Genetic Variability, Combining Ability, Gene Action and Superiority for New White Maize Inbred Lines (*Zea mays* L.)

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Abstract: A half diallel (9 x 9) analysis using nine new white maize inbred lines derived from different sources were evaluated to estimate genetic variability, combining ability, gene action and superiority% of the F_1,s over commercial check hybrids. All possible combinations were done among these lines at Sids Agricultural Research Station in season 2019 to obtain 36 crosses. These crosses along with two commercial hybrids; (SC. 10 and SC. 2031) were evaluated in field trails at three locations; (Sids, Sakha and Nubaria Agricultural Research Stations) using RCBD with three replications in the growing season 2020. Results showed significant differences among the three locations for all the studied traits, indicating that the locations differed in the environmental conditions. The GCA and SCA variances were significant or highly significant for most of the studied traits, indicating that the importance of additive as well as non-additive types of gene effects in the inheritance of these traits. The inbred line-Sd-14 was the best general combiner for earliness, shorter plant and lower ear placement. While the inbred lines Sk-9 and Sk-12 were the best general combiners for longer ear length and high grain yield. Thirteen crosses among all had positive and significant SCA effects for grain yield ard fed^{-1} toward high yielding, indicating that these crosses combinations could effectively be exploited in hybrid breeding programs in the National Maize Research Programs. Positive and significant correlation between grain yield ard fed^{-1} with plant height, ear height, late wilt resistant% and ear length, indicating that the indirect selection for linked traits with yield would be useful and effective for improving grain yield. The cross Sd-1 x Sd-42 showed the best superiority % of yield by value (7.91%) compared to the best check hybrid SC-2031 along with other six single crosses that were significantly positive in compared to the best check hybrid in the yield. The results revealed that the majority of the gene action controlling the grain yield trait is the additive gene, and therefore direct selection is considered useful and would be effective in improve such trait in this study. While, the majority of the gene action controlling days to 50% silking trait is non-additive gene action, and therefore the cross-breeding programs are effective and beneficial in turn of improving such traits in maize crop.

Keywords: Maize, combining ability, diallel analysis, genetic variability, gene action and Superiority

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important and widely grown cereal crops in West and Central Africa as well as North Africa; where Egypt is located in the same African region (Mafouasson *et al.*, 2017). It is a staple food for an estimated 50% of the population (IITA, 2014) and accounts for about 15% of the calorific intake of the population (Badu-Apraku and Akinwale, 2011). This calls for searching away to increase its productivity to meet its needs, where the acreage and production have an increasing tendency with the introduction of crosses due to its high yielding ability under any different environmental conditions. However, new maize crosses thus need to be developed with high yield capacity to meet the demands of maize producers at all required levels. Therefore, in order to choose the best hybrid combinations, a large numbers of subjectively must chose inbred lines consequently, they are interbreed/crossed with each other. It would be considerable advantage to be able to estimate the combining ability of inbred lines, gene effects and heterotic effects of the crosses before making crosses among these inbred lines (Xu and Crouch, 2008). Plant breeders and geneticists often use diallel-mating designs to obtain genetic information about a trait of interest from a fixed or randomly chosen set of inbred lines (Murray *et al.,* 2003; Aly and Mousa, 2011). In the same context, success evaluation of any breeding program depends upon the positively efficacy of the selection, whereas the selection cannot be applied for traits, which are polygenic in nature and are highly influenced by the environmental conditions. Diallel mating models designed by Griffing's (1956) and Gardner and Eberhart (1966) are the standards used in large scale determine combining ability analyses in maize breeding programs to locate the types of combining ability and superiority relative to check hybrid and their interaction across environments are essential in developing breeding programs (Turkey *et al*., 2018). The magnitude of genetic components for confirmed traits would rely fundamentally upon the environmental flexion's under which the breeding materials will be tested. When information on these views is available, the breeders can decide which of the numerous breeding procedures is most likely to succeed (El-Hosary *et al*., 2018). The combining ability studies offer information on the genetic variances governing the inheritance of traits and assist the breeders to choose suitable parents for further crop improvement. Two types of combining abilities are general combining ability (GCA) and specific combining ability (SCA). GCA defined as the average performance of the genotype in a series of hybrid combinations and is a measure of additive gene effects. While, SCA refers in relation to the performance of the genotype in a specific cross in relation to the formal and is a measure of non-additive gene effects (Sharief *et al.,* 2009). The estimates of genetic parameters such

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as variances, coefficient of variation, heritability, genotypic, phenotypic and environmental correlation allow knowing the knowledge of heritability enables the plant breeders to decide the course of selection procedures to be followed under a given situation (Li and Yang, 1985) and the estimates of genetic parameters like heritability and genetic advance helps in predicting the gain under selection. Genetic studies by many authors have been conducted on maize genotype, which derived from different sources of genetic materials, some of them concentrate on genetic variability (Reddy *et al*., 2012; Hussain *et al*., 2016; Wedwessen and Zeleke, 2020) and others investigated combining ability, general and specific (Turkey *et al*., 2018; Ferial *et al*, 2020; Hemada *et al*., 2020; Gad *et a*l, 2021), but other studies spoke around gene action (Abd El-Azeem *et al*., 2021) and other studies investigated superiority% (Uddin *et al*., 2008; Atif *et al*., 2012; Aly and Mousa, 2011; Abd El-Azeem *et al*., 2021). All these studies and researchers indicated the importance of studying these genetic constants in corn breeding programs, which led to the improvement of the maize yield.

Based on what has been mentioned above, it is clear that the main objectives of this investigation were to estimate: the combining abilities effects for the nine inbred lines and its combiners and crosses to improve maize for desirable traits, types of gene action controlling the inheritance of these traits, the relation superiority% than the check hybrid, the genetic parameters as to determine suitable inbred lines and promising crosses for grain yield and other agronomic traits.

MATERIALS AND METHODS

- Plant Material and its sources

The plant materials of this investigation consisted of nine new white maize inbred lines of S_5, which derived from different sources at two Agricultural Research Stations; [Sakha (Sk) and Sids (Sd)]. These lines namely; Sd-63, Sk-9, Sk-12, Sd-1, Sd-2, Sd-7, Sd-14, Sd-42 and Sd-43.

- Experimental Sites and growing seasons

In the growing season 2019, at Sids Agric. Res. Station, all possible combinations without reciprocal crosses among them were made in a half diallel to obtain 36 single crosses. However, in the growing season 2020, the 36 crosses along with two checks; (SC-10 and SC-2031) were evaluated at three locations *viz* Sids, Sakha and Nubaria Agric. Res. Stations.

- Experimental design and its Management

Randomized Complete Blocks Design (RCBD) with three replications was used at each site /location. Plot size was one row, 6 m long and 0.8 m apart. Planting was made in hills spaced at 0.25 m along the row at the rate of two kernels hill^{-1}, which thinned to one plant hill^{-1} after 21 days of planting date. For experimental management, the field trials were kept clean of weeds throughout the growing cycle, whereas all agricultural practices were applied as recommended.

- Data recorded

Date were recorded for number of days to 50% silking (DTS, day), plant height (PHT, cm), ear height (EHT, cm), ear position% (Epos %), late wilt resistant% (LWR %), ear length (EL, cm) and grain yield (GY, ard fed^{-1}). The grain yield was adjusted to 15.5% grain moisture, one ardab = 140 Kg and one feddan = 4200 m^2.

- **Statistical analysis**

The data collected were analyzed using general linear model (GLM) procedure in SAS (SAS institute, version 9.2, 2008). Means for all maize combinations adjusted for block effects through sites/locations were analyzed according to Snedecor and Cochran (1980). Combining ability analysis was performed for trait that showed statistical differences among crosses. Griffing's Method-4, Model-1 (Griffing's 1956) was employed to determine general and specific combining abilities and their interaction effects with locations. Relative superiority% of 36 single crosses was estimated according to Singh *et al*., (2004), expressed as the % deviation of the mean performance of F_1 than the best check hybrid.

RESULTS AND DISCUSSION

Analysis of variance:

Results for variances and mean squares of the genotypes for seven studies traits combined across three locations are shown in Table 1. The results showed significant differences between the three locations for all the studied traits, indicating that the locations differed in the environmental conditions. These findings are agreement with Haddadi *et al*. (2012), Aly (2013) and Abd El-Azeem *et al*. (2021). Genotypes mean squares and their interactions with locations were significant or highly significant for all the studied traits except LWR% for genotypes and LWR% and EL for G x Loc. These results indicate the presence of genetic variation among the materials and desirable genes from these genotypes can effectively be utilized to develop high performing hybrids. These genotypes performed differently across locations, meaning that the relative performances of the genotypes were influenced by varying environmental conditions. Similar results are obtained by Živanovic *et al*. (2010) for GY; Aly and Mousa (2011) for DTS, PHT, EHT and GY; Haddadi *et al*. (2012) for DTS, PHT and Yield; Mosa *et al*. (2016) for DTS, PHT, EHT, EL and GY; Bisen *et al*. (2020) for DTS and PHT; Onejeme *et al*. (2020) for DTS, PHT, EHT and GY; Zeleke *et al*. (2020) for DTS and GY and Abd El-Azeem *et al*. (2021) for DTS, PHT, EHT, Epos% and GY traits.

Table (1): Combined analysis of variance and mean squares of the genotypes for seven studies traits across three locations

sov	df	DTS (day)	PHT (cm)	EHT (cm)	Epos %	LWR %	EL (cm)	GY ard. fed^{-1}
Loc	2	1550.65**	144935.98**	77544.91**	2645.62**	0.15**	51.74**	452.69**
Rep/Loc	6	15.028	576.556	542.395	54.006	0.099	2.320	7.16
Genotypes (G)	37	21.326**	1184.904**	984.383**	58.457**	0.133	6.411*	328.65**
G x Loc	74	6.169**	536.423**	413.798**	29.817**	0.140	2.796	31.40**
Error	222+	0.687	144.233	118.673	14.887	0.142	4.114	9.02

+ included checks
*, ** significant at 0.05 and 0.01 levels of probability, respectively
DTS = days to 50% silking (days) PHT = plant height, cm EHT = ear height, cm Epos% = ear position % LWR = late wilt resistant % EL = ear length, cm and GY = grain yield ard. fed^{-1}

General combining ability (GCA) and specific combining ability (SCA) variances and their interaction with locations for seven traits across three locations are presented in Table 2. Results were showed that the GCA and SCA variances were significant or highly significant for all the studied traits except LWR% for GCA and LWR% and EL for SCA, indicating that the importance of additive as well as non-additive gene effects in the inheritance of these traits. The magnitude of GCA was more than that of SCA for DTS, Epos%, EL and GY, meaning that the additive genes are responsible for most of the genetic variation for these traits. This finding was confirmed by Abd El-Azeem *et al*. (2021) for DTS, PHT, EHT, Epos% and GY; Hemada *et al*. (2020) for DTS, PHT, EHT, EL and GY; Aly and Mousa (2011) for DTS, PHT, EHT, Epos % and GY; El Hosary (2020) for PHT, EHT and Yield; Aly and Mousa (2012) for DTS and GY and Mosa *et al*. (2016) for DTS, PHT, EHT and EL traits. The ratio of GCA/SCA was more than unity for DTS, Epos%, LWR%, EL and GY, indicating the importance of additive gene action in the genetic control of these traits. Similar results were obtained by Haddadi *et al*. (2012) for DTS, PHT and yield; Aly and Mousa (2012) for DTS, PHT, EHT, EL and GY; Ferial *et al*. (2020) for DTS and PHT; Onejeme *et al*. (2020) for DTS, PHT, EHT and GY; Abd El-Azeem *et al*. (2021) for DTS, PHT, EHT, Epos%, LWR% and GY and Gad *et al*. (2021) for EHT and yield.

Table (2): Estimates of general (GCA) and specific (SCA) combining abilities variances and their interaction with locations for all studied traits across three locations

sov	df	DTS (day)	PHT (cm)	EHT (cm)	Epos %	LWR %	EL (cm)	GY ard. fed^{-1}
GCA	8	57.178**	820.520**	914.840**	80.040**	0.190	7.706*	366.74**
SCA	27	11.433**	1345.360**	1050.070**	54.633**	0.125	4.555	321.28**
GCA x Loc	16	12.379**	647.850**	602.600**	35.484**	0.085	3.317	59.05**
SCA x Loc	54	4.423**	434.570**	318.180**	28.480**	0.167	2.431	19.52**
Error	210	0.675	141.61	113.34	14.87	0.149	4.207	8.947
GCA/SCA		5.001	0.610	0.871	1.465	1.528	1.692	1.14
GCA x Loc/ SCA x Loc		2.799	1.491	1.894	1.246	0.507	1.364	3.026

*, ** significant at 0.05 and 0.01 levels of probability, respectively
DTS = days to 50% silking (days) PHT = plant height, cm EHT = ear height, cm Epos% = ear position % LWR = late wilt resistant % EL = ear length, cm and GY = grain yield ard. fed^{-1}

Mean performance:

Mean Performances values of the 36 crosses and the two check hybrids for seven traits across three locations are illustrated in Table 3. The results revealed that the crosses ranged from 63.44 day for cross Sk-9 x Sd-2 to 72.67 day for cross Sd-42 x Sd-43 concerning DTS trait. 22 out 36 crosses were significantly earlier than the earliest check hybrid SC-10, (67.11 days). In the same direction, 26 crosses were significantly earlier than the other check SC-2031 (67.78 days). Generally, 4 crosses (Sk-9 x Sd-2, Sk-9 x Sd-14, Sk-9 x Sd-1 and Sk-9 x Sd-7) among the all crosses were the earliest crosses and scored in respectively 63.44, 63.67, 64.22 and 64.33 days. In respect to PHT cm trait, the crosses ranged from 200.11 cm for cross sd-42 x Sd-43 to 264.00 cm for cross Sd-9 x Sd-42. Results showed that, 12 out 36 crosses were significantly toward shorter plant than the shortest check cross SC-2031 (251.89 cm). Among 36 crosses, only 14 crosses were significantly toward lower ear placement than the check hybrid 2031 (136.33 cm). Concerning Epos% trait, 5 crosses out 36 crosses were significant compared with the best check SC-2031, which possessed 54.11%. About each of both traits EHT and Epos %, it ranged from (100.11 cm and 49.22%) for the cross Sd-42 x Sd-43 to (155.56 cm and 60.44%) for the cross Sd-1 x Sd-43. 33 crosses from all investigated crosses (36 crosses) showed 100% resistant for LWR% trait. Regarding EL cm trait, 17 crosses out 36 crosses were did not differ significantly compared with the best check cross SC-2031, which possessed (21.89 cm). For GY ard fed^{-1} trait, only one cross (Sd-1 x Sd-42) scored 38.90 ard fed^{-1} was significantly superior than higher check cross (SC-2031) and recorded 36.05 ard fed^{-1}. Furthermore, 9 crosses did not differ significantly than the highest check hybrid SC-2031, which obtained value 36.05 ard fed^{-1}; Sk-9 x Sk-12 (35.33), Sk-9 x Sd-7 (33.05), Sk-9 x Sd-43 (36.63), Sk-12 x Sd-2 (36.69), Sk-12 x Sd-42 (35.54), Sk-12 x Sd-43 (37.55), Sd-1 x Sd-43 (36.61), Sd-2 x Sd-42 (36.74) and Sd-2 x Sd-43 (37.31 ard fed^{-1}).

Table (3): Mean performances of 36 crosses and two check hybrids for all studied traits across three locations

Crosses	DTS (day)	PHT (cm)	EHT (cm)	Epos %	LWR %	EL (cm)	GY ard. fed^{-1}
sd-63 x Sk-9	66.11	245.00	127.11	52.11	100.00	21.20	31.22
sd-63 x Sk-12	67.33	245.89	140.00	55.56	100.00	21.22	32.59
sd-63 x Sd-1/2016	66.22	252.11	151.22	59.44	100.00	20.80	26.85
sd-63 x Sd-2/2015	66.44	252.00	140.11	56.00	100.00	21.02	31.08
sd-63 x Sd-7/2015	65.78	251.00	145.67	58.00	100.00	20.16	29.23
sd-63 x Sd-14/2013	65.56	237.00	130.44	54.56	100.00	20.76	24.14
sd-63 x Sd-42/2013	66.89	256.56	151.78	59.00	99.56	21.87	27.25
sd-63 x Sd-43/2013	67.33	255.89	147.33	56.78	100.00	21.40	31.96
Sk-9 x Sk-12	65.33	254.33	139.89	54.89	100.00	23.09	35.33
Sk-9 x Sd-1/2016	64.22	259.56	148.33	56.89	100.00	21.04	31.46
Sk-9 x Sd-2/2015	63.44	238.89	144.44	60.44	100.00	21.11	27.95
Sk-9 x Sd-7/2015	64.33	238.44	134.11	56.00	100.00	20.47	33.05
Sk-9 x Sd-14/2013	63.67	252.00	132.22	52.33	100.00	21.11	28.06
Sk-9 x Sd-42/2013	66.89	264.00	153.33	57.78	100.00	20.78	31.31
Sk-9 x Sd-43/2013	66.11	255.33	138.89	54.00	100.00	22.07	36.63
Sk-12x Sd-1/2016	67.56	249.56	141.89	56.67	100.00	21.04	31.83
Sk-12x Sd-2/2015	67.11	241.67	143.22	59.22	100.00	21.91	36.69
Sk-12x Sd-7/2015	67.11	237.89	127.89	53.78	100.00	20.91	29.80
Sk-12x Sd-14/2013	66.00	235.44	123.11	52.22	100.00	20.69	23.79
Sk-12x Sd-42/2013	68.33	248.22	141.78	57.00	100.00	21.13	35.54
Sk-12x Sd-43/2013	67.67	248.44	139.22	55.78	100.00	20.18	37.55
Sd-1/2016x Sd-2/2015	68.11	223.44	128.11	57.33	100.00	18.84	15.27
Sd-1/2016x Sd-7/2015	66.00	237.11	130.44	55.44	100.00	21.18	30.29
Sd-1/2016x Sd-14/2013	65.44	240.11	134.11	55.56	100.00	20.07	24.97
Sd-1/2016x Sd-42/2013	66.67	256.56	143.89	55.89	100.00	20.31	38.90
Sd-1/2016x Sd-43/2013	66.00	256.22	155.56	60.44	100.00	21.33	36.61
Sd-2/2015x Sd-7/2015	66.11	245.44	146.44	59.56	100.00	20.31	32.50
Sd-2/2015x Sd-14/2013	65.33	233.67	129.56	55.56	100.00	21.02	23.84
Sd-2/2015x Sd-42/2013	65.78	245.56	137.00	55.89	100.00	21.27	36.74
Sd-2/2015x Sd-43/2013	66.22	256.00	139.22	54.00	100.00	20.40	37.31
Sd-7/2015x Sd-14/2013	65.44	239.78	121.56	50.56	100.00	20.02	20.20
Sd-7/2015x Sd-42/2013	67.11	255.33	144.22	56.67	100.00	19.96	33.03
Sd-7/2015x Sd-43/2013	65.56	248.89	144.11	57.89	99.56	21.36	31.95
Sd-14/2013x Sd-42/2013	66.33	248.89	138.89	55.44	100.00	20.98	29.04
Sd-14/2013x Sd-43/2013	65.89	242.78	134.89	55.78	100.00	19.91	30.04
Sd-42/2013x Sd-43/2013	72.67	200.11	100.11	49.22	99.56	19.73	11.59
SC-10	67.11	254.44	147.11	57.33	100.00	21.27	35.28
SC-2031	67.78	251.89	136.33	54.11	100.00	21.89	36.05
LSD 0.05	0.766	11.096	10.065	3.565	0.348	1.874	2.775
LSD 0.01	1.007	14.584	13.229	4.685	0.457	2.463	3.647

DTS = days to 50% silking (days) PHT = plant height, cm EHT = ear height, cm Epos% = ear position % LWR = late wilt resistant % EL = ear length, cm and GY = grain yield ard. fed^{-1}

General Combining Ability (GCA) effects:

General combining ability (g_i) effects of the nine inbred lines for all studied traits across three locations were presented in Table 4. The results revealed that four inbred lines; Sd-9, Sd-2, Sd-7 and Sd-14 had negative and highly significant values (desirable) for DTS toward earliness. Meaning that these lines were good general combiner for early maturity. Each of Zeleke *et al*. (2020) and Abd El-Azeem *et al*. (2021), confirmed these findings. In respect of PHT, EHT and Epos %, the inbred line Sd-14 has negative and highly significant g_i effects (as a desirable characters) toward shorter plants and lower ear placement, implying the tendency of this line to reduce plant height, which is very important for development of genotypes resistant to loading. These results are in harmony with the results reported by Zeleke *et al*. (2020) and Abd El-Azeem *et al*. (2021). In addition, the inbred line Sd-2 had negative and highly significant g_i effects for plant height toward shorter plant. The two inbred lines; Sk-9 and Sk-12 had positive and significant g_i effects for both EL and GY traits toward longer ear and high yielding. Also, the results showed that inbred line Sd-43 has g_i effects positively and significant for high yielding ability. The previous results revealed that the inbred line-Sd-14 was the best general combiner for earliness, shorter plant and lower ear placement. While, the inbred lines; Sk-9 and Sk-12 were the best general combiners for longer ear and high grain yield.

Table (4): General combining ability (GCA) effects of the nine inbred lines for all studied traits across three locations

Parental lines	DTS (day)	PHT (cm)	EHT (cm)	Epos %	LWR %	EL (cm)	GY ard. fed^{-1}
sd-63	0.139**	4.139**	4.171**	0.566	-0.021	0.230	-0.989**
Sk-9	-1.511**	5.869**	1.981	-0.434	0.042	0.580*	1.965**
Sk-12	0.822**	-0.718	-1.067	-0.339	0.042	0.481*	3.126**
Sd-1/2016	-0.067	1.171	4.155**	1.455**	0.042	-0.313	-0.720*
Sd-2/2015	-0.305**	-4.258**	0.520	1.503**	0.042	-0.132	0.021
Sd-7/2015	-0.464**	-1.797	-1.432	0.058	-0.021	-0.351	-0.172
Sd-14/2013	-1.004**	-5.258**	-8.527**	-2.212**	0.042	-0.322	-5.309**
Sd-42/2013	1.425**	1.250	0.933	-0.085	-0.085	-0.113	0.308
Sd-43/2013	0.965**	-0.400	-0.734	-0.513	-0.085	-0.062	1.770**
S.E. Gi	0.098	1.414	1.265	0.458	0.046	0.244	0.355
LSd 0.05	0.191	2.770	2.479	0.898	0.090	0.478	0.696
LSd 0.01	0.251	3.641	3.258	1.180	0.118	0.628	0.915

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

DTS = days to 50% silking (days) PHT = plant height, cm EHT = ear height, cm Epos% = ear position % LWR = late wilt resistant % EL = ear length, cm and GY = grain yield ard. fed^{-1}

Specific Combining Ability (SCA) effects:

Specific combining ability (S_{ij}) effects of 36 crosses for all studied traits across three locations are shown in Table 5. The results revealed that the nine crosses; Sd-63 x Sd-42, Sk-9 x Sd-1, Sk-9 x Sd-2, Sk-12 x Sd-43, Sd-1 x Sd-42, Sd-1 x Sd-43, Sd-2 x Sd-42, Sd-2 x Sd-43 and Sd-7 x Sd-43 had negative and significant SCA effects for DTS toward earliness. Seven crosses; Sd-63 x Sk-9, Sd-63 x Sd-14, Sk-9 x Sd-2, Sd-9 x Sd-7, Sd-1 x Sd-2, Sd-1 x Sd-7 and Sd-42 x Sd-43 had negative and significant SCA effects with PHT trait for shorter plant toward resistant to loading. Also, 4 crosses; Sd-63 x Sk-9, Sd-1 x Sd-7, Sd-7 x Sd-14 and Sd-42 x Sd-43 had negative and significant SCA effects toward lower ear placement due to their values in case of both traits (EHT and Epos %). One cross; Sk-9 x Sd-12 had the best SCA effects for ear length toward longer ear length. However, 13 crosses; Sd-63 x Sd-2, Sk-9 x Sd-43, Sk-12 x Sd-2, Sk-12 x Sd-42, Sk-12 x Sd-43, Sd-1 x sd-42, Sd-1 x Sd-43, Sd-2 x sd-7, Sd-2 x Sd-42, sd-2 x Sd-43, sd-7 x Sd-42, Sd-14 x Sd-42 and Sd-14 x sd-43 had positive and significant SCA effects for GY ard fed^{-1} toward high yielding. From the above mentioned, these crosses could be selected for its SCA to improve grain yield, whereas, the crosses with high values of SCA effects also showed high values of mean performances of GY, indicating good correspondence between SCA effects and mean of grain yield. Each of Bisen *et al*. (2020) and Zeleke *et al*. (2020), detected similarly results. Hence, such crosses combinations could effectively be exploited in hybrid breeding programs in the National Maize Research Programs.

Table (5): Specific combining ability (SCA) effects of 36 crosses for all studied traits across three locations

Crosses	DTS (day)	PHT (cm)	EHT (cm)	Epos %	LWR %	EL (cm)	GY ard. fed^{-1}
sd-63 x Sk-9	1.147**	-10.818**	-17.099**	-3.956**	0.016	-0.461	0.086
sd-63 x Sk-12	0.036	-3.341	-1.163	-0.607	0.016	-0.340	0.296
sd-63 x Sd-1/2016	-0.187	0.992	4.837	1.488	0.016	0.031	-1.592*
sd-63 x Sd-2/2015	0.274	6.310	-2.639	-2.004*	0.016	0.072	1.893*
sd-63 x Sd-7/2015	-0.234	2.849	4.869	1.440	0.079	-0.575	0.236
sd-63 x Sd-14/2013	0.083	-7.691*	-3.258	0.266	0.016	-0.004	0.284
sd-63 x Sd-42/2013	-1.012**	5.357	8.615**	2.583*	-0.302*	0.898	-2.224**
sd-63 x Sd-43/2013	-0.107	6.341	5.837	0.790	0.143	0.380	1.021
Sk-9 x Sk-12	-0.313	3.373	0.917	-0.274	-0.048	1.177*	0.085
Sk-9 x Sd-1/2016	-0.536*	6.706*	4.139	-0.067	-0.048	-0.074	0.062
Sk-9 x Sd-2/2015	-1.075**	-8.532*	3.885	3.440**	-0.048	-0.188	-4.194**
Sk-9 x Sd-7/2015	-0.028	-11.437**	-4.496	0.440	0.016	-0.613	1.098
Sk-9 x Sd-14/2013	-0.155	5.579	0.710	-0.956	-0.048	0.002	1.245
Sk-9 x Sd-42/2013	0.639**	11.071**	12.361**	2.361*	0.079	-0.540	-1.119
Sk-9 x Sd-43/2013	0.321	4.056	-0.417	-0.988	0.079	0.698	2.736**
Sk-12x Sd-1/2016	0.464	3.294	0.742	-0.385	-0.048	0.025	-0.730
Sk-12x Sd-2/2015	0.258	0.833	5.710	2.123*	-0.048	0.710	3.392**
Sk-12x Sd-7/2015	0.417*	-5.405	-7.671*	-1.877	0.016	-0.071	-3.307**
Sk-12x Sd-14/2013	-0.155	-4.389	-5.353	-1.163	-0.048	-0.321	-4.184**
Sk-12x Sd-42/2013	-0.250	1.881	3.853	1.488	0.079	-0.087	1.950*
Sk-12x Sd-43/2013	-0.456*	3.754	2.964	0.694	0.079	-1.093*	2.497**
Sd-1/2016x Sd-2/2015	2.147**	-19.278**	-14.623**	-1.560	-0.048	-1.563**	-14.183**
Sd-1/2016x Sd-7/2015	0.194	-8.071*	-10.337**	-2.004*	0.016	0.990	1.027
Sd-1/2016x Sd-14/2013	0.179	-1.611	0.425	0.377	-0.048	-0.150	0.845
Sd-1/2016x Sd-42/2013	-1.028**	8.325*	0.742	-1.417	0.079	-0.115	9.162**
Sd-1/2016x Sd-43/2013	-1.234**	9.643**	14.075**	3.567**	0.079	0.856	5.409**
Sd-2/2015x Sd-7/2015	0.544*	5.691	9.298*	2.060	0.016	-0.058	2.495**
Sd-2/2015x Sd-14/2013	0.306	-2.627	-0.496	0.329	-0.048	0.625	-1.022
Sd-2/2015x Sd-42/2013	-1.679**	2.754	-2.512	-1.464	0.079	0.660	6.256**
Sd-2/2015x Sd-43/2013	-0.774**	14.849**	1.377	-2.925**	0.079	-0.258	5.364**
Sd-7/2015x Sd-14/2013	0.575*	1.024	-6.544*	-3.226**	0.016	-0.156	-4.478**
Sd-7/2015x Sd-42/2013	-0.187	10.071**	6.663*	0.758	0.143	-0.433	2.735**
Sd-7/2015x Sd-43/2013	-1.282**	5.278	8.218**	2.409*	-0.302**	0.917	0.193
Sd-14/2013x Sd-42/2013	-0.425	7.087*	8.425**	1.806	0.079	0.561	3.884**
Sd-14/2013x Sd-43/2013	-0.409	2.627	6.091*	2.567*	0.079	-0.556	3.426**
Sd-42/2013x Sd-43/2013	3.940**	-46.548**	-38.147**	-6.115**	-0.238*	-0.944	-20.644**
SE sij	0.237	3.435	3.073	1.113	0.111	0.592	0.863
lsd 0.05 sij	0.465	6.733	6.024	2.182	0.218	1.161	1.692
lsd 0.01 sij	0.611	8.849	7.917	2.868	0.287	1.525	2.224

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

DTS = days to 50% silking (days) PHT = plant height, cm EHT = ear height, cm Epos% = ear position % LWR = late wilt resistant % EL = ear length, cm and GY = grain yield ard. fed-1

Correlation Coefficients:

All possible correlation coefficients between all the studied traits as a combined across three locations are illustrated in Table 6. The results showed that positive and significant correlation between GY with PHT (0.739**), EHT (0.650**), LWR% (0.330*) and EL (0.491**), indicating that the indirect selection for linked traits with yield would be useful and effective for improving grain yield. These results are in conformity to the finding of Hussain *et al*. (2016) and Abd El-Azeem *et al*. (2021). DTS was negative and significant correlation coefficients with PHT (-0.443**), EHT (-0.335*) and LWR% (-0.399*). These results are similar with obtained by Alvi *et al*. (2013), Bartaula *et al*. (2019) and Abd El-Azeem *et al*. (2021). PHT was possessed the positive and highly correlation rank with each of EHT (0.846**), Epos% (0.433**), EL (0.437**) and GY (0.739**). The positive and significant correlation values were noted between EHT and each of with Epos% (0.839**), EL (0.360*) and GY (0.650**). The correlation coefficient between LWR% and GY as well as between El and GY were positive and highly significant and scored (0.330*) and (0.491**), respectively.

Table (6): Correlation coefficients between all studied traits as a combined across three locations

parents	DTS (days	PHT (cm)	EHT (cm)	Epos %	LWR %	EL (cm)	GY ard. fed^{-1}
DTS (day)	-----	-0.443**	-0.355*	-0.233	-0.399*	-0.275	-0.279
PHT (cm)		-----	0.846**	0.433**	0.278	0.437**	0.739**
EHT (cm)			-----	0.839**	0.174	0.360*	0.650**
Epos %				-----	0.067	0.165	0.378
LWR %					-----	-0.054	0.330*
EL (cm)						-----	0.491**
GY ard. fed^{-1}							-----

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

DTS = days to 50% silking (days) PHT = plant height, cm EHT = ear height, cm Epos% = ear position % LWR = late wilt resistant % EL = ear length, cm and GY = grain yield ard. fed^{-1}

Superiority %:

The superiority% of crosses relative to the check hybrid SC-2031 for all studied traits across three locations are presented in Table (7). The results revealed that 26 crosses out 36 crosses showed negative and significant superiority% (desirable) toward earliness and ranged from -6.39** for cross Sk-9 x Sd-2 to 7.21** for Sd-42 x Sd-43 for DTS trait. These results are in agreement with Prasad and Shivani (2017) Bartaula *et al.* (2019) and Abd El-Azeem *et al.* (2021). Concerning three traits *via* PHT, EHT and Epos%; it cleared that 11, 3 and 1 crosses had negative and significant superiority% (desirable) than check hybrid toward shorter plants and lower ear placement therefore, these superiority% were desirable for loading resistant. These findings were in the some line, which detected by Abd El-Azeem *et al.* (2021). The superiority % values ranged from -20.56** (Sd-42 x Sd-43) to 4.81** (Sk-9 x Sd-42), and from -26.57** (Sd-42 x Sd-43) to 14.10** (Sd-1 x Sd-43) as well as from -9.03** (Sd-42 x Sd-43) to 11.70** (Sk-9 x Sd-2 and sd-1 x Sd-43) for PHT, EHT and Epos%, respectively.

Numerous researchers *viz* Onejeme *et al.* (2020) and Abd El-Azeem *et al.* (2021), found similar results and they reported a negative and significant superiority% for the mentioned traits (DTS, PHT and EHT). The superiority % of LWR %, scored -0.44* as value for three crosses (Sd-63 x Sd-42, Sd-7 x Sd-43 and Sd-42 x Sd-43), while scored zero (0.00) value for the rest of crosses, which means 33 crosses. Concerning of superiority % for EL trait, it ranged from -13.91 for cross Sd-1 x Sd-2 to 5.48 for cross Sk-9 x Sd-12. On the same direction, three crosses; Sk-9 x Sd-12, Sk-9 x Sd-43 and Sk-12 x Sd-2 had positive and not significant superiority % for the same trait (EL). The superiority % of the crosses for GY ard fed^{-1} trait scored high yielding value than the check hybrid SC-2031 and ranged from the cross Sd-42 x Sd-43 by value -67.86** to the cross Sd-1 x Sd-42 by value 7.91*. The best crosses for superiority% for GY ard fed^{-1} trait was Sd-1 x Sd-42 (7.91%). Furthermore, six crosses had positive and not significant superiority% over check hybrid SC-2031. These crosses are Sk-9 x Sd-43, Sk-12 x Sd-2, Sk-12 x Sd-43, Sd-1 x Sd-43, Sd-2 x sd-42 and Sd-2 x sd-43 and scored their values (1.6%), (1.78%), (4.15%), (1.56%), (1.91%) and (3.49%), respectively. The results of superiority% showed by F_1 hybrid combinations for respective trait desirability, which ranged from negative to positive significant results. This shows that those desirable F_1 hybrid combinations are better than the check and should be considered in breeding programs for the desirable traits. Uddin *et al.* (2008), Atif *et al.* (2012), Aly and Mousa (2011) and Abd El-Azeem *et al.* (2021), confirmed these findings results.

Genetic parameters:

Genetic variability and heritability for grain yield and other agronomic traits are shown in Table 8. The highest values of σ^2g, σ^2e and σ^2p found for PHT (120.42, 141.61 and 262.03) and EHT (100.65, 113.34 and 213.99), respectively. These results were showed that the phenotypic coefficient of variability (PCV) values were slightly higher than the genotypic coefficient of variability (GCV) values, indicating that the traits were less influenced by the environment. These results are in harmony with results reported before by Reddy *et al.* (2012); Langade *et al.* (2013) and Wedwessen and Zeleke (2020). Therefore, response to direct selection may be effective in improving these traits under conditions of this investigation. The values of PCV and GCV for all the studied traits exhibited low (less than 10%), moderate (10-20%) and high values (more than 20%). These results revealed that high estimates of heritability in broad sense were 77.74% for DTS and 80.03% for GY traits. High heritability for these traits, indicates the scape of genetic improvement of these traits through selection, which revealed that these traits less influenced by environment effects. Similar results were obtained by Wuhaib (2012), Abed *et al.* (2017) and Hassan *et al.* (2018), they found that the $h_2b\%$ were highest for GY. Generally, the heritability estimates was moderate for PHT (45.96%), EHT (47.03%) and low for Epos% (25.40%), while the heritability estimate was very low for EL (2.74%). In this connection, Ghirnire and Timsina (2015) and Bartaula *et al.* (2019), obtained similar results and they were reported high heritability value for grain yield.

Table (7): Estimates of Superior heterosis of 36 crosses relative to the check SC 2031 for all studied traits across three locations

Crosses	DTS (day)	PHT (cm)	EHT (cm)	Epos %	LWR %	EL (cm)	GY ard. fed^{-1}
sd-63 x Sk-9	-2.46**	-2.73	-6.76	-3.70	0.00	-3.15	-13.41**
sd-63 x Sk-12	-0.66	-2.38	2.69	2.67	0.00	-3.05	-9.61**
sd-63 x Sd-1/2016	-2.30**	0.09	10.92**	9.86**	0.00	-4.97	-25.51**
sd-63 x Sd-2/2015	-1.97**	0.04	2.77	3.49	0.00	-3.96	-13.79**
sd-63 x Sd-7/2015	-2.95**	-0.35	6.85	7.19**	0.00	-7.92*	-18.92**
sd-63 x Sd-14/2013	-3.28**	-5.91**	-4.32	0.82	0.00	-5.18	-33.04**
sd-63 x Sd-42/2013	-1.31*	1.85	11.33**	9.03**	-0.44*	-0.10	-24.41**
sd-63 x Sd-43/2013	-0.66	1.59	8.07*	4.93	0.00	-2.23	-11.36**
Sk-9 x Sk-12	-3.61**	0.97	2.61	1.44	0.00	5.48	-2.00
Sk-9 x Sd-1/2016	-5.25**	3.04	8.80*	5.13	0.00	-3.86	-12.73**
Sk-9 x Sd-2/2015	-6.39**	-5.16**	5.95	11.70**	0.00	-3.55	-22.48**
Sk-9 x Sd-7/2015	-5.08**	-5.34**	-1.63	3.49	0.00	-6.50	-8.33*
Sk-9 x Sd-14/2013	-6.07**	0.04	-3.02	-3.29	0.00	-3.55	-22.18**
Sk-9 x Sd-42/2013	-1.31*	4.81**	12.47**	6.78	0.00	-5.08	-13.15**
Sk-9 x Sd-43/2013	-2.46**	1.37	1.87	-0.21	0.00	0.81	1.60
Sk-12x Sd-1/2016	-0.33	-0.93	4.07	4.72	0.00	-3.86	-11.71**
Sk-12x Sd-2/2015	-0.98	-4.06	5.05	9.45	0.00	0.10	1.78
Sk-12x Sd-7/2015	-0.98	-5.56*	-6.19	-0.62	0.00	-4.47	-17.33**
Sk-12x Sd-14/2013	-2.62*	-6.53**	-9.70**	-3.49	0.00	-5.48	-34.02**
Sk-12x Sd-42/2013	0.82	-1.46	3.99	5.34	0.00	-3.45	-1.42
Sk-12x Sd-43/2013	-0.16	-1.37	2.12	3.08	0.00	-7.82	4.15
Sd-1/2016x Sd-2/2015	0.49	-11.29**	-6.03	5.95	0.00	-13.91**	-57.64**
Sd-1/2016x Sd-7/2015	-2.62**	-5.87*	-4.32	2.46	0.00	-3.25	-15.98**
Sd-1/2016x Sd-14/2013	-3.44**	-4.68*	-1.63	2.67	0.00	-8.32*	-30.74**
Sd-1/2016x Sd-42/2013	-1.64**	1.85	5.54	3.29	0.00	-7.21	7.91*
Sd-1/2016x Sd-43/2013	-2.62**	1.72	14.10**	11.70**	0.00	-2.54	1.56
Sd-2/2015x Sd-7/2015	-2.46**	-2.56	7.42*	10.06**	0.00	-7.21	-9.85**
Sd-2/2015x Sd-14/2013	-3.61**	-7.23**	-4.97	2.67	0.00	-3.96	-33.86**
Sd-2/2015x Sd-42/2013	-2.95**	-2.51	0.49	3.29	0.00	-2.84	1.91
Sd-2/2015x Sd-43/2013	-2.30**	1.63	2.12	-0.21	0.00	-6.80	3.49
Sd-7/2015x Sd-14/2013	-3.44**	-4.81*	-10.84**	-6.57	0.00	-8.53*	-43.98**
Sd-7/2015x Sd-42/2013	-0.98	1.37	5.79	4.72	0.00	-8.83*	-8.39*
Sd-7/2015x Sd-43/2013	-3.28**	-1.19	5.70	6.98*	-0.44*	-2.44	-11.39**
Sd-14/2013x Sd-42/2013	-2.13**	-1.19	1.87	2.46	0.00	-4.16	-19.45**
Sd-14/2013x Sd-43/2013	-2.79**	-3.62	-1.06	3.08	0.00	-9.04*	-16.67**
Sd-42/2013x Sd-43/2013	7.21**	-20.56**	-26.57**	-9.03**	-0.44*	-9.85*	-67.86**
LSD 0.05	0.766	1.294	10.065	3.565	0.348	1.874	2.775
LSD 0.01	1.007	14.584	13.229	4.685	0.457	2.463	3.647

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

DTS = days to 50% silking (days) PHT = plant height, cm EHT = ear height, cm Epos% = ear position % LWR = late wilt resistant % EL = ear length, cm and GY = grain yield ard. fed^{-1}

Table (8): Genetic variability and heritability for grain yield and other agronomic traits

Gen. Para. / Traits	σ^2 g	σ^2 e	σ^2 p	GCV%	PCV%	$h^2_b\%$
DTS (day)	2.36	0.68	3.03	2.31	2.62	77.74
PHT (cm)	120.42	141.61	262.03	16.54	24.40	45.96
EHT (cm)	100.65	113.34	213.99	7.27	10.60	47.03
Epos%	5.06	14.87	19.93	4.02	7.98	25.40
EL (cm)	0.12	4.21	4.33	1.65	9.97	2.74
GY ard. fed^{-1}	35.86	8.95	44.80	19.86	22.20	80.03

DTS = days to 50% silking (days) PHT = plant height, cm EHT = ear height, cm Epos% = ear position % LWR = late wilt resistant % EL = ear length, cm and GY = grain yield ard. fed^{-1}

REFERENCES

Abd El-Azeem, M. E. M., R. S. H. Aly, W. M. El Sayed and Noura A. Hassan (2021). Combining ability and gene action using 10 x 10 diallel crosses of ten maize inbred lines (*Zea mays* L.). J. of Plant Production, Mansoura Univ., 12(11): 1205-1211.

Abed, N. Y., B. H. Hadi, W. A. Hassan and K. M. Wuhaib (2017). Assessment yield and its components of Italian maize inbred lines by full diallel cross. 15 (special number of 5th Scientific Conf. of the faculty of Agric. Anbar Univ., 114-124.

Alvi, M. B., M. Rafique, M. Shafique, A. Hussain, T. Mohmood and M. Sarwar (2013). Characters association and path analysis of grain yield and yield components in maize. Pakistan J. of Biological Sci., 6(2): 136-138.

ALY, R.S.H (2013). Relationship between combining ability of grain yield and yield components for some newly yellow maize inbred lines via line x tester analysis. Alex. J. Agric. Res., 58(2): 115-124.

Aly, R. S. H. and S. Th. M. Mousa (2011). Combining ability for grain yield and other yield component traits using half diallel crosses of maize inbred lines. J. Agric. Chem. and Biotech., Mansoura Univ., 2(12): 317-329.

Aly, R. S. H. and S. Th. M. Mousa (2012). Evaluation of some promising white maize inbred lines (*Zea mays* L.) through diallel mating design. Egypt. J. Agric. Res., 90(4): 47-61.

Atif, I. A., A. A. Awadalla, M. K. Mutasim, E. I. Atif and M. O. Abdellatif (2012). Combining ability and heterosis for yield and yield components in maize (*Zea mays* L.). Australian Journal of Basic and Applied Sciences, 6(10): 36-41.

Badu-Apraku, B. and R. Akinwale (2011). Identification of early-maturing maize inbred lines based on multiple traits under drought and low N environments for hybrid development and population improvement. Can J Plant Sci., 91: 931-942. https://doi.org/10.4141/CJPS2010-021.

Bartaula, S., U. Panthi, K. Timilsena, S. S. Acharya and J. Shrestha (2019). Variability, heritability and genetic advance of maize (*Zea mays* L.) genotypes. Res. Agric. Livest. Fish., 6(2): 163-169.

Bisen, V., M. S. Yadav, V. Verma, G. S. Gathiye and D. Kewte (2020). Heterosis and combining ability through diallel method in maize (*Zea mays* L.). J. of Pharmacognosy and Phytochemistry, 9(1): 1986-1994.

El Hosary, A. A. A., M. H. Motawea and A. A. Elgammal (2018). Combining ability for yield and some of its attributes in maize across two locations. Egypt. J. Plant Breed., 22(3): 625-640.

El Hosary, A. A. A. (2020). Diallel analysis of some quantitative traits in eight inbred lines of maize and Gge Biplot analysis for elite hybrids J. of Plant Production, Mansoura Univ., 11(3): 275 – 283.

Ferial. M. Turk, M. El. M. El-Badawy, A. A. A. El Hosary, S. A. S Mehasen (2020). Combining ability analysis using diallel crosses among eight inbred lines of maize under two planting dates. Annals of Agric. Sci., Moshtohor, 58(4): 905-914.

Gad, M. S., A. A. El Hosary, G. A. Sary, El Sayed Shokr; E. M. K. EL Galfy and A. A. A. El Hosary (2021). Combining ability analysis using diallel crosses among nine inbred lines of corn under two nitrogen levels. 5th International Conference on Biotechnology Applications in Agriculture (ICBAA), Benha University, 8 April, Egypt, Plant Biotechnology, 247-258.

Gardner, C. O. and S. A. Eberhart (1966). Analysis and interpretation of the variety cross diallel and related populations. Biometrics, 22: 439-452.

Ghimire, B. and D. Timsina (2015). Analysis of yield and yield attributing traits of maize genotypes in Chitwan, Nepal. World Journal of Agricultural Research, 3(5): 153-162

Griffing, B. (1956). Concept of general and specific combining ability in relation to diallel crossing systems. Australian Journal of Biological Science, 9: 463-493.

Haddadi, M. H., M. Eesmaeilof, R. Choukan and V. Rameeh (2012). Combining ability analysis of days to silking, plant height, yield components and kernel yield in maize breeding lines. Afr. J. Agric. Res., 7(36): 5153-5159.

Hassan, W. A., B. H. Hadi and K. M. Wuhaib (2018). Estimation of some genetic parameters for grain yield and its components of maize under watered and water stress. Int. J. Agric. Stat. Sci., 14(2): 553-559.

Hemada, S. Sh., H. E. Yassien, I. N. Abd EL-Zaher and M. H. Haridy (2020). Combining ability and genetic parameters of some white maize (*Zea mays* L.) inbred lines using diallel analysis. Archives of Agric. Sci. journal, 3(3): 82-100.

Hussain, N., B. Rehman and K. Faizal (2016). Phenotypic and genotypic association between maturity and yield traits in maize hybrids (*Zea mays* L.). African J. Agric. and Food Security, 4(3): 157-160.

IITA (2014). Maize 2014. Retrieved June 16, 2014, from http://www.iita.org/maize

Langade, D. M., J. P. Shahi, K. Srivastava, A. Singh, V. K. Agarwal and A. Sharma (2013). Appraisal of Genetic Variability and Seasonal Interaction for Yield and Quality Traits in Maize (*Zea mays* L.). Plant Gene and Trait, 4(18): 95–103.

Li, C. M. and K. C. Yang (1985). Studies on inheritance of quantitative characters for plant type in some inbred lines of maize. Scientia Agriculture Sinical, 9: 28-36.

Mafouasson, A., N. Hortense, R. Kenga, V. Gracen, A. Yeboah, M. Martin, L. Nasser, L. Tandzi and G. Ntsomboh (2017). Combining Ability and

Gene Action of ropical Maize (*Zea mays* L.) Inbred Lines under Low and High Nitrogen Conditions. Journal of Agricultural Science, 9(4): 222-235.

Mosa, H. E., I. A. I. El-Gazzar and M. A. A. Hassan (2016). Combining ability and type of gene action analysis of yield and yield components for some white maize inbred lines. Annals of Agric. Sci., Moshtohor, 54(2): 291–296.

Murray, L. W., I. M. Ray, H. Dong and A. Segovia-Lerma (2003). Classification and re-evaluation of population-based diallel analysis. Crop Sci., 43: 1930-1937.

Onejeme, F. Ch., E. O. Okporie and Ch. E. Eze (2020). Combining Ability and Heterosis in Diallel Analysis of Maize (*Zea mays* L.) Lines. Int. Ann. Sci., 99(1): 188-200.

Prasad, B. and D. Shivani (2017). Correlation and path analysis in maize (Zea mays L.). J. of Genetics, Genomics and Plant Breeding, 1(2): 1-7.

Reddy, V. R., F. Jabeen, M. R. Sudarshan and A. Seshagiri Rao (2012). Studies on Genetic Variability, Heritability, Correlation and Path Analysis in Maize (*Zea mays* L.) over locations. Principal Scientists Acharya N. G. Ranga Agricultural University, Rajendranagar, Hyderabad-30, International Journal of Applied biology and harmaceutical Technology, 195–199.

SAS Institute Inc. (2008). Statistical Analysis System / STAT user's guide, version 9.2. SAS Institute Inc. Cary, NC, USA.

Sharief, A. E., S. E. El-Kalla, H. E. Gado and H. A. E. Abo-Yousef (2009). Heterosis in yellow maize. Aust. J. Crop Sci., 3(3): 146-154.

Singh, A. K., J. P. Shahi and J. K. Singh (2004). Heterosis in maize. J. Applied Biology, 14(1): 1-5.

Snedecor, G. W. and W. G. Cochran (1980). Statistical Methods. 7th Ed. Iowa State Univ. Press, Ames, Iowa, USA.

Turkey, O. H., S. A. Sedhom, M. EL. M. EL-Badawy and A. A. A. EL Hosary (2018). Combining ability analysis using diallel crosses among seven inbred lines of corn under two sowing dates. Annals of Agric. Sci., Moshtohor, 56(2): 293-304.

Uddin, S. M., M. M. Amiruzzaman, S. A. Begum, M. A. Hakim and M. R. Ali (2008). Combining ability and heterosis in maize (*Zea mays* L). Bangladesh J. Genet Pl. Breed., 21(1): 21-28.

Wedwessen, T. and H. Zeleke (2020). Genetic variability, heritability and genetic advance estimates in maize (*Zea mays* L.) inbred lines. Inter. J. of Novel Res. In Life Sci., 7(2): 10-16.

Wuhaib, K. M. (2012). Testing of introduced germplasm of maize by line x tester mating system: II-phenotypic traits. The Iraqi J. of Agric. Sci., 43(2): 45-55.

Xu, J. L. and H. Crouch (2008). Genomics of tropical a stable food and feed across the world.pp.333-370. In Genomics of Tropical Crop Plants, Springer, London. UK.

Zeleke, K., A. Demissew and G. Wosene (2020). Heterosis and combining ability of highland adapted maize (Zea may L.) DH lines for desirable agronomic traits. African J. of Plant Sci., 4(3): 121-133.

Živanovic, T., G. Brankovic and S. Radanovic (2010). Combining abilities of maize inbred lines for grain yield and yield components. Genetika, 42(3): 565-574.

التباين الوراثى، القدرة الإئتلافية، الفعل الجينى والتفوق لسلالات جديدة بيضاء من الذرة الشامية

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تم تقييم تسعة سلالات بيضاء جديدة من الذرة الشامية مشتقة من مصادر وراثية مختلفة بطريقة التزاوج النصف دائري ٩ x ٩ (جريفنج ١٩٥٦ طريقة-٤، نموذج -١) لدراسة التباين الوراثى ، القدرة على التآلف ، طبيعة الفعل الجينى والنسبة المئوية لتفوق الجيل الأول مقارنة بأعلى هجن المقارنة محصولاً. تم إجراء كافة التهجينات الممكنة بين التسعة سلالات بمحطة البحوث الزراعية بسدس في موسم ٢٠١٩للحصول على ٣٦ هجين، ثم تم تقييم هذه الهجن بالإضافة إلى هجينين بيضاء الحبوب (هجين فردى-١٠ وهجين فردى٢٠٣١) كهجن مقارنة في موسم ٢٠٢٠ في تجارب حقلية ذات تصميم القطاعات الكاملة العشوائية بثلاث مكررات في ثلاثة محطات بحثية مختلفة (سدس، سخا و النوبارية). أظهرت النتائج المتحصل عليها وجود اختلافات معنوية بين المواقع الثلاثة لكافة الصفات المدروسة مشيراً إلى وجود اختلافات في الظروف المناخية للبيئات تحت الدراسة. كانت كلاً من القدرة العامة والخاصة على التآلف معنوية أو عالية المعنوية لمعظم الصفات تحت الدراسة، مما يشير إلى أهمية كلاً من الفعل الجيني المضيف وغير المضيف في وراثة هذه الصفات. إمتلكت السلالة سدس-١٤ أفضل قدرة عامة على التآلف لصفات التبكير، وقصر النبات وأفضلية موقع الكوز على النبات، بينما أظهرت السلالتين سخا-٩ و سخا-١٢ الأفضلية للقدرة العامة على التآلف لصفات الكوز الطويل ومحصول الحبوب العالي. إمتلكت ثلاثة عشر هجين قدرة خاصة على التآلف موجبة ومعنوية لصفة محصول الحبوب مما يؤكد إمكانية استخدامها وبشكل فعال في البرنامج القومي لمحصول الذرة الشامية لتحسين صفة محصول الحبوب. رصدت النتائج وجود ارتباط معنوي وموجب بين المحصول وكلاً من ارتفاع النبات، ارتفاع الكوز، مقاومة مرض الذبول المتأخر وطول الكوز مما يعزز إلى أن الانتخاب غير المباشر للصفات المرتبطة للمحصول ربما يكون فعال ومفيد لتحسين صفة محصول الحبوب. أظهر الهجين سدس-١ x سدس-٤٢ أفضل نسبة تفوق في المحصول (٧,٩١%) مقارنة بأفضل هجن المقارنة هجين فردى ٢٠٣١ إلى جانب وجود ستة هجن فردية أخرى موجبة وغير معنوية قياساً بأفضل هجن المقارنة محصولاً. أوضحت النتائج إلى أن أغلبية الفعل الجيني المتحكم في صفة محصول الحبوب هو الفعل الإضافي ومن ثم فإن الانتخاب المباشر يعتبر مفيداً وفعالاً لتحسين هذه الصفة بتلك الدراسة، بينما على الجانب العكسي، فإن أغلبية الفعل الجيني المتحكم في صفة عدد الأيام حتى ظهور ٥٠% من الحراير هو الفعل الجيني غير المضيف ومن ثم فإن برامج التهجين تعد هي الفعالة والمفيدة بدورها في تحسين في مثل هذه الصفات بمحصول الذرة الشامية.