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Studies on G x E Interaction and Combining Abilities for Earliness and Yield Characters in Nigeria Maize (*Zea mays L.)*

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ABSTRACT

Identifying suitable parental materials is an important phase in the development of hybrid seeds. Experiment was carried to determine the relative importance of the effects of general combining ability (GCA) and specific combining ability (SCA) in the expression of earliness and yield- related characters as well as analyze the influence of G x E interaction on grain yield using a diallel set of 55 F_1 crosses among 10 inbred maize cultivars, The experiment was carried out during the early and late cropping seasons of 2009/2010 at three locations (Federal University of Agriculture Abeokuta research farm, Institute for Agricultural Research and Training (IAR&T) Research Farms at Eruwa and Ikenne South West Nigeria). The experiment involved evaluation of F_1 hybrids produced from half-diallele crosses among parental inbred lines at each location for earliness and yield related traits.. Analysis of variance showed that effects of GCA and SCA were significant (P < 0.01) for almost all traits studied. Estimate of GCA showed that parents TZSTR 147 (3), TZEI 11 (5) and TZEI 15 (7) possessed the best general combining ability, while F_1 hybrids 2 x 9, 3 x 5 and 7 x 8 possessed the best specific combining ability for yield and earliness traits. Estimate of GCA was better than SCA in nearly all the traits indicating that additive gene action was more important than non-additive gene action in the inheritance of the traits.

Keywords: Maize cultivar, Hybrid seed, Combining ability, Inheritance, G x E Interaction.

INTRODUCTION

The availability of improved varieties of maize is vital to maize seed industry because high seed viability and vigour produce more uniform plant stands leading to higher grain yields. The use of physical or morphological characteristics of seed may provide a useful management strategy for increasing establishment count in maize field, thereby leading to higher yield. (Oloyede, 2013). Maize yields in the continents have been highly variable as a result of climatic factors and other environmental variables. This has led to high variability in the production of maize. There is need to increase maize productivity in African on a sustainable basis because maize is ultimately contributing its share in solving the problems of food scarcity and poverty.

The objective of maize breeding is to improve yield (Trifunovic *et al.*, 2003), and lines that possess high breeding value for yield and other traits of interest that have an impact on yield warrant recycling in breeding programs. The main objective of maize breeding programs is to develop new inbred lines with high-combining ability to produce higher grain yields and superior agronomic performance in hybrid combinations. In such breeding programs, the choice of parents is crucial, because it will determine the genetic constitution of the source population, which, in turn, determines the probability of selecting a new superior line (Hallauer and Miranda Filho, 1988).

In maize breeding programs, the search for genotypes with high grain yield adapted in the most varied environments is one of the most important objectives for breeders. For that, the choice of populations that show good genetic homeostasis is essential for yield increases.

The measures of GE is extremely important, because it can be used to establish the breeding objectives, such as the choice of genitors, identification of the ideal test conditions and recommendations for regional adapted cultivars (Yan *et al.*, 2000).

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MATERIALS AND METHOD

Ten inbred lines maize were used for this study. The seed varieties were the tropical *Zea mays* (TZM) and *Striga*-resistant (STR) germplasm developed at the International Institute of Tropical Agriculture (IITA) Ibadan, Nigeria. The inbred lines were TZMSTR 139 (P1), TZMSTR 146 (P2), TZMSTR 147(P3) , TZMSTR 148 (P4), TZEI 11(P5), TZE 13(P6), TZEI 15(P7), TZEI 16(P8),TZEI 3(P9), TZEI 25(P10), Other materials used include: pollinating envelopes, tape rule, weighing balance, stapler machine, and label tags.

The lines were crossed in all possible combinations without reciprocals (half-diallel) to produce single cross hybrids and selfed inbred using the formular of Griffing (1956):

$$^{n}C_{r} = n! / 2(n-r)!$$

The 55 F_1 hybrid seeds generated from the crosses made (Table 1) were subjected to multi-locational trial at the University of Agriculture Abeokuta Research Farm (Southern Guinea Savanna) and at 2 different locations namely IAR&T station at Eruwa (Southern Derived Savanna) and IAR&T station at Ikenne (High Rain Forest). The experimental design was Randomized Complete Block Design .

FIELD AND YIELD PERFORMANCE DATA

The F_1 seeds were evaluated for field and yield performance such as; days to 50% flowering, plant height at 50% flowering (cm), and days to maturity. This was followed by laboratory seed weight evaluation after harvesting and drying of the F_1 seeds for 100-seed weight (g), grain yield per plant (g), and grain yield per ha (kg),

DATA ANALYSES

Diallel analysis: Analysis of variance for field and yield performance parameters was conducted. A genetic linear model for Griffing's diallel model 1, method 2 was used to obtain estimate of general (GCA) and specific (SCA) combining abilities, and the interaction between both GCA & SCA and environment, for the field and yield performance traits. The Griffing's (1956) linear model is as follows:

$$Y_{ijkle} = \mu + \alpha_i + b_{kl} + v_{ij} + (\alpha v)_{ijl} + e_{ijklv}$$

Where $v_{ij} = g_i + g_j + S_{ij}$ and $(\alpha v)_{ijl} = (\alpha g)_{il} + (\alpha g)_{il} + (\alpha s)_{ijl}$

In these models,

Y_{ijkle} = Observed value of each experimental unit

μ = Population mean,

α_i = Environment effect

b_{kl} = Block or replication effect in each environment,

v_{ij} = F_1 hybrid effect

$(\alpha v)_{ijl}$ = Interaction between environments and F_1 hybrids

e_{ijklv} = Residual effect,

g_i == GCA effect for *I* th parent

g_j= GCA effect for *j*th parent.,

S_{ij} = SCA for *ij*th F_1 hybrid

$(\alpha g)_{il}$ = interaction between GCA effect for *j*th parent and environments

$(\alpha g)_{il}$ = interaction between GCA effect for *ij*th F_1 hybrid and environments.

$(\alpha s)_{ijl}$ = interaction between SCA effect for *ij*th F_1 hybrid and environments.

Table1. *List of F_1 hybrids with their pedigree (parents involved in each cross)*

Genotypes	Crossing code (Hybrid tag)	Pedigree (parents involved in a cross)
1	1 x 1	TZSTR 139 x TZSTR 139
2	1 x 2	TZSTR 139 x TZSTR 146
3	1 x 3	TZSTR 139 x TZSTR 147
4	1 x 4	TZSTR 139 x TZSTR 148
5	1 x 5	TZSTR 139 x TZEI 11
6	1 x 6	TZSTR 139 x TZEI 13
7	1 x 7	TZSTR 139 x TZEI 15
8	1 x 8	TZSTR 139 x TZEI 16
9	1 x 9	TZSTR 139 x TZEI 3
10	1 x10	TZSTR 139 x TZEI 25
11	2 x2	TZSTR 146 x TZSTR 146
12	2 x 3	TZSTR 146 x TZSTR 147
13	2 x 4	TZSRT 146 x TZSTR 148
14	2 x 5	TZSTR 146 x TZEI 11
15	2 x 6	TZSTR 146 x TZEI 13
16	2 x 7	TZSRT 146 x TZEI 15
17	2 x 8	TZSTR 146 x TZEI 16
18	2 x 9	TZSTR 146 x TZEI 3
19	2 x 10	TZSRT 146 x TZEI 25
20	3 x 3	TZSTR 147 x TZSTR 147
21	3 x4	TZSTR 147 x TZSTR 148
22	3 x 5	TZSTR 147 x TZEI 11
23	3 x 6	TZSTR 147 x TZEI 13
24	3 x 7	TZSTR 147 x TZEI 15
25	3 x 8	TZSTR 147 x TZEI 1
26	3 x 9	TZSTR 147 x TZEI 3
27	3 x 10	TZSTR 147 x TZEI 25
28	4 x 4	TZSTR 148 x TZSTR148
29	4 x 5	TZSTR 148 x TZEI 11
30	4 x 6	TZSTR 148 x TZEI 13
31	4 x 7	TZSTR 148 x TZEI 15
32	4 x 8	TZSTR 148 x TZEI 16
33	4 x 9	TZSTR 148 x TZEI 3
34	4 x 10	TZSTR 148 x TZEI 25
35	5 x 5	TZEI 11 x TZEI 11
36	5 x 6	TZEI 11 x TZEI13
37	5 x 7	TZEI 11 x TZEI 15
38	5 x 8	TZEI 11 x TZEI 16
39	5 x 9	TZEI 11 x TZEI 3
40	5 x 10	ZEI 11 x TZEI 25
41	6 x 6	TZEI 13 x TZEI 13
42	6 x 7	TZEI 13 x TZEI 15
43	6 x 8	TZEI 13 x TZEI 16
44	6 x 9	TZEI 13 x TZEI 3
45	6 x 10	TZEI 13 x TZEI 25
46	7 x 7	TZEI 15 x TZEI 15
47	7 x 8	TZEI 15 x TZEI 16
48	7 x 9	TZEI 15 x TZEI 3
49	7 x 10	TZEI 15 x TZEI 25
50	8 x 8	TZEI 16 x TZEI 16
51	8 x 9	TZEI 16 x TZEI 3
52	8 x 10	TZEI 16 x TZEI 25
53	9 x 9	TZEI 3 x TZEI 3
54	9 x 10	TZEI 3 x TZEI 25
55	10 x 10	TZEI 25 x TZEI 25

RESULTS AND DISCUSSION

The importance of diallel analysis in detecting those parents from the inbred maize used that can help in developing hybrid suitable for desirable traits from different environments and the influence of G x E interaction on grain yield through the application of mating design in the diallel analysis proposed by Griffing (1956) and Hayman, (1954) has however been demonstrated by this study.

Results from this study showed that the interaction between the Genotypes and Environment (Varieties x Location) were highly significant (P<0.01) for only days to tassling but the interaction were not significant for yield characters(Table 2). Similarly, the interaction between the Genotypes and Season (Varieties x Season) were not significant for nearly all the field and yield characters studied. Also, the interaction between the location and season (Location x Season) and the interaction between Varieties, Location and Season (Varieties x Location x Season) were not significant for yield characters.(Table 2). This indicated that change in location and environment does not affect the performance of the genotypes as regards grain yield.

The significant mean squares of GCA and SCA for nearly all the yield characters studied suggests that the parents and their hybrids in the diallel crosses were highly variable.(Table 3) Also, a large portion of the total variability among F_1 hybrids for grain yield in the current study was as a result of action of genes with predominantly additive effects. This is a desirable phenomenon necessary for better crop improvement, especially when seed grain yield is concerned.. \The mean squares due to general combining ability for yield related traits such as grain yield/ha, and seed weight per/plant were statistically significant (P < 0.01) as observed in Table 3. This indicated a greater role of additive gene effects as compared with other genetic action in the inheritance of these traits; this is however, a desirable phenomenon necessary for better crop improvement especially when breeding for quantitative traits such as seed yield which is one of the main objectives of this research. The result of this study also observed that there were no consistency in the magnitude of the interaction between the GCA and environment and SCA and environment for grain yield per ha. This indicated that the environment had no influence on the performance of parents and their progenies for grain yield obtained (Table 3).

Table2. *Combined Mean squares from analysis of variance for field and yield performance of hybrid maize for two seasons in three locations*

Source of variation	Df	Days to tasslling	Days to silking	Plant height (cm)	Days to maturity	100 seed weight (g)	Total seed weight per plant {g]	Grain yield/ha (kg)
Variety (V)	55	47.63**	209.91	5729.13*	708.84	1346.84**	211207.74**	7823126.29**
Location(L)	2	146.56**	157.63	127505.53**	205.63	11041.70**	62637.04**	44445030.00**
Season(S)	1	490.71**	2176.04**	301244.53**	67.99	447.58	76920.20**	2949569.25**
Replicate(R)	2	1.43	161.09	5158.52	1138.26	245.21	24376.95	33194851.00
V * L	110	6.65**	167.00	5210.41	614.61	234.43	9872.69	103694824.00
V * S	55	2.21**	154.94	4341.07	598.07	280.89	5808.48	88855167.00
L * S	2	339.92**	231.33	130110.	387.43	1393.41	60540.72	86514972.00
V * L * S	110	2.35**	167.32	4478.39	630.17	207.91	431.20	11424822.00

Table3. *Mean squares for general and specific combining abilities among F_1 hybrids for field and yield performance traits in three environments among maize genotype*

Source	Df	Days to germination	Days to tasslling	Days to silking	Plant height (cm)	No of tassle finger/plant	Number of ears/plant	Days to maturity	100 seed weight (g)	Total seed weight per plant {g}	Grain yield/plant {kg}	Grain yield/ha{kg }
GCA	9	8.59xx	107.59ns	351.21	1809.77	\ 406.96xx	5.46xx	1142.57	82.07xx	257806.94xx	292.85xx	809174625.20xx
SCA	45	2.67ns	37.01ns	310.25	6428.13	149.55xx	2.48xx	666.74	817.71xx	297680.94xx	201.76xx	780707467.79xx
Progeny	0.17	0.75	0.74	0.53	0.22	0.73	0.69	0.63	0.76	0.55	0.59	0.51

performance {Gca/gca+sca}												
GCA X ENVT	18	10.61^{xx}	6.77^{ns}	215.01	5319.58	100.64^{x}	0.66^{xx}	447.73	116.19^{xx}	8324.27^{xx}	6.65^{ns}	93406997.79^{ns}
SCA X ENVT	90	5.11^{xx}	3.55^{ns}	257.92	4653.43	80.71^{x}	0.39^{xx}	658.34	58.60^{xx}	6508.78^{xx}	5.49^{ns}	109422083.03^{ns}

**** Significant at P<0.05 and 0.01 respectively*

The excellent performance of the progenies in hundred seed weight, , days to 50% tasselling, , and days to maturity (Table3) indicated that any of the progenies can be selected for the improvement of these traits. Iken *et al*., 2002 used the result of progeny performances to select the best location for maize grain yield in Rainforest and Southern Guinea Savanna Zones of Nigeria.

Low GCA effect for plant height at 50% flowering observed in all the parents may be attributed to non-additive gene effects in the inheritance of plant height, thus, many of the parents could be useful in breeding for reduced plant height or dwarf maize varieties (Table 4)

TZSTR 139 (P1), TZSTR 147 (P3), TZEI 11 (P5), TZEI 13 (P6), and TZEI 15 (P7) recorded negative values for days to maturity which favours early maturity, therefore these parents were adjudged the best general combiners for days to maturity. However, TZSTR147 (P3), TZEI 11 (P5), and TZEI15 (P7) might have contributed a maximum number of favourable genes and positive allelomorphs for shorter and longer days to maturity. In the same sense, parents 1 and 3 and parents 3 and 7 which had a high estimate of GCA effects for weight of a hundred seeds and total seed weight per plant respectively were good general combiners and desirable parents to be selected for seed weight in pedigree breeding. Parents 1, 3 and 7 might have contributed a maximum number of useful genes and positive allelomorphs for seed weight in pedigree breeding. They may be recommended for future exploitation. A negative estimate of GCA effect observed in parents 2, 4, 8, 9, and 10 for weight of hundred seeds and total seed weight per plant makes these parents to be undesirable parents for genetic improvement in seed weight.

Table4. *Estimate of GCA effects for field and yield performance among ten tropical inbred maize cultivars*

S/N	Parents	Days to Hundred Per tasseling weight(g)	Days to Plant	Silking maturity	Height (cm)	Days to seed	Yield plant(g)	Yield per ha (kg)
1	TZSTR139	-0.68	-1.08	-1.90	-0.97	4.12	2.83	-186.36
2	TZSTR146	0.84	0.33	-0.90	0.63	-4.07	-39.18	-1789.90
3	TZSTR 137	-0.58	-0.90	5.70	-0.14	4.62	38.37	1497.39
4	TZSTR148	0.89	0.22	1.09	5.89	-3.42	-42.61	-1783.05
5	TZEI 11	-0.81	-1.24	1.94	-2.10	2.94	11.90	1296.42
6	TZEI 13	0.88	0.35	-3.90	-1.79	-0.80	45.56	-3109.18
7	TZEI15	-0.74	-1.21	2.96	-1.91	3.88	50.36	3527.71
8	TZEI 16	0.34	2.09	-0.85	0.51	-0.42	-15.26	-548.33
9	TZEI 3	-0.28	-0.67	0.31	0.19	-2.10	28.68	987.88
10	TZEI 25	0.14	2.04	-3.81	0. 32	-2.66	10.47	756.68

For grain yield per ha, parents 3, 5 and 7 with high and positive values were identified as best general combiners, while other inbred parents, TZEI16 (P8), TZEI3 (P9), and TZEI25 (P10) with low estimate of GCA were grouped as poor combiners for grain yield.

Hybridization of high combiners x high combiners (P_3 x $P_{5,}$) or (P_5 X P_7) or (P_3 x P_7) may be governed by additive x additive gene action, therefore,. Parents 3(TZSTR 147), 5(TZEI 11 and 7(TZEI 15) could be of importance in an intensive breeding programme to exploit both additive and non-additive components of genetic variation for developing high yielding varieties of maize. It was reported that entries with larger positive GCA estimates with larger and significant additive gene effects could provide desirable genes for the improvement of characters under consideration (Baker, 1978).

Despite the apparently low importance of specific combining ability as source of variation, their effects contributed extensively to the performance of outstanding crosses. A large and positive SCA effects for a trait have been reported to suggest the possibility for transgressive segregation for the trait in later generation of selfing, such a trait, according to Singh and Labana (1980), can be exploited for the breeding and development of high yielding varieties. Consequently, selection for increased number of grain yield as observed in this study could likely result in simultaneous selection for higher grain yield. However, highly significant SCA effects do suggest that non-additive gene action (dominance and additive dominance gene effects) could play a vital role in the improvement of tropical inbred maize for the traits being considered.

A high estimate of SCA for plant height observed in genotype 13 (2 x 4) and genotype 26 (3 x 9) suggest these hybrids as best specific combiners for plant height(Table 5). This suggests that non-additive gene action (dominance and additive x dominance gene effects) could play a vital role in the improvement

Table5. *Estimate of SCA effects for field performance and yield traits of F_1 maize*

Crosses	Days to tassling	Days to silking	Plant height (cm)	Day to maturity	100 seed weight (g)	Total seed weigh per plot(g)	Grain yield per ha (kg)
1 x 2	0.06	0.14	-10.46	-1.18	-0.13	-71.87	-4455.80
1 x 3	1.46	0.83	-8.44	-1.21	-0.81	120.53	-6017.21
1 x 4	-0.10	-0.69	15.97	-28.51	2.75	-37.28	715.55
1 x 5	1.14	1.41	8.83	-1.64	1.12	-76.79	-4852.57
1 x 6	-0.05	0.62	-14.92	-2.17	3.83	-37.76	182.37
1 x 7	0.06	-0.49	0.22	-4.16	1.94	129.76	6186.97
1 x 8	-1.28	-2.84	3.98	-7.58	7.51	175.04	8109.80
1 x 9	-1.55	-1.25	11.14	-7.27	6.70	170.55	9062.62
1 x 10	-1.81	-2.72	18.04	-6.64	5.07	135.98	6802.26
2 x 3	-0.55	1.36	-12.88	1.64	-7.07	-71.03	-4332.11
2 x 4	-1.81	0.26	50.01	-3.95	-3.87	-29.21	5377.83
2 x 5	1.34	1.64	-0.87	0.38	-5.76	-77.89	-2797.80
2 x 6	-0.01	0.54	8.69	2.74	0.42	-83.75	-851.53
2 x 7	1.11	1.33	-8.28	1.69	-6.75	-61.35	-5918.04
2 x 8	-1.55	-3.47	1.98	2.05	5.33	15.38	143.27
2 x 9	-0.84	-0.65	-1.85	-0.008	9.09	187.56	10014.29
2 x 10	-1.05	2.52	3.49	-3.51	8.07	183.54	9294.85
3 x 4	-0.72	-0.30	-15.70	16.51	5.96	209.87	10001.81
3 x 5	-0.80	-0.06	-3.51	-4.86	-1.92	131.77	8206.01
3 x 6	0.12	0.62	12.27	-2.72	1.46	136.69	-1205.33
3 x 7	-1.42	0.59	12.42	0.68	3.62	-65.85	-2271.89

Crosses	Days to tassling	Days to silking	Plant height (cm)	Day to maturi ty	100 seed weight (g)	Total seed weigh per plant(g)	Grain yield per ha (kg)	Total seed weigh per plant(g)	Grain yield /plot(kg)	Grain yield per ha (kg)
3 x 8	0.94	-1.00	2.90	-0.47	6.02	-40.06	-3706.94	-40.06	-1.68	-3706.94
3 x 9	-1.05	-0.63	74.70	-0.23	8.58	92.66	104.78	92.66	3.59	104.78
3 x 10	-2.47	-3.78	12.18	-2.25	6.34	99.88	6583.06	99.88	3.19	6583.06
4 x 5	-2.37	-1.25	-1.81	-8.11	1.17	34.42	425.01	34.42	1.41	425.01
4 x 6	-0.12	0.04	6.75	-6.19	6.09	35.23	1037.99	35.23	1.01	1037.99
4 x 7	0.72	1.54	-19.34	-2.19	-1.92	-83.55	-6398.84	-83.55	-2.45	-6398.84
4 x 8	0.69	-1.36	-3.91	-2.44	0.44	19.85	-2174.57	19.85	0.03	-2174.57
4 x 9	0.65	1.35	-27.75	-2.10	-6.32	-72.14	-4955.50	-72.14	-2.09	-4955.50
4 x 10	0.89	-1.19	-0.79	-2.89	-644	-69.14	4519.44	-69.14	-2-2.4	4519.44
5 x 6	-0.23	0.18	6.24	4.02	-5.08	-33.18	1217.81	-33.18	-1.33	1217.81
5 x 7	-0.91	-0.15	-3.96	3.31	6.90	100.34	4743.74	100.34	3.81	4743.74
5 x 8	-1.55	-1.55	17.74	1.77	4.10	62.62	-139.81	62.62	0.77	-139.81
5 x 9	-1.04	-0.75	-0.54	0.92	8.44	77.02	4942.75	77.02	2.76	4942.75
5 x 10	-0.24	-2.61	-1.25	-2.45	8.17	33.56	545.42	33.56	0.64	545.42
6 x 7	0.39	1.09	-16.62	0.88	-0.98	-37.52	-2021.93	-37.52	-0.71	-2021.93
6 x 8	0.32	-1.32	-3.38	0.57	2.26	-12.12	-1144.77	-12.12	-0.21	-1144.77
6 x 9	-0.90	-0.28	0.74	0.39	-8.21	-53.84	-2474.59	-53.84	-1.52	-2474.59
6 x 10	1.83	-0.57	-0.63	2.63	-0.96	-37.02	-2017.86	-37.02	-1.19	-2017.86
7 x 8	-1.11	-2.87	10.17	-5.24	1.82	124.176	20005.72	124.176	5.32	20005.72

7 x 9	-2.16	-1.72	7.99	-0.12	6.92	115.23	3953.96	115.23	2.65	3953.96
7 x 10	-2.36	-4.65	21.09	1.69	7.11	56.78	4484.52	56.78	11.98	4484.52

8 x9	1.23	-0.74	-8.79	2.53	-6.12	-99.15	-5953.10
8 x 10	1.17	24.34	-1.01	0.49	-8.33	-83.16	-4568.23
9 x 10	1.24	-0.46	-4.35	1.31	4.99	-109.87	-5245.10

of tropical maize for the traits being considered. Almost all the genotypes exhibited the same height at 50% flowering indicating limited prospect for selection for plant height at flowering and negative values recorded by most genotypes for plant height indicated that most crosses could be used to breed dwarf maize varieties.

Estimates of SCA for the number of days to maturity were positive and negative. The lowest values of SCA effects for days to maturity were recorded in genotype 18 (2 x 9) with SCA value of -0.008, genotype 25 (3 x 8) with SCA value of -0.47, genotype 45 (7 x 9) which recorded -0.12 and genotype 26 (3 x 9) which obtained -0.23(Table 5). These hybrids could be selected as best specific combiners for days to maturity and for breeding early maturing maize genotypes.

The fact that most of the genotypes flowered and matured at different periods indicated that they were of different genetic background. The hybrids that matured earlier than others genotype 18 (2 x 9), genotype 25 (3 x 8) and genotype 48 (7 x 9) could be selected as best hybrids for early maturity since days to flowering is always correlated with life -span (Ariyo and Odulaja,1991).

The study indicated that genotype 47 (7 x 8), genotype 18 (2 x 9), genotype 21 (3 x 4), genotype 19 (2 x 10) and genotype 22 (3 x 5) with the following SCA values 20,005.72, 10,014, 10,001.81, 9,294.85), 8206.01 respectively were the best specific combiners for grain yield per ha. This result indicated that the best performing hybrids for grain yield were produced from the crosses made between two good parents with high GCA estimate, for instance, TZSTR147 (P3} and TZEI11 (P5) had the higest gca for grain yield and also recorded high positive SCA when crossed for grain yield. This is in agreement with the results obtained by Ogunbodede *et al*. (2000) on combining ability for yield related characters on some Nigeria local maize varieties and Daniel and Oloyede (2010) on combining ability for seed quality traits in maize. These authors reported that the hybridization between two good general combiners governed by additive x additive gene actions would lead to transgressive segregation in the advanced generation for the traits, thus ,producing hybrid with good SCA.

CONCLUSION

This study concluded that two poor performed parents can be best combiner for grain yield as it was observed in P2 (TZSTR 146) and P9 (TZEI 3) which performed poorly as parent for grain yield but performed excellently when combined [genotype 18 (2 x 9)] for grain yield and earliness characteristics. This work also concluded that the performance of parents could be used to predict the performance of crosses. Thus, parents with good general combining ability (GCA) performance can be crossed to develop high quality and high yielding composites that can be used directly for recommendation or for further breeding work as it was observed in parents 3 and 5 (TZSTR 147, TZEI 11) which produced Genotype 22(3 x 5). It was revealed by this study that change in environment and season those not affect the performance of the maize genotypes.

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