DETERMINATION HETEROSIS,COMBINING ABILITY AND GENE ACTION USING HALF DIALLEL CROSSES IN MAIZE.

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ABSTRACT

Six inbred lines of maize were crossed in this study by using half – diallel analysis method , during spring season of 2017, to produce fifteen F1 crosses. The parents and crosses were cultivated during fall season of 2017 by using R.C.B.D with three replications to determine heterosis, general and specific combining ability effects and gene action . Significant differences were found among parental and their crosses for all the traits . The results were showed that the hybrid (Zm - 1× Zm - 5) had the highest heterosis in grain yield.plant^{-1} (113.4%). The hybrid (ART-B-17x SYN-33) produced highest number rows. ear^{-1} (17.9) rows, 500 kernel weight (112.9) gm and grain yield.plant^{-1} (214.7) gm . The values of specific combining ability variances were more than the general combining ability variances for all the traits, indicating that non-additive gene action was responsible for inheritance of all the traits. The values of the broad sense heritability for all characters were higher and average degree of dominance was exceeded one for all the traits . Results indicated that some inbreds could be used in breeding program to develop single crosses which have higher grain yield because all the traits under over dominance gene action

Key words: heritability, degree of dominance, over dominance, grain yield, inbred lines

تقدير قوة الهجين، قابلية الائتلاف والفعل الجيني باستعمال التضريب التبادلي النصفي في الذرة الصفراء

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المستخلص

اجري تضريب ست سلالات نقية من الذرة الصفراء وحسب طريقة التضريب التبادلي النصفي في الموسم الربيعي2017 لإستنباط 15 هجيناً فردياً، زرعت بذور الآباء وهجنها الفردية في الموسم الخريفي 2017 وفق تصميم القطاعات الكاملة المعشاة بثلاث مكررات بهدف تقدير قوة الهجين وتأثيرات قابلية الائتلاف العامة والخاصة والفعل الجيني ، وجدت فروقات معنوية بين الآباء وهجنها للصفات المدروسة. أظهرت النتائج بان الهجين (Zm – 1×Zm – 5) أعطى أعلى قوة هجين في حاصل الحبوب بلغت (113.4%). تفوق الهجين (ART–B–17x SYN–33) في عدد الصفوف بالعرنوص (17.9) صف ووزن 500 حبة (112.9) غم وحاصل حبوب النبات (214.7) غم . كانت مكونات تباين قابلية الائتلاف الخاصة اكبر من قابلية الائتلاف العامة لجميع الصفات، وكان التباين غير المضيف أكثر أهمية من التباين المضيف وهذا يدل على ان هنالك فعلاً جينياً غير مضيف يتحكم في وراثة الصفات. قيم نسبة التوريث بالمعنى الواسع كانت عالية لجميع الصفات المدروسة وكانت تقديرات معدل درجة السيادة اكبر عن 1 لجميع الصفات. يستنتج من الدراسة إمكانية استعمال بعض الآباء المتفوقة تضريباتها في استنباط هجن فردية ذات قابلية ائتلاف خاصة لإنتاج حاصل حبوب عالي لان جميع صفاتها كانت تقع تحت تأثير السيادة الفائقة.

الكلمات المفتاحية: قوة الهجين، قابلية الائتلاف، الفعل الجيني، درجة التوريث، الذرة الصفراء

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INTRODUCTION

Maize (*Zea mays L.*) is considered the third cereal crop after rice and wheat all over world for production and consumption (15) in addition to its use as a human food (3). Maize breeders do their best to explore the genetic material in order to develop new maize genotypes which characterized by high yielding and better quality (20). They need information about the type and relative amount of genetic variances component and their interaction by environment as well as the information on heterosis is essential for developing new hybrids ,therefore heterosis has been used with plant breeders for improving the yield components and yield of different crops which could be used in hybridization programs to develop superior hybrids. The important genetic parameters of diallel analysis are GCA and SCA which are essential in developing plant breeding (20). Several investigators reported that non-additive gene action was responsible for inheritance of grain yield and most of its characters in maize (26). Genetic parameters in F1 for corn yield and its components were studied (22). The objective of this study to determine the combining ability and gene action using half diallel crossing method (11).

MATERIALS AND METHODS

Maize genetic materials used in this study consisted of six inbred lines (ART-B-17, Zm-5, SYN-33, Zm -1, Inb - 27 and Zm - 6) as parents and their F1 crosses (15) were planted in a randomized complete block design with three replications during July at Agricultural Research at Ramadi . Seeds were planted in the rows with 75 cm between the rows at 25 cm within the rows for each genotype, collected data were analyzed according half diallel crosses (11). Heterosis in term deviation of F1 from the high parent for all the characters studied (21)

$$\text{Heterosis} = \frac{F1-HP}{HP} \times 100$$

Heritability in broad sence

$h^2b.s = \sigma^2G / \sigma^2P$

Heritability in narrow sence

$h^2n.s = \sigma^2A / \sigma^2P$

General and specific combining ability

$\sigma^2A = 2\,\sigma^2gca$, $\sigma^2D = \sigma^2sca$,

σ^2E = MSe- = Mse/r

$\sigma^2G = \sigma^2A + \sigma^2D = 2\,\sigma^2gca + \sigma^2sca$

$\sigma^2P = \sigma^2G + \sigma^2E$

The average degree of dominance

$$\bar{a} = \sqrt{2\sigma^2D/\sigma^2A}$$

where: σ^2A= additive genetic variances

σ^2D = dominance genetic variances

σ^2P = phenotypic variances

σ^2E = environmental variances

The variance of the general and specific combining ability was calculated according to (21).

σ^2gca= (MSgca –MSe) / (P+2)

σ^2sca= (MSsca – MSe)

RESULTS AND DISCUSSIONS

Results Table1 , shows mean squares of the analysis of variance for genotypes GCA and SCA of the traits under study. The result of joint analysis of variance showed highly significant genotype mean sum square for all the characters. Estimation of variance due to GCA and SCA for all studied traits (4,6,8) . The ratio of components revealed that GCA variances was lower than SCA for days to silking , plant height and kernel weight (9,18,19,26).This indicated predominance of non-additive gene action in the inheritance of plant height (12,16,17) .SCA for most of traits recorded highly significant than GCA which was predominance controlled by non-additive gene action.

Table 1. Analysis of variance for various traits in maize

Character / SOV	DF	days to silking	Plant height	Leaf Area	No. of ears Plant^{-1}	No. of rows ear^{-1}	No. of kernels row^{-1}	kernel weight	Grain yield per plant
REP	2	13.5	1.49	0.0024	0.022	1.44	9.48	62.63	79.8
Geno.	20	**11.53	**521.5	**0.014	**0.031	**4.69	**76.21	**389.3	**5232.6
G.C.A	5	**4.77	**144.3	**0.009	**0.010	**0.775	**20.30	**117.3	**1313.2
S.C.A	15	**3.61	**184.3	**0.003	**0.0107	**1.83	**27.12	**125.6	**1888.3
MSE^	40	0.60	13.92	0.0008	0.0014	0.16	2.82	14.88	38.22
$\delta^2gca/2\delta^2gca$		0.17	0.09	0.45	0.11	0.045	0.08	0.11	0.08

The mean value (parents and F15) for analyzed traits have shows in Table 2 .the analysis of variance of mean (parents and F15) revealed highly significant differences for all the traits under study. The mean grain yield of the crosses ranged (107.5 gm.plant⁻¹ to 214.7 gm.plant⁻¹) . The highest heterosis value for grin yield in Table (3) was observed from the cross (zm-5 X zm-1) (113.4%) .low heterosis value were also observed for grain yield of cross (ART-B-17 X Syn33) (9.23%) .(2,5,10,13). The estimates of GCA and SCA effects of the parents and single crosses are shows in Table 4 significant negative variation was observed in parent(2) (8.5) for grain yield . The grain of yield eleven cross combination showed significant positive value SCA recorded in seven crosses .the highest crosses (ART-B-17 X Zm -5) gave (57.22) in grain yield . while the cross (ART-B-17 X Syn-33) gave the lowest negative value SCA recorded(-10.8) . this was accepted by (7,14,24).

Table 2. Means of parents and their F1 for the studied characters in maize

Character / Genotype	Days to silking	Plant height	Leaf Area	No. of ears. plant^{-1}	No. of rows. ear^{-1}	No. of kernals row^{-1}	kernal weight	Grain yield. Plant^{-1}
1	67.6	147.1	0.367	1	13.8	29.9	87.6	103.8
2	61.3	145.1	0.423	1.08	14.5	28.9	74.5	94.2
3	59.2	151.6	0.419	1.1	14	20.9	101.7	78.7
4	59.6	157.5	0.489	1.21	14.1	27.3	81.5	96.6
5	56.2	158.3	0.399	1.12	15.3	28.6	68.9	85.5
6	60.1	143.8	0.351	1.19	13.4	22.8	85.3	87.6
1X2	54.2	160.3	0.432	1.1	17.9	34.3	112.9	214.7
1X3	56.3	167.8	0.434	1.14	14.9	27.1	83.7	113.4
1X4	58.4	188.1	0.523	1.13	17.4	36.4	79.6	161.7
1X5	58.2	187	0.456	1.41	16.9	40.5	65.9	203.8
1X6	57.9	170.9	0.513	1.26	15.2	32.7	78.6	152.3
2X3	59.4	149.4	0.417	1.23	14.3	24.3	100.3	107.1
2X4	54.9	156.4	0.601	1.32	16.5	35.4	80.7	206.2
2X5	58.2	162.2	0.45	1.31	14.6	30.5	80.1	145.7
2X6	60.1	172.1	0.431	1.18	16.3	33.1	85.7	174
3X4	55.2	158.2	0.487	1.16	13.9	28.6	93.7	130.8
3X5	56.3	174.2	0.381	1.23	15.1	31.4	82.3	127.5
3X6	57.8	177.7	0.405	1.21	16.6	39.1	72.5	133.4
4X5	55.1	180.1	0.602	1.2	15.4	27.4	90.3	140.5
4X6	59.1	154.4	0.465	1.19	16.2	29.3	91.2	167.6
5X6	57.8	166.1	0.353	1.4	14.9	34.2	86.6	178.7
LSD5%	2.23	10.6	0.084	0.11	1.16	4.8	11.02	17.67

Table 3 . Heterosis estimations of 15 hybrids in maize

Characters / Genotype	days to silking	Plant height	Leaf Area	No. of ears Plant^{-1}	No. of rows ear^{-1}	No. of kernels row^{-1}	kernel weight	Grain yield plant^{-1}
1X2	-5.07	8.95	2.12	1.85	23.4	14.7	28.9	106.8
1X3	-1.40	10.68	3.57	3.63	6.14	9.33	-17.6	9.23
1X4	2.27	19.42	6.95	-6.61	23.1	21.8	-9.13	55.8
1X5	3.55	18.13	14.2	25.8	10.4	35.4	-24.8	96.3
1X6	1.4	16.15	39.7	5	10.1	9.46	-10.2	46.7
2X3	0.33	-1.45	-1.41	11.8	-1.37	-15.7	-1.37	13.7
2X4	-7.88	-0.69	22.9	9.91	13.7	22.7	8.28	113.4
2X5	3.55	2.47	6.38	16.9	-4.76	5.53	7.51	54.6
2X6	0	18.6	1.89	-1.66	12.6	14.6	0.46	84.7
3X4	-6.75	0.45	-0.40	-4.13	-1.41	5.2	-7.86	35.4
3X5	0.17	10.04	-9.06	9.82	-1.50	9.68	-19.0	49.1
3X6	-2.36	17.21	-3.34	1.66	18.2	71.3	-28.7	52.3
4X5	-1.95	13.77	23.1	-0.82	0.45	-4.16	10.8	45.4
4X6	-0.83	-1.96	-4.90	-1.65	14.8	7.32	6.91	73.4
5X6	2.84	4.92	-11.3	16.6	-2.60	19.6	1.52	103.9

Table 4. GCA effects and SCA effect the studied characters in maize.

Characters / Genotype	days to silking	Plant height	Leaf Area	No. of ears plant^{-1}	No. of rows ear^{-1}	No. of kernels row^{-1}	kernel weight	Grain yield plant^{-1}
1	-0.69	3.2	-0.005	-0.03	0.34	2.07	0.17	10.66
2	0.66	-6.50	0.005	-0.01	0.19	0.16	1.77	8.5
3	-0.08	-1.53	-0.02	-0.02	-0.53	-2.74	5.17	-24.78
4	-0.25	1.2	0.06	0.005	0.06	-0.30	0.5	4.02
5	0.67	5.44	-0.01	0.04	0.05	0.85	-6.44	-0.06
6	1.13	-1.74	-0.03	0.02	-0.11	-0.04	-1.17	1.67
1X2	-3.51	0.35	-0.01	-0.04	2.02	1.52	26.03	57.22
1X3	-0.60	2.84	0.01	0.01	-0.23	-2.86	-6.57	-10.8
1X4	1.67	20.48	0.01	-0.02	1.65	4	-5.99	8.72
1X5	1.91	15.17	0.02	0.2	1.16	7.01	-12.7	54.93
1X6	-0.27	6.18	0.1	0.07	-0.29	0.04	-5.33	1.69
2X3	1.07	-5.74	-0.01	0.07	-0.62	-3.70	8.43	-14.8
2X4	-3.20	-1.50	0.08	0.13	0.93	4.96	-6.52	55.39
2X5	0.56	0.03	0.008	0.07	-0.95	-1.07	-0.15	-1.02
2X6	0.6	17.27	0.01	-0.03	0.95	2.34	0.13	25.55
3X4	-2.20	-4.71	-0.004	-0.01	-0.92	1.06	3.06	13.26
3X5	-0.59	7.1	-0.03	0.01	0.28	2.66	-1.33	14.06
3X6	0.39	14.81	-0.08	0.03	1.74	11.57	-18.1	15.93
4X5	-1.61	10.2	0.1	-0.05	-0.05	-3.78	11.34	-1.67
4X6	0.52	-8.24	-0.01	-0.04	0.98	-0.94	6.97	23.66
5X6	-0.23	-0.85	-0.04	0.12	-0.30	2.74	9.24	38.86
SE $\hat{g}_i-\hat{g}_j$	0.39	1.86	0.014	0.02	0.2	0.84	1.92	3.09
SE$\hat{S}_{ij}-\hat{S}_{ik}$	1.03	4.93	0.039	0.051	0.53	2.22	5.1	8.17

Table 5 shows, estimates of additive genetic variance, dominance variances, genotypic variances, phenotypic variances, environmental variance, average degree of dominance, heritability in broad sence ,heritability in narrow sence. It was revealed that non-additive variances represent a major part of genotypic variances for all the traits, that is indication of the presence of over dominance gene action to all the studied traits (7,12,17) . heritability in broad sence was higher for grain yield 98.26% (1, 10). heritability in narrow sence was lowest for all the studied traits, rang from (7.67% for number of rows ear^{-1} to 39.99% for leaf area) because the additive gene was lowest (13, 14) The average degree of dominance more than 1 for all the studied traits thin in due to the dominant of dominance gene action to the additive gene action

Table 5. Estimates of genetic parameters and heritability in maize

Characters / GENETIC PARAMETERS	Days to Silking	Plant height	Leaf Area	No. of ears plant^{-1}	No. of rows ear^{-1}	No. of kernels row^{-1}	kernel weight	Grain yield plant^{-1}
σ^2A	1.04	32.61	0.0021	0.002	0.15	4.36	25.60	318.7
σ^2D	3.00	170.42	0.0024	0.009	1.67	24.30	110.80	1850.0
σ^2G	4.04	203.04	0.0045	0.011	1.82	28.66	136.41	2168.8
σ^2p	4.65	216.91	0.0054	0.012	1.98	31.49	151.29	2207.8
σ^2gca	0.52	16.30	0.001	0.001	0.07	2.18	12.80	159.3
σ^2sca	3.00	170.42	0.0024	0.009	1.67	24.30	110.80	1850.0
$\delta^2gca/2\delta^2gca$	0.17	0.09	0.45	0.11	0.045	0.08	0.11	0.08
$\bar{a}$	2.40	3.23	1.48	2.93	4.67	3.33	2.94	3.40
h^2b.s%	86.91	93.58	84.08	88.38	91.69	91.01	90.16	98.26
h^2n.s %	22.35	15.03	39.99	16.60	7.67	13.86	16.92	14.44

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