Description of cultivar

Gacela H72: early maize hybrid to rainfed and irrigated areas of Central Highlands of Mexico

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Abstract

Due to the climate change that is manifested in the irregular distribution of rainfall less than its incidence in temporary and higher temperatures, the problem of lack of early corn hybrids arises, especially for regions of low and medium productive potential of the central table of Mexico, which cover 1 200 000 ha of cultivated area. The hybrid of early corn Gacela H72, was generated to respond to the conditions of climate change, since it is a double hybrid of early cycle and great hardiness, presents growth and vigorous development in the initial vegetative stage, so it exceeds the size of plant to other maize hybrids during the 30 days after emergence, is tolerant to drought in the vegetative and reproductive stages and yields well in conditions of low chemical fertilization. Its yield has a range of 3 to 11 t ha^{-1} which surpasses the 50% and creole varieties and 20% private commercial hybrids. It has a period of steepness between 95 and 100 days at altitudes of 2 600 m where other hybrids and varieties reach it between 110 and 115 days. It is resistant to the charcoal of the spike (*Sphaceloteca reiliana*) and to the putrescence of the cob (*Fusarium* spp.) And has the quality of nixtamalera-tortillera. Gacela H72, being a double hybrid, has progenitors with higher productivity in the seed than other hybrids, its female parent renders 7.5 t ha^{-1} in the High Valleys, which gives it 25% more profitability in the production of the registered and certified seed with respect to other maize hybrids. Plant size facilitates intensive sowing with 70 000 plants ha^{-1} and with double-row planting to 100 000 plants ha^{-1} yields of 10 to 11 t ha^{-1} have been achieved. The harvest can be done at 150 days with a moisture content in grain 25%, so the cob must undergo a drying process to reduce the moisture content of the grain 14%. In areas of irrigation and good weather has potential for the production of forage. The main economic impact of the Gacela H72 is the difference of 3 to 4 t ha^{-1} over the yield of the creole variety, which represents 12 000.00 to 16 000.00 pesos per hectare, which makes corn production profitable.

Keywords: *Zea mays* L., semicrystalline white grain, double hybrid, early maturity.

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In the Central Plateau of Mexico, 1 689 572 ha are planted with corn and are distributed in three production strata: 1) irrigation with high yield; 2) temporary with high performance; and 3) temporary with low performance, covering areas of 12.6, 48.3 and 39% of the total (Arellano, 1984). The effects of climate change in the High Valleys are manifested in temporary and limited adverse environmental conditions that affect the month of May and the presence of moderate intensity frosts or frosts or frosts during the month of September, which determine that the growing season be shortened to 140 days to obtain good quality corn harvests.

It has been proposed to achieve the highest performance through multiple environmental conditions, requiring genotypes that maintain a greater productive response to the environment with a consistent or stable behavior and high yield (Kang, 1998; Lu'quez *et al*., 2002), this it is feasible based on the capacity of the generic potential of the hybrid to buffer adverse agroclimatic conditions and the application of technological components such as the use of mycorrhizae, population densities and an effective integral fertilization program. Early corn hybrids with high yield and grain quality, are an alternative to maintain profitable production in boundary conditions and rain temperatures and higher temperature during the growing season in the High Valleys of Central Tableu of México.

Generation of the Gacela H72 hybrid. The GACELA H-72 corn hybrid was generated from the inbred lines ich. 21 Comp.1-7-2-14-1-3 with S_5 inbreeding level, identified in its registry as M-54 and Tlax. 151 SFC1-11-2-2-2 with inbreeding level S_4, registered as M-55, both lines were generated by the pedigree method with selection. The origin of the M-54 line is found in the creole variety called Michoacan 21, while in the M-55 line in the creole variety Tlaxcala-151.

The crossing of these lines gave rise to the female progenitor M-54 X M-55. Also, involved in the generation of this hybrid SMCs-242 lines and CML-354 line have levels of inbreeding S_7, both derived from the population 85 early white semidented obtained in the International Maize and Wheat Improvement Center (CIMMYT, for its acronym in Spanish) whose genealogies are: Batan 8785 MH 10-1-1-2TL-1-3TL-3-1TL-b for CML-242 and Pob. 85C4 13-4-10-4Tl-3-1Tl-B # # for CML-354. The crossing of these lines gave rise to the male parent.

The process of derivation and selection of lines of the simple female cross of the Gacela H72 hybrid, was carried out from 1946 to 1984, during the period from 1985 to 2009, simple experimental crosses of the female were obtained, evaluated and selected, while the simple cross male was generated in 2008 and its yield potential was evaluated in 2009. The double hybrid Gacela H72 was generated in 2009 and from 2010 to 2016, experimental evaluations were carried out and its semi-commercial validation was carried out in localities of the High Valleys.

In 2017, the required documents for its official registration were submitted to SNICS. Figure 1 shows the classical hybridization scheme for obtaining the Gacela H72 hybrid, from cobs representative of the parents and the hybrid. It can be observed that the progenitor M-54 is of small cob of conical type with round grain of semi-hardened texture and creamy color, while the line M-55 is of long cob with irregular rows and thin pointed grain and semicrystalline of color white. The crossing of both parents generates the female M-55 X M-54 progenitor that exhibits considerable heterosis in size and weight of the cob that is of conical type with grain of creamy white texture.

While the progenitor lines CML-242 and CML-354 are of small cob of cylindrical shape with semicrystalline type grain of white color. The crossing of these lines generates the male progenitor CML-242 x CML-354 that shows significant heterosis in size and weight of cob with cylindrical shape and grain of semicrystalline type of white color. The female parent, when crossing with the male parent, generates the combination that gave rise to the new double-gazelle hybrid Gacela H72 of large cone-cylindrical type of regular rows with white semicrystalline type grain (Figure 1).

Figure 1. Scheme for obtaining the hybrid of early maize Gacela H72 and phenotypic characteristics of the cobs representative of the progenitors and the hybrid.

Registration of the hybrid of Gacela H72 maize in the national catalog of plant varieties. Based on the Production, Certification and Seed Trade Act in force in Mexico and after having met the requirements for registration, the Gacela H72 maize hybrid was registered in June 2018 in the National Catalog of Varieties of Vegetables (CNVV) with the registration number: MAZ-1856-090318.

Description of the morphological characteristics of hybrid Gacela H72 and its progenitors. In Table 1, the main morphological characteristics of the Gazelle H72, of the simple female cross (M-54 x M-55) and of the male cross (CML-242 x CML-354) are presented based on the technical guide for the varietal description (SNICS, 2014).

Table 1. Morphological characteristics of the maize hybrid Gacela H72, the simple female cross M-54 x M-55 and the male simple cross CML-242 x CML-354.

Characteristics	Variety description		
	Gacela H72 Hybrid double	M-54 x M-55 Progenitor female	CML-242 X CML-354 Progenitor male
Coloring of the pod by anthocyanins in the first leaf	Absent or weak	Absent	Absent
Layout of the blade on the cob sheet	Slightly curved-curved	Slightly curved	Rectilinear
Orientation of leaves above the upper ear	Erect-semierect	Semi-direct to semihorizontal	Erect to semierect

Characteristics	Variety description		
	Gacela H72 Hybrid double	M-54 x M-55 Progenitor female	CML-242 X CML-354 Progenitor male
Ripple of the laminar margin of the upper cob sheet	Absent	Slightly wavy	Slightly wavy
Longitudinal wrinkles on the upper cob sheet	Absent	Occasional to always present	Occasionally present
Color of the pod on the cob leaf	Green to Purple Green	Green to dark green	Lemon green to normal green
Pubescence on the margin of the scabbard	Abundant	Abundant to very abundant	Absent or mild
Panicle coverage by the flag leaf	Absent to mild	Absent to mild	Absent to mild
Days to 50% flowering (anthesis)	73-76 (2 300 masl)	68-79 (2 300 masl)	73-79 (2 300 masl)
Coloring by anthocyanins at the base of the glumes in the middle third of the main axis of the panicle	Absent to dim	Intermediate to very strong	Absent to dim
Coloring by anthocyanins in the glumes (excluding the base) in the middle third of the main axis of the panicle	Absent	Absent to dim	Absent to dim
Panicle length (cm)	27-35	27-43	16-31
Days to 50% of female flowering	75-79 (2 300 masl)	73-84 (2 300 masl)	80-86 (2 300 masl)
Coloring by anthocyanins in stigmas	Absent	Absent	Presented
Coloring of the base of the stigmas of the upper jilote	Yellow	Yellow	Pink
Coloring by anthocyanins in the leaf sheath (in the middle part of the plant)	Absent or dim	Weak to medium	Absent
Height from the ground level to the insertion knot of the main cob (cm)	130-140	130-150	100-120
Length of ear, from the base to the apex (cm)	10-20	10-20	10-15
Diameter of the ear of the central part (cm)	4.1-6	4.1-6	4.1-5
Shape of the cob	Conical-cylindrical	Conical	Conical-cylindrical
Number of rows per corn	12-16	12-16	12-16
Number of grains per row on the cob	21-30	21-30	20-30
Type of grain in the central third of the cob	Semi-crystalline	Semidentate-semicrystalline	Semi-crystalline
Ungraded grain color	White-creamy	White-creamy	White-creamy
Endosperm color	White	White	White
Coloring anthocyanins of the glumes of the olote	Absent	Absent	Absent

Agronomic behavior of the Gacela H72 hybrid in localities of Valles Altos

The agronomic behavior of the hybrid Gacela H72 was evaluated experimentally and in lots of commercial production from 2009 to 2016 in 25 representative localities of environments of deficient, intermediate and favorable weather or with irrigation of aid, with the purpose of studying better the performance of the global performance and that of the interaction genotype x environment of performance. At a global level, the yields varied from 4.3 to 11.2 t ha^{-1} and represent values of 85 to 126% with respect to the joint yield of commercial controls H-48, H-70, AS-722 and the creole variety.

The number of days at male flowering ranged between 75 and 109, corresponding to sites located at altitudes of 2 250 and 2 650 m respectively; that is to say, at higher altitude, the emergence, development of the spike and dispersion of the pollen is slower due to lower temperatures of the place. Regarding plant height, Gacela H72 showed a plant size that varied from 170 to 230 cm the highest plant height is usually associated with higher altitude and very humid environments. The planting that showed Gacela H72 ranged between 3 and 9%, which represents values of minimum to moderate lodging. The stockings; through, localities for yield, male flowering, plant height and planting were 7.9 t ha^{-1}, 96 days, 210 cm and 6%, respectively. Through the test environments, Gacela H72 was 14% higher in performance than the average of commercial controls (Table 2).

Table 2. Performance (%) of the yield with respect to the controls and plant characters of the Gacela H72 corn hybrid by location and year in the Central Highlands of Mexico.

Location	Yield (t ha^{-1})	(%) of the control	FM (days)	AP (cm)	Acame (%)
2009					
Zotoluca, Hidalgo (2 450*)	7.5	124	97	230	8
Calpulalpan, Tlaxcala (2 600*)	11	130	95	235	9
2010					
San Luis Huamantla (2 450*)	9.1	110	99	219	2.5
2012					
Calimaya, Estado de México (2 600*)	8.8	110	102	225	8
Zinacantepec, Estado de México (2 600*)	7.8	105	102	220	3
Jiquipilco, Estado de México (2 550*)	6.2	113	104	217	5
Netzahualcoyotl, Estado de México (2 230*)	7.3	105	77	222	6
Benito Juárez, Tlaxcala (2 529*)	4.5	125	109	170	8
The Madalena Soltepec, Tlaxcala (2 530*)	4.3	119	103	170	8
San Luis Huamantla, Tlaxcala (2 450*)	9	94	107	200	5
San José Teacalco, Tlaxcala (2 581*)	7.5	85	107	201	7
San Nicolas Panotla, Tlaxcala (2 222*)	6.4	130	96	200	8
San Miguel P. Ixtacuixtla, Tlaxcala (2 521*)	6.2	101	96	200	6
S. Francisco Tetlanohcan, Tlaxcala (2 433*)	6.1	93	108	200	8

Location	Yield (t ha^{-1})	(%) of the control	FM (days)	AP (cm)	Acame (%)
2013					
Francisco Villa, Tlaxcala (2 536*)	10.1	119	98	201	1
San Nicolas Panotla, Tlaxcala (2 222*)	10	128	91	230	16
San Miguel Ixtacuixtla, Tlaxcala (2 478*)	12	111	83	169	0
Cuapiaxtla, Tlaxcala (2 490*)	9.1	107	91	205	1
2014					
San Miguel, Ixtacuixtla Tlaxcala (2 521*)	6	126	96	205	0
San Damian Texoloc, Tlaxcala (2 225*)	11	112	99	218	0
2015					
Chapingo, Estado de México (2 230*)	11.2	132	75	220	6
Coatlinchan, Estado de México (2 230*)	9.4	114	77	230	5
Axocomanitla, Tlaxcala (2 200*)	11.2	113	92	216	3
The Magdalena Soltepec, Tlaxcala (2 530*)	7	100	95	220	2
Francisco V. Huamantla, Tlaxcala (2 525*)	8.6	113	102	189	3
Nexnopala, Altzayanca, Tlaxcala (2 512*)	7.7	101	91	223	3
2016					
Coatlinchan, Estado de México (2 230*)	9.4	98	77	230	7
Nexnopala, Altzayanca, Tlaxcala (2 512*)	11	126	90	230	0
The Magdalena Soltepec, Tlaxcala (2 530*)	7.8	152	95	212	0
Average	8.4	114	95	211	5

Rend= performance; FM= male flowering; AP= plant height; *=altitude (m). Cultivars included in the average control: H-70, AS-722 and creole variety.

The agronomic management technology for the commercial production of the Gacela H72 hybrid is the same as that indicated in Technical Booklet No. 13 for the production of H-70 (Arellano *et al*., 2011).

Seed productivity of the progenitors of the Gacela H72 corn hybrid in localities of High Valleys.

In the Valley of México Experimental Field located in the town of Coatlinchan, Texcoco, State of Mexico at 2 240 meters above sea level, experimental grain yields were recorded for progenitor lines M-54, M-55 and CML-242 of 2.6, 2.5 and 2 t ha^{-1}, respectively. In terms of yield and seed vigor characters, the lines indicated above were classified as stable when evaluated in three locations of High Valley and Bajío (Hernández, 2018). Regarding the performance of the female progenitor M-55 x M-54 established in irrigated field at sowing date of May 20 in the town of Coatlinchan (2 230 meters above sea level), State of Mexico, a production of 10 t ha^{-1} (Virgen *et al.*, 2009).

On the other hand, it was found that in plantings with producers from Espiritu Santo-Ixtacuixtla and Francisco Villa, both of Tlaxcala, located at altitudes of 2 430 and 2 530 m respectively, the simple female crossing yielded 6.5 and 6.2 t ha^{-1}, respectively, with the population density of 83 thousand plants ha^{-1} and sowing date of april 19, these yields exceeded 1.5 and 3 t ha^{-1} of the female crosses of the commercial hybrids H-40 and H -50, respectively (Virgen *et al*., 2009; Virgen *et al*., 2010). In the towns of Texoloc, Benito Juárez and San Nicolas Panotla in the state of Tlaxcala at altitudes of 2 225, 2 530 and 2 200 m respectively, the female parent (M-54 x M-55) yielded 8.6, 6.9 and 6.4 t ha^{-1} respectively, while the male progenitor (CML-242 x CML-354) yielded 7, 3.5 and 3.9 t ha^{-1}, respectively (Virgen *et al*., 2013).

On the other hand, in the town of San Miguel The Presa, Tlax. (2 600 meters above sea level) the male parent surrendered 11.9 t ha^{-1} with a high population density of 68 thousand plants per hectare and with a low density of 42 thousand plants, 7.89 t ha^{-1}, in Tlaxco, Tlax. (2 580 meters above sea level) produced 8 t ha^{-1} with high density and 6.83 with low density. In the town of Panotla, Tlax. (2 200 meters above sea level) the yields with the high and low densities were of 7.5 and 7.2 t ha^{-1}, respectively, while in Francisco Villa (2 530 meters above sea level), the male progenitor produced 7.4 t ha^{-1} with high density and 6.2 t ha^{-1} with low density. Based on the previous results, it is possible that the male parent CML-242 x CML-354 can act as a female parent in localities where its yield is higher than 6 t ha^{-1} since it has a plant type of less height than M-55 x M-54, which would facilitate the desespigue work and achieve greater genetic purity of the certified seed.

The previous results indicate the possibility of obtaining very favorable seed yields of the parents and the Gacela H72 hybrid in localities located between 2 200 and 2 600 masl, which makes the multiplication of certified seed of this new hybrid of corn in a reliable and profitable way. Localities of the High Valleys.

The recommended sowing period for the production of certified seed in the Central Highlands of Mexico is established in april, while the female-male sowing ratio is 6:2, where the male parent should be planted a week before than the female, both under the population density of 65 000 plants ha^{-1}. The beginning of the detasseling period marks the emergence of the spikes, it is recommended to carry out this activity in six days and to consider in the last, the elimination of the spike (Arellano *et al*., 2010).

Conclusions

In terms of the productive potential of the regions of the central Highlands of Mexico and the adaptability of Gacela H72, it is established that there are at least 75 000 ha in the state of Tlaxcala, 150 000 in Puebla, 200 000 in the State of Mexico and 90 000 in Hidalgo, where the new maize hybrid can participate successfully to increase yields under rainfed or irrigated crops.

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