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TROPICAL CORN (*Zea mays* L) GENOTYPES WITH HIGH YIELD AND TOLERANCE TO CORN STUNT DISEASE IN THE GULF OF MEXICO REGION

[GENOTIPOS DE MAÍZ (*Zea mays* L.) TROPICAL CON BUEN RENDIMIENTO Y TOLERANCIA A LA ENFERMEDAD DEL "ACHAPARRAMIENTO" EN LA REGIÓN GOLFO DE MÉXICO]

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SUMMARY

In the humid tropic of México, there are 2.5 million hectares of corn with average yield of 2.0 t ha^{-1}. In this area, corn stunt disease has caused more than 25 % damages in commercial fields in Yucatán and Veracruz states and the coast region of the Gulf. The objectives of this research were to determine yield and agronomic characteristics of tropical corn genotypes and to identify those well adapted and tolerant to corn stunt disease. Thus, during the spring summer season in 2005/05, experiments were carried out using maize genotypes, in Medellín de Bravo, Tlalixcoyan and Ignacio de la Llave in Veracruz State, under a randomized complete block design with 10 entries and two replications, in plots of eight rows 10 m long and 80 cm wide, which produced about 62 500 plants ha^{-1}. The agronomic traits registered were: grain yield, percentage of damaged plants and ears by corn stunt and severity of damage. From the combined analysis for all traits registered, there were highly significant differences for genotypes (G) and locations (L). For the interaction GxL, with the exception of the percentage of damaged plants, there were highly significant differences for the others traits. Genotypes that registered the best yield, agronomic characteristics and tolerance to corn stunt disease were: H-520, H-513, H-518 and C-343.

Key words: *Dalbulus maidis; Spiroplasma kunkelii; Phytoplasm;* Corn stunt Maize bushy stunt; tolerant genotypes; humid tropic.

RESUMEN

En el trópico húmedo de México se siembran 2.5 millones de hectáreas con maíz con un rendimiento de 2.0 t ha^{-1}. En esta área, la enfermedad del achaparramiento ha causado daños mayores del 25% en siembras comerciales en los estados de Yucatán, Veracruz y en la región costera del Golfo. Los objetivos de esta investigación fueron: Conocer el rendimiento y las características agronómicas de genotipos tropicales de maíz e identificar las que mejor se adapten y presenten tolerancia a la enfermedad achaparramiento. Así, durante el ciclo primavera-verano 2005/05 se establecieron experimentos de genotipos de maíz en los municipios de: Medellín de Bravo; Tlalixcoyan e Ignacio de la Llave en el estado de Veracruz, bajo un diseño bloques al azar con 10 tratamientos y dos repeticiones en parcela útil de ocho surcos de 10 m de largo separados a 80 cm con una densidad de 62 500 plantas ha^{-1}. Se registraron las variables: Rendimiento de grano, porcentaje de plantas y mazorcas dañadas por achaparramiento, severidad del daño y características agronómicas. De los análisis de varianza combinados en las variables: Rendimiento de grano, porcentaje de daño y severidad por achaparramiento en planta y porcentaje de mazorcas con achaparramiento, se encontró diferencia altamente significativa para genotipos (G) y para localidades (L) en las cuatro variables. Para la interacción GxL excepto para porcentaje de plantas con achaparramiento (PPA), en el resto de las variables se encontró diferencia altamente significativa. Los genotipos con mayor rendimiento, tolerancia al achaparramiento fueron: H-520, H-513, H-518 y C-343.

Palabras clave: *Dalbulus maidis*; *Spiroplasma kunkelii*; Fitoplasma; Achaparramiento; Enanismo arbustivo del maíz; genotipos tolerantes; trópico húmedo.

INTRODUCTION

In Mexico, maize (*Zea mays* L.) is the most important crop by its planted area and, value of the production; In addition is the main food to the population and to occupy 20% of the economically active population. In 2002, in Mexico were planted 6,48 million hectares with this crop with an average yield of 2,32 t ha^{-1}. (SAGARPA, 2002). In tropical area 2,5 million hectares, which of them, one million are included in agronomic provinces of good and very good productivity and where it is feasible to use of hybrids and synthetic varieties improved seed (Sierra *et al*., 2001). In the State of Veracruz 431 thousand hectares are planted (INEGI, 2002). In this frame, maize is fundamental for Mexican consumption, 209,8 kilograms *per capita* (Morris and Lopez, 2000).

The stunt maize disease is one of major limiting factor in the production of corn in several countries of America among them: The United States, Mexico, Honduras, Guatemala, El Salvador, Dominican Republic, Haiti, Costa Rica, Nicaragua, Panama, Peru and Argentina (Nault *et al*., 1979, Bradfute *et al*., 1980, Henríquez y Jeffers, 1997; Gordon *et al*., 1997; Urbina, 1997; Giménez *et al*., 2002), and have been a limiting factor in tropical and subtropical zones. The disease is observed since the sea level to intermediate or high regions and in latitudes from 40 º North latitude to 30 º South latitude, in regions where the climatologic conditions are favorable for the development of the vector, as they are: rain shortage, high temperatures and low relative humidity (De León, 1984; Gordon *et al*., 1997; Urbina, 1997; Ibarra-Aparicio *et al*., 2005).

In Mexico damages in the Yucatan Peninsula have been reported and in the coastal region of the Gulf, mainly in delayed sowings, registering greater damages to 25% in commercial sowings in Veracruz, mainly in areas where the production of green ear is important and the farmers establish staggered sowings, which does not allow to break with the life cycle of the vector and the disease becomes endemic (Cano *et al*., 2000; Sierra-Macias *et al*., 2004). This disease is caused by the interaction of three pathogens: the maize fine stripe virus (MRFV), spiroplasma of maize CSS (*Spiroplasma kunkelii*) and the Phytoplasma of the maize bushy stunt MBSM (Bradfute *et al*., 1981).

Symptoms caused by MBSM begin with small chlorotic stripes that develop at the leaf bases of young plants after about 25-30 days. The chlorotic stripes become fused and extend further toward the leaf tips in the older leaves with green spots and stripes on a chlorotic back-round. The infected plants have much shorter internodes and a proliferation of secondary shoots in leaf axils. Reddening on leaves varies depending on the corn genotype and environmental conditions (Bajet y Renfro 1989; Toffanelli y Bebendo 2001; Nault, 1980),

The CSS was reported initially in California (USA), identified like the “Race Grande River” of the stunt maize disease. Later it was also reported in several countries of Central and South America and the Caribbean. The causal agent is mycoplasm helical mollicute or Spiroplasma that measures 0,15 to 0,2 nm of diameter and near 2 to 15 nm of length. The symptoms are observed as broad bands on the base of the young leaves, the plants are stunted due to the shortening of internodes, leaf reddening or purpling, yellowing, and the presence of chlorotic stripes at the base of younger leaves, which might turn purple-red toward the tip. Foliar symptoms normally appear close to flowering time, axillary buds develop as barren shoots or ears at many nodes, and there is excessive root branching. In severe cases, plants are barren, or there is a significant reduction in ear diameter or poor seed set (Shurtleff, 1980; De León, 1984; Bajet y Renfro 1989).

The maize fine stripe virus (MRFV) has been reported in Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua, Panama and Mexico (Bradfute, *et al.*, 1980). Henríquez y Jeffers (1997) mention that the MRFV induces the formation of small, isolated chorotic spots. Then the spots become more numerous and forming stripes that advance along the veins bordered (Bajet y Renfro, 1989; Rocha, 1981; De León, 1984). In susceptible genotypes the plants can become stunted and can get confounded with CSS or MBSM symptoms (Henríquez y Jeffers, 1997). The leafhopper is the vector insect *Dalbulus maidis* (DeLong & Wolcott) y *D. elimatus* Ball. (Bajet y Renfro, 1989; Henríquez y Jeffers, 1997).

In Mexico MBSM is more prevalent than the CSS in high elevations (2000 m), whereas in elevations smaller than 2000 meters is the opposite. Both pathogens are transmitted efficiently by leafhoppers of the genus *Dalbulus and Baldulus. D. maidis* , but, is more prevalent in low o medium elevations (smaller than 750 m) and can transmit both pathogens; whereas, *D. elimatus* is found in high elevations (greater than 750 m) and also transmits both pathogens (Madden and Nault, 1983)

The life cycle of *Dalbulus maidis* varies with the temperature and the host plant. The nymphs have five instars which can occur in 12 to 34 days to 10 ^{o}C; of 6 to 13 days with 16 ^{o}C, of 3 to 4 days to 27 ^{o}C and of 2 to 4 days to 32 ^{o}C. The average longevity of the adult is of 67 days for males and 38 days for females to 10 ^{o}C; of 107 days for males and 52 for females to 16 ^{o}C and 78 days for males and 30 days for females to 27 ^{o}C; of 16 days in males and 10 in females to 32 ^{o}C (Tsai, 2004). In Argentina, the populations of

Dalbulus maidis appears once emerged the maize, with conditions average of temperature maxima and minim of 29.63 ^{o}C and 16.88 ^{o}C, respectively, with an average density of 7,5 insects male and 4,5 insects female (Virla, *et al*., 2003). The period of latency of the MBSM within the insect vector, *Dalbulus maidis*, at greenhouse level, was of 24,2 days; whereas for CSS was of 19 days (Nault, 1980).

The International Maize and Wheat Improvement Center (CIMMYT) and the Regional Maize Program in Central America have developed single and three-way maize tropical hybrids with resistant to the complex of the maize stunt disease (Jeffers *et al*., 2004). When 10 hybrids were evaluated, with and without infestation, of *D. maidis* in Cotaxtla, Veracruz, the hybrid H-371C yielded 4.66 t ha^{-1}, and the H-513 yielded 2,27 t ha^{-1}. The tolerance was due to the genotypes had less percentage of plants and ears affected by the maize stunt disease complex (Sierra-Macias *et al*., 2004). The INIFAP (National Institute for Forestry, Agricultural and Livestock Research) has developed the H-518 and H-520 hybrids which are three-way hybrids that uses as female parent the single cross hybrid H-513. H-520 has showed tolerance to the disease of the maize stunt disease (Sierra *et al.,* 2004)

Several authors, found negative and highly significant between the grain yield and the symptom of maize stunt disease in both plant and ear, which suggests that the disease has a direct influence on the yield; and it was also reported a positive and highly significant correlation between the percentage of plants and ears with maize stunt disease (Gordon *et al.,* 1997; Obando, *et al.,* 1997).

The objectives of this work were: 1) To know the yield and the agronomic characteristics in tropical maize genotypes; and 2) To identify maize genotypes with good yield and tolerant to the stunt maize disease.

MATERIALS AND METHODS

During the season spring summer 2005/05, genotypes with normal and high quality of protein grain were evaluated in the localities of Cotaxtla, Municipality of Medellín de Bravo, La Torrecilla, Municipality of Tlalixcoyan, and Zapotal Numero Uno, Municipality of Ignacio de la Llave in Veracruz State, that in agreement with the climatic classification of Köppen modified by Garcia (1981), belong to the climates Aw1, Aw" 2 (w) (e) g, Aw" 2 (w) (i') for the three locations, respectively, and correspond to climates warm subhumid with rains in summer. Aw1 with a quotient precipitation: temperature between 43,2 and 55,3 and the case of greater Aw2 of 55,3 and is most humid of the subhumid ones. The localities of Tlalixcoyan and Ignacio de la Llave are areas where year with year sowing maize in dates staggered for the production and commercialization of green corn and therefore is not broken with the life cycle of the vector of the stunt maize disease, *Dalbulus maidis*, reason why this disease is endemic in that region and other areas where green corn is produced. Thus also, in delayed dates of sowing during the month of July they are propitious for the presence in natural form of the disease of the stunt maize disease. Besides, cattle areas in the zone with grass sowings exist that help to increase the populations of the vector (Table 1).

Used Germplasm. The three-way hybrids of recent liberation H-518 and H-520; the H-513, VS-536, Synthetic 3 tolerant to drought were included, along with the genotypes with high quality of protein H-519C, V-537C, and V-556AC, and the commercial hybrids C-343 and A-7573, this last one with main destiny for the production of green corn.

Description of the experiments

The experiments were planted the 5, 11 and 12 of July of the 2005, for the localities of Cotaxtla, the Torrecilla and Numero Uno, respectively, in plots of eight rows of 10 m of length separated to 80 cm. Two seeds were planted per hill each 20 cm apart and thinned to one plant, so that in both experiments had a density of 62500 plants ha^{-1}. The control of the weeds was with herbicide Atrazine in dose of 3 kg ha^{-1}. The experiments were fertilized with the formula 161-46-00; distributed with 100 kg of urea and 100 kg of Concentrated Superphosphate during the first 10 days from the planting date and the rest of nitrogen at the time of floral differentiation.

Variables and registry of data

The variables registered were: Grain yield, percentage of plants with stunt maize disease damage, severity of the damage by stunt maize disease with scale from 1 to 9 where, 1 is the smaller damage and 9 represent the greater damage (taking into account the yellow-reddish coloration in the leaves of the third part of the plant, reduction of the height and proliferation of ears), percentage of ears with damage of stunt maize disease (small ears, without grain), plant and ear height, days to male and female flowering, aspect and health of plant and ear with scale from 1 to 5, where 1 is the best and the 5 worse one, percentage of plant lodged, percentage of ears with bad cover tip, and percentage of rotted ears. The variable percentage of stunt maize disease in plant was registered during the period of previous grain filling to September, 21 in the Torrecilla locality, and September, 30 in Ignacio de la Llave, severity of damage by stunt maize disease was registered in plant the September, 30 in the three localities.

Statistical methods

Individual analyses of variance for the variables in study and combined analysis for yield, percentage of plants and severity by stunt maize disease in plant and percentage of damage by stunt maize disease in ear were made. The data registered in percentage were transformed to angular degrees (bliss). There were made phenotypic correlations between the variables: yield with percentage of damage by stunt maize disease in plant and ear, severity, percentage of damage in plant with percentage of damage in ear, and this last with aspect and health of ear.

RESULTS AND DISCUSSION

The combined analyses of variance for the localities of Cotaxtla, Tlalixcoyan and Ignacio de la Llave, and for the variables: grain yield, percentage of damage and severity by stunt maize disease in plant and percentage of damage in ear (Table 2), it was found statistical significance to the 0,01 of probability for genotypes, (g) and localities (l) in the four variables. The G x L interaction, except in percentage of plants with stunt maize disease damage (PPS), had highly significant difference. For the four analyzed variables, the variance for the factor localities was more important (Table 2).

The results indicate that the yield and the presence of the disease of the stunt maize disease in each locality were different. The coefficient of variation was 12,17% for grain yield, 10,17% for percentage of damage by stunt maize disease in plant, 19,16% for severity of the damage, and 15,59% for percentage of ear damaged by stunt maize disease, relatively low values. The low values in the coefficient of variation suggest that the conduction of the experiments, the handling and the obtained results are reliable (Reyes, 1990).

The Table 3 shows that the locality of Cotaxtla registered a mean in grain yield of 7,46 ** t ha^{-1}; in the variable percentage of damage in plant by stunt maize disease, in Ignacio de la Llave had an average of 47,45% the highest value **, followed by la Torrecilla, Municipality of Tlalixcoyan with 21,44% and the lowest value was for Cotaxtla 6,57%; for the variable severity of the damage by stunt maize disease, the localities of Ignacio de la Llave and La Torrecilla, Ver., had the highest values (5,4 and 5,2, respectively). Particularly, Tlalixcoyan and Ignacio de la Llave are areas where maize is planted for the important production and commercialization of green corn, and the planting in stepped dates does not allow to break with the life cycle of the vector, *D. maidis*. The climatologic conditions are also propitious for the development and transmission of the disease. (Nault, 1980; Urbina, 1997; Cano *et al*., 2000; Virla, *et al*., 2003; Sierra-Macías *et al*., 2004; Ibarra-Aparicio *et al*., 2005).

Table 1. Description of the localities of evaluation of maize genotypes.

Location	Climate	masl*	Annual mean Temperature ^{0}C	Annual total Precipitation (mm)
Cotaxtla	Aw_1	15	25	1300
Tlalixcoyan	Aw"$_2$(w)(e)g	84	26.6	1483
Ignacio de la Llave	Aw"$_2$(w)(i')	8	26.5	1816

* meters above sea level

Table 2. Mean squares and significance in the analysis of variance combined for grain yield, percentage of damage by stunt maize disease in plant and ear and severity. Veracruz 2005 B.

Source of variation	DF	GY	PPS	SDS	PDSM
Genotypes) (G)	9	8.05**	3.6**	9.5**	7.4**
Locations (L)	2	102.1**	96.1**	37.0**	112.6**
Interaction G x L	18	1.7**	0.4 NS	25.9**	1.54**
Error	27	0.3	0.22	0.75	0.65
CV (%)		12.17	10.19	19.16	15.59

DF= Degre free, GY = Grain Yield, PPS= Percentage of plants with stunt maize disease; SDS = Severity of damage by stunt maize disease; PDSM= Percentage of damage by stunt maize disease in ear; Coefficient of variation; Non significant NS =; ** Significance of the treatments to the 0,01 of probability

Table 3. Significance for localities in the analysis combined for the variables grain yield, percentage of damage by stunt maize disease in plant, severity and percentage of ears with damage. Veracruz 2005 B.

Location	GY	PPS	S	PMS
Ignacio de la Llave	3.32	47.45**	5.40*	34.69
La Torrecilla	3.81	21.44	5.20*	55.05**
Cotaxtla	7.46**	6.57	2.95	7.25

* Significance for localities to the 0,05 of probability; ** Significance for localities to the 0,01 of probability; GY = Grain yield; PPS = Percentage of plants with stunt maize disease; S =Severity of the damage, PMS=Percentage of ears with stunt maize disease

Grain yield

In relation to the grain yield of hybrids and varieties of maize (Table 4), the three-way hybrid H-520 had the best yield by locality and through localities (6,98 t ha^{-1}). Nevertheless, it is observed that genotypes like C343 and A7573 registered high yield in the locality of Cotaxtla, but low in Tlalixcoyan and Ignacio de la Llave, Ver., where the pressure of the disease of the stunt maize disease was greater. Cotaxtla had the mean yield more high (7,46 t ha^{-1}), whereas, Tlalixcoyan and Ignacio de la Llave had the lowest yields (3,81 and 3,32 t ha^{-1}, respectively), which means a loss of 51 and 44%, for each locality, due to the presence of the stunt maize disease. This suggests the importance of obtaining genotypes with high potential of yield and tolerant to the disease. The results confirm the reported by several investigators, among them: De León, 1984; Gordon *et al*., 1997; Henriquez y Jeffers, 1997; Cano *et al*., 2000 y Sierra-Macías *et al.*, 2004.

Damage by stunt maize disease

The main symptoms observed were the reddish coloration and the proliferation of small ears that correspond to the *Phytoplasm* pathogen of the maize bushy stunt (MBSM); in smaller proportion It appeared symptoms of white and yellow bands that correspond to the presence of the *Spiroplasm* pathogen of the maize (CSS); the symptoms of maize fine stripe (MRFV) were not observed. Showed data are in agreement with the symptoms described by Nault *et al.* 1979; Shurtleff, 1980; Bradfute *et al*. 1980; Nault 1980; Bradfute *et al*. 1981; Rocha, 1981; De León , 1984; Bajet and Renfro, 1989; Henriquez and Jeffers, 1997; Toffanelli y Bebendo 2001; and Giménez *et al*. 2002.

Table 4. Grain yield in experiments of hybrids and varieties of maize. Veracruz 2005B.

Genealogy	Cotaxtla, Medellín de Bravo	La Torrecilla, Tlalixcoyan	Numero Uno, Ignacio de la Llave	Average	% Relative
H-520	9.81*	5.81*	5.26*	6.98**	163
H-513	7.54	5.48*	5.04*	6.02	141
H-518	8.79*	4.38**	3.92*	5.70	133
C-343	9.36*	4.49**	2.41	5.42	127
H-519C	7.98**	2.43	3.51**	4.64	109
SINT 3	6.48	3.73	3.39**	4.53	106
VS-536	6.21	3.32	3.27	4.27	100
A-7573	7.95**	3.25	1.26	4.15	97
V-537C	5.87	2.80	2.98	3.88	91
V-556AC	4.62	2.40	2.16	3.06	72
Average	7.46	3.81	3.32	4.86	
CV (%)	8.26	12.86	19.52	12.67	
MSE	0.38	0.24	0.42	0.35	

* Significance of the treatments to the 0,05 of probability; CV = % Coefficient of variation ** Significance of the treatments to the 0,01 of probability; MSE = Mean Square Error

The damages of the disease of the stunt maize disease in ear were bareness or poor grain set and lightweight ears (Shurtleff, 1980; De Leon, 1984). Table 5 shows information on the damage by stunt maize disease in plant and ear. Thus, the percentage of damage by stunt maize disease in maize plants in the localities of la Torrecilla, Municipality of Tlalixcoyan, Ignacio de la Llave, and Cotaxtla, Ver., registered a percentage of damage average of 21,44, 47,45 and 6,57% in each locality, respectively. The genotypes that registered the smaller damage by this disease at the level of significance of the 0,01 of probability were: the hybrids H-520, H-513, H-518 and C-343 with 14,57, 16,91, 17,74 and 21,97% for each genotype, respectively. On the contrary, the genotypes with greater damage were V-556 AC V-537 C and H-519 C, genotypes with high quality of protein, and A7573, green corn commercial hybrid. In relation to the severity of damage by stunt maize disease in plant, the localities of Tlalixcoyan and Ignacio de la Llave presented the greater severity of damage average with values of 5,2 and 5,4; whereas, Cotaxtla showed the smaller severity (2.95). The genotypes in which the damage was less severe were: H-520, H-513 and C-343 with values average of 2,5, 2,83 and 3.83. On the contrary, greater severity was registered in the genotypes V-556, V-537 C and H-519 C with values of 6,17, 6,17 and 5,33, respectively. Regarding the percentage of damage by stunt maize disease in ear, it was different in the three locations, thus, registered averages of 55,05% in Tlalixcoyan, 34,69% in Ignacio de la Llave and 7,25% in Cotaxtla, with a general average of 32,38%. Through the three localities, the genotypes that registered the percentage of damage in ear significantly lower were: H-520, H-513 and H-518. On the contrary A-7573 registered higher percentage of damage (67,88%).

In general, it was observed that the presence of the disease was different for each location and that the genotypes with greater tolerance to the stunt maize disease were H-520, H-513, H-518 and C343, The genotypes, H-520 and H-518 have as female parent the hybrid of single cross H-513 which is tolerant to the disease and it agrees with the reported by Jeffers *et al.*, 2004, Sierra-Macías *et al*., 2004, y Sierra *et al.*, 2004. These genotypes represent an alternative in commercial sowings for the maize production in Veracruz state.

Phenotypic correlations

On the average of the three locations, grain yield and percentage of stunt maize disease in plant were negative (- 0,78 **), severity of the damage in plant (- 0,81 **) and with percentage of stunt maize disease in ear (- 0,71 **), which indicates that grain yield is affected by the stunt maize disease in plant and ear, and in severity. The variable percentage of stunt maize disease in plant registered positive and highly significant correlation with severity of the damage (0,77 **), with the percentage of ears with stunt maize disease (0.44*) and plant health (0,81 **). Finally, it was found a positive and highly significant correlation between percentage of ears with the stunt maize disease and the variables ear aspect (0,84 **) and ear health (0,81 **). These results suggests that exists germoplasm resistant to the disease, in agreement with Jeffers *et al.* 2004; Sierra-Macías *et al.* 2004 y Sierra *et al*. 2004. These genotypes represent an alternative for the maize production in Veracruz and to improve the diet of the consumers (Morris and Lopez, 2000).

Table 5. Percentage of damage and severity by stunt maize disease in plant and ear of maize in three locations in Veracruz state. 2005B

	Torrecilla			Ignacio de la Llave			Cotaxtla			Average		
Genotype	PPS	S	PDE	PPS	S	PDE	PPS	S	PDE	PPS	S	PDE
H-520	7.86*	3.5*	22.17*	32.49*	2.5*	24.99*	3.35*	1.5*	1.35	14.57*	2.5*	16.18*
H-513	11.77*	4*	36.94*	34.69*	3*	10.94*	4.28*	1.5*	6.10	16.91*	2.83*	17.99*
H-518	15.22*	5	40.36*	34.19*	3.5	25.62*	3.82*	3.5	8.72	17.74*	4	24.90**
C-343	15.46*	3*	64.27	47.27*	6.5	44.47	3.19*	2*	6.27	21.97**	3.8**	38.34
SINT 3	18.75**	5	52.38	46.78*	5*	24.96*	6.18*	3**	9.50	23.90	4.33	28.95
VS536	24.26	7	59.66	45.96*	5*	25.73*	6.37*	4	5.60	25.53	5.33	30.33
H519C	28.15	7	65.26	58.33	6**	38.30	4.69*	2.5*	12.96	30.39	5.17	38.83
A-7573	25.57	4*	99.10	58.04	6.5	92.80	15.07	4	11.57	32.89	4.83	67.83
V537C	35.88	7	64.43	57.06	7.5	24.80*	6.14*	4	5.28	33.03	6.17	31.50
V556AC	31.53	6.5	45.88**	59.75	8.5	34.32	12.61	3.5	5.15	34.63	6.17	28.45
Average	21.44	5.20	55.05	47.45	5.4	34.69	6.57	2.95	7.25	25.16	4.52	32.33
CV (%)	8.57	15.7	8.35	8.28	21.2	19.13	18.25	17.61	16.83	10.19	19.15	15.59

* Significance of the treatments to the 0,05 of probability; ** Significance of the treatments to the 0,01 of probability; PPS = Percentage of plants with stunt maize disease; S = Severity; PDE = Percentage of damage in ear; CV = % Coefficient of variation

Agronomic characteristics

As for the agronomic characteristics (Table 6), the excellent genotypes by their yield and tolerance to the disease of the stunt maize disease were: H-520, H-518 and H-513, also registered the best qualifications of aspect and plant and ear health, and minor ear rotted percentage, low plant and ear height and intermediate maturity, 53 to 55 days to the male and female flowering, smaller percentage of stalk lodged and good cover of ear tip, important characteristics for the maize sowings in the humid tropic of Mexico.

These values suggest that the disease of the stunt maize disease directly affects the grain yield and also the quality of ear and grain. These results agree with the reported thing by Gordon, *et al*. 1997 y Obando, *et al.* 1997, who found that the disease of the stunt maize disease has a direct influence in the grain yield.

Table 6. Agronomic characteristics of maize genotypes [1/] Veracruz 2005 B.

Genotype	PH.	EH	DMF	AP.	HP.	AE	HE	% SL	% EBC	% RE
H-520	228	139	54	1.67**	2.08*	1.75**	1.75**	1.46*	1.64*	5.89*
H-513	212	113	53	2	2.25**	1.83**	2.0**	3.64	3.54*	7.60*
H-518	199	110	54	2.5	2.83	2.42	2.67	1.44*	2.85*	9.46*
C-343	211	120	53	3	3.17	2.75	3.08	1.83*	2.25*	12.98
SINT 3	209	114	54	2.92	2.83	2.92	3.0	3.81	5.51	23.76
VS-536	233	135	55	3	3.33	2.83	3.0	3.81	1.67*	11.89
H-519 C	221	136	55	2.75	3.17	3.0	3.17	2.62	4.49*	18.18
A-7573	192	108	51	3.33	3.5	4.33	4.33	0.0*	4.04*	57.32
V-537 C	207	122	53	3.25	3.92	3.0	3.17	3.12	2.49*	16.05
V-556 AC	211	117	51	3.33	3.92	3.33	3.5	6.78	6.96	16.14
Average	212.35	121.47	53.18	2.78	3.1	2.82	2.97	2.78	3.55	17.93
C.V. (%)	7.13	11.91	2.36	12.43	10.50	10.63	10.10	10.64	35.77	16.59
LSD 0.05	17.91	17.12	1.48	0.08	0.39	0.36	0.36	2.22	3.69	7.22
LSD 0.01	25.96	23.14	2.00	0.11	0.52	0.48	0.48	3.20	4.99	9.75

1/ Average of the localities of de Cotaxtla, Tlalixcoyan and Ignacio de la Llave, Ver.

* Significance of the treatments to the 0,05 of probability; ** Significance of the treatments to the 0,01 of probability; PH = Plant Height; EH = Ear Height; DMF = Days to male flowering; AP.= Aspect of Plant; HP = Health Plant; AE = Aspect of Ear;; HE = Health Ear; % Stalk Lodged; % EBC= % Ear bad tip cover; % RE = % Rotted Ear.

CONCLUSIONS

In the combined analyses of variance for yield, percentage of damage by stunt maize disease in plant and ear and severity, the variance due to locations was the most important factor.

The genotypes that registered the highest yield and minor percentage of damage and severity by stunt maize disease in plant and ear were: H-520, H-513, H-518 and C-343

Ignacio de la Llave and Tlalixcoyan, Ver., were the locations that registered the highest percentages of damage and severity by stunt maize disease in plant and ear.

Cotaxtla, Ver., registered the best grain yield of and minor damage by stunt maize disease.

Grain yield was affected by the percentage of stunt maize disease in plant, severity of the damage in plant and percentage of stunt maize disease in ear.

The percentage of stunt maize disease in plant was associate with severity of the damage, percentage of ear with stunt maize disease and health of plant

The percentage of ears with stunt maize disease affected significantly the variables ear aspect and ear health.

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