Essay

Genetic improvement of sorghum at INIFAP

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Abstract

In Mexico, genetic improvement of sorghum began in 1944 at the Office of Special Studies. Later, improvement activities were carried out in three regions with the introduction of genetic material from which lines were derived and the first adapted sorghum hybrids were generated. The program has focused on the generation of genetic material for several niche markets including balanced food, food for human consumption and biofuel production. Among the genetic materials, the hybrid RB-3030 stands out for having been the one with the highest production by PRONASE at the time. To date, 36 hybrids and varieties have been generated, of which 12 are currently being used, among which the red-orange bean sorghums RB-Norteño and RB-Huasteco and the white sorghum variety RB-Paloma stand out. As well, the forage sorghum Sinaloense 202 and Gavatero-203 stand out. On the other hand, the sorghum RB-Cañero, RB Cañaveral, RB Tehua and RB-Pirulí have been formed for bioethanol production. In addition, there are parental lines of hybrids that are acquired by companies for the production of certified seed. There are several challenges such as increasing production, but in the short term it is necessary to increase the promotion and marketing of genetic materials, and in the medium term to strengthen research in disease control, tolerance of draughts and salts, and obtain varieties with better nutritional and energy quality.

Keywords: seeds, tolerance, varieties.

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Background

In the early 40's, the Ministry of Agriculture and Livestock (SAG) created the Office of Special Studies, dedicated to research on basic crops for food, in which the technical staff attached to the Rockefeller Foundation and the staff of SAG worked together. In Mexico, the first sorghum research began in 1944, and in 1961 the National Institute of Agricultural Research (INIA) was created, where the experimental station of Roque, Guanajuato was the first in the generation of sorghum technologies.

During the period 1973-74, three strategic areas were defined where research on genetic improvement of sorghum was carried out, for which the headquarters of the northern region was the Río Bravo Experimental Field, that of the central region was the Bajío Experimental Field and the region south of the Uxmal Experimental Field. In all these areas, the introduction and evaluation of sorghum germplasm came from various institutions, including the International Research Center for the Semi-Arid Tropics (ICRISAT) and Texas A&M University.

Contributions of the genetic improvement program

As a result of the research carried out at the Experimental Field Bajío during the period 1968-1975, the hybrids INIA Zacapil, INIA Tejón, INIA Maratín, INIA Mayapen, INIA Malinche and INIA Janambre were released for northern Tamaulipas (Betancourt-Vallejo, 1975). At the Experimental Field of Río Bravo, the genetic improvement of sorghum began in 1973. The main objective of the program was to generate and produce hybrids and varieties of sorghum with adaptation to the Northern Mexico area with tolerance of diseases, such as head smut [*Sporisorium reilianum* (Kühn) Langdon and Fullerton].

In 1978 the sorghum INIA RB-2000, INIA RB-2010 and INIA RB-2020 were released (Williams-Alanis and Betancourt-Vallejo, 1979). From 1979 population improvement was carried out with introduced germplasm from the United States of America, using the genetic andro-sterility source of Coes ms3 (where ms3ms3= sterile and MS3MS3 or MS3ms3= fertile) (Williams-Alanis *et al*., 1995).

In 1982 the source of A2 gene-cytoplasmic andro-sterility was introduced to the elite lines of the program (Rodríguez *et al*., 1994). In 1980, the hybrids BJ83 and BJ84 for the Mexican Bajío and the sorghums INIA RB-3030 and INIA RB-3006 for northern Tamaulipas were released, and in 1989 the hybrid RB-4000 for irrigated conditions was released, which showed a potential yield higher by 500 to 600 kg ha^{-1} than that of the best commercial sorghums recommended at the time.

From 1993, some fertile genotypes were transformed into lines A and B using the backcrossing method (Rodríguez and Torres, 1992). Until 1994, about 100 pairs of A and B lines and 54 R lines tolerant of diseases had been selected. In the sorghum genetic improvement program, new sorghum progenitor lines have been evaluated, derived and released, using the line SBA22/SBB22 as maternal progenitor.

The hybrids RB-3006 and RB-Norteño were formed and released (Montes *et al*., 2013a) and with the line SBA25/SBB25 the RB-Huasteco was formed and released (Montes *et al*., 2013b), which have shown good adaptation to northeastern Mexico.

In relation to varieties of human consumption, white grain sorghums have been released, among which Blanco-86, Tropical-401, Costeño-201, Pearl-101, Mazatlán-16 and RB-Paloma stand out, which have characteristics to be used in the dough and tortilla industry, as well as in the bakery industry. Regarding forage genotypes, the varieties Gavatero-203, Sinaloense-202, VCS-Diamante, VCS-Tornasol, VCS-Brillante and Fortuna have been developed, which are presented as dual-purpose materials in forage conservation practices such as haylage and silage.

Similarly, in 2010 the sweet sorghum RB-Cañero was released, which is the first genetic material of sweet sorghum to produce biomass and sugars for the purpose of obtaining bioethanol in Mexico, followed by the sweet sorghum RB-Pirulí, RB Tehua and RB Cañaveral (Cisneros *et al*., 2018). It should be underlined that all genetic materials have their registration in the National Catalogue of Plant Varieties of SNICS and that breeder's rights of some of the hybrids and varieties recently released are held.

Seed production and marketing

In the early 70's, PRONASE began producing hybrids released by the former INIA, today INIFAP. In the 80's, in the north of Tamaulipas 28 000 t of sorghum seed certified were produced in 21 000 ha; however, there were some problems that hindered the commercial production of this seed, such as the presence of environmental genetic sterility in lines A (females), dissemination of Johnson grass weeds, poor management and care of the production lots, difficulties in isolation and lack of coincidence in flowering in progenitors.

Some of these problems have been eliminated through the seed production technology that has been generated, as well as in the constant training and communication with seed producers. From the 80's and until 2002, seed of the new hybrids released by INIFAP was produced, which did not present problems in seed production and were produced in Río Bravo (RB), representing 70% of the sorghum marketed by PRONASE in the country.

Currently, hybrids and varieties formed by INIFAP have been produced and marketed by seed production companies and other organizations nationwide.

Challenges

There are challenges, but the most important is the adoption of genetic materials, for which it is essential to have diffusion and marketing programs for the hybrids and varieties of INIFAP, coupled with the realization of seed production agreements with public and private organizations in order to impact Mexican agro with competitive, low-cost genetic materials, adapted to the various areas and that are a viable alternative to all producers to increase their profitability.

Conclusions

Over time, in the genetic improvement program of sorghum at INIFAP, 36 hybrids and varieties have been generated, of which the red grain sorghums RB-Norteño, RB-Huasteco, RB-3030 and the white sorghum variety RB-Paloma stand out. Likewise, the forage sorghum Sinaloense 202 and

Gavatero-203. On the other hand, the sorghum RB-Cañero, RB Cañaveral, RB Tehua and RB-Pirulí have been formed to produce bioethanol. There are parental lines that are available for the production of certified seed. In the short term, it is required to improve the nutritional and energy quality of grain and forage.

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