Description of cultivar

Atziri Puma: white grain corn hybrid for the High Valleys of Mexico

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Abstract

Mexico imported 18 million tons of yellow grain corn in the last two years. It is the world's largest importer. Due to its importance in the economy and food, it is convenient to achieve food sufficiency and sovereignty in corn. It is urgent to increase production, so public improved corn varieties, with good productivity, are required. The Atziri Puma hybrid was generated in the Corn Genetic Improvement Program of the Cuautitlán Faculty of Higher Studies, with the collaboration of researchers from the National Institute of Forestry, Agricultural and Livestock Research, Valle de México Experimental Field. It is a trilinear hybrid, with C-type androsterility and restoration of fertility. It solves the problem of removing tassels from female plants in the production of hybrid corn seed. It favors the genetic quality of the seed and saves 24 to 50 daily wages ha^{-1}. This hybrid is the first with fertility restoration in 79 years of public research in Mexico. It is of intermediate cycle, its male flowering (tassel) appears at 86 days and the female flowering (ear) at 88 days, at altitudes of 2 250 m. It reaches physiological maturity at 164-167 days. It can be cut and then harvested, if this work is done manually, on the other hand, with machinery it can be threshed at 179 days. Its average yield is 10.5 t ha^{-1}. Atziri Puma is recommended for the High Valleys of Mexico (2 200 to 2 600 masl).

Keywords: *Zea mays* L., androsterility, fertility restoration, seed production.

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Mexico is the country that imported the most corn, with 18 million tons, the last two years, this crop is the most important for its sown area, and consumption of more than 200 kg per person (Lopez *et al*., 2021). Due to the importance in the economy and food, it is necessary to achieve food sufficiency and sovereignty. It is urgent to increase grain production, for which improved public varieties with good productivity are required (Luna *et al*., 2012; Tadeo-Robledo *et al*., 2016; Martínez-Gutiérrez *et al*., 2018).

In the High Valleys of Mexico, located from 2 200 to 2 600 masl more than two million hectares of corn were harvested in 2014, with an average yield of 2.82 t ha^{-1} (Virgen-Vargas *et al*., 2016). With the application of technological recommendations and a greater use of improved varieties, corn yields could be raised, in 300 000 ha of the High Valleys, with residual moisture, irrigation tip and good rainy season, where the average yield is 3.5 t ha^{-1} of corn grain, high-yield hybrids could be sown, which would exceed the yield taking it to 6 t ha^{-1} (Tadeo-Robledo *et al*., 2016; Martínez-Gutierrez *et al*., 2018).

To facilitate seed production, as well as support the level of adoption of corn hybrids in the High Valleys, androsterility, gene-cytoplasmic, type C, by being incorporated into hybrid progenitor lines, avoids the need to remove the tassels from female plants in the seed production process (Martínez-Lázaro *et al*., 2005; Tadeo-Robledo *et al*., 2018b), therefore, since 1992, researchers from the Cuautitlán Faculty of Higher Studies, of the National Autonomous University of Mexico (FES-UNAM, for its acronym in Spanish) and the National Institute of Forestry, Agricultural and Livestock Research (INIFAP, for its acronym in Spanish) have worked with sources of male sterility, as well as using the restoration of fertility, incorporating it into the progenitors of hybrids already existing and in the process of development (Tadeo-Robledo *et al*., 2016; Tadeo-Robledo *et al*., 2018a).

As a product of these works, the trilinear corn hybrid Atziri Puma was obtained, whose progenitors were developed with the genealogical or pedigree genotechnical method (lines IA424F, IA249, IA449RMIA44) and the IA424 AEC line was obtained by manual backcrosses to incorporate the source of C-type androsterility into the IA424F line and other backcross cycles to achieve the isogenic version of the line, with androsterility characteristics (IA424 AEC). This hybrid was registered in the National Catalog of Plant Varieties (CNVV, for its acronym in Spanish), obtaining the definitive registration 3478-MAZ-1827-210617/C, in 2017, it was also registered with the International Union for the Protection of New Varieties of Plants (UPOV, for its acronym in Spanish), on March 27, 2019, with the breeder's title number 2134, in favor of UNAM.

Atziri Puma is a trilinear hybrid, with white and semi-toothed grain, of intermediate cycle, male flowering (tassel) at 86 days and female flowering (ear) at 88 days after sowing, at altitudes of 2 250 m. It reaches physiological maturity at 164-167 days. It can be cut and then harvested, manually, while with machinery it can be cut at 179 days, with mechanical harvester. The sowing date at altitudes in the Valley of Mexico is from March 15 to April 20. Its yield in experiments carried out in Cuautitlán (FESC, UNAM), CEVAMEX and Ixtlahuaca was 10.5 t ha^{-1} (Martínez-Gutiérrez *et al*., 2018).

The technology in the Atziri Puma hybrid considers that the progenitor IA424F is the fertile maintainer version of the isogenic line IA424 AEC, which is C-type gene-cytoplasmic androsterile, this line is combined with the male line of the female IA249 to have the single cross

(IA424AECXIA249), which is combined with the male line IA449RMIA44, with fertility restorative capacity. In this way, the trilinear hybrid (IA424AECXIA249) X IA449RMIA44 is obtained, which is 100% fertile.

Sterility in the female line of the female and male restorer of male fertility facilitates the production of seeds, which favors maintaining genetic quality and supports the supply of seeds, by seed companies and groups of producers (Tadeo-Robledo *et al*., 2018a).

In Cuautitlán, FESC-UNAM, CEVAMEX and Ixtlahuaca, State of Mexico, the average yield of Atziri Puma was 11 400 kg ha^{-1}, with a variation from 8.5 to 13 t ha^{-1}, on average the behavior is 25% higher than the control hybrid 'H-48', second most used in the High Valleys of the State of Mexico. The use of Atziri Puma could benefit commercial corn producers, who use H 48, which has been on the market for 24 years (Espinosa *et al*., 2003; Martínez-Gutérrez *et al*., 2018) (Figure 1).

Figure 1. Plant and ear appearance of the Atziri Puma corn hybrid.

The structure of the hybrid is (IA424 AEC X. IA249 X IA449RMIA44), in its single cross, the androsterile single cross (IA424 AEC X. IA249) is used, in which the IA424 line, androsterile AEC, has its fertile isogenic version IA424 F. The A424F line was obtained from a compound of broad genetic base, with the genealogical method of pedigree, from selections in self-fertilizations, plant-to-plant crosses, self-fertilizations and fraternal advance cycles, until locating the IA424F line; the IA424 AEC line was developed at UNAM, by incorporating into the IA424 F line, the C-type gene-cytoplasmic androsterility, identified and owned by UNAM with the CxP3PL7 genealogy, characterized by its stability and action in group C, IA424F was used as a male progenitor to cross with the source of androsterility, later six backcrosses to the IA424F line were made to have the male sterility version of the IA424AEC line, which is the isogenic version, whose maintainer is the IA424F line itself in its fertile version. IA249 is a line of the Cónico race-derived and advanced in UNAM, through the genealogical method of pedigree, from the F2 of a hybrid obtained in UNAM itself.

The IA449RMIA44 line was obtained by pedigree, derived and advanced from the cross of the IA449 line, already registered by UNAM, which was crossed with the MIA44 line, with the characteristic of male fertility restoration capacity, owned by UNAM itself, after verifying the restorative capacity, two fraternal recombination cycles were obtained, later six cycles of self-fertilization were advanced.

To ensure the genetic purity of Atziri Puma, the seed of this trilinear hybrid and its progenitors (three lines, single cross and trilinear hybrid); that is, the categories of high registration, must be increased in lots isolated from other lands sown with corn; separated at least 300 m for basic (lines) and registered (single cross) seeds and 200 m to multiply certified seeds, another option is to isolate by time, with a difference of 20 days in the date of sowing, with respect to other neighboring corns, in such a way that there is no coincidence of the flowering of the Atziri Puma seed production lot with other nearby lots (SNICS, 2021).

Off-type or diseased plants should be removed at least in three stages, at 25 days, 50 days and before flowering (pollen release). At the time of harvest, the quality of the seed batch can still be improved, removing off-type, malformed ears or with some degree of rot or with holes. For the renewal and maintenance of the original seed, of the Atziri Puma hybrid, the IA424F line must be increased by self-fertilization.

The IA424AEC line is androsterile and preserves its identity by combining with the IA424F line, which is its fertile isogenic maintainer. The IA249 line needs to be increased through self-fertilization or fraternally. The IA449RMIA44 line should be increased by fraternal or chain crosses. The female single cross, androsterile version of the trilinear hybrid, preserves its varietal identity by crossing the lines IA424AEC X IA249. The trilinear hybrid in the field is obtained using the conformation (IA424AEC X IA249) X IA449RMIA44, since the IA449RMIA44 line has the restorative capacity of male fertility, the resulting seed is the trilinear hybrid with full fertility, not requiring any other version or mixtures of androsterile and fertile seed.

The final Atziri Puma hybrid is 100% fertile (Tadeo-Robledo *et al*., 2018b). Agronomic practices to preserve the characteristics that identify the hybrid must adhere to the recommendations to produce seed of this type of hybrids, unmix three times, adhere to the description. For the increase of each line, a minimum of 100 plants are required to preserve the characteristics that identify each line. In hybrid seed production, it is convenient to use the established categories, basic for the IA449RMIA44 line and registered for the single cross (IA424AEC X IA249).

Conclusions

The Atziri Puma corn hybrid exceeded the yield of H 48, a commercial hybrid in use, so it could be used where the latter thrives, in the High Valleys of Mexico (2 200 to 2 600 masl).

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