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Varietal crosses, an alternative of improved corn seed use in the Mexican tropics

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Resumen

Durante la temporada de verano de primavera en 2013 y otoño de invierno de 2013/14, se evaluaron en la estación experimental de Cotaxtla Ver., 40 cruces de variedades de maíz, 21 sintéticos experimentales y tres híbridos, utilizados como controles, bajo diseño de celosía alfa 8x8 con 64 entradas y dos Replicaciones con densidad de plantas de 62.500 plantas ha-1. Se registraron los rasgos: Días a borla, altura de planta, aspecto de planta y oído, cobertura de cáscara mala y pudrición de oreja. Del análisis combinado, se encontraron diferencias significativas para los genotipos (G) y Ambientes (E) para todos los rasgos evaluados; La interacción GxE sólo fue significativa para el rendimiento de grano y la putrefacción de la oreja. Las cruces registraron un rendimiento promedio de 5.13 tha-1, 28% más que las variedades sintéticas de los padres; Además, eran más altos, con mejor aspecto de planta y oído, mejor cobertura de la cáscara, y menos podredumbre de la oreja. Se encontraron 31 cruces significativamente diferentes, algunos de ellos fueron: SINT6CxSINT4B, SINT2BxSINT10C, SINT2Cx SINT4B, SINT1CxSINT2B, SINT2CxSINT3SEQ, TS6xSINT6C con el mejor valor de heterosis (63,3%) y V-537CxSINT9C con proteína de alta calidad, 25% más de rendimiento que el VS- 536 la variedad de maíz sintético más utilizada en el sureste de México.

Cruces de variedades, maíz, heterosis

Abstract

During spring summer season in 2013 and fall Winter season 2013/14, there were evaluated in Cotaxtla Experimental Station Ver., 40 maize variety crosses, 21 experimental sinthetics and three hybrids, used as checks, under alpha lattice design 8x8 with 64 entries and two replications with plant density of 62,500 plants ha^{-1}. There were registered the traits: Days to tassel, height of plant, plant and ear aspect, bad husk cover and ear rot. From the combined analysis, there were found significant differences for Genotypes (G) and Environments (E) for all evaluated traits; The GxE interaction was only significant for grain yield and ear rot. Crosses registered an average in yield of 5.13 tha^{-1}, 28% more than the synthetic varieties parents; besides, they were higher, with better plant and ear aspect, better husk cover, and less ear rot. There were found 31 crosses significant different, some of them were: SINT6CxSINT4B, SINT2BxSINT10C, SINT2Cx SINT4B, SINT1CxSINT2B, SINT2CxSINT3SEQ, TS6xSINT6C with the best heterosis value (63.3%) and V-537CxSINT9C with high quality protein, 25% more yield than VS-536 the most used synthetic maize variety in the southeast of México.

Variety crosses, maize, heterosis

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December 2016 Vol.3 No. 5 1-6

Introduction

The corn crop is the most important because it is the main food of the population, because of its area planted, value of production and occupy 20% of the economically active population. Particularly in Mexico, 8.2 million hectares are planted with corn, with a production of 22 million tons of grain, and an apparent per capita consumption of 209.8 kg. (Morris and Lopez, 2000). For direct consumption in human food, 12.3 million tons are used, of which 36% is through the flour industry and 64% through the dough and tortilla industry in the process of nixtamalización; Of corn is obtained 59% of the energy and 39% of the protein that the Mexican ingests (SAGARPA, 2012).

2.5 million hectares are planted annually in southeastern Mexico. Of these, one million are included in agronomic provinces of good and very good productivity and 100,000 hectares are planted under irrigation conditions (Sierra et al., 2004) . In this area, hybrid sowing is recommended in which the benefits of heterosis in the commercial production of corn are exploited, since they express their genetic potential to the maximum under conditions of climate, soil and management by farmers (Gómez, 1986, Sierra et al., 1992 Sierra et al., 2004 Sierra et al., 2004a Sierra et al., 2005, Vasal et al., 1992).

In the commercial production of hybrids the type of gene action is taken advantage of, deviation of additivity when crossing different individuals genetically, as long as their genes are compatible, that is to say the yield is greater as the genetic divergence is greater (Reyes, 1985) . On the other hand, Vasal et al., (1993) found that the interpopulation hybrids were superior in performance over the intra-population of 8 to 15.6%.

Thus, for the tropical region, the double cross hybrids H-503 and H-507 were formed and in which the heterotic pattern Tropic moist x Dry Tropic (Reyes 1971) was used. Serra et al., 2004, used as in-tester the inbred lines of High Specific Combinatorial Aptitude (ACE), LT154, LT155, CML247 and CML254, which allowed to identify outstanding advanced lines and to separate heterotic groups that form superior hybrids.

During the last years hybrids and varieties with great potential of yield, adapted to the tropical humid conditions of the Southeast of Mexico, were generated, among them of current use the trilineal hybrid H-520, the synthetic variety of free pollination VS-536, the genotypes Of high-quality H-519C, V-537C, V-556AC and recently released H-564C high-quality hybrid protein (Sierra et al., 2004a)

Varietal crosses can be an alternative in the commercial production of corn because it takes advantage on the one hand the advantages offered by heterosis in the commercial production of the hybrid, seed production and the maintenance of their parents because they are synthetic varieties Of free pollination (Reyes, 1985).

The objectives of this research were: To know the yield and agronomic characteristics of corn varietal crosses for the Mexican tropics and to determine the heterosis with respect to the best progenitor

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Materials y methods

Localization. The formation and evaluation of corn varietal crosses was carried out at the Cotaxtla Experimental Field, belonging to INIFAP, located in the municipality of Medellín de Bravo, Veracruz, located at 18 ° 56 'North latitude and 96 ° 11' West Longitude And an altitude of 15 msnm.

The climate according to the classification of köppen modified by García (1981), with an area of influence in the Humid Tropics of Mexico, includes the climatic group A (Aw, Am and Af), warm humid and subhumid with average annual temperature of 25 ° C and annual precipitation of 1400 mm, distributed from June to November. The soil is of alluvial origin, deep, with medium texture throughout the profile, slope less than 1%, and good drainage and slightly acidic pH (6.6).

Germplasm used. In the present research, 40 varietal crosses, 21 experimental crosses, of which 12 have been formed with lines converted to the high quality character of protein and denominated SINT 1, 2, 3, 4, 5, 6, 7 , 8, 9, 10 and 11C and the variety V-537C with high quality of protein, the rest of the experimental synthetics are of normal endosperm; Hybrid H-520, H-564C and H-519C used as controls were also included.

Process. During the spring summer 2013 and autumn winter 2013/14 cycles, 40 maize varietals, 21 varieties and three control hybrids were prepared and evaluated, which were distributed under an 8x8 alpha lattice design with 64 treatments and two replicates in plots of 1 Furrow 5m long separated at 80 cm and with a density of 62,500 ha-1 plants. Weed control was based on Atrazine in preemergent application; It was fertilized with the formula 161-46-00 and pests of the foliage were controlled during the development of the crop.

Variables and data recording. During the development of the crop and at the time of harvest, the following variables were recorded: grain yield, plant height, days at male flowering, plant and ear aspect, ears with poor coverage and bad ears

Statistical methods. Analysis of variance was performed for all variables; the percentages registered: % poor coverage and% of rotten ears, were transformed to bliss degrees for analysis through the formula, since some plots presented values with zero. For the separation of means, the Significant Minimum Difference test was applied at 0.05 and 0.01 of probability (Reyes, 1990). Comparisons of cross groups and synthetic parent varieties were made and the t-test at 0.05 and 0.01 probability was applied. Also, the percentages of heterosis with respect to the best progenitor were calculated as follows:

$$\% \text{ de Heterosis} = \frac{F1 - \text{Best parent}}{\text{Best parent}} \times 100$$

Results and discussion

From the analysis of combined variance for the following variables: Grain yield, Days at male flowering, plant height, plant and ear aspect,% of cobs with poor coverage and% of rotten ears were found statistically significant at 0.05 and 0.01 of Probability for Genotypes (G) and Environments (A) in all variables; The interaction GxA was only significant in the variables grain yield and% of rotten ears (Table 1). The highest variance was recorded for the Source of variation Environments, which means that these environments were different and that the behavior of the genotypes during the spring summer 2013 and fall 2013/14 winter cycle was also different.

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The coefficient of variation obtained for grain yield was 13.89%, a relatively low value suggesting that the conduction of the experiments and the results obtained are reliable (Reyes, 1990).

Source of variation	GL	Rend t ha^{-1}	Días a flor	Alt pl	Asp pl	Asp mz	% Cob	% Pod
Genotipes (G)	63	1.75**	9.47**	385.46**	0.37**	0.44**	3.09**	1.65**
Enviroments (A)	1	90.01**	5614.5**	22041.3**	0.75*	2.42**	16.84**	3.42*
Interaction GxA	63	3.436**	2.12 NS	197.2 NS	0.16 NS	0.22 NS	1.41 NS	1.43**
Error	126	0.435	1.695	165.84	0.17	0.165	1.485	0.84
CV (%)		13.89	2.31	6.26	16.11	17.36	41.17	28.73

GL = degrees of freedom; Rend = Yield; Alt pl = Plant height; Asp pl = Aspect of plant; Asp mz = Aspect of cob; % Cob = Percent of cobs with poor coverage; % Pod = Percent of rotten ears; CV = Coefficient of variation.

Table 1 Mean squares and significance of analysis of combined variance of maize varietal crosses for the tropics of Mexico. Cotaxtla 2013B and 2014A

Agronomic performance and characteristics

Through the DMS test at 0.05 probability (Reyes, 1990), 31 varietal crosses were found that were outstanding for grain yield and significantly exceeded the variety VS-536, the synthetic variety of maize of greater use in the Mexican southeast of 9 to 29% (Table 2). From this group of crosses stands the presence of SINT 4B, which participates in 9 outstanding combinations, SINT 10C in five combinations and the synthetics SINT 2B, SINT2C, TS6 SINT 1C and SINT 5B participating in four outstanding combinations which suggest good general combinatorial ability Of these synthetics. In relation to crosses, heterosis values were found with respect to the best progenitor from -2.2 to 63.30% (Sierra et al., 2004; Sierra et al., 2004; Sierra et al., 2004) 2005; Vasal et al., 1992; Vasal et al., 1993; Gómez et al., 1986).

The best crosses for its yield and agronomic characteristics were SINT6C xSINT4B, SINT2BxSINT10C, SINT2Cx SINT4B, SINT1CxSINT2B, SINT2CxSINT3 SEQ, TS6xSINT6C, with the best heterosis value (63.3%), V-537CxSINT9C, crosses varietal with high quality 8% More yield in relation to the trilineal hybrid H-520 and 25% more than the synthetic variety VS-536, of greater use in the southeast of Mexico and 41.3% of heterosis and also registered good aspect of plant and of cob; The synthetics SINT2BxSINT2C, SINT6CxSINT5B, SINT5B xSINT11C, SINT1BQxSINT10C, SINT4Bx SINT8C and SINT4BxV-537C with good yield and agronomic characteristics, (Reyes, 1985).In the majority of the outstanding crosses, combinations between synthetic formed with lines converted to the character of high quality of protein and synthetic ones formed with normal lines participate, which suggests genetic divergence between the progenitors (Reyes, 1985; Sierra et al., 2004; In the present study, it was observed that, in the present study.

Trat	Genealogía	Rend	% Rel	% Het	Flor	Alt Pl	Asp Pl 1/	Asp Mz 1/	% Cob	% Pod
12	SINT6CxSINT4B	5.73*	129	30.3	58.0	201.5	2.25	2.15	6.20	11.20
34	SINT2BxSINT10C	5.70*	128	24.5	57.5	214.0	2.40	1.90	12.80	7.15
5	SINT2CxSINT4B	5.65*	127	28.4	56.5	210.5	2.25	1.90	7.80	9.15
3	SINT1CxSINT2B	5.63*	127	23	56.0	201.5	2.25	1.90	8.20	9.69
4	SINT2CxSINT3SEQ	5.63*	127	32.5	56.5	217.5	2.40	2.05	8.05	5.95
22	TS6xSINT6C	5.55*	125	63.3	55.5	204.0	2.50	2.05	10.45	9.20
27	V-537CxSINT9C	5.55*	125	41.3	55.5	215.0	2.55	2.00	6.75	6.20
32	SINT2BxSINT2C	5.50*	124	20.1	57.0	211.5	2.65	2.15	9.50	5.55
13	SINT6CxSINT5B	5.48*	123	22.4	57.5	212.5	2.25	1.90	2.70	8.15
40	SINT5BxSINT11C	5.48*	123	19.7	57.0	196.5	2.50	2.05	5.70	4.90
29	SINT1BQxSINT10C	5.45*	123	23.6	57.0	205.5	2.35	2.15	17.60	9.85
37	SINT4BxSINT8C	5.43*	122	23.4	57.0	214.0	2.55	2.15	5.85	8.04
38	SINT4BxV537C	5.37*	121	22.1	58.0	202.5	2.55	1.90	2.60	7.60
6	SINT3CxSINT4B	5.28*	119	20	57.5	220.0	2.15	2.30	11.05	9.70
26	VS536xSINT9C	5.23*	118	31.4	53.5	200.0	2.40	2.30	8.80	7.95
33	SINT2BxSINT8C	5.20*	117	13.6	58.0	217.5	2.65	2.05	7.50	9.30
10	SINT5CxSINT5B	5.13*	115	14.5	57.5	215.5	2.25	1.90	4.70	7.25
24	LPSC3xSINT3C	5.13*	115	18.5	55.0	212.5	2.40	2.25	7.10	7.80
28	SINT1BQxSINT2C	5.13*	115	16.4	55.5	206.5	2.15	2.40	9.25	10.10
30	SINT1BQxSINT4B	5.13*	115	16.4	58.5	227.5	2.15	1.80	0.00	4.95
62	H-520	5.13*	115		57.5	203.0	2.30	1.65	3.60	4.15
2	SINT1CxVS536	5.10*	115	28.8	55.0	186.5	2.65	2.40	15.40	14.30
23	TS6xSINT10C	5.10*	115	32.5	56.0	210.0	2.25	2.15	5.50	4.65
59	SINT-3B	4.60	104		58.0	209.0	2.25	2.15	12.20	11.00
51	SINT-11C	4.58	103		55.0	197.5	2.80	2.65	22.25	10.85
58	SINT-2B	4.58	103		58.5	221.5	2.15	2.05	4.40	7.25
61	SINT-5B	4.48	101		57.5	206.5	2.80	2.15	6.05	10.65
55	VS-536	4.44	100		61.0	214.0	2.40	2.90	1.15	18.75
57	SINT 1BQ	4.41	99		59.0	215.5	2.55	2.55	5.30	4.80
60	SINT-4B	4.40	99		57.5	209.0	2.40	2.40	3.70	6.10
43	SINT-3C	4.33	98		56.0	203.0	2.40	2.65	7.55	20.90
42	SINT-2C	4.25	96		55.5	195.0	2.75	2.50	12.25	10.25
47	SINT-7C	4.18	94		54.5	189.0	2.50	2.80	12.95	7.45
48	SINT-8C	4.05	91		56.5	206.5	3.00	2.65	11.40	13.80
49	SINT-9C	3.93	88		55.5	193.0	3.30	2.75	10.60	16.25
50	SINT-10C	3.85	87		56.0	194.0	2.90	2.50	12.85	11.95
54	SINT3-SEQ	3.85	87		56.5	210.5	2.65	2.55	11.75	9.35
45	SINT-5C	3.75	84		56.0	208.0	2.80	2.40	7.80	7.50
44	SINT-4C	3.63	82		56.5	187.5	3.05	2.65	12.20	10.05
41	SINT-1C	3.60	81		56.5	189.0	3.25	2.75	22.15	13.20
53	LPS-C3	3.50	79		56.5	195.0	3.13	3.00	1.80	14.55
56	V-537C	3.50	79		54.0	195.5	2.90	3.30	15.70	21.00
52	TS6	3.40	77		54.0	184.0	3.25	2.65	8.80	10.10
46	SINT-6C	3.08	69		54.5	198.0	2.90	3.05	6.20	19.65
	PROMEDIO	4.75			56.46	205.1	2.56	2.34	8.92	9.83
	CME	0.435			1.70	165.84	0.17	0.17	1.49	0.84
	DMS0.05	0.925			1.80	17.85	0.57	0.57	1.68	1.27

Table 2 Yield and agronomic characteristics in corn varietal crosses for the tropics. Cotaxtla 2013B and 2014A

December 2016 Vol.3 No. 5 1-6

Comparisons and tests of t

In the comparisons and tests of t for crosses and synthetic varieties, statistical significance was found for yield and agronomic characteristics; Particularly crosses recorded an average grain yield of 5.13 tha-1, 28% more relative to synthetic parent; So the crosses showed significantly higher plant height, better plant and ear appearance, lower percentage of cobs with poor coverage and lower percentage of rotten ears (Table 3). This suggests that there is genetic divergence between the parents, which is also reflected in the values of heterosis with respect to the best progenitor that varied from -2.2 to 63.3%. (Reyes, 1971; Reyes, 1985; Sierra *et al.*, 2004; Sierra *et al.*, 2004a; Sierra *et al.*, 2005; Vasal *et al*., 1992).

Comp	RG	% Rel	Tc	Alt Pl	Tc	Asp pl1/	Tc	Asp mz1/	Tc	% Cob	Tc	% Pod	Tc
Cruza	5.13	128	8.89**	208	4.08**	2.46	5.54**	2.22	7.14**	8.51	3.2**	8.75	2.02*
Sint	4.01	100		201		2.77		2.62		9.95		12.6	

T0.05 (126) = 1.98; T0.01 (126) = 2.62

A = Autumn winter cycle; B = Spring summer cycle; 1 / = Rating scale from 1 to 5, 1 for best and 5 for worst; COMP = Comparison; SINT = Synthetic; RG = grain yield; % Rel = Relative percentage; Tc = t calculated; Alt pl = Plant height; Asp pl = Aspect of plant; Asp mz = Aspect of cob; % Cob = Percentage of ears with poor coverage; % Pod = Percentage of rotten ears

Table 3 Comparisons and t tests for yield and agronomic characteristics for varietal and synthetic crosses. Cotaxtla 2013B and 2014A

Conclusions

The crosses recorded an average grain yield of 5.13 tha-1, 28% more in relation to the synthetic ones. The crosses showed a better appearance of plant and cob, lower percentage of ears with poor coverage and lower percentage of ears with respect to synthetic ones. Crosses showed heterosis values in performance with respect to the best progenitor of -2.2 to 63.3%.

We found a group of 31 crosses that were outstanding for their performance and agronomic characteristics, among them: SINT6CxSINT4B, SINT2BxSINT10C, SINT2CxSINT4B, SINT1CxSINT2B, SINT2Cx SINT3SEQ, TS6xSINT6C with the best heterosis value (63.3%), V-537CxSINT9C with high quality Of protein and 25% more yield relative to the variety VS-536, SINT2BxSINT2C, SINT6C xSINT5B, SINT5B xSINT11C, SINT1BQx SINT10C, SINT4Bx SINT8C and the cross SINT4BxV-537C.

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