Description of cultivar

V238AC: new QPM yellow grain corn variety

Bulmaro Coutiño Estrada[1§]
Gricelda Vázquez Carrillo[2]

[1]Experimental Center of Chiapas-INIFAP. Carretera Ocozocoautla-Cintalapa km 3, Ocozocoautla, Chiapas. CP. 29140. Tel. 01 (800) 0882222, ext. 86306. [2]Valley of Mexico Experimental Field-INIFAP. Highway Los Reyes-Texcoco km 13.5, Coatlinchán, Texcoco, State of Mexico. Tel. 01 (800) 0882222, ext. 85364. (vazquez.gricelda@inifap.gob.mx).

[§]Corresponding author: coutino.bulmaro@inifap.gob.mx.

Abstract

The producers of the Meseta Comiteca region, Chiapas, belong to the Tojolabal ethnic group and are characterized by having very high rates of malnutrition, cultivating more than 82 000 ha of corn, using Creole varieties of the Comiteco race, with an average yield of 1.7 t ha^{-1}, so an improved variety with higher nutritional quality is required. In 2002, a genetic improvement scheme was initiated by rackcross in Synthetic A, from a compound of 17 Creole varieties of the yellow-grain Comiteco breed, in order to incorporate the opaque-2 gene, using the CML-172 line as a donor. After two backcrosses, a compound was formed with the best lines with more than 50% lysine and tryptophan and it was registered in the SNICS with the denomination V238AC. This new variety can produce from 5 to 7 t ha^{-1} in the Meseta Comiteca, at altitudes of 1 500 to 1 800 m, with more than 600 mm of rainfall.

Keywords: *Zea mays* L., Comiteco race, backcrosses in corn, QPM V238AC corn.

Reception date: April 2018
Acceptance date: July 2018

During 2015, in the Meseta Comiteca region, Chiapas, 82 276 ha of maize were cultivated and 144 597 t of grain were produced, equivalent to 13.5% of the total state production (SIAP, 2017). The cultivated varieties are exclusively creole, of the Oloton race, mainly (Perales *et al*., 2005) with yields of 1.7 t ha^{-1}. The producers belong to the Tzeltal and Tzotzil ethnic groups and are characterized by having very high rates of malnutrition (INEGI, 2017), since their diet is based on the consumption of corn grain in its multiple forms of food such as tortillas, pozol, atoles, corn, tamales, etc. The disadvantage of corn is its low protein content, around 9% and the low content of amino acids lysine and tryptophan, which are considered essential for a good body and mental development, especially of infants.

In the decade of the 60's, was discovered at the University of Purdue, Indiana, USA, a recessive mutant gene in corn called opaque-2, which increases by almost double the amount of the amino acids lysine and tryptophan (Mertz *et al*., 1964), this gene was incorporated into many maize, but its commercial use had many problems due to the soft or mealy consistency of the endosperm, which caused low grain weight and susceptibility to field and storage pests, what the research on this gene declined. The International Maize and Wheat Improvement Center (CIMMYT) continued to work on a small scale, and in 1992 it was able to change the endosperm mealy texture with the inclusion of modifier genes, which gave the opaque-2 maizes a harder texture, very similar to that of a normal corn, without changing its protein quality, so these new maizes were called Quality Protein Maize (QPM) to replace the designation opaque-2 (Vasal *et al*., 1980).

As in the tortilla, in other food products such as chips and corn, the protein value is also maintained, including corn kernels QPM contains significantly higher amounts of lysine and tryptophan compared to normal corn (Ortega *et al*., 1991). Scheuch and Francis (1975) present several conversion methods to incorporate the opaque-2 gene to normal corn and recommend that extension and integral development programs include in their objectives the improvement of human nutrition based on a high quality corn of protein.

With this background, a genetic improvement work was started by backcrossing to offer the inhabitants of the rural areas new improved varieties with higher nutritional quality. The conversion was started using the synthetic variety-A, from two cycles of selection of half-sib families made in the Comiteca yellow population, as a recurrent parent and as a donor of the opaque-2 gene, the CML-172 line from CIMMYT was used. In 2002, F1 was obtained and in 2003 self-fertilizations were made to obtain S1 lines, with more than 61 and 67% of lysine and tryptophan. In 2004, these S1 lines of the F2 were planted to make the first backcross (RC1) to the Comiteco yellow parent. In 2005, the RC1 were planted and the plants with the Comiteco phenotype were selfed to obtain the F2. From each line, the segregating grains were selected with 25% opacity and their amino acid content was determined in the laboratory to select a group of 21 lines with more than 50% amino acids, compared to the normal grain control.

In 2006, the second backcross (RC2) was performed using these 21 best lines with more than 50% lysine and tryptophan, which were crossed with the Comiteco yellow progenitor. In 2007, the backcrosses were planted and plants were fertilized with the Comiteco phenotype to obtain the F2 of the RC2, these self-pollinations were determined the lysine and tryptophan content and with the higher protein quality a mechanical compound was made to obtain the original seed of the "Comiteco yellow QPM" variety, which has 87.5% of Comiteco germplasm and 12.5% of the QPM donor.

With this seed, in 2011, 15 evaluation plots were planted with producers from the municipality of Comitan, obtaining an average yield of 5.29 t ha^{-1} and surpassing from 5 to 7% the Creole witnesses from 2012 to 2016 were tested with producers from Comitan, The Trinitaria, and The Margaritas, obtaining an average yield of 5.318 t ha^{-1}. In March 2015, it was registered in the National Catalog of Varieties of Plants of the National Seed Inspection and Certification Service of the SAGARPA, with the name of V238AC with the definitive registration number MAZ-1612-050315. The breeder's title is currently in process before the same agency.

The plants of the V238AC corn variety grow to 2.5 m and the cob is inserted at 1.45 m, start the release of pollen at 101 days, reach corn at 135 days, which are very sweet at 13.5 °Brix, and the grain can be harvested after 200 days. It is very similar to creole varieties, but its added value is that the yellow grain contains essential amino acids that make it more nutritious than a normal corn. The ears are conical-cylindrical, 20 cm long and 4 cm in diameter, have 12 to 16 rows of grain and each row can have 40 to 45 grains (Figure 1). The grains are of endosperm yellow color and intermediate texture, between semi-crystalline and semi-deciduous, they contain 12.1% protein, which make them more nutritious than the grains of other varieties, but what gives them the greatest nutritional value is that they contain from 50 to 60% more of the essential amino acids lysine and tryptophan.

Figure 1. Appearance of plant in corn and ears of the V238AC.

Its hectoliter weight is 76.9 kg hl, so the grains are top quality for the production of tortillas. For each kilogram of nixtamalized grain, 1.71 kg of dough and 1.4 kg of tortilla are produced, which are pleasant yellowish in color and of good quality. It can be grown in the Rural Development Districts of San Cristóbal of the Casas and Comitan, in the municipalities of Amatenango, Teopisca, The Rosas, Huixtan, Comitan, The Margaritas, The Trinitaria, The Independencia, Tzimol, climate A(C)w, semi-warm sub-humid, and others similar to altitudes of 1 200 to 1 800 m and precipitations of 800 mm, both in sowings of pul-jha (to throw water, of the Tojolabal) and of temporary.

Since it is a recessive gene that confers the highest nutritional value of the grain, if the female flowers are pollinated by a normal corn, this nutritional value will not be obtained, so the isolation of the seed and grain production lots should be very strict.

Conclusions

In order to maintain genetic purity and for the production of certified seed, it is suggested to plant at population densities of 50 000 ha^{-1} plants, following the recommendations of the SNICS for isolation by space or time and making the appropriate demixing. In the Experimental Field Center of Chiapas, seed is produced in the registered category for seed companies that are interested in the production and marketing of the certified category.

Acknowledgments

Fomix-Chiapas is thanked for the financing of the Project: Introduction of the modified opaque-2 gene to the Oloton and Comiteco regional maize to increase its protein quality, during the years 2004 to 2007. The field support provided by the MC Grisel Sánchez Grajalez and Eng. David Rincón Espinosa.

Cited literature

Coutiño, E. B. 1993. Normas y técnicas para producir semilla certificada de variedades de maíz. Folleto técnico No. 7. Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias (INIFAP). Campo Experimental Centro de Chiapas. Ocozocoautla, Chiapas, México. 33 p.

INEGI. 2017. XII Censo general de población y vivienda. Regiones pobres del estado de Chiapas. Microregiones de Chiapas. www.inegi.gob.mx.

Mertz, E. T.; Bates, L. S. and Nelson, O. F. 1964. Mutant gene that changes protein composition and increases lysine content of maize endosperm. Science. 145:279-280.

Ortega, E. I.; Villegas, E.; Bjarnason, M. and Short, K. 1991. Changes in dry matter and protein fractions during kernel development of quality protein maize. Cereal Chem. 68(6):482-486.

Perales, H. R.; Benz, B. F. and Brush, S. 2005. Maize diversity and ethnolinguistic diversity in Chiapas, Mexico. Proc. Natl. Acad. Sci. 102(3):949-954.

Scheuch, F. y Francis, A. C. 1975. Sistemas rápidos para aumentar la calidad proteínica del maíz harinoso con el gene opaco-2. *In*: maíz de alta calidad proteínica. Compendio de las ponencias presentadas en el simposio internacional Cimmyt-Purdue. Ed. Limusa, SA.109-126 pp.

SIAP. 2017. SAGARPA. Anuario estadístico de la producción de maíz en el estado de Chiapas. Ciclo agrícola 2015. www.siap.sagarpa.gob.mx.

Vasal, S. K; Villegas, E.; Bjarnason, M.; Gelaw, B. and Goertz P. 1980. Genetic modifiers and breeding strategies in developing hard endosperm opaque-2 materials. *In*: improvement of quality traits of maize for grain and silage use. Pollmer, W. G. and Phipps, R. H. (Eds.). The Hague, The Netherlands. 37-73 pp.