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Combing ability for grain yield and its components among elite maize (Zea mays L) genotypes in central of the Sudan

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Abstract

The successful of development hybrids depends largely on the identification of the best parents to ensure maximum combining ability. This study was conducted to estimate genetic variability and combining ability for grain yield and its components of seven inbred lines of maize (Zea mays L.) across two irrigated seasons, 2016 and 2017, Gezira, Sudan. The experiment was arranged in a randomized complete block design with three replicates. The traits measured were days to 50% tassel, plant height, ear height, ear length, ear diameter, hundred kernels weight and grain yield. Significant differences were observed among the parents and crosses for most of studied traits in both seasons. The crosses showed high genetic variability and tall plants than their parents which suggested some degree of hybrid vigor. The TEEI 5 followed by TEEI 10 and TEEI 11, indicating earliness for flowering time among the two seasons, and the earliest crosses were obtained by (TEEI 1 x TEEI 5) and(TEEI 1 x TEEI 5) followed by (TEEI 1 x TEEI 29) and (TEEI 1 x TEEI 20) . The highest yielding hybrids had long ears and better shape, e.g., (TEEI 1 x TEEI 20) and (TEEI 11 x TEEI 21).The top ranking crosses for grain yield across locations were (TEEI 4 x TEEI 11) (1929.6 kg/ha) followed by (TEEI 4 x TEEI 21) (1717.1kg/ha) and (TEEI 1 x TEEI 5) (1665.1 kg/ha). The inheritance of most traits was controlled by non-additive gene action except ear height and grain yield. The best combiner for grain among the two seasons was TEEI 4. Also the best crosses through the two seasons were given by (TEEI 4 x TEEI 11) followed by (TEEI 4 x TEEI 21) and (TEEI 5 x TEEI 29). The ratio of GCA to SCA variance for the most traits was less than one, suggesting that the inheritance was due to non-additive gene effect with the exception of grain yield being more than one, indicating that inheritance of this trait was due to GCA effects, and was largely controlled by additive gene action in the base material. From these results it is recommended that parent TEEI 4 to be used in recurrent selection, while, crosses (TEEI 4 x TEEI 11), (TEEI 4 x TEEI 21) and (TEEI 5 x TEEI 29) to be tested in multi-locations trials for commercial utilization.

Key word: maize , combing ability , Sudan.

INTRODUCTION

Maize (Zea mays L., 2n = 2x = 20) is the most important food crops world-wide, serving as table food, livestock feed, and industrial raw material (Troyer, 1996). Maize is ranked top among the world cereal crops in production and consumption. However, maize surpasses both wheat and rice in terms of productivity. For instance, about 70% of the world maize production area is found in developing countries. However, these countries contribute to only 49% of the world's maize production (FAOSTAT, 2012). In the developed world, maize is mostly used for animal feed (70%) and humans consume only small percentage (5%). The average yield increase of major food crops amounts to approximately 0.5 - 1.5% per year. This yield increase is the result of improvement in soil cultivation, fertilizer application, and plant protection, but also largely by continuous breeding progress made by plant breeders for all crops, because 50% of the yearly yield increases in crop production is attributed to genetic modification and selection. Therefore, plant breeding is playing a key role in this process, because the average yield increase of major crops is currently slightly lower than the growth rate of the world population of currently approximately 1.8% (Daily et al., 1998). In Sudan, Maize is among the substitute crops to replace wheat in the agricultural scheme, especially in some irrigated schemes. It can occupy an important position in the economy of the country due to the possibility of blending it with wheat for making bread (Meseka, 2006). Maize breeding programs designed for specific-end uses, improved maize genotypes and development of commercial maize hybrids usually require a good knowledge of combining ability of the breeding materials to be used. Hence, the relevance of combining ability studies for successful maize breeding such as the development of higher grain yield. Evaluation of crosses among inbred lines is an important step towards the development of hybrid varieties in maize (Hallauer, 1990). Ideally, this process should be through the evaluation of all possible crosses (diallel crosses), where the merits of each inbred line can be determined. The diallel analysis provides good information on the genetic identity of genotypes especially on dominance-recessive relations and some other genetic interactions (Sujiprihati et al., 2001). Advantages of hybrids over open pollinated cultivars are higher yield, uniformity, high quality and resistance to diseases and pests. In spite of having yield potential, the production of maize in Sudan is very low. One of the reasons for this is the cultivation of exotic hybrids, which are not well adapted to our agro-climatic conditions. One of the strategies of the Agricultural Research Corporation (ARC) of the Sudan for maize breeding program is to develop new hybrids as an attempt to incorporate both advantages for higher yield and adaptability to environmental conditions. Thus, getting the benefit from the use of hybrids is the main purpose in maize breeding program. Therefore, the objective of this study is to estimate the magnitude of combining ability in twenty eight topcross hybrids of maize for grain yield and its components across two irrigated seasons in Gezira location and to identify high yielding topcross hybrids for future testing and commercial utilization.

MATERIALS AND METHODS

The plant material used consisted of 7 inbred lines used as lines crossed in diallel cross arrangement (Table 1). Hand pollination was used to develop the breeding material. Pollen grain was collected into a paper bag from the tassel of male parent and then dusted on the silk of the female parent. The ear was covered with a bag and information regarding the cross was written on the bag. A total of 28 cross combinations was obtained through hand pollination. In July 2016 and 2017, the 7 parental material and 28 cross hybrids were grown and evaluated for two consecutive irrigated seasons consequently , Medani, Gezira Research Station Farm (GRSF) , Gezira State, Sudan. The trials were arranged a randomized complete block design with three replicates. The plot size was maintained as 2 rows x 3 m long with inter and intra row spacing of 80 and 25 cm, respectively. Seeds were sown at the rate of 3- 4 seeds per hill. Plants were thinned to one plant per hill after three weeks from sowing. Nitrogen was applied at 86 kg/ha in a split dose after thinning and before flowering. The crop was irrigated at intervals of 10-14 days, and plots were kept free of weeds by hand weeding. Data were analyzed using the Statistical Analysis System (SAS) computer package. The analysis was done for each season for traits days to 50% tasseling, plant height, ear length, ear diameter, kernels weight and grain yield and then combined. Mean performance was separated using Duncan's Multiple Range Test (DMRT). Data from each season was analyzed separately and across seasons to determine the general and specific combining ability of each line was measured according to Griffing,s Method 2 (1956).

RESULTS AND DISCUSSION

The performance of the material tested for most traits is high across the two seasons. However, significant differences among the parents and their hybrids for most traits were shown indicating the diversity of the material.

The mean performance

Mean days to 50% tasseling indicates that the pollen shedding ability of maize genotypes is an indicator of the earliness of genotypes. Mean days to tasseling across seasons for parents and their crosses scored 60.9 days as the general mean. Mean of parents ranged between 60 days to 61.3 days for TEEI 5 and TEEI 20, respectively (Table 2). The mean of crosses ranged between 59.8 days for (TEEI 1 x TEEI 5) to 62.1 days for (TEEI 5 x TEEI 21) (Table 2). Identification of early tasseling genotypes is very important in developing hybrids and choosing hybrids to suit different agro-ecological zones as well as grower's requirements. Earliness was a desirable trait especially under rainfed conditions. It is important for better use of water resources and avoidance of late season infestation with stem borers. Hence, the earliest crosses were (TEEI 1 x TEEI 5) and (TEEI 1 x TEEI 5) followed (59.3 days) by (TEEI 1 x TEEI 29) (60 days) and (TEEI 1 x TEEI 20) (60.3 days) respectively (Table 2).

Tallness was not a desirable trait in grain maize production, since tall maize plants tend to be susceptible to stem and root lodging. Highly significant differences for tallness were detected among the studied parents and their crosses having a general mean being of 101.7 cm. The trends in breeding work are to develop cultivars that are dwarf or of moderate height to avoid lodging of the crop which adversely affects yield. Therefore, among the studied genotypes the short plant type obtained by parent TEEI 10 followed by TEEI 4 and TEEI 11, on the other hand the shorter crosses was given by (TEEI 29 x TEEI 21), (TEEI 10 x TEEI 20) and (TEEI 5 x TEEI 11) respectively table 1. The lower ear placement parents were TEEI 4, TEEI 5 and TEEI 10 ,and also the lower ear placement obtained by cross (TEEI 10 x TEEI 20) followed by (TEEI 5 x TEEI 11) and (TEEI 10 x TEEI 29.7). These results indicated that crosses were later than their parents. Also, the taller crosses were late maturing than short ones. Generally, the crosses were taller than their parents which suggested some degree of hybrid vigor.

Ear length and diameter traits were an important selection index for grain yield in maize. The ear length and diameter means of parents, as expected, were found to be shorter than those of the crosses at the two seasons, with the general means being of 11.7 and 2.8 cm. The parents mean ranged between (10.7 to 12.9 cm and from 2.3 to 2.9 cm) for TEEI 1 to TEEI 29 cm (Table 1). The crosses mean for ear length varied from 11.1 cm for cross (TEEI 1 x TEEI 20) to 12.7 cm for cross (TEEI 11 x TEEI 21) . but the ear size was ranged from 2.3 cm for (TEEI 10 x TEEI 20) to 3.0 cm for (TEEI 29 x TEEI 21), however, the longest ear length and big ear size crosses were obtained by crosses (TEEI 1 x TEEI 20) and (TEEI 11 x TEEI 21) respectively table 2.The heavy kernel weight index was importance factor for higher grain yield, therefor, the tested parent and their crosses having highly significant difference with the general mean being of 20.3g. The best parent obtained a heavy kernel weight were TEEI 20 (22.3g) followed by TEEI 29 (20.1g) and TEEI 1 (19.1g), the mean crosses weight was ranged between 17.4g for cross (TEEI 10 x TEEI) to 23.8g for cross (TEEI 4 x TEEI 21) respectively table 1.

A significant difference was detected among the testes genotypes and their crosses for grain yield with the general mean of 1224.9 kg/ha, the higher grain yield parents was given by parent TEEI 29 (1651.0kg/ha) followed by TEEI 5 (1553.0 kg/ha) and TEEI 1 (1495.8 kg/ha) , but also the highest grain yield production crosses was given by (TEEI 4 x TEEI 11) (1929.6 kg/ha) followed by (TEEI 4 x TEEI 21) (1717.1kg/ha) and (TEEI 1 x TEEI 5) (1665.1 kg/ha) table 1. these results in agreement with finding of Alhussein et al., 2007,who reported that the maize hybrids have been reported to show high yield potential than the open pollinated varieties and landraces.

Combing ability

The breeding method to be adopted for improvement of a crop depends primarily on the nature of gene action involved in the expression of quantitative traits of economic importance. Combining ability leads to identification of parents with general combining ability effects and in locating cross combining showing high specific combining ability effects. In this study the good combiner parents, those having significant negatively GCA effects, for 50% days to tasseling were TEEI 5 followed by TEEI 10 and TEEI 11, indicating earliness for flowering time among the two seasons, while, the latest, having positive GCA effect was TEEI 4 (Table 3).The earliest crosses having negative SCA effects were TEEI 1 x

TEEI 5 and TEEI 5 x TEEI 11, while, the latest crosses were TEEI 4 x TEEI 11 and TEEI 5 x TEEI 21 he the two seasons respectively, (Table -3).

The shortness was a desirable trait the therefore, the shortness parents in season 2017 were TEEI 10 and TEEI 1 and also the lower ear placement were giving by TEEI10 and TEEI 11,but in season 2016 the best combiner was obtained by parents TEEI 4 and TEEI 11, so the lower ear placement parents were TEEI 5 and TEEI 11which were detected in table 3. The best crosses for shortness and ear placement in season 2016 were shown by crosses TEEI 10 x TEEI 29 flowed by TEEI 5 x TEEI 21 and TEEI 1x TEEI 20 in the desirable direction, but in season 2017 the best crosses were giving by TEEI 1 x TEEI 5 flowed by TEEI 29 x TEEI 21 and TEEI 11 x TEEI 21, but the latest one was observed by TEEI 4 x TEEI 29 and TEEI 10 x TEEI 29 for both season respectively, table 4.

For the ear characteristics among the two seasons the best parents those were shown positively and highly significantly effects, such as parent TEEI 4which was obtained a longest ear length and heavy ear weight among the two seasons, but the ear size was detected by parent TEEI 11 table 3 respectivelly.The best crosses for ear length and size among the two seasons was recorded by cross TEEI 1 x TEEI 10, and the heaviest ear weight was given by cross TEEI 4 x TEEI 21 respectively, table 4. These results emphasized that ear characteristics has a direct effect for improving grain yield. This is in agreement with the finding of Vedia and Claure (1995) who found that ear aspect was the most important yield component.

For the grain yield the best combiner parent have a positively and significantly effects, which was obtained by parent TEEI 4 through the tow seasons, in season 2016 the best combiner parents were observed by TEEI 1,TEEI 5 and TEEI 11. The best crosses through the two seasons were given by TEEI 4 x TEEI 11 followed by TEEI 4 x TEEI 21 and TEEI 5 x TEEI 29 table 4, cross TEEI 4 x TEEI 21 having a good ear characteristics which was reflected on a good performance and higher grain yield, the General combing ability variance for grain yield is greater than the mean square for specific combining ability indicating the importance of additive gene action in controlling grain yield. This finding is in agreement with that of Barakat and Osman (2008) who found GCA effects are larger than SCA effects for grain yield indicating that the additive genetic variance is a major source of variations responsible for inheritance of grain yield.

Recommendation

The ratio of general combining ability variance for grain yield was greater than specific combining ability indicating the importance of additive gene action in controlling this trait hence the good combiner parent for grain yield across seasons was TEEI 4 so it could be used in recurrent selection. Also enormous variability was detected in the studied population which makes cyclic selection more effective. The best crosses were TEEI 4 x TEEI 11 followed by TEEI 4 x TEEI 21 and TEEI 5 x TEEI 29 indicating that dominance and epesitic interaction seemed to be predomint, hence, higher heterosis gratified and recommended those crosses for future testing in multi-locations trials for commercial utilization in order to be released as a hybrid.

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Table1 the plant material used in this study

No.	Parents and their crosses
1	TEEI 1
2	TEEI 1 x TEEI 5
3	TEEI 1 x TEEI 10
4	TEEI 1 x TEEI 11
5	TEEI 1 x TEEI 29
6	TEEI 1 x TEEI 20

7	TEEI 1 x TEEI 21
8	TEEI 4
9	TEEI 4 x TEEI 10
10	TEEI 4 x TEEI 11
11	TEEI 4 x TEEI 29
12	TEEI 4 x TEEI 20
13	TEEI 4 x TEEI 21
14	TEEI 5
15	TEEI 5 x TEEI 11
16	TEEI 5 x TEEI 29
17	TEEI 5 x TEEI 20
18	TEEI 5 x TEEI 21
19	TEEI 10
20	TEEI 10 x TEEI 29
21	TEEI 10 x TEEI 20
22	TEEI 10 x TEEI 21
23	TEEI 11
24	TEEI 11 x TEEI 20
25	TEEI 11 x TEEI 21
26	TEEI 29
27	TEEI 29 x TEEI 21
28	TEEI 20
29	Hudiba-2- local check

Table 2 Mean performance of parental lines and their crosses for the measured traits in maize at Medani location combined.

No.	Parents and their crosses	DST	PH	EH	EL	ED	KW	GY
92	TEEI 1	60.6ab	103.6abc	36.1ab	11.8a	2.8b	19.05ab	1495.8abc
2	TEEI 1 x TEEI 5	59.8ab	102.5abc	38.6ab	12.1a	2.6b	19.45ab	987.2abc
3	TEEI 1 x TEEI 10	60.5ab	104.3abc	38ab	10.8ab	2.9b	21.71ab	1571.5ab
4	TEEI 1 x TEEI 11	60ab	99.1abc	37.3ab	10.6ab	2.7b	19.98ab	910.8bc
5	TEEI 1 x TEEI 29	60ab	113.6abc	44ab	10.9ab	2.8b	21.7ab	825.6bc
6	TEEI 1 x TEEI 20	60.3ab	98.5abc	38.6ab	11.1ab	2.6b	21.15ab	1054.5abc
7	TEEI 1 x TEEI 21	60.5ab	99.6abc	37.5ab	12.2a	2.8b	19.80ab	1194.2abc
93	TEEI 4	61.1ab	95.5abc	35.5ab	11.1ab	2.6b	18.76ab	1258.0abc
15	TEEI 4 x TEEI 10	61.8a	110.1abc	42.3ab	12.3a	2.8b	22.2ab	1114.0abc
16	TEEI 4 x TEEI 11	62a	115.5ab	42.3ab	12.3a	2.8b	22.2ab	1929.6a
17	TEEI 4 x TEEI 29	61.8a	121.5a	44.5a	13.2a	2.7b	21.20ab	1502.5abc
18	TEEI 4 x TEEI 20	60.8ab	108.8abc	42.6ab	11.6ab	2.9b	20.78ab	1242.2abc
19	TEEI 4 x TEEI 21	61.8a	111.5abc	42.1ab	11.3ab	3.0b	23.8a	1717.1ab
94	TEEI 5	60ab	96.1abc	36.3ab	11.5ab	2.5b	19.16ab	1553.0ab
27	TEEI 5 x TEEI 11	61.1ab	90.1abc	33.1ab	12.1a	2.7b	19.50ab	1328.3abc
28	TEEI 5 x TEEI 29	59.3b	99.8abc	35.5ab	10.7ab	2.9b	21.85ab	1665.1ab
29	TEEI 5 x TEEI 20	61.6ab	110abc	40.6ab	11.6ab	2.7b	19.60ab	921.4bc
30	TEEI 5 x TEEI 21	62.1a	99.8abc	36ab	11.6a	2.7b	20.81ab	854.6bc
95	TEEI 10	61.5ab	91abc	34ab	11.1ab	2.7b	17.21b	1168.2abc
38	TEEI 10 x TEEI 29	61.3ab	92.1abc	34.6ab	13.3a	2.5b	18.26ab	961.3bc
39	TEEI 10 x TEEI 20	61.8a	89.6bc	32.1ab	10.7ab	2.3b	17.48ab	963.1c
40	TEEI 10 x TEEI 21	60.8ab	103abc	38.3ab	11.9a	2.7b	21.30ab	1237.4abc
96	TEEI 11	60.6ab	96.5abc	35.5ab	12.9a	2.7b	19.16ab	1139.7abc
48	TEEI 11 x TEEI 20	60.3ab	91.1abc	36.5ab	12.1a	3.2b	19.58ab	857.9bc

49	TEEI 11 x TEEI 21	61.5ab	95.6abc	37.8ab	12.7a	2.8b	19.40ab	949.6bc
97	TEEI 29	61ab	115.6abc	42.1ab	12.2a	2.8b	20.16ab	1651.0ab
57	TEEI 29 x TEEI 21	61.5ab	83.3c	30.1b	11.5ab	3.0b	20.53ab	1328.3abc
98	TEEI 20	61.3ab	107.5abc	36.5ab	12.4a	2.5b	22.38ab	1041.2abc
106	Hudiba-2	60ab	103.6abc	34.3ab	8.8b	4.2b	18.93ab	1323.5abc
	Mean	60.9	101.7	37.8	11.7	2.8	20.3	1224.9
	CV %	2.80	21	25.5	17.1	23.2	21.3	45
	F Value	1.14	1.05**	0.87	1.27	1.39	0.77	1.47**

DT= days to 50% tasseling, DS= days to 50% silking, PH= plant height, EH= ear height, EL= ear length, ED= ear diameter CD= cob diameter,
NRE= number of rows per ear, NKR= number of kernels per row, KW= kernels weight, GY= grain yield.
*, ** Significant at 0.05 and 0.01 levels of probability, respectively.

Table 3 Estimates of GCA effects for measured traits on seven parents of maize in Medani, seasons, 2016 and 2017.

Parents	DT		PH		EH		EL		ED		KW		GY	
	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017	2016	2017
TEEI 1	0.01	0.01	5.88**	-3.29	2.74**	-2.11	-0.43*	-0.21	0.10*	-0.10**	0.89*	-0.99*	273.71**	-326.02**
TEEI 4	0.27	0.27*	-3.30*	13.86**	-0.26	4.48*	-0.34*	0.50*	0.01	0.00	-0.05	1.13**	-132.16*	407.18**
TEEI	-0.36*	-0.36*	-1.26	-0.03	-1.96*	0.78	0.10	-0.55*	-0.01	-0.03	0.17	0.20	120.73*	87.07
TEEI 10	-0.03	-0.03	-2.75*	-6.54*	-1.44*	-2.48	-0.12	-0.11	-0.11*	-0.03	-1.91**	-0.13	-168.88**	95.81
TEEI 11	-0.17	-0.17	1.48	-2.92	1.70*	-1.63	0.10	0.91	-0.05	0.13**	0.17	-0.62*	0.98*	-163.10**
TEEI 29	0.20	0.20	1.70	-1.62	0.11	0.22	0.27	-0.53*	0.03	0.05	-0.60	-0.05	-111.89*	7.11
TEEI 20	0.08	0.08	-1.75	0.53	-0.89	0.74	0.42*	-0.03	0.03	-0.01	1.32*	0.46	17.51	-108.06*
SE	0.32	0.23	2.05	4.98	1.19	4.14	0.33	0.34	0.08	0.06	0.85	0.62	80.64	136.02

DT= days to 50% tasseling, DS= days to 50% silking, PH= plant height, EH= ear height, EL= ear length,
ED= ear diameter CD= cob diameter, KW= kernels weight, GY= grain yield.
*, ** Significant at 0.05 and 0.01 levels of probability, respectively.