J. Agric. Chem. and Biotechn., Mansoura Univ. Vol. 9(12): 303 - 310, 2018

Heterosis and Combining Ability in Hybrids of Teosinte

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ABSTRACT

Seven teosinte inbred lines (four lines as females and three lines as male parents) derived through selection from segregating generation of three crosses were used in this investigation. They were utilized in a factorial mating design in the 2014 summer season at El-Serw Agricultural Research Station to produce 12 F_1 hybrids. The seven parental lines and their 12 F_1 hybrids were evaluated during 2015 and 2016 summer season using Randomized Complete Block Design with three replications. In this study, the amount of heterosis and nature of gene action were investigated for green fodder yield and its component traits. The results indicated that highly significant differences were detected among the studied genotypes. In addition, the mean squares of interactions with years were highly significant for all studied traits. The P_4 had highest and desirable mean values for most studied traits. The hybrid $P_3 \times P_5$ showed the highest mean performances for most studied traits for three cuts. The amounts of heterosis over the mid-parent ($H_{M.P}$%) for green fodder yield per plant ranged from 5.77% for $P_2 \times P_5$ at C_1 to 259.23% for $P_1 \times P_6$ at C_3. The values of heterosis for dry fodder per plant ranged from 1.03% for $P_2 \times P_6$ at C_1 to 145.68% for $P_1 \times P_6$ at C_3. The inbred line P_6 was the good combiner for green fodder yield per plant and dry fodder yield per plant. The highest SCA effects were observed in the hybrid $P_3 \times P_5$ for most traits in the three cuts and could be promising cross improving green yield in teosinte breeding programs. The presence of large and significant estimates of additive and non-additive types of genetic variances indicated the importance of both types suggested the utilization of both types for ultimate improvement. The results showed that the phenotypic distances (PD) ranged from 479.3 to 2864.9 for parental lines and from 416.9 to 3716.7 for F_1 hybrids.

Keywords: Teosinte, Heterosis, Combining ability, Gene action, Heritability.

INTRODUCTION

Mexican teosinte is an annual, warm-season grass introduced from Mexico. It is similar to corn in general vegetative appearance and stands 10 to 15 feet in height and considered as one of the major summer fodder crop in the different place (Sallam and Ibrahim, 2014). Teosinte (Zea mexicana), summer fodder yield was introduced into Egypt in a long time. Teosinte is one of the cereal fodder crop rich in energy and fair in crude protein (Upreti and Shrestha, 2006 and Devkota *et al*., 2015). Also have the ability of producing large plant biomass yield than other popular non-legume summer fodders, such as; maize (Khan-Niazi *et al*., 2015).

The breeders began to use heterosis for many years. It lets the joint development of traits for yield and its components. Some varieties are good parents when crossed in series of crosses according to good combining ability or by their ability to transmit good characters to their progeny. Knowledge of the expression levels of heterosis are useful to help breeders to select the best hybrid combinations, which will assist as the basis for the selection of superior genotypes. When tests for general combining ability are significantly important, selected new varieties having higher combining, ability values should prove to be superior parents in crosses. Estimation of GCA and SCA are indicators for the nature of gene action. GCA is due to genes which are additive in nature, while SCA is due to genes with non-additive effect (dominance or epistatic effects). The factorial mating design technique is widely used for the evaluation of combining ability.

Information of genetic diversity of a crop usually helps the breeder in selecting desirable parents for the breeding program. The more varied genotypes can be crossed to produce superior hybrids. Understanding the wealth of genetic diversity in teosinte will help the more improvement of this crop for its genetic architecture. Morphological traits are conservative tools to analyze the genetic diversity (Prasanna, 2010). Morphological assays generally require neither sophisticated equipment nor preparatory procedures. They are generally simple and cheap to score. These easily observable quantitative morphological traits are a useful tool for primary evaluation because they offer a fast and useful approach for assessing the extent of diversity.

This study was undertaken to estimate the general and specific combining ability and heterosis of different inbred lines of teosinte genotypes in F_1 combinations for forage traits as a criteria for developing superior dual purpose teosinte cultivars.

MATERIALS AND METHODS

Genetic materials:

The genetic materials used in this investigation were seven teosinte inbred lines derived through selection from segregating generations of four teosinte crosses. These lines divided into four as females [Damietta with Central plateau (P_1); Damietta with Balsas (P_2); Damietta with Guatemala (P_3) and Central plateau with Balsas (P_4)] and three as male parents [Central plateau with Guatemala (P_5); Guatemala with Central plateau (P_6) and Guatemala with Balsas (P_7)]. During the teosinte growing season of 2014, the male parents were mated to the female parents in factorial mating design (four female x three male) by manual pollination to produce 12 F_1 hybrids at El-Serw Agricultural Research Station, Damietta Governorate, Egypt.

Experimental Design and procedures:

In 2015 and 2016 teosinte growing seasons, seven parental lines and their 12 F1 hybrids were evaluated. The experimental design used was a Randomized Complete Blocks Design as outlined by Cochran and Cox (1957) for three replications in both two years. Each plot was one row 6 m. long and 0.6 m wide. Hills were spaced 0.3 m. Land preparation, fertilizer applications and other field practices were in accordance with the regular procedures used in El-Serw Agricultural Research Station. Three cuts were taken during the teosinte growing season. Data were recorded on the following traits: number of tillers per plant (No.T./P.), plant height (P. H. cm), number of leaves per plant (No. L./ P.), leaf area (L.A. cm2), green fodder yield per plant (G. F. Y. / P. g) and dry fodder yield per plant (D. F. Y. /P. g).

Heterosis was determined for mid-parents (HM.P%), better parent (HB.P%) and the significance of heterosis was determined using the least significant difference value (L.S.D,), which was suggested by Steel and Torrie (1960). The combining ability analysis was done using Female × Male procedure as suggested by Kempthorne (1957). GCA variance (σ^2gca), SCA variance (σ^2sca). In addition to additive genetic variance (σ^2A) and dominance (σ^2D) genetic variance, heritability in broad (h^2b) and narrow (h^2n) senses were calculated according to Allard (1960) and Mather (1949). Phenotypic distance was done using the program (Kovach, 2001) cluster analysis by Euclidean Phenotypic Distances PD analysis was performed based on traits data according to Nei, (1987) using the formula:

$$PD_{i\&j} = \sqrt{\sum_{k=1}^{\overline{x}} (\overline{X}_{ik} - \overline{X}_{jk})^2}$$

i or j: genotypes and k = No. of trait

RESULTS AND DISCUSSION

Analysis of variance:

The major objectives of this study derived towards evaluation the 12 F1 hybrids produced from seven parental lines (four as female and three as male lines) of teosinte. In addition for gather information about the genetic behavior of fodder yield component traits in teosinte. The combined analysis of variance and the mean squares of all genotypes for all studied traits over the two years at three cuts are presented in Table 1. The magnitudes of the mean squares for genotypes were highly significant for all studied traits. In addition, the mean squares of years were highly significant for all studied traits except for plant height in centimeters (P.H. cm) at the second (C_2) and the third (C_3) cuts and for dry fodder yield per plant in grams (D.F.Y./P.g) at the third (C_3) cut. Furthermore, the magnitudes of the mean squares for the interaction of genotypes x years were highly significant for all studied traits except for number of tillers per plant (No.T./P.), plant height in centimeters (P.H.cm and dry fodder yield per plant in grams (D. F. Y. /P. g) at the third (C_3) cut. These results indicated the presence of genetic variation between these genotypes. The magnitudes of the mean squares of parents and parents x years interaction were highly significant for all studied traits. In addition, the magnitudes of the mean squares of crosses and crosses x years interaction were highly significant for all studied traits except for few cases. Moreover, the magnitudes of the mean squares of female, male, female x male interaction and interactions with years were highly significant for all studied traits except for few cases. Therefore, the planned comparisons for understanding the nature of variation and the determination of the amounts of heterosis for all studied traits are valid. Thus, the partition of the genetic variation to its components could be made through the analysis of factorial mating design. Several researchers found significant differences for all studied traits not only between parental lines, but also between their F1 hybrids. Among those researchers Akabari *et al*., (2012), Abdel-Aty *et al*., (2013) and Al-Aaref *et al*., (2016) for all the studied traits in both locations and the combined analysis in sorghum and Ghazy (2016) for all studied traits except for the effect of genotypes x year in plant height.

Table 1. Combined analysis of variance and mean squares over both years in three cuts for all studied traits.

S.O.V.	d.f	No. T./P.			P.H. (cm)			No. L./P.		
		C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
Rep./Years	4	1.19*	4.78	2.27	420**	345.4	1.98	10.4	91.5	8.3
Years (Y.)	1	35.77**	1389**	52.70**	5603**	72.19	132.3	2092**	35150**	8564**
Genotypes (G.)	18	16.03**	128.8**	161.7**	295.1**	1315**	1785**	661.6**	5070**	16866**
Parents (P.)	6	34.2**	209.7**	209.2**	282.7**	1724**	2084**	1500**	10651**	8886**
P. *VS*. C.	1	10.52**	4.85	86.9**	448.7**	3083.4**	10.77	423.6**	2192**	71212**
Crosses (C.)	11	6.63**	95.91**	142.6**	287.8**	931.4**	1784**	225.5**	2287	16278**
Females (F.)	3	14.1**	185.7**	175.7**	342.7**	461.5	1637**	252**	5368	1085.2**
Males (M.)	2	2.71**	14.99**	152.7**	260.4**	841.4*	4157**	2.31	789.2**	25982**
F. x M.	6	4.22**	77.99**	122.8**	269.5**	1196**	1066	286.7**	1246	20640**
G. x Y.	18	14.5**	105.1**	3.3	375.9**	931.4**	109.9	485.7**	2182.9**	2315**
P. x Y.	6	65.2**	356.2**	217.4**	1602.4**	3882.8**	2296.9**	2641**	13976**	8906**
P.*VS*. C. x Y.	1	23.8**	736.9**	69.94**	6106**	3874**	122.6	1554**	19968**	41793**
C. x Y.	11	6.74**	91.95**	0.90	104.7*	1136**	63.83	172.5**	1758**	3778**
F. x Y.	3	8.64**	144.8**	3.03	813.8**	1214**	10.1	357.9**	337.8	2461**
M. x Y.	2	1.62**	19.32*	6.03	829.3**	3014**	47.83	744.6**	356.9	4177**
(F. x M.) x Y.	6	7.5**	102.6**	5.24	491.3**	471.8	127.9	743.4**	3173**	4303**
Error	72	0.34	4.00	3.48	44.2	224.8	113.5	24.92	134.8	40.93
S.O.V.	d.f	L.A. (cm^2)			G. F. Y. / P. (g)			D. F. Y. /P. (g)		
		C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
Rep./Years	4	582	139	186.2**	644.5	1619	3580	3.37	30.3	374
Years (Y)	1	45777**	124682**	12807**	619917**	4064822**	186745**	9128**	105974**	42.5
Genotypes (G.)	18	5790**	9221**	10988**	50634**	61088**	4202170**	1340**	23200**	119879**
Parents (P.)	6	6528**	11004**	12321**	124662**	797143**	3187921**	3009**	33611**	162214**
P.*VS*.C.	1	1797*	3484	3682**	77898**	70193**	3997434**	308**	423.9	19749**
Crosses (C.)	11	5751**	8771**	10926**	7778**	558436**	4774010**	523.5**	19591**	105890**
Females (F.)	3	9612**	2134	23091**	7803**	1002161**	3073857**	448.8**	29077**	111577**
Males (M.)	2	2011**	8041*	406.5	448.0	22241	10676345**	859.7**	3705**	247219**
F. x M.	6	5068**	12332**	8350**	10208**	515305**	3656641**	448.7**	20144**	55967**
G. x Y.	18	14923**	8164**	921.84**	84615**	317517**	35349*	2530**	12977**	409.1
P. x Y.	6	46787**	22468**	12354**	333967**	1114162**	3196338**	7457**	52944**	162483**
P.*VS*. C. x Y.	1	25995**	67050**	11815**	376128**	2225736**	2246397**	6616**	53448**	9906**
C. x Y.	11	2460**	7106**	1490**	24295**	346655**	53252**	1714**	10691**	522.4*
F. x Y.	3	8537**	1247	4069**	13407**	378456**	95766**	3019**	3946**	596
M. x Y.	2	6947**	5108	4001**	18897**	48595**	237177**	3014**	14531**	1381*
(F. x M.) x Y.	6	11093**	14107**	636.3**	31538**	462505**	29312	628**	22471**	199.3
Error	72	356.5	1620	152.8	815.7	8169	14796	18.41	204	254.7

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

Mean performance of genotypes:

The means of seven parental lines and their 12 F_1 hybrids for all studied traits from the combined data over two years at the three cuts are presented in Table 2. The means showed that no specific parent and/or cross were superior or inferior for all studied traits. However, the P_4

line exhibited the highest mean values for number of tillers per plant at the first (C_1) and second (C_2) cuts and number of leaves per plant at the three cuts. Also, it had the highest mean values for plant height in centimeters (154.85 cm), green fodder yield per plant (1450.58 g) and dry fodder yield per plant (283.11 g) at the second cut (C_2). While, the P_3 line exhibited the highest means for leaf area, green and dry fodder yield per plant in grams at the third cut (C_3) with overall means 334.55 cm^2, 2453.33 g and 498.20 g , respectively. Although, the P_6 were the best lines for the same traits at the first (C_1) cut with overall means 357.78 cm^2, 596.25 g and 77.00 g, respectively.

Regarding F_1 hybrids, the means showed that the greatest value for number of tillers per plant and number of leaves per plant cuts at the first (C_1) and third cuts was $P_3 \times P_5$. Also, it had the greatest mean values for plant height and dry fodder yield per plant at the third (C_3) cut. While, the hybrid $P_4 \times P_6$ had the greatest mean values for number of tillers per plant (20.61 tillers), plant height (148.83 cm), number of leaves per plant (111.08 leaves) at second (C_2) cut and leaf area (336.97 cm^2) at third (C_3) cut. Moreover, the cross between $P_2 \times P_5$ was the best for green fodder yield per plant at the first (C_1) and second (C_2) cuts and for dry fodder yield per plant at second (C_2) cut.

Table 2. Mean performance of parents and their hybrids for all studied traits over two years in the three cuts.

Genotypes		No. T. /P.			P.H. (cm)			No. L. / P.		
		C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
Females	P_1	5.77	7.75	8.67	92.22	121.05	142.03	37.88	51.28	54.97
	P_2	7.21	8.32	9.71	93.81	111.49	109.53	50.22	58.42	52.00
	P_3	7.09	12.86	21.92	99.96	139.17	161.55	51.50	82.50	87.22
	P_4	12.91	24.86	19.92	103.47	154.85	156.67	80.25	175.50	150.17
Males	P_5	7.13	9.53	9.25	108.58	149.11	165.50	45.97	81.17	48.50
	P_6	8.79	13.25	12.22	100.05	152.01	146.50	76.83	109.17	66.67
	P_7	9.80	9.75	6.80	110.41	125.70	150.00	59.03	71.50	36.17
$P_1 \times P_5$		7.07	9.27	10.42	85.89	114.28	157.75	39.33	52.25	52.75
$P_1 \times P_6$		6.31	9.88	7.33	87.41	121.22	164.37	46.88	50.17	183.67
$P_1 \times P_7$		7.49	10.02	13.97	105.20	119.03	146.67	57.87	65.33	108.50
$P_2 \times P_5$		6.72	11.70	16.23	97.98	138.92	131.05	59.03	87.33	113.50
$P_2 \times P_6$		8.08	8.83	20.68	104.68	121.17	161.82	57.42	95.92	175.33
$P_2 \times P_7$		6.42	10.39	8.00	97.22	128.25	122.75	52.25	77.67	64.92
$P_3 \times P_5$		9.78	19.56	23.31	98.69	122.26	176.25	61.42	99.00	225.58
$P_3 \times P_6$		8.29	15.17	18.38	89.25	131.50	149.33	52.50	90.55	98.83
$P_3 \times P_7$		8.22	13.46	12.83	93.92	123.55	143.10	53.00	97.50	72.33
$P_4 \times P_5$		8.41	9.81	14.25	98.54	100.56	138.62	53.48	63.58	137.83
$P_4 \times P_6$		8.92	20.61	16.64	99.17	148.83	162.55	58.12	111.08	140.25
$P_4 \times P_7$		7.35	14.43	11.36	107.28	135.42	122.17	49.36	79.72	98.00
L.S.D 0.05		0.95	3.25	3.03	10.80	24.36	17.31	8.11	18.86	10.40
L.S.D 0.01		1.26	4.31	4.02	14.33	32.31	22.96	10.76	25.02	13.79

Genotypes		L.A. (cm^2)			G. F. Y. / P. (g)			D. F. Y. /P. (g)		
		C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
Females	P_1	312.19	242.05	213.45	149.48	403.17	606.97	20.42	72.72	94.98
	P_2	329.51	359.12	310.09	457.70	526.67	1596.33	62.57	97.77	230.82
	P_3	313.44	235.75	334.55	390.37	544.08	2453.33	65.96	106.35	498.20
	P_4	266.75	277.56	250.74	378.58	1450.58	2197.08	69.04	283.11	445.40
Males	P_5	339.97	254.92	324.83	266.00	598.17	911.50	30.91	141.02	141.17
	P_6	375.78	290.35	311.50	596.25	939.08	1133.17	77.00	194.09	164.17
	P_7	329.72	248.61	259.17	456.05	541.00	713.83	75.30	87.45	110.67
$P_1 \times P_5$		267.18	229.40	211.42	267.75	303.83	615.17	46.85	58.51	134.13
$P_1 \times P_6$		322.34	290.98	225.68	348.25	428.13	3125.55	61.52	88.86	318.33
$P_1 \times P_7$		266.07	295.73	264.32	349.05	652.25	1135.67	59.00	117.14	208.87
$P_2 \times P_5$		307.99	302.59	258.10	382.72	1287.25	1037.38	58.11	214.88	169.27
$P_2 \times P_6$		343.57	337.47	312.39	363.74	647.67	2005.08	70.50	138.18	320.47
$P_2 \times P_7$		306.54	254.29	275.47	338.07	617.83	694.97	42.39	92.02	90.73
$P_3 \times P_5$		353.63	298.47	316.45	363.75	1136.87	2913.22	55.92	204.68	508.00
$P_3 \times P_6$		284.93	308.71	226.60	278.02	937.33	2528.50	45.39	163.30	418.43
$P_3 \times P_7$		311.91	249.37	246.29	305.24	992.92	1086.50	38.06	183.49	182.95
$P_4 \times P_5$		325.47	229.41	294.33	306.14	411.27	1215.50	54.57	61.99	203.62
$P_4 \times P_6$		351.98	268.65	336.97	351.32	910.83	2451.33	62.25	207.28	446.53
$P_4 \times P_7$		346.54	343.93	326.60	314.68	867.25	2327.58	52.34	106.01	215.35
L.S.D 0.05		30.68	65.42	20.08	46.41	146.86	197.65	6.97	23.21	25.93
L.S.D 0.01		40.69	86.75	26.63	61.54	194.76	262.11	9.25	30.78	34.39

(P_1) Damietta with Central plateau; (P_2) Damietta with Balsas; (P_3) Damietta with Guatemala; (P_4) Central plateau with Balsas; (P_5) Central plateau with Guatemala; (P_6) Guatemala with Central plateau and (P_7) Guatemala with Balsas

Heterosis:

The estimated amounts of heterosis relative to mid-parents ($H_{M.P}$ %) were determined for all studied traits at the three cuts over the two years and the obtained results are shown in Table 3. The results showed that most of studied crosses exhibited different heterotic values at the different three cuts, which could be due to the difference in the performance of the genotypes when subjected to different environment. However, one, one and four out of 12 crosses exhibited positive and highly significant heterosis relative to their mid-parent ($H_{M.P}$ %) estimates for number of tillers per plant at first (C_1), second (C_2) and third (C_3) cuts, respectively. These heterotic values were 37.58 %, 74.65 % ($P_3 \times P_5$) at C_1 and C_2 cuts and it was 88.66 % ($P_2 \times P_6$), 80.67 % ($P_1 \times P_7$), 71.16 % ($P_2 \times P_5$) and 49.55 % ($P_3 \times P_5$) at third (C_3) cut. For plant height, the crosses $P_2 \times P_6$ (8.00 %), $P_2 \times P_7$ (8.14 %) and $P_2 \times P_6$ (26.40%) exhibited positive heterosis at C_1, C_2 and C_3, respectively when the averages of the hybrids were compared to the mid-parent value. These results were disagreement with Rady (2007); Sakr and Ghazy (2010) and Ghazy *et al*., (2016) which they found that all hybrids were significantly taller than their mid-parent.

Table 3. Estimates of heterosis (%) relative to the mid-parent ($H_{M.P.}$%) for all studied traits over two years at three cuts.

Crosses	No. T. /P.			P.H. (cm)			No. L. / P.		
	C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
$P_1 \times P_5$	9.65	7.23	16.28	-14.46**	-15.40	2.59	-6.18	-21.10	1.97
$P_1 \times P_6$	-13.31*	-5.87	-29.77*	-9.07	-11.22	13.93**	-18.27**	-37.47**	202.00**
$P_1 \times P_7$	-3.75	14.46	80.67**	3.83	-3.52	0.45	19.43**	6.42	138.11**
$P_2 \times P_5$	-6.33	31.01	71.16**	-3.18	6.61	-4.70	22.73**	25.13*	125.87**
$P_2 \times P_6$	1.02	-18.10	88.66**	8.00	-8.03	26.40**	-9.62	14.47	195.51**
$P_2 \times P_7$	-24.51**	15.00	-3.08	-4.79	8.14	-5.41	-4.35	19.56	47.26**
$P_3 \times P_5$	37.58**	74.65**	49.55**	-5.35	-15.18*	7.78	26.03**	20.98*	232.34**
$P_3 \times P_6$	4.52	16.18	7.67	-10.75*	-9.68	-3.05	-18.18**	-5.51	28.45**
$P_3 \times P_7$	-2.61	19.05	-10.62	-10.71*	-6.71	-8.14	-4.10	26.62*	17.27*
$P_4 \times P_5$	-16.09**	-42.98**	-2.29	-7.06	-33.84**	-13.95**	-15.25**	-50.45**	38.76**
$P_4 \times P_6$	-17.78**	8.16	3.56	-2.55	-3.00	7.23	-26.01**	-21.96**	29.37**
$P_4 \times P_7$	-35.32**	-16. 61*	-14.95	0.32	-3.46	-20.33**	-29.12**	-35.45**	5.19
$L.S.D_{0.05}$	0.82	2.81	2.62	9.36	21.10	14.99	7.02	16.34	9.00
$L.S.D_{0.01}$	1.09	3.73	3.48	12.41	27.98	19.88	9.31	21.66	11.94
	L.A. (cm^2)			G. F. Y. / P. (g)			D. F. Y. /P. (g)		
	C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
$P_1 \times P_5$	-18.06**	-7.68	-21.45**	28.89**	-39.31**	-18.98	82.53**	-45.25**	13.60
$P_1 \times P_6$	-6.29	9.31	-14.02**	-6.60	-36.21**	259.23**	26.30**	-33.39**	145.68**
$P_1 \times P_7$	-17.10**	20.54	11.85**	15.29*	38.16**	71.97**	23.27**	46.27**	103.13**
$P_2 \times P_5$	-7.99*	-1.44	-18.70**	5.77	128.88**	-17.27*	24.33**	79.97**	-8.99
$P_2 \times P_6$	-2.57	3.92	0.51	-30.98**	-11.63	46.92**	1.03	-5.31	62.27**
$P_2 \times P_7$	-7.00	-16.32	-3.22	-26.00**	15.74	-39.83**	-38.51**	-0.64	-46.86**
$P_3 \times P_5$	8.24*	21.66	-4.02	10.84	99.06**	73.16**	15.45*	65.49**	58.91**
$P_3 \times P_6$	-17.32**	17.36	-29.85**	-43.64**	26.40**	41.00**	-36.50**	8.71	26.34**
$P_3 \times P_7$	-3.01	2.97	-17.03**	-27.87**	83.01**	-31.39**	-46.12**	89.37**	-39.90**
$P_4 \times P_5$	7.29	-13.83	2.27	-5.01	-59.85**	-21.80**	9.20	-70.77**	-30.57**
$P_4 \times P_6$	9.56*	-5.39	19.87**	-27.92**	-23.77**	47.22**	-14.76**	-13.13**	46.51**
$P_4 \times P_7$	16.20**	30.73**	28.10**	-24.59**	-12.91*	59.92**	-27.48**	-42.79**	-22.55**
$L.S.D_{0.05}$	26.57	56.65	17.39	40.19	127.19	171.17	6.04	20.10	22.46
$L.S.D_{0.01}$	35.24	75.13	23.07	53.29	168.67	226.99	8.01	26.65	29.78

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

(P_1) Damietta with Central plateau; (P_2) Damietta with Balsas; (P_3) Damietta with Guatemala; (P_4) Central plateau with Balsas; (P_5) Central plateau with Guatemala; (P_6) Guatemala with Central plateau and (P_7) Guatemala with Balsas

Although, three, three and ten out of 12 crosses exhibited positive and highly significant heterosis for number of leaves per plant at first (C_1), second (C_2) and third (C_3) cuts, respectively. Regarding the leaf area, the cross $P_4 \times P_7$ exhibited positive and highly significant heterosis at all the three cuts with heterosis estimates of 16.22, 30.73 and 28.10 %, respectively. For green fodder yield per plant in grams, the results showed that two, five and seven out of 12 crosses exhibited positive and significant heterosis estimates at first (C_1), second (C_2) and third (C_3) cuts, respectively. The values of heterosis ranged from 15.29% ($P_1 \times P_7$) at C_1 to 259.23% ($P_1 \times P_6$) at C_3. These results agree with Prakash *et al*., (2010) who observed that positive and high magnitude of heterosis for green fodder yield/plant in sorghum. Concerning the dry fodder yield per plant in grams, the results showed that five, four and six out of 12 crosses exhibited positive and significant heterosis values at first (C_1), second (C_2) and third (C_3) cuts, respectively. The values of heterosis ranged from 15.45% ($P_3 \times P_5$) at C_1 to 145.68% ($P_1 \times P_6$) at C_3.

The estimated amounts of heterosis relative to better parents ($H_{B.P}$ %) were determined for all studied traits at the three cuts over the two years and the obtained results are shown in Table 4. The results showed that one, one and three out of 12 crosses exhibited positive and highly significant better parents heterosis for number of tillers per plant at first (C_1), second (C_2) and third (C_3) cuts, respectively. These heterotic values were 37.14% ($P_3 \times P_5$) at C_1, 52.05% ($P_3 \times P_5$) at C_2 and it was 61.21% ($P_1 \times P_7$), 67.12% ($P_2 \times P_5$), and 69.29% ($P_2 \times P_6$) at C_3, respectively. Regarding to the plant height, one, one and three out of 12 crosses exhibited positive heterosis ($H_{B.P}$%) at first (C_1), second (C_2) and third (C_3) cuts, respectively. These heterotic values ranged from 2.03% ($P_2 \times P_7$) at the second (C_2) cut to 12.20 % ($P_1 \times P_6$) at the third (C_3) cut. For leaf area, the cross $P_4 \times P_7$ exhibited positive heterosis at all the three cuts (C_1, C_2 and C_3) with $H_{B.P}$% values of 5.10, 23.91 and 26.02 %, respectively. Although, two and four out of 12 crosses exhibited positive and highly significant heterosis for green fodder yield per plant at second (C_2) and third (C_3) cuts, respectively. For dry fodder yield per plant, the results showed that one, four and three out of 12 crosses exhibited positive and highly significant $H_{B.P}$% at the three cuts, respectively. These heterotic values ranged from 33.96% ($P_1 \times P_7$) at C_2 to 93.91% ($P_1 \times P_6$) at C_3. These manifestations of heterosis are in agreement with those reports by Abd El-Maksoud *et al*., (1998 and 2001) in teosinte. The same trend was observed in other forage crops with respect to number of tillers and number of leaves, such as sorghum (El-Adl *et al*., 1991 and Manickam and Das, 1994).

General combining ability effects for each parental line:

Positive or negative general combining ability effects (g_i) estimates would indicate that a given inbred is much better or poorer than the average of the group involved within the factorial crosses mating design. The estimates of general combining ability effects (g_i) for each parental line for the studied agronomic traits in the three cuts are shown in Table 5. Regarding the first cut, it could be seen from this Table that the line P_2 was the best general combiners among female lines which exhibited positive largest magnitudes for number of leaves per plant, green fodder yield per plant and dry fodder yield per plant. However, the line P_3 was the best general combiners for number of tillers per plant. The line P_4 was the best general combiners for plant height and leaf area. For the second and the third cuts, the line P_3 was the best general combiners among this set of lines which exhibited positive largest magnitudes for number of tillers per plant, number of leaves per plant, green fodder yield per plant and dry fodder yield per plant. Therefore, it could be recommended P_3 as the best donor desirable to improving these traits through its engagement in teosinte breeding programme. For males, line P_6 was the best general combiners among this set of lines which exhibited positive largest magnitudes for most studied trait at the three cuts except few cases.

Table 4. Estimates of heterosis (%) relative to the better parent ($H_{B.P}$%.) for all studied traits over two years at three cuts.

Crosses	No. T. /P.			P.H. (cm)			No. L. / P.		
	C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
$P_1 \times P_5$	-0.84	-2.80	12.61	-20.90**	-23.36**	-4.68	-14.44	-35.63**	-4.03
$P_1 \times P_6$	-28.21**	-25.41*	-39.97**	-12.63*	-20.26*	12.20*	-38.99**	-54.05**	175.50**
$P_1 \times P_7$	-23.57**	2.72	61.21**	-4.72	-5.31	-2.22	-1.98	-8.62	97.39**
$P_2 \times P_5$	-6.84	22.67	67.12**	-9.77	-6.84	-20.82**	17.53*	7.60	118.27**
$P_2 \times P_6$	-8.04	-33.33**	69.29**	4.63	-20.29*	10.46	-25.27**	-12.14	163.00**
$P_2 \times P_7$	-34.50**	6.56	-17.60	-11.95*	2.03	-18.17**	-11.49	8.62	24.84*
$P_3 \times P_5$	37.14**	52.05**	6.33	-9.11	-18.01*	6.50	19.26*	20.00	158.65**
$P_3 \times P_6$	-5.60	14.48	-16.16*	-10.79*	-13.49	-7.56	-31.67**	-17.05	13.32*
$P_3 \times P_7$	-16.10**	4.65	-41.44**	-14.94**	-11.22	-11.42*	-10.22	18.18	-17.06**
$P_4 \times P_5$	-34.88**	-60.56**	-28.45**	-9.25	-35.06**	-16.24**	-33.35**	-63.77**	-8.21*
$P_4 \times P_6$	-30.92**	-17.09*	-16.46*	-4.16	-3.89	3.76	-27.58**	-36.70**	-6.60
$P_4 \times P_7$	-43.11**	-41.95**	-42.95**	-2.83	-12.55	-22.02**	-38.49**	-54.58**	-34.74**
L.S.D 0.05	0.95	3.25	3.03	10.80	24.36	17.31	8.11	18.86	10.40
L.S.D 0.01	1.26	4.31	4.02	14.33	32.31	22.96	10.76	25.02	13.79
Crosses	L.A. (cm^2)			G. F. Y. / P. (g)			D. F. Y. /P. (g)		
	C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
$P_1 \times P_5$	-21.41**	-10.01	-34.92**	0.66	-49.21**	-32.51**	51.55**	-58.51**	-4.98
$P_1 \times P_6$	-14.22**	0.22	-27.55**	-41.59**	-54.41**	175.82**	-20.1**	-54.22**	93.91**
$P_1 \times P_7$	-19.30**	18.95	1.99	-23.46**	20.56	59.09**	-21.65**	33.96*	88.73**
$P_2 \times P_5$	-9.41*	-15.74	-20.54**	-16.38**	115.20**	-35.01**	-7.12	52.37**	-26.67**
$P_2 \times P_6$	-8.57*	-6.03	0.29	-39.00**	-31.03**	25.61**	-8.44	-28.81**	38.83**
$P_2 \times P_7$	-7.03	-29.19**	-11.17**	-24.16**	14.20	-56.46**	-43.71**	-5.88	-60.69**
$P_3 \times P_5$	4.02	17.08	-5.41	-6.82	90.06**	18.75**	-15.22**	45.14**	1.97
$P_3 \times P_6$	-24.18**	6.32	-32.27**	-53.37**	-0.19	3.06	-41.06**	-15.87**	-16.01**
$P_3 \times P_7$	-5.40	0.31	-26.38**	-33.07**	82.49**	-55.71**	-49.46**	72.54**	-63.28**
$P_4 \times P_5$	-4.27	-17.35	-9.39**	-19.13**	-71.65**	-44.68**	-20.96**	-78.10**	-54.28**
$P_4 \times P_6$	-6.33	-7.47	8.18*	-41.08**	-37.21**	11.57*	-19.16**	-26.79**	0.25
$P_4 \times P_7$	5.10	23.91*	26.02**	-31.00**	-40.21**	5.94	-30.50**	-62.56**	-51.65**
L.S.D 0.05	30.68	65.42	20.08	46.41	146.86	197.65	6.97	23.21	25.93
L.S.D 0.01	40.69	86.75	26.63	61.54	194.76	262.11	9.25	30.78	34.39

***, ** Significant at 0.05 and 0.01 levels of probability, respectively.**
(P_1) Damietta with Central plateau; (P_2) Damietta with Balsas; (P_3) Damietta with Guatemala; (P_4) Central plateau with Balsas; (P_5) Central plateau with Guatemala; (P_6) Guatemala with Central plateau and (P_7) Guatemala with Balsas

Table 5. General combining ability effects of the seven parental genotype for all studied traits in the three cuts.

Parents		No. T. /P.			P.H. (cm)			No. L. / P.		
		C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
Females	P_1	-0.80*	-3.04**	-3.88**	-4.27	-7.24	8.23*	-5.36*	-24.93**	-7.65*
	P_2	-0.68*	-2.45*	0.52	2.85	4.03	-9.50*	2.84	6.13	-4.71
	P_3	1.01**	3.30**	3.72**	-3.15	0.36	8.19*	2.25	14.84*	9.63**
	P_4	0.47*	2.19*	-0.37	4.56	2.85	-6.92	0.27	3.95	2.74
L.S.D 0.05		0.27	0.94	0.87	3.12	7.03	5.00	2.34	5.45	3.00
L.S.D 0.01		0.36	1.24	1.16	4.14	9.33	6.63	3.10	7.22	3.98
Males	P_5	0.24	-0.18	1.6	-1.83	-6.41	2.88	-0.07	-5.30	9.79*
	P_6	0.14	0.86	1.31	-1.97	5.26	11.48*	0.34	6.09	26.9*
	P_7	-0.38	-0.69	-2.91*	3.80	1.15	-14.36*	-0.27	-0.79	-36.69**
L.S.D 0.05		0.24	0.81	0.76	2.70	6.09	4.33	2.03	4.72	2.60
L.S.D 0.01		0.31	1.08	1.00	3.58	8.08	5.74	2.69	6.25	3.45
Parents		L.A. (cm^2)			G. F. Y. / P. (g)			D. F. Y. /P. (g)		
		C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
Females	P_1	-30.48**	-12.05	-40.75**	-9.04	-304.71**	-135.91*	1.88	-48.19**	-47.61**
	P_2	3.69	14.03	7.44	30.78*	84.80*	-515.56**	3.09	12.00*	-74.57**
	P_3	1.14	1.43	-11.44*	-15.06	256.25**	414.70**	-7.45**	47.46**	101.74**
	P_4	25.65*	-3.42	44.75**	-6.68	36.34	236.77**	2.48	-11.27*	20.44**
L.S.D 0.05		8.86	18.884	5.80	13.40	42.39	57.06	1.74	6.70	7.49
L.S.D 0.01		11.75	25.04	7.69	17.76	56.22	75.66	2.31	8.88	9.93
Males	P_5	-2.11	-19.11	-4.48	-0.64	18.69	-316.05**	-0.04	-1.35	-14.3*
	P_6	10.03	17.37	0.86	4.6	-35.13	766.25**	6.01*	13.04*	107.89**
	P_7	-7.91	1.74	3.62	-3.97	16.44	-450.19**	-5.96*	-11.70*	-93.58**
L.S.D 0.05		7.67	16.35	5.02	11.60	36.72	49.41	2.01	5.80	6.48
L.S.D 0.01		10.17	21.69	6.66	15.38	48.69	65.53	2.67	7.69	8.60

***, ** Significant at 0.05 and 0.01 levels of probability, respectively.**
(P_1) Damietta with Central plateau; (P_2) Damietta with Balsas; (P_3) Damietta with Guatemala; (P_4) Central plateau with Balsas; (P_5) Central plateau with Guatemala; (P_6) Guatemala with Central plateau and (P_7) Guatemala with Balsas

Specific combining ability effects for each cross:

Specific combining ability effects of each cross for studied traits were determined and the obtained results are presented in Table 6. The results revealed that the crosses $P_1 \times P_7$ had positive and largest significant value for number of tillers per plant, plant height and number of leaves per plant at the first cut (C_1). Although, the crosses $P_3 \times P_5$ showed significant and largest positive magnitudes for leaf area (at three cuts), green fodder yield per plant, dry fodder yield per plant (at the first and third cuts) and plant height, number of leaves per plant (at the third cut). Moreover, the cross $P_4 \times P_6$ showed significant positive and largest magnitudes for number of tillers per plant and dry fodder yield per plant at the second cut (C_2). These results are in agreement with Rady (2007) and Sakr and Ghazy (2010).

Table 6. Specific combining ability effects of the crosses genotype for all studied traits in the three cuts.

Crosses	No. T. /P.			P.H. (cm)			No. L. / P.		
	C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
$P_1 \times P_5$	-0.12	-0.28	-1.76*	-5.12	2.52	-1.39	-8.62**	1.63	-72.01**
$P_1 \times P_6$	-0.79**	-0.70	-4.55**	-3.44	-2.22	-3.38	-1.49	-11.84*	41.80**
$P_1 \times P_7$	0.92**	0.98	6.31**	8.56**	-0.30	4.77	10.11**	10.20	30.22**
$P_2 \times P_5$	-0.59*	1.57	-0.34	-0.15	15.88*	-10.37*	2.87	5.66	-14.21**
$P_2 \times P_6$	0.86**	-2.34*	4.41**	6.69*	-13.54*	11.80*	0.85	2.86	30.52**
$P_2 \times P_7$	-0.27	0.77	-4.06**	-6.54*	-2.34	-1.42	-3.71	-8.52	-16.31**
$P_3 \times P_5$	0.77**	3.67**	3.53**	6.57*	2.90	17.14**	5.85*	8.52	83.54**
$P_3 \times P_6$	-0.62*	-1.76	-1.10	-2.73	0.49	-18.38**	-3.48	-11.22*	-60.31**
$P_3 \times P_7$	-0.16	-1.92*	-2.43**	-3.84	-3.37	1.24	-2.37	2.60	-23.23**
$P_4 \times P_5$	-0.05	-4.96**	-1.43	-1.29	-21.3**	-5.38	-0.10	-15.91**	2.68
$P_4 \times P_6$	0.55*	4.80**	1.25	-0.52	15.31*	9.96*	4.12	20.20**	-12.01**
$P_4 \times P_7$	-0.50	0.17	0.19	1.82	6.00	-4.58	-4.02	-4.29	9.33**
L.S.D $_{0.05}$	0.47	1.63	1.51	5.40	12.18	8.65	4.06	9.43	5.20
L.S.D $_{0.01}$	0.63	2.16	2.01	7.16	16.15	11.48	5.38	12.51	6.89

Crosses	L.A. (cm^2)			G. F. Y. / P. (g)			D. F. Y. /P. (g)		
	C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
$P_1 \times P_5$	-15.91	-23.52	-17.91**	-53.30**	-176.26**	-694.24**	-8.90**	-28.31**	-72.01**
$P_1 \times P_6$	27.12**	1.58	-8.98	21.96	1.86	733.84**	-0.27	-12.35	-10.00
$P_1 \times P_7$	-11.21	21.94	26.89**	31.33*	174.4**	-39.60	9.17**	40.67**	82.01**
$P_2 \times P_5$	-9.26	23.59	-19.41**	21.85	417.65**	107.63	1.16	67.86**	-9.92
$P_2 \times P_6$	14.18	21.98	29.55**	-2.37	-168.12**	-6.97	7.49**	-23.22**	19.10*
$P_2 \times P_7$	-4.92	-45.58*	-10.14	-19.48	-249.53**	-100.65	-8.65**	-44.64**	-9.18
$P_3 \times P_5$	38.92**	32.07	57.81**	48.72**	95.81*	1053.2**	9.51**	22.21**	152.51**
$P_3 \times P_6$	-41.92**	5.82	-37.37**	-42.26**	-49.91	-413.82**	-7.07**	-33.57**	-59.25**
$P_3 \times P_7$	3.00	-37.89*	-20.44**	-6.46	-45.90	-639.38**	-2.43	11.36	-93.26**
$P_4 \times P_5$	-13.75	-32.14	-20.49**	-17.27	-337.20**	-406.58**	-1.77	-61.76**	-70.58**
$P_4 \times P_6$	0.62	-29.38	16.81**	22.67	216.18**	-313.05**	-0.15	69.14**	50.15**
$P_4 \times P_7$	13.13	61.52**	3.68	-5.4	121.02**	779.64**	1.91	-7.39	20.43**
L.S.D $_{0.05}$	15.34	32.71	10.04	23.20	73.43	98.82	3.49	11.60	12.97
L.S.D $_{0.01}$	20.34	43.38	13.32	30.77	97.38	131.05	4.62	15.39	17.19

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

(P1) Damietta with Central plateau; (P2) Damietta with Balsas; (P3) Damietta with Guatemala; (P4) Central plateau with Balsas; (P5) Central plateau with Guatemala; (P6) Guatemala with Central plateau and (P7) Guatemala with Balsas

Nature of gene action and heritability:

Genetic parameters which included additive (σ^2A) and dominance (σ^2D) variances in addition to heritability in broad (h^2_b%) and in narrow (h^2_n%) senses for all studied traits are presented in Table 7. The negative values obtained for variances were considered equal to zero during the calculations of heritability and dominance degree. The results indicated the magnitudes of additive genetic variances were larger than their corresponding estimates of non-additive genetic variances with respect to all studied traits except for plant height, leaf area and dry fodder yield per plant at the second cut (C_2). Also, the same results found for number of leaves per plant at the first (C_1) and second (C_2) cuts and green fodder yield per plant at the first cut (C_1). Suggests that both additive and non-additive (dominance) genetic variance contributed in the inheritance of these traits. These could be verified by the dominance degree ratio $(\sigma^2D/\sigma^2A)^{1/2}$ which were less than one, revealing the importance of incomplete dominance and that additive effects played the major role in the inheritance of these traits. Similar results were reported by Fouman *et al*., (2003) found that the differences among lines and testers general combining ability indications the importance of additive effects of genes, for plant height, number of tillers per plant, green yield, and dry matter. On the other hand, Chikuta *et al*., (2017) and Ghazy (2016) found that the non-additive genetic variance played the major role in the inheritance of the all studied traits in maize –teosinte hybrids.

High heritability values in broad sense were ($h^2_{b.s}$ %) detected for all traits. These values ranged from 41.87 to 99.86% for plant high at C_2 and green fodder yield per plant at C_3, respectively. While heritability in narrow sense ($h^2_{n.s}$%) ranged from 0.00 to 97.88 % for plant height at C_2 and fodder yield per plant at C_3, respectively.

Phenotypic discrimination:

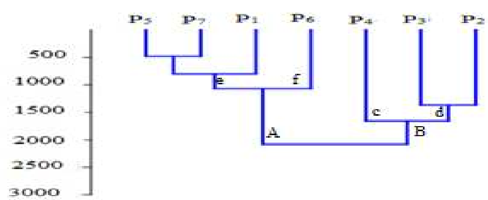
Phenotypic distance (PD) matrix and UPGMA clustering for seven parental lines and 12 F_1 hybrids based on yield traits are shown in (Tables 8, 9 and Fig. 1, 2 respectively). Phenotypic distance (PD) based on morphological data were found to range from 479.3 (between P_5 and P7) to 2864.9 (between P_1 and P_4). At the same time, the parental inbred lines divided into two clusters A and B. The first cluster A had a maximum number of parental inbred lines (four) followed by cluster B (three). The cluster A included two sub-clusters e (included P_4) and f (involved the two parents P_3 and P_2). At the same time, the second cluster B included two sub- clusters c (involved the P_1, P_5 and P_7) and d (involved P_6). Genetic divergence study suggested that crosses between the parental inbred lines of sub-cluster e and parental inbred lines of sub-cluster d for getting better hybrid vigour in F_1 or better hybrids and also for good recombinants in segregating population. These results are in agreement with Abd El-Aziz *et al*., (2016) and Ahalawat *et al.* (2018).

Table 7. The relative magnitudes of different genetic parameters for studied traits.

Genetic parameters	No. T. /P.			P.H. (cm)			No. L. / P.		
	C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
σ^2A	21.25	157.72	174.63	161.22	-2331.42	6314.52	-538.17	9161.83	-38384.4
σ^2D	0.646	12.33	19.89	37.55	161.92	158.89	43.63	185.25	3433.23
$(\sigma^2D/\sigma^2A)^{1/2}$	0.174	0.279	0.337	0.483	>1.00	0.159	>1.00	0.142	>1.00
H^2_b%	97.19	97.70	98.24	81.81	41.87	98.28	63.65	98.58	98.82
H^2_n%	95.57	90.62	88.19	66.35	0.00	95.91	0.00	96.63	0.00
Genetic parameters	L.A. (cm^2)			G. F. Y. / P. (g)			D. F. Y. /P. (g)		
	C_1	C_2	C_3	C_1	C_2	C_3	C_1	C_2	C_3
σ^2A	6014.30	-31341.87	22667.63	-21388.6	379553.0	9832844.0	657.39	-4860.1	439585.9
σ^2D	785.22	1785.31	1366.26	1565.48	84522.6	606974.0	71.74	3323.3	9280.51
$(\sigma^2D/\sigma^2A)^{1/2}$	0.361	>1.00	0.246	>1.00	0.472	0.249	0.330	>1.00	0.145
H^2_b%	95.02	52.43	99.37	65.74	98.27	99.86	97.54	94.22	99.94
H^2_n%	84.05	0.00	93.72	0.00	80.37	94.05	87.94	0.00	97.88

Table 8. Phenotypic distance (PD) matrix for seven studied parental lines of teosinte.

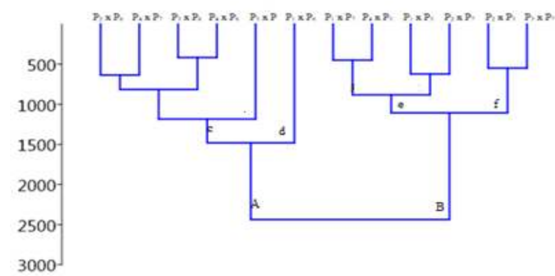
Phenotypic Distance	P_1	P_2	P_3	P_4	P_5	P_6
P_2	1563.5					
P_3	2713.6	1368.3				
P_4	2864.9	1843.4	1472.8			
P_5	839.6	1315.0	2298.3	2269.4		
P_6	1414.9	1354.3	2108.3	1840.9	882.3	
P_7	758.8	1528.5	2563.3	2551.6	479.3	911.4



Euclidean Phenotypic Distance

Figure 1. UPGMA clustering dendrogram showing relationship among seven parental lines of teosinte based on phenotypic distances (PD) according to Sneath and Sokal, (1973).

For the hybrids, Phenotypic distance (PD) were found to range from 416.9 (between P_3 x P_6 and P_4 x P_6) to 3716.7 (between P_1 x P_5 and P_3 x P_5). The hybrids divided into two groups A and B, the first group A involved two sub-groups c and d. The sub-group c included the five hybrids P_2 x P_6, P_4 x P_7, P_3 x P_6, P_4 x P_6 and P_3 x P_5, while the sub-group d involved the hybrid P_1 x P_6. At the same time, the second group B included two sub-groups e and f. The sub-group e involved the four hybrids P_1 x P_7, P_4 x P_5, P_1 x P_5 and P_2 x P_7 while the sub-groups f contains the two hybrids P_2 x P_5 and P_3 x P_7.



Euclidean Phenotypic Distance

Figure 2. UPGMA clustering dendrogram showing relationship among 12 F_1 hybrids of teosinte based on phenotypic distances (PD) according to Sneath and Sokal, (1973).

Table 9. Phenotypic distance (PD) matrix for 12 F_1 hybrids studied of teosinte.

Phenotypic distance	P_1 x P_6	P_1 x P_7	P_1 x P_5	P_2 x P_6	P_2 x P_7	P_2 x P_5	P_3 x P_5	P_3 x P_6	P_3 x P_7	P_4 x P_5	P_4 x P_6
P_1 x P_7	2875.6										
P_1x P_5	3613.8	1022.8									
P_2 x P_6	1667.2	1264.7	2122.5								
P_2 x P_7	3494.0	682.2	621.4	1902.2							
P_2 x P_5	3228.1	1049.1	1576.2	1729.6	1201.9						
P_3 x P_5	1561.4	2752.1	3716.7	1704.0	3386.6	2970.2					
P_3 x P_6	1293.0	2058.5	2977.1	947.7	2697.4	2328.7	880.9				
P_3 x P_7	3027.5	630.5	1222.7	1451.0	842.5	548.3	2854.6	2150.0			
P_4 x P_5	2739.6	449.7	994.8	1209.9	829.5	1398.2	2777.6	2056.6	931.0		
P_4 x P_6	1486.0	2015.7	2960.0	986.2	2640.1	2347.0	823.2	416.9	2150.6	2008.2	
P_4 x P_7	1397.4	1742.7	2612.9	634.9	2351.5	2007.4	1329.9	592.5	1803.1	1720.3	736.8

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قوة الهجين والقدرة على التآلف في هجن الذرة الريانة

علی ماهر محمد العدل[1] ، رحاب محمد محمد حبيبه[1] ، حسام الدين عثمان صقر[2] و ماجدة محمد محمد عبد الهادى[2]

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فى هذه الدراسة تم استخدام سبعة سلالات (أربعة سلالات كامهات وثلاثة سلالات كآباء) من الذرة الريانة ناتجة من خلال الإنتخاب للأجيال الإنعزالية لثلاثة هجن, إستُخدمت فى تصميم التزاوج العاملى لإنتاج 12 هجين. تم تقييم الآباء والهجن خلال الموسم الصيفى 2015 و2016 فى تجربة قطاعات كاملة العشوائية فى ثلاث مكرارات. تم تقدير قوة الهجين وطبيعة الفعل الجينى لصفات محصول العلف الأخضر ومكوناته. أظهرت النتائج وجود اختلافات عالية المعنوية بين التراكيب الوراثية المدروسة. بالاضافة الى أن متوسط مربعات التفاعل بين التراكيب الوراثية والسنوات كان عالي المعنوية لجميع الصفات المدروسة. اظهر الأب الرابع (P_4) أعلى قيم للمتوسطات لمعظم الصفات المدروسه, كذلك أظهر الهجين $P_3 \times P_5$ أعلى آداء لمعظم الصفات المدروسه فى الثلاث حشات. تراوحت قيمة قوة الهجين بالنسبة لمتوسط الآباء من 5,77 (للهجين $P_2 \times P_5$ فى الحشه الاولى) الى 259,23 % (للهجين $P_1 \times P_6$ فى الحشه الثالثة) لمحصول العلف الأخضر لكل نبات. تراوحت قيمة قوة الهجين لصفة لمحصول العلف الجاف 1,03 (للهجين $P_2 \times P_6$ فى الحشه الاولى) الى145,68 % (للهجين $P_1 \times P_6$ فى الحشه الثالثة). وكانت السلالة P_6 أفضل الاباء من حيث القدرة العامه على التآلف لصفتى محصول العلف الغض والجاف. وأظهر الهجين $P_3 \times P_5$ أعلى قدرة خاصة على التآلف فى معظم الصفات المدروسه فى الثلاث حشات ولذلك يعد هذا الهجين من افضل الهجن لصفة محصول العلف الاخضر فى برنامج التربية للذرة الريانه. ويشير وجود قيم كبيرة ومعنوية للفعل الجينى المضيف والغير مضيف إلى أهمية كلا النوعين من االتباين الوراثى مقترحا اهميتهما فى برامج التربية. كما اظهرت النتائج ان المسافات المظهرية تراوحت من 479,3 إلى 2864,9 للأباء ومن 416,9 إلى 3716,7 للهجين.