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(Original Article)

Line × Tester Analysis Using Three-way Crosses of Yellow Maize in a Multi-location Trial

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Abstract

Eleven new yellow maize inbred lines were top crossed with three testers, i.e., SC162, SC-173 and SC-177 during 2022 summer season. The 33 three-way crosses (TWC) and the two check hybrids TWC-360 and TWC-368 were evaluated at three locations; Sids, Mallawy, and Gemmeiza Agric. Res. Stations, Egypt, during 2023 summer season. The objectives of this research were to estimate the combining abilities of eleven new yellow maize inbred line and their crosses, to identify the superior three-way crosses in yielding ability, and to estimate the correlation coefficient between the studied traits. Results revealed that locations (Loc) were significant for all studied traits except ear position% (Ep %) trait. Mean squares of lines (L), testers (T), L × T and their interactions with locations; L × Loc, T × Loc and L × T × Loc were significant (p<05-p.01) for most traits. Results showed that only four crosses did not outyielded the highest check TWC-368. Two inbred lines; L10 and L11 were desirable for general combining ability (GCA) effects of days to 50% silking emergency (DS), plant height (PH) and ear height (EH) traits. Also, two inbred lines L2 and L5 had positive and significant general combining ability (GCA effects for grain yield (GY) toward high yielding. T1 and T3, the best testers have general combining ability (GCA) effects toward high yielding. While, T2 has the best general combiner for earliness, short plant and ear heights. Six crosses: L3 × T2, L4 × T3, L5 × T2, L6 × T3, L7 × T1 and L8 × T1 had positive and significant Specific combining ability (SCA) effects for grain yield ardab/ feddan (ard. fed.$^{-1}$); (1 ard. = 140kg and 1 fed = 4200m^2). Based on these results, these promising three-way crosses should be evaluated in advanced trials to confirm their potential in breeding programs aimed at developing superior crosses with improved traits.

Keywords: *Correlation، GCA، Line × tester، SCA، Zea mays.*

Introduction

Maize (*Zea mays* L.; 2n = 20) is an important cereal crop in the world. It ranks third after rice and wheat in Egypt (FAO 2022). Maize is the primary stable food in many developing countries that provides feed, food, fuel and other industrial raw materials. Single- and three-way crosses are the major hybrids used for high production in Egypt. Hence, these crosses play an important role in increasing the area and high productivity of maize. Several methods are used to

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determine combining abilities for inbred lines and their crosses such as, diallel, line × tester and others. The mating design line × tester was developed by Kempthorne (1957), which offers trustworthy information on the combining abilities (GCA and SCA) effects of parents and other crosses combine. GCA refers to the average performance of the genotype in its cross combinations and is a measure of additive gene action. While SCA is the better or worse performance of a hybrid based on GCA and measures the non-additive gene action (Sharief *et al*., 2009; Sprague and Tatum, 1942). Venkatesh *et al.* (2001) used L × T method and found significant differences between L, T and L × T combinations. This method can be used to estimate heritability and types of gene action that influence traits (Singh and Chaudhary, 1979) and this mating is the simplest method. In addition, it provides complete genetic information (Kose 2017; Yehia and El-Hashash 2022). The type of gene action plays an important role in developing effective breeding programs. For GY, SCA and SCA × locations were more important than GCA and GCA interaction with locations. Several researchers reported that the GCA was more affected by environmental conditions than SCA for studied traits (Parvez *et al.,* 2006; Rather, 2006; Aly and Mousa (2008) for GY) and Aly *et al.,* (2023) for ear height and ear position%. On the other hand, the non-additive gene action was more affected by environmental than additive gene action as reported by Aly (2004) and Aly and Amer (2008) for plant height (PH), Mosa (2010) for 50% silking emergency (DS), and grain yield, and Aly *et al.* (2023) for plant height (PH), 50% silking emergency (DS), plant height (PH)and grain yield. The objectives of this research were to estimate the combining abilities of eleven new yellow maize inbred line and their crosses in addition to identifying superior three-way crosses in yielding ability.

Materials and Methods

Plant materials and their sources

The examined eleven new yellow maize inbred lines were developed from different geographical regions at maize breeding program at Sids and Giza Agricultural Research Stations, and Field Crops Research institute (FCRI), Agricultural Research Center (ARC) are shown in Table 1.

Table 1. Name, line symbol and origin of the eleven new yellow maize inbred lines and the three used testers.

Inbred lines	Line Symbol	Origin
Sd-3118	L_1	
Sd-3120	L_2	
Sd-3161	L_3	
Sd-3162	L_4	
Sd-3166	L_5	Sids Agric. Res. Sta.
Sd-15/2013	L_6	
Sd-21/2015	L_7	
Sd-61/2013	L_8	
Sd-2/2021	L_9	
Sd-9/2021	L_{10}	
Gz-666	L_{11}	Giza Agric. Res. Sta.
Testers		
SC-162	T_1	
SC-173	T_2	Maize Breeding Program, FCRI, ARC
SC-177	T_3	

Sd= Sids, SC= Single Cross and Gz= Giza

Locations and growing seasons

In 2022 summer growing season, the eleven new yellow maize inbred lines were crossed with the three testers: SC-162, SC173 and SC-177 in a line × tester mating design at Sids Station. To obtain 33 three-way crosses. During 2023 summer growing season, the resulted 33 crosses along with two yellow check hybrids; TWC-360 and TWC-368 were evaluated in a yield trials at three locations; Sids, Mallawi, and Gemmeiza Agricultural Research Stations, Egypt.

Experimental design and its management

A randomized complete blocks design (RCBD) with three replications was used. Plot size was one row, 6 m long and 0.8 m a part. Seeds were planted in hills evenly spaced at 0.25 m within a row at the rate of two kernels hill^{-1}, which was thinned to one plant hill^{-1} three weeks later. The field trials were kept clean of weeds throughout the growing season, and the recommended cultural practices for maize production were applied

Data recorded

The data collected on number of days to 50% silking emergency (DS), plant height (PH cm), ear height (EH cm), ear position% (EP %) and grain yield (GY ard. fed^{-1}) adjusted to 15.5% moisture content, (1 ardab=140 kg and one feddan=4200 m^2).

Statistical analysis

Data was analyzed using general linear model (GLM) procedures in *SAS* (2008). Means for all maize combinations adjusted for block effects through sites were analyzed according to Snedecor and Cochran (1989). Combining ability analysis was performed for traits that showed statistical differences among crosses. Kempthorne (1957) method was employed to determine general and specific combining abilities and their interaction effects with three locations. The least significant differences (L.S.D.) at 5% level of probability were calculated to compare treatment means. Simple correlation coefficients among all studied traits were calculated.

Results and Discussion

Analysis of variance

Mean squares of the combined analysis for the five studied traits are presented in Table 2. Results revealed that locations (Loc) mean squares was significant for all studied traits except EP% trait, indicating the differences of edaphic factors in the three locations. These results are similar to those obtained by Aly *et al*., (2011), Abd El-Mottalb (2017), Alsebaey *et al. (*2021), Ibrahim *et al*. (2021), and Mosa *et al.* (2023). The mean squares *of* crosses (C) and their interaction with locations (C × Loc) were significant for all the studied traits. These results are agreement with numerous researchers; Aly *et al.* (2011), Alsebaey *et al.* (2020*),* Biradar *et al*. (2020), Aldulaimy and Hammadi (2021), Ibrahim et al.

(2021), Alsebaey *et al.* *(*2021), Rachman *et al.* (2022), Abd El-Azeem *et al.* (2023 and 2024, and Abo-Elwafa *et al*. (2023).

Table 2. Mean squares of the combined analysis for five studied traits

S.V.	Df	DS	PH	EH	EP%	GY
Locations (Loc.)	2	218.21**	55945.86**	11557.32*	493.91	943.15**
Reps/Loc.	6	6.71	724.08	1360.22	100.53	26.04
Crosses (C)	34	31.76**	1173.66**	540.92**	22.47**	135.11**
C × Loc	68	3.96*	311.88**	217.67**	17.07**	32.91**
Pooled error	204	2.722	161.322	129.002	10.960	10.292

*, ** significant at p ≥ 0.05 and p ≥ 0.01 levels of probability, respectively.
DS = days to 50% silking emergency (days) PH = plant height (cm) EH = ear height (cm)
EP% = ear position% GY = grain yield ard. fed.$^{-1}$

Line × Tester analysis for the five studied traits across three locations are illustrated in Table 3. Results showed that mean squares of lines (L), testers (T) and interaction of L × T were significant for all studied traits except for T of EP% trait. The significance of lines and/or testers reflected the presence of additive gene action in these traits, however the significance of L*T indicating the non-additive gene action. These results are in harmony with those reported by Abd El-Mottalb (2017) and Aly *et al*., (2011 and 2023) for L and T of DS, PH, and EH; Gamea (2019) for L, T and L × T of PH, EH, and GY; Tesfaye *et al*. (2019) for L, T, and L × T of DS, EH and GY; Alsebaey *et al*. (2020) for L, T, and L × T of PH, EH, and GY, and Abd El-Azeem *et al*. (2023) for L, T, and L × T of DS, PH, EH, and GY mean. Mean squares of L × Loc, T × Loc, and L × T × Loc were significant for all studied traits except for L × Loc of DS and L × T × Loc of DS, EH, and Ep% traits. Similar results were obtained by Aly *et al*. (2011 and 2023) for L × T × Loc of GY; Gamea (2019) for L × T × Loc of DS; Tesfaye *et al*. (2019) for L × T × Loc of DS and EH; Alsebaey *et al*. (2020) for L × Loc and T × Loc of GY; Alsebaey *et al*. (2021) for L × Loc and T × Loc of PH, EH, and GY and for L × T × Loc of GY, and Abd El-Azeem *et al*. (2023) for L × Loc of PH, EH, EP%, and GY, for T × Loc of DS, PH, EH, and EP% and for L × T × Loc of EH and EP% traits.

Table 3. Line × Tester analysis for five studied traits across under three locations.

S.V.	Df	DS	PH	EH	EP%	GY
Lines (L)	10	24.79**	635.30**	329.45*	23.76*	83.89**
Testers (T)	2	254.01**	9031.18**	3361.44**	10.89	1031.20**
L × T	20	9.19**	610.89**	307.10**	22.57**	77.93**
L × Loc.	20	3.43	405.47**	455.54**	28.59**	25.34**
T × Loc.	4	9.92*	899.44**	386.05*	34.13*	32.97*
L × T × Loc	40	3.55	221.59*	98.51	11.15	34.35**
Pooled error	192	2.759	161.907	133.927	11.353	10.484

*, ** significant at p ≥ 0.05 and p ≥ 0.01 levels of probability, respectively.
DS = days to 50% silking emergency (days) PH = plant height (cm) EH = ear height (cm)
EP% = ear position% GY = grain yield ard. fed.$^{-1}$

Mean performance

Average mean performance of the 33 three-way crosses and the two check hybrids for five studied traits across three locations are given in Table 4. For DS (towered earliness) 26 crosses out 33 crosses were significantly earlier than the two checks; TWC 360 (64.78 days) and TWC 368 (64.67 days) and the best crosses were L2 × T2 (58.33), L3 × T2 (59.67), L10 × T2 (58.56), and L11 × T2 (59.78). For PH, the crosses ranged from 223.00 for cross L4 × T1 to 265.33 cm for cross L6 × T3. Sixteen crosses were significantly shorter than the two checks; TWC 360 (257.33 cm) and TWC 368 (263.78 cm), the best crosses from them were L4 × T1 (223.01), L4 × T2 (228.67), L9 × T2 (227.22), and L11 × T2 (229.56).

Table 4. Mean performance of the 33 Three-way crosses and the two check hybrids for five studied traits across three locations.

Cross	DS	PH	EH	EP %	GY
L1 × T1	63.33	247.11	141.56	57.36	23.63
L1 × T2	60.44	241.78	137.33	56.83	19.48
L1 × T3	62.56	253.00	146.67	58.12	27.38
L2 × T1	63.00	253.22	146.56	58.03	26.44
L2 × T2	58.33	237.11	137.33	58.19	23.82
L2 × T3	63.67	255.00	145.33	56.84	28.52
L3 × T1	63.67	250.78	138.56	55.32	20.69
L3 × T2	59.67	243.44	133.11	54.70	20.32
L3 × T3	64.11	254.00	143.00	56.46	24.23
L4 × T1	60.67	223.00	137.22	61.39	17.37
L4 × T2	60.78	228.67	127.11	55.41	16.89
L4 × T3	62.78	262.56	151.78	57.74	27.93
L5 × T1	65.22	249.33	143.11	57.36	27.43
L5 × T2	60.67	242.56	141.33	58.32	27.26
L5 × T3	64.11	255.33	146.44	57.47	24.18
L6 × T1	64.22	258.56	145.67	56.24	23.18
L6 × T2	60.33	231.11	126.00	54.02	15.82
L6 × T3	64.22	265.33	154.44	58.28	27.86
L7 × T1	64.22	243.56	138.89	57.08	28.70
L7 × T2	60.11	241.56	139.33	57.77	17.89
L7 × T3	62.33	245.89	133.67	54.49	21.64
L8 × T1	62.67	256.33	140.78	54.86	27.47
L8 × T2	60.44	243.78	140.67	57.87	19.12
L8 × T3	63.22	264.89	150.78	57.01	24.92
L9 × T1	61.56	264.22	151.33	57.39	25.51
L9 × T2	60.89	227.22	127.67	55.98	19.06
L9 × T3	61.56	258.22	147.33	57.04	25.12
L10 × T1	60.44	249.22	142.00	57.26	26.64
L10 × T2	58.56	235.22	127.22	54.10	20.46
L10 × T3	61.00	242.33	135.33	56.02	26.23
L11 × T1	62.11	249.11	137.44	55.29	24.56
L11 × T2	59.78	229.56	130.67	57.09	16.61
L11 × T3	60.33	250.44	134.89	54.16	25.14
TWC360	64.78	257.33	144.22	56.10	23.68
TWC368	64.67	263.78	155.56	59.08	27.30
LSD 0.05	1.29	9.41	8.70	2.53	2.59
LSD 0.01	1.69	12.37	11.43	3.32	3.40

DS = days to 50% silking emergency (days) PH = plant height (cm) EH = ear height (cm)
EP% = ear position% GY = grain yield ard. fed.$^{-1}$

For EH, the crosses ranged from 126.00 cm for cross L6 × T2 to 154.44 cm for cross L6 × T3. Nine crosses showed significantly lower in ear height than the two checks TWC 368 (155.56 cm) and TWC 360 (144.22 cm), the best crosses from them were L4 × T2 (127.11), L6 × T2 (126.0), L9 × T2 (127.67), and L10 × T2 (127.22). For EP% toward lower ear placement, 13 crosses were significantly short EP% than the check hybrid TWC 368 (59.08%). While most crosses did not differ significantly than the check TWC 360 (56.10%) toward lower placement, the best crosses for EP% were L6 × T2 (54.02), L10 × T2 (54.10), and L11 × T3 (54.16). For GY, 10 crosses significantly outyielded the check TWC 360 (23.68 ard. fed.$^{-1}$) and did not differ significantly than the highest check TWC 368 (27.30 ard. fed.$^{-1}$), the best crosses were L2 × T3 (28.52), L4 × T3 (27.93), L6 × T3 (27.86), and L7 × T1 (28.70). Based on these results, these promising three-way crosses should be evaluated in advanced trials to confirm their potential in breeding programs aimed at developing superior crosses with improved traits.

Combining abilities effects

General combining ability (GCA) effects for eleven new yellow maize inbred lines and three testers for five the studied traits combined across under three locations are presented in Table 5. Negative GCA effects values for DS, PH, EH and EP% indicate desirable effects on maturity, short plants, lowest ear height, and lower ear placement, respectively. However, GCA positively affected values are preferred for yield and its components. Results revealed that two inbred lines; L10 and L11 had negative (desirable) and significant GCA effect values for DS, PH and EH toward earliness, short plants, and ear height, these lines possessed (-1.848** and -1.108**), (-4.815* and -4.837*) and (-5.165* and -5.684*), respectively. Two lines; L3 and L11 had negative and significant GCA effect values for EP% toward lower ear placement and scored -1.219* and -1.200*, respectively.

Table 5. General combining ability effects of the 11 inbred lines and 3 testers for five studied traits across the three locations

Line and Tester	DS	PH	EH	EP %	GY
L1	0.263	0.222	1.835	0.726	0.117
L2	-0.182	1.370	3.057	0.977	2.884**
L3	0.633	2.333	-1.795	-1.219*	-1.631**
L4	-0.441	-9.000**	-1.313	1.470*	-2.649**
L5	1.485**	2.800	3.613	1.003	2.910**
L6	1.077**	4.593	2.020	-0.530	-1.094
L7	0.374	-3.407	-2.721	-0.267	-0.635
L8	0.263	7.926**	4.057	-0.134	0.458
L9	-0.515	2.815	2.094	0.092	-0.149
L10	-1.848**	-4.815*	-5.165*	-0.919	1.065
L11	-1.108**	-4.837*	-5.684*	-1.200*	-1.275*
SE gi (L)	0.320	2.449	2.227	0.648	0.623
LSD $_{gi}$ 0.05	0.627	4.800	4.365	1.271	1.221
0.01	0.823	6.308	5.737	1.670	1.605
T1	0.980**	2.421	2.084	0.340	1.314**
T2	-1.848**	-10.529**	-6.582**	-0.323	-3.677**
T3	0.869**	8.108**	4.498**	-0.018	2.363**
S.E. gi (T)	0.167	1.279	1.163	0.339	0.325
LSD $_{gi}$ 0.05	0.327	2.507	2.280	0.664	0.638
0.01	0.430	3.294	2.996	0.872	0.838

*, ** significant at $p \geq 0.05$ and $p \geq 0.01$ levels of probability, respectively.
DS = days to 50% silking emergency (days) PH = plant height (cm) EH = ear height (cm)
EP% = ear position% GY = grain yield ard. fed.$^{-1}$

Regarding GY, two inbred lines; L2 and L5 had positive and significant GCA effects with values of 2.884** and 2.910** toward high yielding. Meanwhile, the best testers for GCA effects were T1 and T3 for high yielding for GY (1.314** and 2.363**). While T2 was the best tester of GCA effects for DS, PH, and EH toward earliness, short plants, and ear height.

Estimation of specific combining ability (SCA) effects of 33 crosses of maize for five studied traits across the three locations are shown in Table 6. Results showed that three crosses; L2 × T2 (-1.485**), L4 × T1 (-1.721**) and L11 × T3 (-1.276*) had negative and significant SCA effects (desirable) toward earliness. Two crosses (l6 × T2 and L9 × T2) exhibited negative and significant SCA effects (desirable) for PH and EH toward shorter plants and lower ear height.

Table 6. Specific combining ability effects of 33 top crosses of maize for five studied traits across the three locations

Cross	DS	PH	EH	EP %	GY
$L_1 \times T_1$	0.242	-2.606	-2.380	-0.422	-1.177
$L_1 \times T_2$	0.182	5.010	2.064	-0.281	-0.341
$L_1 \times T_3$	-0.424	-2.404	0.316	0.703	1.518
L_2 × T1	0.354	2.357	1.397	0.004	-1.132
L_2 × T2	-1.485**	-0.805	0.842	0.823	1.236
L_2 × T3	1.131*	-1.552	-2.239	-0.827	-0.104
L_3x T1	0.205	-1.051	-1.751	-0.510	-2.373*
L_3x T2	-0.966	4.566	1.471	-0.470	2.251*
L_3x T3	0.761	-3.515	0.279	0.980	0.122
L4x T_1	-1.721**	-17.495**	-3.566	2.867**	-4.677**
L4 × T2	1.219*	1.121	-5.010	-2.448**	-0.164
L4 × T3	0.502	16.374**	8.576*	-0.420	4.840**
L5 × T1	0.909	-2.162	-2.603	-0.699	-0.169
L5 × T2	-0.818	4.010	4.286	0.930	4.644**
L5 × T3	-0.091	-1.848	-1.684	-0.231	-4.474**
L6 × T1	0.316	4.468	1.545	-0.277	-0.421
L6 × T2	-0.744	-10.027*	-9.455*	-1.837*	-2.786**
L6 × T3	0.428	5.559	7.909*	2.114*	3.207**
L7 × T_1	1.020*	-2.532	-0.492	0.293	4.642**
L7 × T_2	-0.263	8.418*	8.620	1.645*	-1.178
L7 × T_3	-0.758	-5.886	-8.128*	-1.938*	-3.463**
L8 × T1	-0.424	-1.088	-5.380	-2.062*	2.316*
L8 × T2	0.182	-0.694	3.175	1.611*	-1.038
L8 × T3	0.242	1.781	2.205	0.451	-1.278
L9 × T1	-0.758	11.912**	7.138	0.245	0.968
L9 × T2	1.404**	-12.138**	-7.862*	-0.503	-0.497
L9 × T3	-0.646	0.226	0.724	0.258	-0.471
L10 × T1	-0.535	4.542	5.064	1.123*	0.886
L10 × T2	0.404	3.492	-1.047	-1.370*	-0.312
L10 × T3	0.131	-8.034	-4.017	0.247	-0.574
L11 × T1	0.391	3.653	1.027	-0.562	1.138
L11 × T2	0.886	-2.953	2.916	1.900*	-1.815
L11 × T3	-1.276*	-0.700	-3.943	-1.338*	0.677
SE Sij	0.55	4.24	3.86	1.12	1.08
LSD $_{Sij}$ 0.05	1.09	8.31	7.56	2.20	2.12
0.01	1.43	10.93	9.94	2.89	2.78

*, ** significant at $p \geq 0.05$ and $p \geq 0.01$ levels of probability, respectively.

DS = days to 50% silking emergency (days) PH = plant height (cm) EH = ear height (cm)

EP% = ear position% GY = grain yield ard. fed.$^{-1}$

In addition, the cross L4 × T1 (-17.495**) and cross L7 × T3 (-8.128*) had negative and significant SCA effects for PH and EH, respectively. Six crosses; L4 × T2 (-2.448**), L6 × T2 (-1.837*), L7 × T3 (-1.938*), L8 × T1 (-2.062*), L10 × T2 (-1.370*), and L11 × T3 (-1.338*) showed negative and significant SCA effects for EP% toward lower ear placement. The previous results indicate that the promising TWC were one cross L4 × T1 for earliness, short plants and ear heights, two crosses: L6 × T2 and L9 × T2 for short plant and ear heights, one cross "L6 × T2" for short plant, ear heights and lower ear placement toward loading resistant. For, six TWC had positive and significant SCA effects toward high yielded; L3 × T2 (2.251*), L4 × T3 (4.840**), L5 × T2 (4.644**), L6 × T3 (3.207**), L7 × T1 (4.642*), and L8 × T1 (2.316*). These results revealed that these crosses can be used as new promising crosses after testing their performance in advanced trials under different environmental conditions.

Estimation of genetic Parameters and their interaction with locations for five studied traits are presented in Table 7. Results revealed that the σ^2GCA values were higher than those of σ^2SCA for DS, PH, and GY, indicating that the additive gene effects were more important than the non-additive in the inheritance of these traits. Meanwhile, σ^2SCA values were higher than those of σ^2GCA for EH and EP% traits, indicating that non-additive gene effects were more important in the inheritance of these traits. Several researchers found that additive gene action play the major role in the inheritance of studied traits, between them, supported these results, Mosa *et al.* (2017), EL-Hosary (2020), and Alsebaey *et al.* (2021*)* for PH. Also, results showed that, the magnitudes of the interaction of σ^2GCA × loc was greater than those of σ^2 SCA × loc for PH, EH, and EP% traits, indicating that the additive gene effects were more affected by the environmental conditions than the non-additive gene effects for DS, PH and GY and Abd EL-Azeem *et al*., (2023) for DS trait (Ibrahim *et al.,* 2021). The interaction of σ^2SCA × loc was greater than those of σ^2 GCA × loc for DS and GY, indicating that the non-additive gene effects were more affected by the environmental conditions than the additive gene effects for these traits. These results are in agreement with the findings of several investigations such as, Ibrahim *et al*. (2021) for DS, PH, and GY; Alsebaey *et al.,* (2021) for DS, PH, EH, and GY; Abd EL-Azeem *et al*., (2023) for DS, PH, EH, EP%, and GY traits, and Aly *et al.,* (2023) for EH, DS, PH, EP%, and GY.

Table 7. Genetic Parameters and their interaction with locations for five studied traits across the three locations.

Genetic parameters	DS	PH	EH	EP%	GY
σ^2 GCA	2.107	66.362	22.614	0.001	8.387
σ^2SCA	0.627	43.256	23.176	1.270	4.842
σ^2 GCA × Loc	0.188	23.387	13.895	0.971	0.898
σ^2SCA × Loc	0.274	20.089	0.001	0.062	8.021

DS = days to 50% silking emergency (days) PH = plant height (cm) EH = ear height (cm)
EP% = ear position% GY = grain yield ard. fed.-1

Simple correlation coefficient between the five studied traits across the three locations are presented in Table 8. Results revealed that the correlation coefficient was positive and significant, indicating that, increase in any trait led to increase the other traits and vice versa. These results are in agreement with Mousa and Aly (2012) for correlation between GY with PH and EH, and correlation between PH with EH; Zarei *et al.*, (2012) for correlation between GY with PH and DS and correlation between PH with DS; Heakel and Hany (2017) for correlation between GY with PH; Yahaya *et al*. (2021) for correlation between GY with PH; Aly *et al*. (2023) for correlation between GY with PH, EH, and EP% traits and Abd El-Latif *et al*. (2023) for correlation between GY and each of PH and EH.

Table 8. Simple correlation coefficient between all studied traits across the three locations.

	DS	PH	EH	EP%	GY(ard.fed^{-1})
DS	--------	0.154**	0.227**	0.155**	0.285**
PH		--------	0.796**	-0.093	0.514**
EH			--------	0.525**	0.443**
EP%				--------	0.005
GY					--------

*, ** significant at p ≥ 0.05 and p ≥ 0.01 levels of probability, respectively.
DS = days to 50% silking emergency (days) PH = plant height (cm) EH = ear height (cm)
EP% = ear position% GY = grain yield ard. fed.$^{-1}$

Conclusion

The results suggest that the best crosses were L2 × T3, L4 × T3, L6 × T3, and L7 × T1. Based on these results, these promising three-way crosses should be evaluated in advanced trials to confirm their potential in breeding programs to develop superior crosses with improved traits.

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تحليل السلالة × الكشاف باستخدام تهجينات ثلاثية الاتجاهات للذرة الشامية الصفراء في تجربة متعددة المواقع

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الملخص

تم إجراء التهجين القمي لأحد عشرة سلالة صفراء جديدة من الذرة الشامية مع ثلاث كشافات وهم هجين فردى 162، هجين فردى 173 وهجين فردى 176 خلال موســم2022 بمحطـة البحوث الزراعية بسدس خلال موسم 2023. تم تقييم الــ 33 هجين الثلاثي الأصفر الناتجة مع اثنين من هجن المقارنـة وهما هجين ثلاثي 360 وهجين ثلاثي 368 في ثلاثـة مواقع وهي محطـة البحوث الزراعية في سدس وملوى والجميزة. الهدف من البحث هو تقدير القدرة العامة لإحدى عشر سلالة جديدة من الذرة الصـــفراء المهجنة وتهجيناتها وتحديد أفضـــل التهجينات الثلاثية في القدرة على الإنتاج. وكانت أهم النتائج المتحصـــل عليها أن تباين مربعات القيم للمواقع كانت معنويةً أو عالية المعنوية لجميع الصـفات المدروسـة فيما عدا صـفة النسـبة المئوية لموقع الكوز على النبات مشيراً إلى اختلاف الظروف المناخية من موقع لأخر. كانت تباين مربعات القيم لكلاً من الســـلالات، الكشـــافات، الســـلالات في الكشـــافات وكذلك تفاعلهم مع المواقع معنوي أو عالي المعنوية لمعظم الصـــفات المدروســـة. أظهرت النتائج عدم وجود اختلافات معنوية مقارنة بأفضـــل هجن المقارنة وهو هجين ثلاثي 368 لصفة محصول الحبوب أردب/ فدان في أربعة هجن ثلاثية وهي سلالة2 × كشاف3، سلالة4 × كشاف3 وسلالة6 × كشاف3 وسلالة7 × كشاف1. امتلكت كلاً من السلالة10، والسـلالة 11 قدرة ائتلاف عامة سـالبة ومعنوية مرغوبة لصـفات التزهير، ارتفاع النبات وإرتفاع الكوز ناحية الأفضـــلية للتبكير، قصـــر النبات وأفضـــلية موقع الكوز على النبات وكذلك امتلكت السـلالة2 والسـلالة5 قدرة ائتلافية عامة موجبة ومعنوية لصـفة محصـول الحبوب تجاه المحصـول العالي. امتلكت سـتة هجن ثلاثية وهي (سـلالة3 × كشـاف2)، (سـلالة4 × كشـاف3) (سـلالة5 × كشاف2)، (سلالة6 × كشاف3)، (سلالة7 × كشاف1) و(سلالة8 × كشاف1) قدرة ائتلاف خاصة موجبة ومعنوية لصـــفة محصـــول الحبوب أردب /فدان. وبناءً على هذه النتائج، ينبغي تقييم هذه التهجينات الواعدة ثلاثية الاتجاهات في تجارب متقدمة لتأكيد إمكاناتها في برامج التربية التي تهدف إلى تطوير تهجينات متفوقة ذات خصائص محسنة.

الكلمات المفتاحية: *الذرة الشامية، السلالة في الكشاف، القدرة الخاصة على الائتلاف، القدرة العامة على الائتلاف، معامل الارتباط.*