2013 cropping season

S.O.V	Df	SS	MS	P > F	% of Total
Inbred lines (G)	15	4702	313.5**	< 0.00000	50.05
Planting dates (D)	3	2532	844.0**	< 0.00000	26.95
DXG	45	1192	26.5**	< 0.00000	12.69
IPC1	17	621	36.5**	< 0.00000	6.61
IPC2	15	315	21.0**	< 0.00000	3.35
Residual	13	257	19.8		
Error	180	913	5.1		9.72
Total	255	9395	36.8		

Table 5: Analysis of variance for grain yield of 16 maize inbred lines in four planting dates during the 2012 and 2013 cropping seasons

S.O.V	Df	SS	MS	P > F	% of Total
Inbred lines (G)	15	4344	289.6**	< 0.00000	59.13
Planting dates (D)	3	1800	599.8**	< 0.00000	24.49
DXG	45	662	14.7**	< 0.00000	9.01
IPC1	17	423	24.9**	< 0.00000	5.76
IPC2	15	157	10.5**	< 0.00000	2.14
Residual	13	82	6.3		
Error	180	427	2.4		5.81
Total	255	7347	28.8		

The AMMI analysis also identified the best planting date as D2 which had the highest PCA1 and the best 1PCA2 values of 1.84 and 1.59, respectively (Table 6). However, high PCAs show unstable yields which could be used in the selection site for genotypes to be grown in specific environments (Akcura *et al*., 2011). Thus, this study identified the sowing dates which optimized genotype selection on the basis of their discriminating ability and representativeness. From the AMMI analysis, inbred lines (G10) Giza 603 and (G7) Sids34 performed well in two of these sowing dates (Table 6).

Table 6: Sowing dates ranked on IPCA scores including the first four recommended inbred lines for each sowing dates based on AMMI the estimates

Sowing dates	Dm	IPCAe[1]	IPCAe[2]	1	2	3	4
D1	12.02	1.00166	-1.84476	Giza603	Sids34	Giza629	Giza628
D2	15.48	1.83742	1.59545	Sids34	Giza603	Giza629	Gemmeiza1021
D3	12.16	-0.45164	0.25233	Sids34	Giza603	Giza629	Giza628
D4	8.00	-2.38744	-0.50165	Giza603	Sids34	Giza602	Giza628

The first two PCs explained 94.80%, 91.18% and 96.31% of the total GGE variation in data for 2012 and 2013 sesons and the two-year average, respectively. The graphical method was employed to investigate sowing dates variation and interpret the G × D interaction Fig. 1.The ranking of 16 inbred lines based on their mean grain yield and yield stability for 2012 and 2013 seasons and the two-year average, respectively, is shown in Fig. 1. It has been reported that when PC1 in a GGE biplot approximates the lines (mean performance), PC2 must approximate the G × D associated with each genotype, which is a measure of instability (Yan *et al*., 2000; Yan, 2002). The line passing through the biplot origin and the sowing dates average is indicated by circles and is known as the average sowing dates coordinate (ADC) axis, which is defined by the average PC1 and PC2 scores for all sowing dates. Projection of genotype markers on to this axis should, therefore, approximate the mean yield of the genotypes. Thus, inbred lines Sids 34, Giza 629, Gemmeiza 1021, Sids7, Giza 612, Giza628, Gz603, Gemmeiza 1004 and Giza602 had higher grain yield, followed by genotypes Gemmeiza 2, Gemmeiza 18, Gemmeiza 27, Sids 63, Gemmeiza 2, Gemmeiza 4 and Gemmeiza 1002 for all data set. The line which passes through the origin but is perpendicular to the ADC with double arrows represents the status of the genotypes' stability. A position in either direction away from the biplot origin, on this axis, indicates greater G × D interaction and reduced stability (Yan, 2002).Therefore, inbred lines Gemmeiza 1021, Sids63 and Giza602 showed a more variable and less stable performance than the other genotypes. Genotypes Giza603, Sids 34, Giza 628, Gemmeiza 2, Gemmeiza 4, Gemmeiza 1002 and Gemmeiza 18 in the two-year average were more stable than the others Fig. 1.

Fig. 2 provides a summary of the interrelationships among sowing dates. The lines connecting the biplot origin and the markers for the sowing dates are called sowing dates vectors. The angle between the vectors of two sowing dates is related to the correlation coefficient between them. Based on the angles of the sowing dates vectors, the four sowing date were clustered into two groups in all cases. Group one included first sowing date (D1) and second sowing date (D2) Group two included third sowing date (D3) and fourth sowing date (D4).

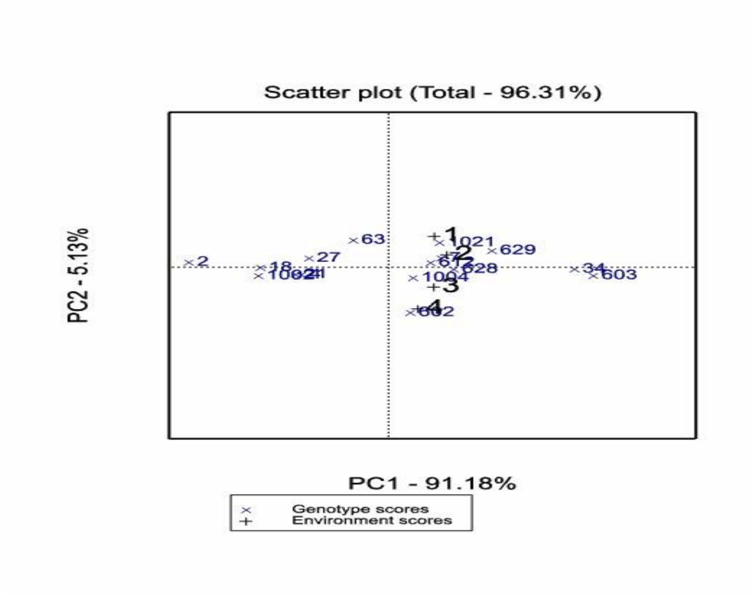

Figure 1: The Average Tester Coordination View (Genotype focus scaling)

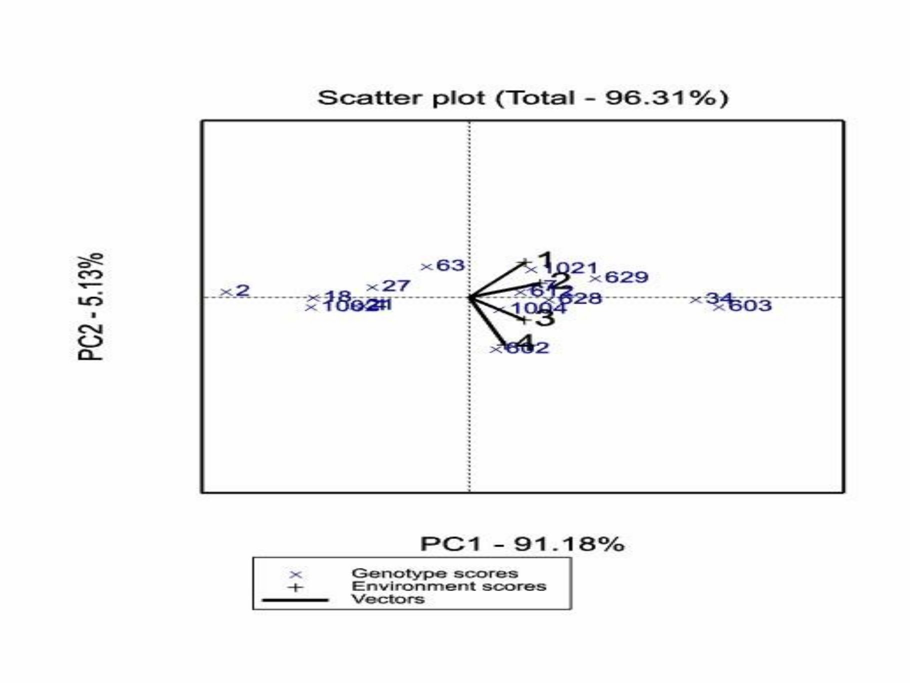

Figure 2: Discriminating power and representativeness of test environments

For example, the fact that the smallest angle is between first, second sowing date and third, fourth sowing date implies that there was the highest correlation between them. The large angle between D1 and D4indicates the poor correlation between these locations Fig. 2. Another interesting observation from the vector point of view of the biplot is that the length of the environment vectors approximates the standard deviation within each environment, which is a measure of its discriminating ability (Yan and Kang, 2003). Thus sowing date1 and 4 are the most discriminative sowing dates Fig. 2. Another important feature of a test sowing date is how much it represents the target sowing date. To measure representativeness using a biplot, an average sowing date has to be defined and used as a reference. Inbred lines Sids34, Giza 629, Gemmeiza 1021, Sids 7, Giza 612, Giza 628, Giza 603, Gemmeiza 1004 and Giza 602 had higher grain yield than the grand mean in sowing date1. Sowing dates could also be ranked according to one inbred line. Inbred line Giza 603 had the maximum grain yield and high yield stability Fig 1.

Sowing dates are ranked along this axis in the direction of the dot representing inbred line Giza 603 in Fig. 2. For example, the relative performance of line Giza 603 in different sowing dates in Fig. 2 ranks as follows: D2>D3>D1>D4. The line perpendicular to the inbred line Giza603 axis separates sowing dates in which inbred line Giza 603is below and above the mean. However, inbred line Giza603 is above the mean in all four sowing dates. It could be summarized that the 16 maize inbred lines showed very high variation for grain yield.- The four sowing date were clustered into two groups in all cases.- Inbred line Giza 603 the best performer in all inbred lines, followed by Sids 34, Giza 629 and Giza 628 - Inbred lines Giza 603, Sids 34, Giza 628 ,had the highest yield stability into the best sowing dates. Thus sowing date 1 and 4 are the most discriminative sowing dates. This inbred lines intervention in the production of many commercial hybrids.

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استخدام طرق احصائية لتقييم بعض سلالات الذرة الشامية تحت مواعيد زراعة مختلفة

هدى السيد العربى ابراهيم[1] و محمد محمود محمد حسان[2]
١- المعمل المركزي لبحوث التصميم والتحليل الاحصائى – مركز البحوث الزراعية – الجيزة – مصر
٢- معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – الجيزة – مصر

اثبتت النتائج أن كلا من تحليل المكون الرئيسى PCA وGGE bi plot وسيلة فعالة لتقييم المحصول فى بيئات متعددة .كما أن النأثيرات الرئيسية المضافة والتفاعل المضاعف AMMI هى طريقة بديلة لتقييم الثبات المظهرى والقدرة على التكيف .
تم إسنخدام ١٦ سلالة من الذرة الشامية لتقييم أدائها تحت ٤ مواعيد زراعة وذلك عن طريق تحليل AMMI, GGE bi plotخلال الموسمين الصيفيين ٢٠١٢و ٢٠١٣ أجريت تحليلات الأداء بإستخدام السلالات من خلال مواعيد الزراعة بناء على كلا من متوسط المحصول وثبات المحصول .

١- أوضحت النتائج أن السلالات جيزة ٦٠٣- سدس ٣٤ – جيزة – ٦٢٩ – جيزة ٦٢٨ متفوقة و كان أكبر متوسط للأداء بين السلالات تحت الدراسة.
٢- تم إستخدام تحليل الرسوم البيانية لتحديد السلالات الأكثر ملائمة لكل بيئة إختبار.
٣-اشارت النتائج ان السلالات سدس ٣٤ –جيزة ٦٢٩- جميزة ١٠٢١ – سدس ٧ – جيزة ٦١٢- جيزة ٦٢٨ – جيزة ٦٠٣ – جميزة ١٠٠٤ – جيزة ٦٠٢ مناسبة لجميع مواعيد الزراعة.
٤- لقد اظهر تحليل AMMI ان أفضل ميعاد زراعة هو الميعاد الثانى الذى أعطى أعلى أول مكون رئيسى وأفضل ثانى مكون رئيسى .
٥- جمعت الرسوم البيانية ل GGE bi plot مواعيد الزراعة الأربعة فى مجموعتين فى كل الحالات أشتملت المجموعة الأولى الميعاد الأول والثانى والمجموعة الثانية الميعاد الثالث والرابع وكان أحسن أداء فى كل السلالات أداء السلالة جيزة ٦٠٣ يليها سدس ٣٤ – جيزة ٦٢٩ – جيزة ٦٢٨وسجلت أعلى ثبات للمحصول السلالات جيزة ٦٠٣- سدس ٣٤- جيزة ٦٢٨كما أن الميعاد الأول والرابع أكثر تمايز على أداء الأصناف. وهذه السلالات تدخل فى إنتاج الهجن التجارية .