Genetic Behaviour for Forage Yield and Its Components for Maize –Teosinte Hybrids

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Received on: 22/9/2016 *Accepted: 27/10/2016*

ABSTRACT

In this investigation, three lines of teosinte (Sakha, inbred line 3 and inbred line 5) which were derived from selection among segregation generations were crossed by each of three female parents of maize(S.C.10, S.C.168 and T.W.C. 352) to produce nine hybrids in the 2012 summer season at Sakha Agriculture Research station. The nine crosses and their parents were evaluated during 2013 and 2104 summer seasons in a randomized complete block design with three replicates. The obtained results could be summarized in the following:

1- Significant mean squares for all traits were observed. In addition, mean squares of interactions with year were highly significant for most of the studied traits.

2- The parents T1(Sakha) teosinte had the highest mean performance for all traits except for stem diameter and ear weight, where, the highest values were provided by L_1(S.C.10 maize). Also, the cross ($L_2 \times T_2$) (S.C.168 x Inbred line 3) was superior and had the highest mean performance for all traits. The highest SCA effect was observed in the cross L_2 x T_2 (S.C.168 × Inbred line 3) for all traits except for stem diameter and number of tillers. plant^{-1}. The cross $L_1 \times T_1$ (S.C.10 × Sakha) had the highest SCA effect for the aforementioned traits.

3- Estimation of σ^2SCA was larger than σ^2GCA for most studied traits, indicated that, the non-additive genetic variance played the major role in the inheritance of these traits. Also, the contribution of tester to the total variance was larger than the contribution of lines or lines x tester for most of traits

4- In conclusion, from the previous results, it might be recommended that, the best crosses with highest SCA effects should be used as started materials for selection breeding program to improve fodder yield components.

Key words: Genetic behaviour, line x tester, maize, forage yield.

INTRODUCTION

Teosinte "Zea mexicana" is one of the most important summer forage crops which closely relate to maize in most allelometric characters. It has the advantage of tillering and regeneration as a fodder crop, it is a good source of energy and crude fiber. Teosinte was recently expanded as a summer forage crops in Egypt.

Zea mexicana is a summer multi cut grass and has high productivity and it recover quickly after grazing or cutting. The first cut can be taken after 70 days of sowing where the plant height is 80-100 cm. total fresh forage yield reaches 30 – 40 t fed^{-1}. (3-4 cuts). Teosinte has a high nutritive value because it has a high leaf / stem ratio. It also has high protein content as well as high TDN, therefore, it more palatable. Average protein content %, crude fiber % , ash % and Ether extract % were 11.2, 30.0, 9.8 and 1.95, respectively.

Maize as fresh forage crop, produce only one cut with limited quality. Meanwhile, teosinte is a highly productive summer forage crop. Characterized by strong leafy stem, much tillers and high palatability. Both teosinte(Zea mexicana) and maize(Zea maize) are botanically closely related. So that, highly productive and nutritive hybrid teosinte × maize might be expected (Jode *et al*., 1996, Jode and James 1996 and Abdel-Aty *et al.*, 2013).

Maize teosinte hybrids have been of considerable interest to both maize and teosinte breeders. In this respect, Chaudhury and Prasad(1969) reported a successful production of hybrids between maize and teosinte and a considerable amount of heterosis was observed in most hybrids, Information about the hybrids between maize and teosinte has been given by many authors(Smith *et al*., 1984; Aulicino and Magoja, 1991; Alan and Sundberg, 1994; Rady, 2007; Habeba, 2006; Sakr *et al*., 2009; Sakr and Ghazy, 2010 ; Nancy *et al*., 2012 and Hatab 2014).

Brriera *et al*.(1984) studied protein content and agronomic value of maize × teosinte progenies and reached that top crosses were of high fodder and protein yields. Shieh-Guang *et al*.(1995) studied tillering, ratooning and some agronomic characteristics of maize, teosinte and their hybrids. They found that the hybrids had fewer tillers than the teosinte and the hybrid had the best ratooning ability.

Abd El-Maksoud et al.(1998) revealed that both general and specific combining ability mean squares were highly significant in most occasions, indicating that both additive and non-additive gene actions were important in the expression of studied traits in teosinte. Also, Todorova and Lidanski(1985) and Corcuera(1991) found that, additive, dominance and epistatic effect were involved in control of the characters maize teosinte of hybrids.

The main objectives of the present study, 1) to study the inheritance of forage characters of maize × teosinte hybrids 2) determine the mode of gene action that control traits under study i.e. dry yield, number of ears plant^{-1}, ear weigh, fresh yield, plant height, number of stems plant^{-1}, stem diameter and number of leaves plant^{-1}, 3) identify the superior top crosses for high production of fresh fodder or silage yields.

MATERIALS AND METHODS

The recent study was carried- out at sakha Agricultural research Station. In 2012 summer season, three teosinte male and three maize female parents were crossed according to line × tester design producing nine F_1 hybrids as outlined by kempthorne(1957). The three teosinte lines derived through selection in segregating generations. Those were; Sakha(T_1), line 3(T_2) and line 5(T_3). Maize female parents represented by three cultivars. These were; single cross(S.C.) 10 (L_1), S.C. 168 (L_2) and three way cross(T.W.C.) 352(L_3). During the summer seasons of 2013 and 2014, testers, lines and crosses were evaluated in a randomized completed block design with three replications. Plot size was one row, 4 m length and 80 m apart. Seeds were planted in hills evenly spaced at 35 cm along the row at the rate of three kernels per hill. Seedlings were thinned to one plant per hill after 21 days from planting. Other for maize production in the region agronomic practices were applied as recommended.

In each season, data recorded on ten guarded plants, chosen randomly. The following forage traits were measured, whole plant weight(kg plant^{-1}), dry plant weight(kg plant^{-1}), plant height(cm), number of stems plant^{-1}, stem diameter(cm), number of leaves plant^{-1}, number of ears plant^{-1}, ear weight and crude protein percentage at silage stage(95 days for maize and 110 days for teosinte and hybrids.

Statistical analyses were performed for each season. The combining ability analysis was done using line x tester procedure as suggested by Kempthorne (1957). Combined analysis over years was done whenever homogeneity of variances was detected (Stell and Torrie, 1980).

RESULTS AND DISCUSSION

Analysis of variance:

Analysis of variance for the Combined the results are presented in Table(1). Years affect was significant for all studied traits except for stem diameter and crude protein percent. Genotypes highly significantly varied in all studied traits indicating a wide diversity among the studied materials. Also, mean squares due to parents, crosses and their interaction with years were highly significant for all studied traits except for the effect of genotypes x year in plant height and stem diameter. Also the effect of crosses x year in fresh weight plant^{-1} and plant height, was not significant. Parents versus crosses by year(P vs. C × Y) were highly significant for most studied traits. Lines(L), tester(T) and L × T mean squares were highly significant for all traits. The interactions of line × year(L × Y) were not significant for most traits with few exceptions such as dry weight plant^{-1}, number of stems plant-1 and ear weight.

Table1: Line x tester analysis for all studied traits over two seasons

S.OV.	df	Fresh weight. plant^{-1}	Dry weight. plant^{-1}	Plant height	No. of tillers. plant^{-1}	Stem diameter	No. of leaves. plant^{-1}	No. of ears. plant^{-1}	Ear weight	Crude protein %
Years	1	9.474**	0.779**	0.077*	0.833**	0.038	201.69*	767.3**	69.573*	0.002
Rep/year	4	0.065	0.007	0.012	0.018	0.009	9.044	29.028	3.671	0.056
Genotypes (G)	14	23.70**	0.22**	0.52**	16.32**	0.851**	5643.0**	7122.3**	70122**	3.27**
Parents (P)	5	8.38**	0.77**	0.78**	35.6**	1.2**	13255.0**	13620.7**	127093.6**	0.052
Crosses	8	5.16**	0.97**	0.05**	0.36**	0.15**	304.5**	553.0**	43.1**	1.45**
(P) *vs.* (C)	1	248.60**	19.44**	3.03**	47.2**	4.55**	10298.0**	27184.6**	345906.7**	33.90**
Lines	2	4.16**	1.10**	0.03**	0.46**	0.276**	467.5**	536.5**	62.91**	2.26**
Testers	2	10.28**	1.62**	0.09*	0.72**	0.205**	384.0**	1075.5**	57.9**	1.29**
Lines × testers	4	3.10**	0.58**	0.04**	0.13**	0.070**	183.0**	300.0**	25.77**	1.12**
G x Y	14	0.55**	0.08**	0.009	0.05**	0.006	23.5**	32.1**	5.0*	0.14*
C x Y	8	0.72	0.082**	0.003	0.05**	0.019*	35.4**	31.3**	3.29	0.25**
P x Y	5	0.03	0.005	0.021	0.11**	0.005	5.9	22.2*	5.8*	0.002
P vs. C x Y	1	1.83**	0.06*	0.01	0.07**	0.01	18.4*	87.5**	0.6	0.06
Lines x Y	2	0.1	0.12**	0.001	0.08**	0.004	9.1	4.9	6.94*	0.11
Tester x Y	2	1.01**	0.1**	0.002	0.07**	0.001	14.4	68.2**	4.22	0.84**
Lines × tester × Y	4	0.88**	0.05**	0.002	0.015	0.001	58.90**	26.0**	1.93	0.03
Error	70	0.110	0.014	0.01	0.01	0.006	6.48	8.88	2.281	0.06

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

Also, tester × year (T × Y) interactions were significant for most traits, except for, plant height ,stem diameter number of leaves plant^{-1} and ear weight. On the other hand, the second order interaction among L × T × Y was highly significant for fresh weight plant^{-1}, dry weight. Plant^{-1}, number of leaves Plant^{-1} and number of ears plant^{-1} .Similar results were recorded by Sakr *et al*.(2009), Abdel-Aty *et al*.(2013) and Hatab (2014). in teosinte × maize hybrids, Abd EL-Maksoud *et al*. (1998) in teosinte and Barakat and Osman (2008) and EL-Shenawy *et al*.(2003) in Maize.

Mean performance:

The performances of the tested genotypes from combined data were presented in Table (2). Performance of the studied genotypes cleared that no one of the parental genotypes was significantly superior in all studied traits. The results in Table (2) showed that, the tester No. one had the highest and desirable mean values in all traits except for stem diameter, ear weight, and crude protein percentage(C.P.%). Line No. one had the highest desirable mean values with mean values, 271.3g.

The mean performance of the nine crosses over the two years cleared that, the cross L_2 x T_2 (S.C.168 × inbred line3) had the best desirable means for all studied traits with mean values of 8.23, 2.72, 334, 5.17, 2.60, 96.0, 101.02, 13.31 and 10.6 for fresh weight plant^{-1}, dry weight plant^{-1}, plant height, no of tillers plant^{-1}, stem diameter, no of leaves plant^{-1}, no of ears plant^{-1}, ear weight and crude protein (%), respectively. On the other hand, the cross(T.W.C.352 × inbred line5)(L_3 × T_3) had the lease values for most traits with mean values of 5.28, 1.42, 4.41, 2.29, 22.3, 69.5 and 5.12 for fresh weight plant^{-1}, dry weight plant^{-1}, number of stems plant^{-1}, stem diameter, number of leaves plant^{-1}, number of ears plant^{-1} and ear weight, respectively.

These results are in agreement with those obtained by Habeba (2006), Rady(2007), Sakr *et al*. (2009), Sakr and Ghazy (2010), Nancy *et al*. (2012), Abdel-Aty *et al* (2013) and Hatab(2014).

Combining ability:

a. General combining ability effects:

General combing ability (GCA) effects for the parental three lines and the three testers were estimated from the combined data over the two years. The obtained results were and resented in Table (3). The results indicated that, the tester no. 3 (Inbred Line No 5) had the highest negative and significant GCA effects for all the studied traits except for, stem diameter, Also, line no. 3 (T.W.C.352) had the highest negative GCA effect. Tester no. 2(Inbred line 3) that showed appositive and significant GCA effects might be recommended for advanced stages of evaluation through the breeding program. Also, These results are in agreement with those of Abdel-Aty *et al*.(2013) and Hatab(2014) in maize teosinte hybrids, Abd El-Maksoud *et al*.(1998 and 2001) in teosinte and Aly and Mousa(2008) in maize and Chaugale and Chavan (1965) and Chaudhury and Prasad(1969).

b. Specific combining ability effects:

Estimates of specific combining ability effects of nine top crosses for all traits for the combined data over the two years were shown in Table(4).

Table 2: Mean performance of genotypes the studied traits

	Fresh weight. plant^{-1}	Dry weight. plant^{-1}	Plant height	No. of Tillers. plant^{-1}	Stem diameter	No. of leaves. plant^{-1}	No. of ears. plant^{-1}	Ear weight	Crude protein %
Line 1	2.15	0.69	268	1.00	2.47	15.92	1.82	271.3	8.28
Line 2	1.78	0.56	244	1.00	2.41	14.78	1.77	266.0	8.17
Line 3	1.52	0.41	228	1.00	2.41	14.14	1.72	261.8	8.13
Mean lines	1.82	0.55	246.67	1.00	2.43	14.95	1.77	266.37	8.19
T_1	4.23	1.29	317	5.82	1.71	105.13	95.05	0.79	8.14
T_2	3.65	1.10	305	5.33	1.59	99.3	87.6	0.77	8.08
T_3	3.87	1.16	303	5.16	1.54	97.4	82.7	0.78	8.00
Mean testers	3.92	1.18	308.33	5.44	1.61	100.61	88.45	0.78	8.07
$L_1 \times T_1$	7.05	2.03	322	4.87	2.61	84.1	83.9	8.28	9.34
$L_1 \times T_2$	6.08	1.69	304	4.67	2.46	79.3	73.8	7.43	9.32
$L_1 \times T_3$	5.88	1.61	310	4.50	2.35	73.9	76.0	4.97	9.03
$L_2 \times T_1$	6.68	2.08	321	4.91	2.59	80.7	89.2	7.84	9.56
$L_2 \times T_2$	8.23	2.72	334	5.17	2.80	96.0	101.02	13.31	10.60
$L_2 \times T_3$	6.00	1.61	315	4.64	2.40	76.6	77.67	5.66	8.93
$L_3 \times T_1$	5.48	1.53	313	4.45	2.34	75.5	74.6	4.73	9.15
$L_3 \times T_2$	5.63	1.68	310	4.65	2.51	77.8	79.4	6.21	9.35
$L_3 \times T_3$	5.28	1.42	307	4.41	2.29	72.3	69.5	5.12	9.19
Mean hybrids	6.26	1.82	315	4.70	2.48	79.6	80.57	7.06	9.39
LSD 0.05	0.37	0.13	0.11	0.11	0.12	2.92	3.42	1.85	0.28

Table 3: Estimates of general combining ability effects of lines and testers for all the studied traits

Genotypes	Fresh weight. plant^{-1}	Dry weight. plant^{-1}	Plant height	No. of tillers plant^{-1}	Stem diameter	No. of leaves. plant^{-1}	No. of ears. plant^{-1}	Ear weight	Crude protein %
SC10	0.14	0.06	0.03	0.030	0.04	0.53	2.00**	-0.11	-0.03
SC168	0.39**	0.211**	0.01	0.105**	0.013**	4.80**	4.17**	1.92**	0.37**
TWC352	-0.53**	-0.27**	0.04*	-0.136**	-0.12**	-5.34**	-6.17**	-1.81**	-0.33**
LSD 0.05	0.15	0.05	0.04	0.035	0.04	1.2	1.3	0.70	0.11
LSD 0.01	0.20	0.07	0.06	0.046	0.05	1.5	1.8	0.92	0.13
Inbred line Sakha	0.07	-0.04	0.03	-0.010	-0.01	-0.46	-2.66**	-0.16	-0.15
Inbred line 3	0.71**	0.31**	0.08**	0.112**	0.20**	4.83**	8.70**	1.87**	0.31**
Inbred line 5	-0.79**	-0.27**	-0.05**	-0.10**	0.19**	-4.37**	-6.04**	-1.70**	-0.15*
LSD 0.05	0.15	0.05	0.04	0.035	0.04	1.2	13	0.70	0.11
LSD 0.01	0.20	0.07	0.06	0.046	0.05	1.5	1.8	0.92	0.13

** Significant at 0.05 and 0.01 levels of probability, respectively.

Table 4: Estimates of specific combining ability effects for F_1 crosses in all studied traits

Genotypes	Fresh weight. plant^{-1}	Dry weight. plant^{-1}	Plant height	No. of tillers plant^{-1}	Stem diameter	No. of leaves plant^{-1}	No. of ears plant^{-1}	Ear weight	Crude protein %
$L_1 \times T_1$	0.56**	0.19**	0.06	0.14**	0.10**	4.48**	4.01**	1.49**	0.14
$L_1 \times T_2$	-0.43**	-0.11	-0.05	-0.04	-0.03	-4.26**	-2.09	-0.98	-0.09
$L_1 \times T_3$	-0.12	-0.07	-0.001	-0.10*	-0.06*	-0.22	-1.92	-0.51	-0.04
$L_2 \times T_1$	-0.64**	-0.29**	-0.08	-0.14**	-0.12**	-4.57**	-8.29**	-1.38*	-0.28**
$L_2 \times T_2$	0.87**	0.37**	0.09*	0.13*	0.09**	6.76**	7.54**	2.45**	0.53**
$L_2 \times T_3$	-0.22	-0.07	-0.01	0.01	0.02	-2.18	0.75	-1.06	-0.25
$L_3 \times T_1$	0.08	0.10	0.02	0.001	0.01	0.08	4.28**	-0.11	0.13
$L_3 \times T_2$	-0.43**	-0.25**	-0.03	-0.08	-0.06*	-2.50	-5.45**	-1.46**	-0.43**
$L_3 \times T_3$	0.35	0.15*	0.016	0.08	0.04	2.41	1.16	1.57	0.29
LSD 0.05	0.26	0.09	0.09	0.09	0.06	2.06	2.4	1.2	0.19
LSD 0.01	0.34	0.10	0.10	0.10	0.08	2.71	3.31	1.6	0.26

*,** Significant at 0.05 and 0.01 levels of probability, respectively.

The results cleared that the best desirable estimates SCA effects for all studied traits was that presented the cross (L_2 x T_2) (S.C.168 x inbred line 3), except for, to number of stems plant^{-1} the cross L_1 x T_1 was the best SCA effect for this trait so that, it might be considered as a good combiner for all traits. These results are in harmony with those obtained by Desai *et al*.(2000), Gill and Patil (1985), Alan and Sundberg(1994), Rady(2007), Habiba(2006), Sakr *et al*.(2009) and Sakr and Ghazy (2010), Abdel-Aty *et al*(2013) and Hatab (2014).

Genetic variance components:

Estimates of genetic variance components for all studied traits over the two years and their interaction with years were illustrated in Table(5). The results indicated that, estimate of σ^2SCA variance was higher than variance for most studied trait, indicating that, specific was more important and played the major role in the inheritance of these traits. On the other hand, ear weight and crude protein percentage showed GCA variance larger than SCA variance. These results might indicate that, the additive genetic variance was important and played the major role in inheritance of these two traits.

As for fresh weight plant, number of leaves plant^{-1}, number of ears plant^{-1} and crude protein percentage, the results cleared that the estimate of σ^2T x Y was larger magnitude relative to σ^2 L x Y. These results indicated that tester was much affected by environment than lines.

Regarding contribution of lines, tester, and lines x tester to variance, the results cleared that, the contribution of tester was the largest followed by lines then lines x tester for fresh and dry weight, plant height, number of stems plant^{-1} and number of ears. On the other hand, the contribution of lines was larger than tester and line x tester for the other studied traits. These results are in agreement with obtained by Abd El-Maksoud *et al*.(2001) in teosinte, Jha *et al*.(1998), Singh and Dash(2000) in fodder maize, Sakr *et al*.(2009), Sakr and Ghazy (2010) and Abdel-Aty *et al*(2013) and Hatab (2014) in maize, teosinte hybrids.

In conclusion, from the previous results, it could be recommended that the best crosses with highest SCA effects should be used as started materials for selection breeding program to improve fodder yield components**,** of teosintc- maize forage**.**

Table 5: genetic variance components for all studied traits over the two years and their interaction

Genotypes	Fresh weight. plant^{-1}	Dry weight. plant^{-1}	Plant height	No. of tillers. plant^{-1}	Stem diameter	No. of leaves. plant^{-1}	No. of ears. plant^{-1}	Ear weight	Crude protein %
K^2L	0.11	0.02	0.01	0.01	0.007	12.73	14.76	1.55	0.05
K^2T	0.25	0.04	0.002	0.01	0.005	10.28	27.90	1.49	0.01
K^2GCA	0.18	0.03	0.002	0.01	0.006	11.49	21.30	1.52	0.03
k^2SCA	0.18	0.04	0.003	0.11	0.069	10.33	22.80	1.98	0.09
k^2GCA/K^2SCA	1.0	0.75	0.66	0.09	0.080	1.10	0.93	0.76	0.33
σ^2 L x Y	0.0	0.005	-0.001	0.003	0.0001	0.14	-0.22	0.25	0.002
σ^2 T x Y	0.05	0.004	0.0001	0.003	0.0001	0.44	3.29	0.10	0.043
σ^2GCA X Y	0.02	0.004	-0.001	0.003	0.0001	0.29	1.17	0.17	0.022
σ^2SCA x Y	0.12	0.006	-0.001	0.005	0.0001	8.75	2.85	-0.05	-0.005
σ^2GCA/σ^2SCA x Y	0.16	0.66	1.00	0.60	0.0001	0.03	0.4	-3.5	-4.4
Contribution line	20.14	28.39	14.0	32.05	44.35	38.38	24.26	36.4	38.95
Contribution testers	49.78	41.74	46.08	49.87	33.20	31.58	48.62	33.6	22.32
Contribution LxT	30.08	29.86	39.00	18.08	22.45	30.04	27.13	29.9	38.752

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الملخص العربي

السلوك الوراثي لصفات محصول العلف ومكوناته في هجن الذرة الشامية × الذرة الريانـة

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أجريت الدراسة الحالية في محطة البحوث الزراعية بسخا حيث تم استخدام ثلاث سلالات من الذرة الريانة ناتجة من برامج الانتخاب وهى سخا، سلالة ٣، وسلالة ٥(قسم بحوث العلف) كآباء كما تم استخدام ثلاث هجن من الذرة الشامية وهى هجين فردي ١٠، هجين فردي ١٦٨، وهجين ثلاثي٣٥٢ من(برنامج بحوث الذرة الشامية) كأمهات وتم التهجين فى موسم ٢٠١٢م بنظام السلالة × الكشاف للحصول على ٩ هجن فى موسمي ٢٠١٣، ٢٠١٤ تم تقييم التراكيب الوراثية المستخدمة وهى ٩ هجن بالإضافة إلى الآباء الستة فى تجربة قطاعات كاملة العشوائية من ثلاث مكررات ومن خلال النتائج يتضح الآتي:

- أظهرت النتائج وجود فروق عالية المعنوية بين التراكيب الوراثية المدروسة كما أظهرت معنوية التفاعلات المختلفة مع السنوات لمعظم الصفات تحت الدراسة.
- بالنسبة لقيم متوسط الآباء كانت السلالة(سخا) من الذرة الريانة هى أفضل الأباء لمتوسطات معظم الصفات الموجودة تحت الدراسة باستثناء صفات متوسط سمك الساق، وزن الكوز، ونسبة البروتين الخام حيث أظهر الهجين فردي ١٠ من الذرة الشامية أفضل متوسط لها. أما بالنسبة لمتوسطات الهجن فإن الهجين $L_2 \times T_2$(هجين فردي ١٦٨ × السلالة ٣) أعطي أفضل متوسط لكل الصفات الموجودة تحت الدراسة.
- فيما عدا صفتي متوسط سمك الساق، ومتوسط عدد الأفرع للنبات حيث كان الهجين(هجين فردي ١٠ × سخا) الأفضل لهذه الصفات.
- أظهرت أيضا النتائج أن تباين القدرة الخاصة على التألف كان أعلي من تباين القدرة العامة على التألف لمعظم الصفات تحت الدراسة بما يوضح أن تأثير الفعل الجيني غير المضيف له الدور الأكبر في توارث الصفات تحت الدراسة.
- من النتائج السابقة يتضح إمكانية استخدام هجين فردي ١٦٨ وسلالة ٣ فى برامج التربية لتحسين صفات العلف.