Grain Yield Stability To Enhancement Of Food Security Among New Grain Maize Genotypes (Zea Mays L.) In Sudan

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Abstract: Maize consider as the most important cereal crop worldwide, and also per quest for staple food to fill the gap of male nutrition for human. Therefore, to enhancement of maize productivity under Sudan condition through development of high-yielding open pollinated varieties is the main objective of the Maize Research Program. In Sudan low yield of old released varieties causing considerable decrease in yield it restricted to be renewed with the other yielding ones, hence, it's necessary to seeking for anew open pollinated varieties having a high yielding coupled with will adaptability. A multi-environment trial was conducted in representative maize growing areas to evaluate the agronomic performance and stability of elite maize genotypes developed by the program. All the experiments were conducted over ten environments in five locations via Gezira (seasons 2012, 2013, 2014 and 2015), New Halfa (seasons 2012, 2013 and 2014), Sinnar (season 2014), Rahad (season 2015) and Hudiba (season 2015) research stations farms. A total of fifteen maize genotypes with one local check Hudiba-2 were evaluated over ten environments during consecutive cropping seasons, respectively. The plot size were maintained in 2 rows x 5m x 80 cm, with inter row spacing of 20 cm arranged in RCBD design with 3 replicates. The studied agronomic parameters such as days to 50% tasseling, silking, plant height, ear height, and grain yield. The analysis of variance (ANOVA) and AMMI (Additive Main Effect and Multiplicative Interaction) analyses showed that the grain yield was significantly affected by genotypes, environments, and the genotype x environment interaction the stable genotypes for grain yield according to AMMI selection and AMMI Stability Value (MSV) the stable genotypes having a lower AMMI stability value coupled with high mean grain yield and also comparable yields with the check such as HSD-4592 having a mean grain yield of 2318 kg/ha and low AMMI Stability Value (MSV) of 17.7 and another stable genotype was HSD-5514 obtained mean grain yield of 2185 kg/ha and low AMMI Stability Value (MSV) of 2.9. From the obtained results on multi environments' revealed that those genotypes have a high yielding and looking forward to be recommended for released as the promising varieties.

Keywords: Stability, Maize genotypes, grain yield, Sudan.

Introduction

Maize or corn (Zea mays L.) is a cereal crop that is grown widely throughout the world in a range of agro-ecological environments and also it is considered as the third world most important cereal crop after wheat and rice [3]. Maize was introduced into Africa in the 1500s and has since become one of Africa's dominant food crops. Maize is the most important cereal crop in sub-Saharan Africa (SSA) and an important staple food for more than 1.2 billion people in SSA and Latin America. All parts of the crop can be used for food and non-food products. The worldwide production of maize was more than 960 million MT in 2013, in global production was grown at 3.4% from 967 million MT. Cultivated area 2.2% from 177 million hector, USA is the largest production at 37%, China 22%, Brazil7%, and other countries 17% [6]. In Sudan maize is the fourth cereal crop after Sorghum, Millet and wheat [4]. Maize is of recent introduction and occupies 36960 hectares with 70000 tones production and yielded 1894 Kg/hectare it also grown under irrigation in central, eastern and northern States[5]. Maize is among substitute crops to replace the wheat in agricultural schemes especially in irrigated schemes such as Gezira, it can occupy an important position in the economy of the country due to the possibility of blending it with wheat for making bread [5]. There has been an increasing interest in developing Maize cultivates. It is introduced in the diversification policy as a new food crop in the irrigated schemes. Local varieties are adapted to the unfavorable growing conditions; they constitute a good source of genes for breeding program [1]. Moreover, it necessary to develop a new varieties to cope with advantage of high yielding and a good performance, therefore, the objectives of this study to evaluate the agronomic performance and stability of promising maize genotypes in multi-locational and seasonal experiments, to better understand GE interaction and to propose two genotypes for release under Sudan condition.

Materials and Methods

Plant materials: The tested materials consist of fifteen genotypes namely HSD3538, HSD 3537, HSD4292, HSD5007, HSD5011, HSD5158, HSD5514, HSD6695, HSD5872, OBATANPA-IR-#-#, PR-89B-5655, S99TLWQHG-AB-#-#, S99TLWQ-1, S00TLWQ-#-#-# and POOL 15QPM-IR-#-# compared with the one local check (Hudiba-2) to evaluated their yield and it is components in different seasons and locations.

Experimental sites and conditions

Observation nursery trial: this experiment was consisted of forty one accessions conducted in Gezira Research

Farm in seasons 2010, appendix table-1. Preliminary yield trial: in season 2011were conducted two preliminary yield trials for evaluation a total of twenty six genotypes, sixteen of them there were selected from observation nursery trial and ten introduced genotypes appendix tabls-2 and 3, both of them there were grown in Gezira Research Farm. Multi locations trials: from the preliminary yield trial there were selected the elite fifteen genotypes to evaluated their performance and stability over multilocations, these trials were conducted in five locations via Gezira Research Station Farm in seasons 2012, 2013, 2014 and 2015, New Halfa Research Station Farm in seasons 2012, 2013 and 2014, Sinnar Research Station Farm in season 2014, Rahad Research Station Farm in season 2015 and Hudiba Research Station Farm season, 2015 in a total of ten environments. All the experiments were arranged in randomized complete block design with three replicates. The plot size was 2 rows with 5 m long with the inter and intra row spacing of 80 x 20 cm, the seeds were sown in rate of three seeds per hill then thinned to one plant per hill. Fertilization was done using urea in split-applied dose by broadcasting after two weeks from sowing and before flowering stage at a rate of 86 kg ha-1 of N. Irrigation was carried out at 10-14 days intervals to avoid any water stress. Weeding was done manually at least twice to keep the crop free from weeds. Overall, the trials were conducted under standard cultural practices recommended by ARC for maize production.

Data collection

The agronomic parameters were recorded such as days to 50% tasseling, days to 50% silking, plant height, ear height, and grain yield.

Statistical analysis

The statistical analysis was conducted for each location in each year and then combined to test significant differences among the genotypes. The analysis of variance was done according to statistical methods computer package SAS program for each season separately and then combined. Each season-location combination was considered as an environment. Genotypes, environments and their interaction were considered as fixed effects whereas environments and replications nested within environment were considered as random effects. The genotype x environment (GE) interaction was partitioned according to the additive main effect and multiplicative interaction (AMMI) model [2]. The AMMI analysis is an efficient mean to determine stable and high yielding genotypes. Genotypes with a first principal component (PC) axis value near zero represent stable genotypes and their mean performance can be predicted from the main effects model [2] . The number of bilinear terms retained in the analysis was determined according to the proportion of the sum of squares (SS) of the GE interaction explained by each IPCA. To further ascertain grain yield stability according to AMMI Stability Value (MSV) and identify superior genotypes (which won where), genotype and genotype x environment (GGE) were conducted, the lower value AMMI Stability Value (MSV) coupled with higher grain yield consider as stable genotype.

Results and Discussion

The studied genotypes evaluated in may step for selections to verification their yield stability, firstly they were subjected to selection in observation nursery trial and preliminary yield trail.

Observations nursery trial season 2010:

A total of forty one genotypes, twenty nine as accessions introduced from (Gene bank unit of Agricultural Research Corporation) and the twelve genotypes developed locally in maize program presented in table 1 appendix .The experiment was grown in Gezira Research Station Farm, season ,2010 , the plot size was maintained in two rows (5m x 80 cm) for each genotype in non replicated trial, the selection criteria depend on their good performance in grain yield, shortness, earliness and morphological plant aspect during grown season in the field. The grain yield is important trait consider as the best criteria for selection for high yielding genotypes, therefore, from the obtained results the best genotypes selected for grain yield were HSD3537 , HSD 3542 and HSD 4307 . Also the best genotypes for earliness for pollen shedding were given by HSD 5008 and HSD 5158 (44 days),HSD 5009 and HSD 5007 (46 days), HSD 3543 and HSD 3536 (48 days),therefore, the earliest plant for the silk emergence and also have a best anthiess intervals (ASI) genotypes were obtained by HSD 3536, HSD 3543and HSD 5518. The shortness was a desirable trait in windy seasons so the tall plant was subjected to stem and root lodging, therefore, the shortest genotypes were HSD 4308 (108 cm), HSD 3543(109) also there were shown the earliest for time to flowering. The lower ear placement was obtained by HSD 3543 (39 cm) followed by HSD 5510 (47 cm) and HSD 5008 (54 cm). generally, from these results concluded that the selection criteria was build up on the best plant morphological aspect and shortness, earliness and higher grain yield, therefore, a fifteen maize genotypes were selected for further investigation in preliminary yield trial.

Preliminary yield trial:

There were two trials for evaluation, the first was presented in appendix table-2, included a number of fifteen local genotypes such as HSD3540, HSD3538, HSD 3542, HSD3537, HSD3543, HSD4592, HSD5007, HSD5011, HSD5158, HSD5514, HSD5518, HSD6695, HSD5872, HSD5876 compared with the one local check (Hudiba-2) was presented in table -3, the obtained results reveled that most of the genotypes pollen shed in a range of 42-59 days and from 44 -62 days for silk emergence, therefore, the earliest genotypes were HSD-5876,PR89B-5655 and HSD-3543, the short plant type and ear placement was ranged between122 cm for genotype HSD-4592 to 94 cm for HSD-5518, so the ear placement ranged from 37 cm for genotype HSD-5518 to 59cm for HSD-6695, the best genotypes having a high grain yield comparable with the local check and also selected for multi locations trial were HSD3538, HSD 3537, HSD4292, HSD5007, HSD5011, HSD5158, HSD5514, HSD6695 and HSD5872 The another trial included a ten genotypes presented in appendix table-3, namely; S99TLWQHG"AB"-#-#, S99TLWQ-1, S00TLWQ-#-#-#, ACROSS763-#-#, POOL 15QPM-IR-#-#, ACROSS8762-IR-#-#, OBATANPA-IR-#-#, PR-89B-5655, S99TLWQHG-AB-#-# and Hudiba-2 as the local check also was evaluated in Gezira research station farm season

2011for their yield and important yield components. The obtained results were presented in table 4 respectively, the time for flowering have average ranged between 44 days to 51days for pollen shed and from 47 to 54 days for silk emerge, so the earliest genotypes were PR89B-5655, ACROSS763-## and S99TLWQ-# # #, the short plant and lower ear placement were given by genotypes ACROSS8762-IR # #, POOL 15QPM-IR # #and S99TLWQ-1, grain yield was ultimate objective for evaluated these genotypes therefore, the high grain yielding genotypes were OBATANPA-IR-#-#, PR-89B-5655, S99TLWQHG-AB-#-#, S99TLWQ-1, S00TLWQ-#-#-# and POOL 15QPM-IR-#-# . From the two preliminary yield trials and from the rest of twenty six tested genotypes despite of most of them obtained higher grain yield and comparable with local check but only sixteen genotypes having a best agronomic performance coupled with higher grain yield there were selected to evaluated in multi locations trials to verification their grain yield stability.

Multi locations yield trials:
These trials were conducted for verification for yield stability in multi locations for elite sixteen maize genotypes selected from preliminary yield trials, such as HSD3538, HSD 3537, HSD4292, HSD5007, HSD5011, HSD5158, HSD5514, HSD6695, HSD5872, OBATANPA-IR-#-#, PR-89B-5655, S99TLWQHG-AB-#-#, S99TLWQ-1, S00TLWQ-#-#-# and POOL 15QPM-IR-#-# compared with the one local check (Hudiba-2). Grain yield is a complex trait conditioned by the interaction of various growth and physiological processes throughout the life cycle, and it consider as the a polygenic factor affected by other component, and it was ultimate objective of this study coupled with the stability in performance over a wide range of ten environmental condition, therefore, a significant differences in mean grain yield among the tested genotypes were found in all locations, and also most of them obtained higher average mean grain yield and comparable with local check being of 2058.8 kg/ha, therefore, the best three genotypes having higher potential of grain yield were SOOTLWQ-#-#-# obtained (2350.8 kg/ha) followed by HSD-4592 (2275.5 kg/ha) and HSD-5514 (2185 kg/ha) respectively table 4.

Stability analysis:
The ANOVA of AMMI analysis showed that the maize grain yield was significantly ($p < 0.01$) affected by environment (E), genotype (G) and their interaction (GEI). From the total sum of squares due to treatments (G + E + GEI), 92.6 % of the variance was due to E. The GEI accounted for 6.14% while the genotypes explained only 1.23 % of the variance. The total variance due to GE interactions was further partitioned by the first two terms which were shown in Table 6. The first and second principal component analysis (IPCA1 and IPCA2) accounted for 40.2 and 24.4%, respectively. In each environment, the best four genotypes were selected according to AMMI estimate. Among the all environments, Therefore, in all environments, genotype HSD-4592 has been selected 5 times in six environments as one of the best four genotypes and also having a low AMMI Stability Value (ASV) of (2.9) followed by genotypes HSD-5514 selected four times and have low (ASV) of (16.7), while the checks Hudiba-2 was selected one time in one environment (Table 6 and 7 and Fig-1-4). From above results the stable genotypes for grain yield and all so have a comparable yields with the checks were HSD-4592 (2318 kg/ha) and HSD-5514 (2185 kg/ha).

The mean performance of agronomic traits
The tested genotypes were shown a significant differences among the studied traits such as days to 50% flowering , plant height, ear height and grain yield, this was indicates the genetic variability observed among the tested genotypes in different environments.

Days to 50% flowering (tasseling):
The mean days to 50% tasseling indicates the ability of pollen shedding for evaluated maize genotypes and also sign of earliness. The mean days to tasseling across all environments scored 52 days as the general mean, the earliest genotypes over all environments were HSD-5011 tasseled in 50 days followed by HSD-3537 (51 days) and local check Hudida-2 was tasseled in 51days, the latest genotypes were HSD-5876 (56 days), HSD-5872 (55 days) and HSD-5514 (54 days) respectively, table respectively.

Days to 50% flowering (silking):
A significant difference were observed among evaluated genotypes with the general mean being of 54 days, the earliest silk emergence were HSD-5011 (53 days) this was earliest in both flowering time tasseling and silking having anthiess interval of three days, followed by Hudiba-2 (54 days) and HSD-3443 (54 days), on the other hand the late genotypes were shown by HSD-5876 and HSD-5872 both there were late in flowering time tasseling and silking emerged silk in 56 days and having anthiess intervals of one day, followed by HSD-5514 also late in tasseling and silking 56 days and also HSD-3542 (55 days) table 4.

Plant and ear height:
A significant different were detected with the general means of 132.3 cm and 60.1 cm for both plant and ear height. Shortest genotypes were HSD-3540 having 126.4 cm plant height and 55 cm ear placement followed by HSD-5007 obtained 131.5 cm and 57.5 cm also this genotype was earliest in both flowering time tassel and silking and also the local check Hudiba-2 obtained the same results 129.4 cm and 58.1cm respectively. The tallest genotypes and also late were HSD-5518 (137cm and 63.2 cm) followed by HSD-4592 (134.9cm and 62.8 cm) table-4, generally the tallness positively correlated with the lateness in flowering time.

Conclusion
Most of the studied genotypes having a good agronomic performance coupled with higher grain yield and comparable with the check. Therefore, in all environments, genotype HSD-4592 has been selected 5 times in six environments as one of the best four genotypes and also having a low (ASV) of (2.9) followed by genotypes HSD-5514 selected four times and have low (ASV) of (16.7), while the checks Hudiba-2 was selected one time in one environment. From above results the stable genotypes for grain yield and all so have a comparable yields with the checks were HSD-4592 (2318

kg/ha) and HSD-5514 (2185 kg/ha).

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***Table-1** Performance of local accessions genotypes evaluated for yield and important agronomic traits at Gezira Research Station Farm season, 2010.*

ENT. No	Pedigree	Days to 50% tasseling	Days 50% silking	Plant height	Ear height	Grain yield
1	HSD 3540	50	53	144	72	840
2	HSD 3538	49	53	155	75	920
3	HSD 3542	52	55	177	96	1500
4	HSD 3537	52	56	148	80	1600
5	HSD 3536	48	50	153	74	660
6	HSD 3543	48	50	109	39	240
7	HSD 4307	51	53	168	70	1370
8	HSD 4308	47	50	108	49	400
9	HSD 4292	52	54	163	82	760
10	HSD 5007	46	47	134	65	650
11	HSD 5008	44	47	129	54	840
12	HSD 5009	46	49	123	56	600
13	HSD 5010	48	50	135	72	640
14	HSD 5011	48	51	122	57	1200
15	HSD 5158	44	47	139	63	150
16	HSD 5510	52	55	102	47	270
17	HSD 5514	53	54	149	66	420
18	HSD 5518	48	50	146	73	660
19	HSD 6695	50	52	145	69	1100
20	HSD 5872	52	54	164	80	990
21	HSD 5876	51	56	163	84	640
22	HSD 5877	50	52	153	79	1120
23	HSD 10484	49	62	90	43	350
24	HSD 10467	48	61	85	35	430
25	HSD 1042	55	60	103	35	250
26	MUT-101	57	60	164	77	1120
27	MUT-113	48	56	174	85	820
28	MUT-114	56	60	163	82	980
29	MUT-115	52	54	170	90	1530
30	P1(32)	52	54	160	81	1120
31	P2(33)	51	53	145	65	1300
32	P3(35)	49	54	150	65	1000
33	P4(46)	50	52	159	79	950
34	C1(19)	48	50	154	72	1300
35	C2(5)	49	52	145	69	1460
36	C3(26)	49	52	139	77	650
37	C4(2)	51	53	158	76	1370
38	C5(1)	51	54	157	84	1100
39	C6(20)	48	51	142	67	820
40	C7(24)	52	53	151	74	0
41	C8(22)	50	53	142	74	800

Table 2- *The mean performance of sixteen local maize genotypes evaluated at Gezira Research Station Farm season, 2011.*

	Genotypes	DT		DS		PH		EH		GY	
		Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank	Mean	Rank
1	HSD-3540	49	7	53	7	120	2	57	2	787.5	13
2	HSD-3538	52	4	55	4	108	8	55	6	1020.8	9
3	HSD-3542	48	11	51	12	108.3	7	49.3	12	870.8	12
4	HSD-3537	52	5	54	5	100	15	46	14	1008	10
5	HSD-3543	47	13	50	14	111	4	53.7	8	658.3	14
6	HSD-4592	50	6	53	6	122	1	56	3	1029.2	8
7	HSD-5007	48	9	52	9	107	10	55	5	1570.8	1
8	HSD-5011	49	8	53	8	104.3	13	51.7	10	1037.5	7
9	HSD-5158	48	10	51	10	107	11	55.3	4	1100	6
10	HSD-5514	47	12	51	11	113.1	3	53.7	7	1420.8	2
11	HSD-5518	56	2	59	2	94	16	37	16	645.8	15
12	HSD-6695	55	3	58	3	108.6	6	50.3	11	1220.8	4
13	HSD-5872	44	14	51	13	108.7	5	58.7	1	1254.2	3
14	HSD-5876	44	15	47	15	105.3	12	44	15	975	14
15	PR-89B-5655	42	16	44	16	107	9	53	9	1145.8	5
16	Hudiba-2	59	1	62	1	103.3	14	49.3	13	637.5	16
	Mean	49		52		108.1		51.6		1024.1	
	CV%	16.52		16.47		8.92		13.4		30.5	
	F value	1.63^{NS}		1.50^{NS}		1.47^{NS}		1.94*		2.21*	

DT= days to 50% tasseling, DS= days to 50% silking, PH= plant height (cm), EH= ear height and GY= grain yield (t/ha).
,, Significant at 0.05 and 0.01 levels of probability, respectively.*
Note: - those promising advance genotypes were selected from forty one local accessions (table -1)

Table 3- *The mean performance of ten introduced maize genotypes evaluated at Gezira Research Station Farm season, 2011.*

	Entries	DT	DS	PH	EH	GY
1	S99TLWQHG"AB"-#-#	49 ab	52abc	138 a	65.7 a	1083.3 a
2	S99TLWQHG-AB-#-#	51a	54 a	122.3 ab	60.3 a	500.0a
3	S99TLWQ-1	46 c	49cd	120 ab	52.7 a	675.0a
4	S00TLWQ-#-#-#	47 a	52 abc	130 ab	56 a	900.0a
5	ACROSS763-#-#	45 c	47d	131.7 ab	60 a	700.0 a
6	POOL 15QPM-IR-#-#	49 a	53 ab	128.3 ab	59.7a	854.2a
7	ACROSS8762-IR-#-#	49 ab	52abc	129.3 ab	54.3 a	708.3 a
8	OBATANPA-IR-#-#	46 ac	49 bcd	129.3 ab	59a	733.3 a
9	HUDIBA-2	45c	48 d	118.3b	59.7 a	604.2a
10	PR-89B-5655	44 c	47 d	135.7 ab	63a	1045.8 a
	Mean	47	50	128.4	59.1	780.4
	CV%	3.57	3.58	7.53	16.8	41
	F value	6.79**	5.45**	1.34	0.46	0.99

DT= days to 50% tasseling, DS= days to 50% silking, PH= plant height, EH= ear height and GY= grain yield.
,, Significant at 0.05 and 0.01 levels of probability, respectively.*

Table 4 *The mean performance of sixteen maize genotypes evaluated I multilocational trails in ten irrigated environments from seasons , 2012, 2013,2014 and 2015.*

	Genotypes	DT	DS	PH	EH	GY
1	HSD-3540	53.9bcdef	55bcd	125.9 b	51.3d	2000b
2	HSD-3538	53.5efg	54cde	128.6 ab	56.0abcd	1780.9d
3	HSD-3542	54.3abcd	55abc	132.5ab	56.9abc	1920.1cd
4	HSD-3537	54bcde	55abcd	131.1ab	56.9abc	2010.8bcd
5	HSD-3543	53.2fg	54cde	131.3ab	55.5abcd	2143.4abc
6	HSD-4592	53.4efg	54cde	133.9a	52.1bcd	2318 a
7	HSD-5007	54abcde	55abcd	129.9ab	53.7abcd	2036.7abcd
8	HSD-5011	53g	53e	126.3 b	55.6bc	1960.2bcd
9	HSD-5158	53.7defg	55bcd	134.1a	55.5abcd	2015.2bcd
10	HSD-5514	54.5abc	56ab	131.6ab	55.9abcd	21185.6ab
11	OBATANPA-IR-#-#	54bcde	54bcde	134.7a	57.1ab	2163abc
12	PR-89B-5655	53.8cdfe	55abcd	129.1ab	54.6abcd	2077.4abcd
13	S99TLWQHG"AB"-#-#	54.8a	56ab	131.6ab	55abcd	2011.6bcd
14	S99TLWQ-1	54.6ab	56a	130.7abc	55.5abcd	2153.6abc
15	S00TLWQ-#-#-#	54abcde	55abcd	130 ab	55.0abcd	2350.8a
16	Hudiba-2	53.4efg	54de	126.6 b	52.0cd	2075.3abcd
	Mean	53.9	55	130.5	55	2058.8
	CV%	2.5	2.7	9.5	15.5	28.6

F value	3.79***	3..3***	1.6*	1.59*	2.11***

DT= days to 50% tasseling, DS= days to 50% silking, PH= plant height (cm), EH= ear height and GY= grain yield (t/ha).
,, Significant at 0.05 and 0.01 levels of probability, respectively.*

Table 5. *Additive main effects and multiplicative interaction ANOVA for grain yield (kg ha^{-1}) of 16 maize genotypes in 10 environments in seasons 2012,2013 ,2014 and 2015.*

Source of variation	DF	SS	MS	F	Percent explained
Total	479	87352386	873523586	*	
Treatments	159	742981104	4672837	12.55***	
Genotypes (G)	15	9168174	611212	1.64*	1.23
Environments (E)	9	688180914	76464546	81.02***	92.6
Block	20	18875839	943792	2.54***	
GE Interactions	135	45632015	338015	0.91*	6.14
IPCA1	23	18353440	797976	2.14**	40.2
IPCA2	21	11152474	531070	1.43*	24.4
Residuals	91	16126101	177210	0.48	
Error	300	111666643	372222	*	

**** Significant at P < 0.001.*

Table 6 *The best four genotypes in each environment for grain yield according to AMMI selection*

Number	Environments	Estimated Yield(kg/ha)	Best four genotypes				
			Score	1st	2nd	3rd	4th
4	E4	2047	16.07	G5	G7	G10	G16
5	E5	2949	9.17	G15	G16	G11	G12
9	E9	445	8.76	G5	G4	G10	G6
8	E8	762	8.34	G15	G5	G16	G11
3	E3	1126	6.72	G5	G6	G10	G15
6	E6	3270	3.77	G5	G4	G6	G10
1	E1	1370	3.72	G15	G6	G16	G11
10	E10	4027	-6.36	G15	G14	G6	G4
7	E7	1505	-7.60	G15	G6	G14	G12
2	E2	3572	-42.58	G14	G15	G6	G12

E1= Gezira Research Station Farm, season ,2012.
E2= New Halfa Research Station Farm, season ,2012.
E3= Gezira Research Station Farm, season ,2013
E4= New Halfa Research Station Farm, season ,2013.
E5= Gezira Research Station Farm, season ,2014
E6= New Halfa Research Station Farm, season ,2014.
E7= Gezira Research Station Farm, season ,2015.
E8= Sinnar Research Station Farm, season ,2014.
E9= Rahad Research Station Farm, season ,2015.
E10= Hudiba Research Station Farm, season ,2015.

Table7 *the mean grain yield and AMMI stability value (ASV) among sixteen maize genotypes evaluated in ten environments*

Genotypes	Pedigree	Mean (grain yield)	ASV
1	**HSD-3540**	1941	18.9
2	**HSD-3538**	1839	16.8
3	**HSD-3542**	1984	12.1
4	**HSD-3537**	2067	24.9
5	**HSD-3543**	2210	27.4
6	**HSD-4592**	**2318**	**16.7**
7	**HSD-5007**	2057	13.4
8	**HSD-5011**	1979	23.9
9	**HSD-5158**	2063	15.8
10	**HSD-5514**	**2158**	**2.9**
11	**OBATANPA-IR-#-#**	2199	14.6
12	**PR-89B-5655**	2105	23.9
13	**S99TLWQHG"AB"-#-#**	2056	21.5
14	**S99TLWQ-1**	2187	45.5
15	**S00TLWQ-#-#-#**	2411	33.0
16	**Hudiba-2**	2144	29.9

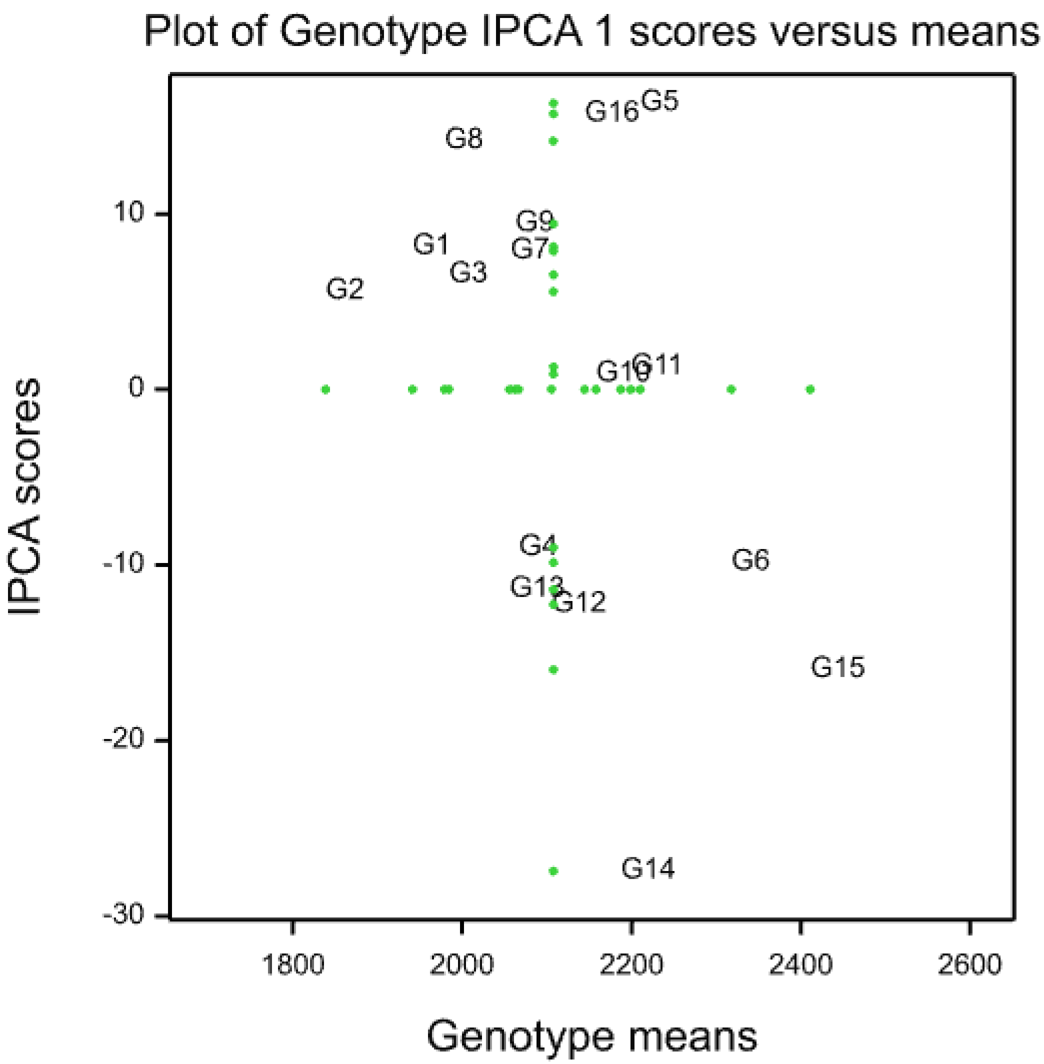

Fig 1 *The plot of genotypes IPCA1 scores versus means of genotypes grain yield.*

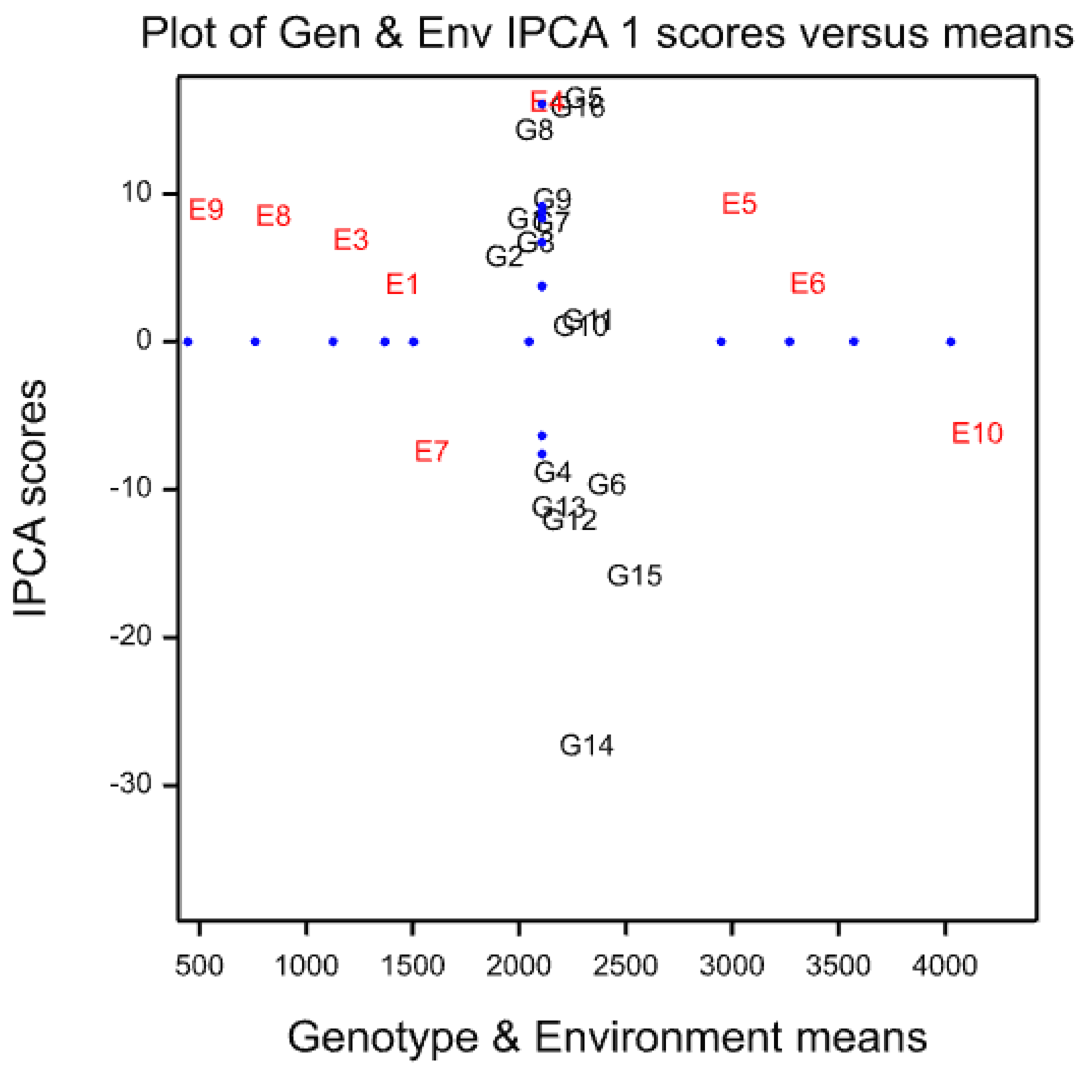

***Fig 2** The plot of genotypes and environment IPCA1 scores versus means of genotypes grain yield and environments effects.*

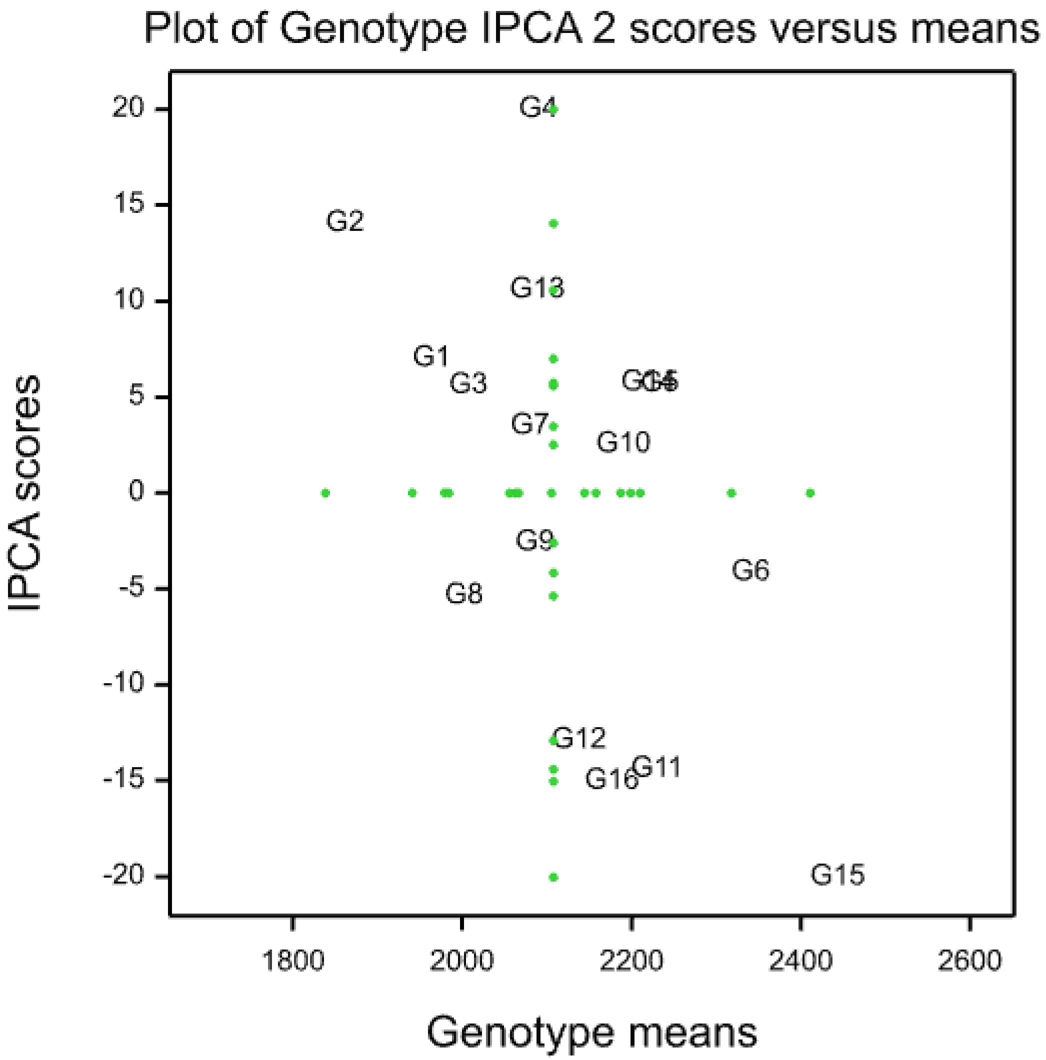

Fig 3: The plot of genotypes IPCA2 scores versus means of genotypes grain yield.

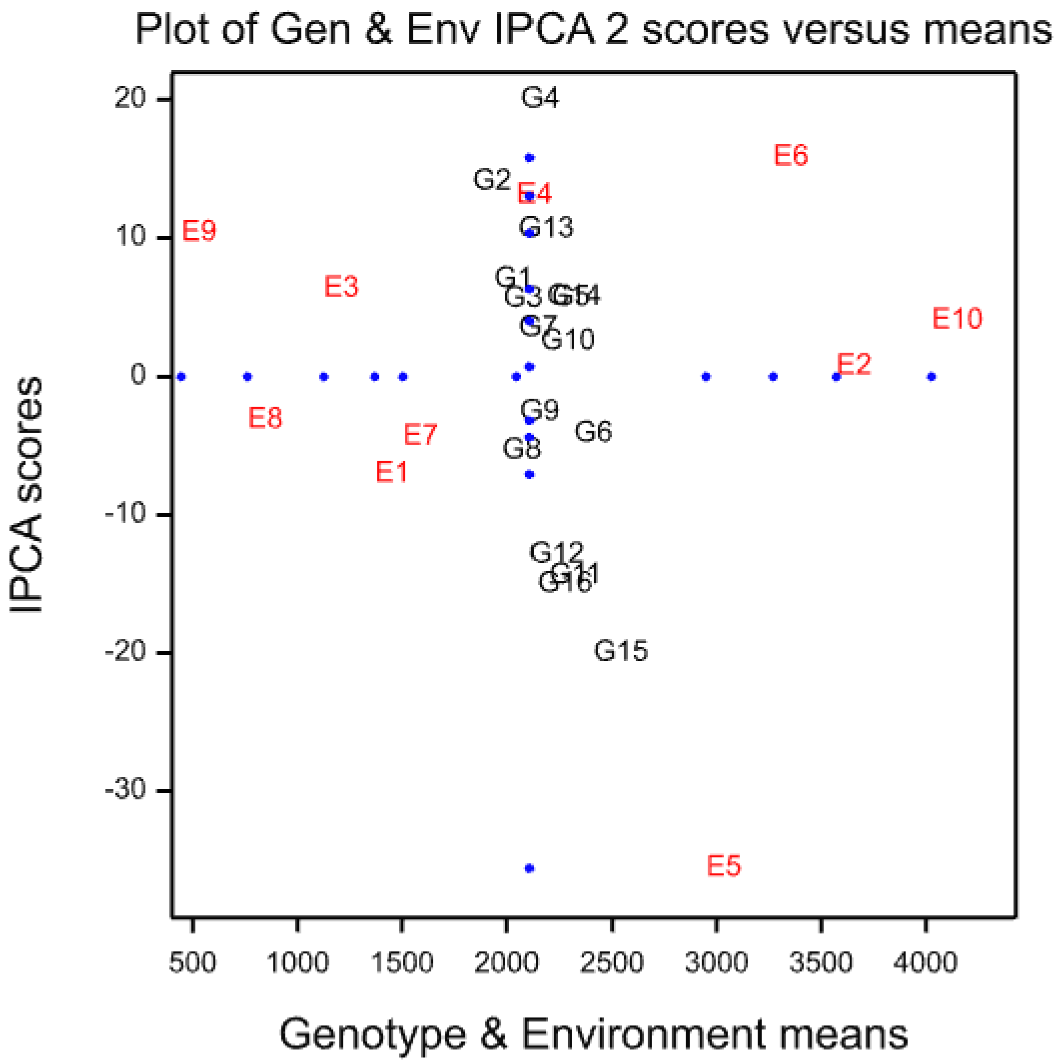

Fig 4 *the plot of genotypes and environment IPCA2 scores versus means of genotypes grain yield and environments mean effects.*