Crop Breeding and Applied Biotechnology 14: 124-127 2014
Brazilian Society of Plant Breeding. Printed in Brazil

CULTIVAR RELEASE

http://dx.doi.org/10.1590/1984-70332014v14n2c21

BRS Vivi: single-cross super sweet corn hybrid

Flavia França Teixeira[1*], Maria Cristina Dias Paes[1], Elto Eugênio Gomes e Gama[1], Israel Alexandre Pereira Filho[1], Rubens Augusto de Miranda[1], Paulo Evaristo de Oliveira Guimarães[1], Sidney Netto Parentoni[1], Luciano Viana Cotta[1], Walter Fernandes Meirelles[1], Cleso Antonio Patto Pacheco[1], Lauro José Moreira Guimarães[1], Adelmo Resende da Silva[1] and Jane Rodrigues de Assis Machado[1]

Received 26 November 2013

Accepted 15 December 2013

Abstract – *This study aims to describe the single-cross, super sweet corn hybrid BRS Vivi, with above-average ear diameter, light-colored grains and competitiveness with other sweet corn cultivars. BRS Vivi is a contribution to the expansion of the range of available cultivars on the market and the genetic basis of sweet corn in Brazil.*

Key words: Zea mays*, specialty corn, shrunken.*

INTRODUCTION

Corn (*Zea mays* L.) is one of the most important and dynamic agricultural crops in the world. This dynamism is related to the multiple applications of the crop. The different applications allow the use of grain for so-called special purposes, according to the specific characteristics, and corn with this utility is called specialty grain. In this sense, the sweet or super sweet corn is considered special, for containing one or more genes that alter the sugar concentration, resulting in changes in the sensory characteristics of the grain, including texture, flavor and aroma. The appearance of plant and ear, and seed viability and shape of this specialty corn type are also different.

The sugary taste of sweet corn grain is due to variations in the starch and sugar levels in the endosperm. The fully developed and mature corn grain of normal cultivars contains only 3% sugar, compared to sweet corn grain with 9 to 14%. There are also cultivars known as super sweet, with a grain content of 15 to 25% sugar. These variations are genetically controlled and the alleles that determine the sweet phenotype are recessive for most of the commercially used mutants. Among the different alleles that confer the phenotype known as sweet corn, those with the genes *shrunken-2* (*sh2*) (Yousef and Juvik 2002) and *brittle-2* (*bt2*) (Brewbaker and Banafunzi 1975, Brewbaker 1977), both super sweet, have the greatest commercial potential.

Sweet corn has some characteristics that classify it as a vegetable, since the ears are harvested fresh with approximately 75% moisture and the cultivation is intensive, usually irrigated and occurs in small areas with high technology investment. This product with high added value is designed exclusively for human consumption and is rather perishable.

In the United States and Canada, sweet corn is very popular and its use is continuously growing in East Asia and several countries of the European continent. However, Brazilians do not have the habit of consuming fresh sweet corn (Pereira Filho and Cruz 2002), although most of the canned corn currently marketed in Brazil is sweet. Thus, sweet corn in Brazil is mostly produced for the canned food industry, despite the potential for consumption as fresh corn (Guia Veja 2013).

According to the Brazilian association of trade of seeds and seedlings (ABCSEM), the national sweet corn production reached a value of R$ 120.8 million in 2010. However, when considering the agroindustrial chain of sweet corn, the monetary turnover exceeded R$ 500 million. Table 1 shows information on the market of sweet corn seeds in Brazil. It was observed that the cultivation area and seed quantity sold in the country have not increased in the last decade. However, the production increased clearly, due to the breeding of new cultivars along with enhanced agricultural practices, improving productivity. Despite the limited

[1] Embrapa Milho e Sorgo, Rod MG 424, km 65, 35.701-970, Sete Lagoas, MG, Brazil. *E-mail: flavia.teixeira@embrapa.br

information available, this is confirmed by the increased sales of the seed industry (also in Table 1). Between 2001 and 2009, the sale of sweet corn seeds increased 210.6%, as a result of the use of high technology seeds. In June 2013, the sweet corn cultivars registered by the Ministry of Agriculture, Livestock and Supply (MAPA) (http://www.agricultura.gov.br/vegetal/registros-autorizacoes/registro/registro-nacional-cultivares) were, aside from BRS Vivi, 38 sweet corn cultivars registered by six different companies. However, most of these cultivars are not on the market.

Currently, the Brazilian market of sweet corn seed is dominated by the Anglo-Swiss company Syngenta Seeds Inc., with the single-cross hybrid Tropical Plus, classified as super sweet. Apart from the limited availability of sweet corn cultivars on the market, the genetic basis of the elite lines for breeding is narrow. There are only about 300 open-pollinated varieties in the world (Tracy 2001). In Brazil, the situation is similar, since the active corn genebank (Teixeira et al. 2011) comprises only 20 accessions classified as sweet corn, which were mostly derived from introductions of improved genotypes.

The development of sweet corn cultivars in Brazil was initiated by Embrapa Milho e Sorgo in 1979, when basic lines from some American universities (Minnesota, Illinois, Florida and Hawaii) were introduced in Brazil and crossed with dent lines derived from common corn breeding programs. In the 1980s, through the use of simple mass selection methods and S_1 progenies, lines adapted to Brazilian conditions were bred. This resulted in the release of the sweet corn varieties BR-400 (Superdoce), BR-401 (Doce-de-ouro), BR-402 (Doce cristal), BR-420 (Docemel), and BR-421 (Lili) (http://www.cnph.embrapa.br/cultivares/docemel.htm).

Given the virtual absence of sweet corn cultivars in the country, Embrapa Milho e Sorgo initiated efforts towards the development of new sweet corn lines in the 1990s. Recessive alleles of the genes brittle and shrunken were introduced into elite lines with normal endosperm of the breeding program, for hybrid production. The objective of this paper is to present the characteristics of the single-cross super sweet corn hybrid, registered as BRS Vivi.

Breeding methods

The parents used for the development of the single-cross sweet corn hybrid BRS Vivi were the compound shrunken, formed by exotic lines containing the recessive allele of the gene shrunken2 (sh2), and dent and semi-dent corn lines adapted to tropical conditions obtained in the corn breeding program of Embrapa Milho e Sorgo.

These two germplasm groups were crossed, and the F_1 generation was sown for backcrossing with the common corn lines. In the RC_1 generation, selection was initiated, based on the quality of plants and ears. The wrinkled seeds from the selected ears, indicating the sweet character, were separated for sowing. In the field, the seeds of a single ear were sown per row. The best plants of each row were selfed. New selections and selfing were repeated for three more years. This established some lines with desirable agronomic characteristics, which contained, on average, 25% sweet temperate and 75% common tropical maize germplasm. In the S_5 generation, some of these lines were crossed in a diallel scheme for the selection of promising single-cross hybrids.

Tests of Value for Cultivation and Use (VCU) were carried out to compare the single-cross hybrid BRS Vivi with the hybrids Tropical Plus (Syngenta Seeds) and SWB 551 (Dow Seeds), all super sweet corn. It is worth mentioning that in VCU tests, cereals are harvested at the point of maturation while the commercial harvest of sweet corn occurs in the milky-grain stage (grain moisture between 70 and 75%). For this reason, the yield data were evaluated in the maturation phase in these VCU tests. The tests were

Table 1. Market of sweet corn seed in Brazil

Year	Segment	Sold seed quantity (kg)	Return	Planted area (ha)
2001	Hybrid	354.880	R$ 3.523.232.00	44.360*
	Variety	6.610	R$ 96.945.00	826*
2002	Hybrid	300.000	R$ 4.500.000.00	37.500*
	Variety	4.350	R$ 8.700.00	544*
2007	Hybrid	296.135	R$ 8.884.075.00	35.536
	Variety	2.310	R$ 13.860.00	289
2008	Hybrid	310.098	R$ 9.302.944.00	37.212
	Variety	4.743	R$ 28.458.00	593
2009	Hybrid	340.923	R$ 10.943.634.00	40.911
	Variety	5.216	R$ 62.592.00	652

Source: ABCSEM * Estimate of the planted area, in hectares, considering 8 kg ha^{-1} of seeds.

carried out in Sete Lagoas and Nova Porteirinha, in Minas Gerais, and in Londrina, Paraná, in the growing seasons of 2008/2009 and 2009/2010. Aside from the VCU tests, BRS Vivi was evaluated for mass loss of ears stored under refrigeration, in comparison with Tropical Plus and SWB 551, and for canned storage. In additional tests, data related to grain quality were collected at the commercial harvest. In these, BRS Vivi was compared with SWB 551 and AG 1051 (Agroceres).

Performance Characteristics

The diallel analysis resulted in the selection of two lines that originated the single-cross hybrid BRS Vivi. The male line is called CMS M039 and the female CMS M040. Both lines are protected by MAPA (http://extranet.agricultura.gov.br/php/snpc/cultivarweb/detalhe_protecao.php?codsr=3325 and http://extranet.agricultura.gov.br/php/snpc/cultivarweb/detalhe_protecao.php?codsr=3326, respectively).

The single-cross hybrid BRS Vivi is registered by MAPA (http://extranet.agricultura.gov.br/php/snpc/cultivarweb/detalhe_cultivar.php?codsr=26714). The recessive allele *shrunken2,* in homozygosis in BRS Vivi, confers the phenotype called super sweet to the grains. However, in the presence of the dominant allele for the locus *shrunken2,* the grains are normal. Therefore, the cultivation should be spatially and temporally isolated from other corn fields, to avoid pollen contamination by other cultivars. An important piece of information for seed producers is that to obtain BRS Vivi, the sowing of male and female lines requires no temporal sequencing.

In the VCU tests, the trait grain yield was affected by genotype-environment interaction, however, the average of the three hybrids tested were similar in most environments except in the tests in Sete Lagoas, where the grain yield of BRS Vivi was higher. For the traits ear length and female flowering, the hybrid means were also at the same level. BRS Vivi had larger ear diameter, higher ear yield and slightly lighter-colored grains. Table 2 shows some results of hybrid BRS Vivi in the VCU test. Characteristics related to the quality of stored ears and of grains of Vivi BRS at commercial harvest are listed in Tables 3 and 4.

Sweet corn seeds are more susceptible to deterioration

Table 2. Mean agronomic traits of single-cross hybrid BRS Vivi and other commercial sweet corn hybrids and descriptive characters of single-cross hybrid BRS Vivi, resulting from VCU tests carried out in Sete Lagoas and Nova Porteirinha, Minas Gerais, and Londrina, Paraná, in the 2008-2009 and 2009-2010 growing seasons

Traits	BRS Vivi	SWB 551	Tropical Plus
Number of days from plant emergence to female flowering	54.8	54.0	54.2
Plant height (m)	2.50	2.59	2.36
Ear height (m)	1.13	1.17	1.03
Grain yield (kg ha^{-1})[1, 2]	2230	2560	1610
Ear yield (kg ha^{-1}) [1, 2]	3050	2760	2010
Ear length (cm)	16.4	17.1	17.1
Ear diameter (mm)	49.2	44.6	44.1
Descriptive traits of BRS Vivi			
Grain type	Super sweet		
Grain color	Yellow		
Ear coverage	Total		
Number of grain rows[3]	14		

[1] mean density of 50.000 plants ha^{-1}. [2] Considering the grain yield at physiological maturity and grain samples corrected to a moisture content of 13%. [3] Considering the most frequent number of rows per ear.

Table 3. Mean quality-related ear and storage characteristics, evaluated at the point of harvest for fresh corn.

Assessment of unprocessed grain of BRS Vivi and after 5 days of storage[1]			
	Unprocessed	After storage	
pH grain	6.68	5.38	
Soluble solids content (º Brix)	15.42	8.72	
Titratable acidity	6.09	1.83	
Evaluations of mass loss of stored ears[2]			
	BRS Vivi	SWB 551	Tropical Plus
Mass loss (%)	3.32	3.41	3.19

[1] Preserved in acidified brine (1.5% NaCl, 3.5% sucrose in acidified citric acid (pH 4.3)). [2] percentage mass loss of sanitized and dried ears packed in polystyrene trays wrapped in plastic film, at continuous 5 °C, with light for 9 hours a day for nine days.

Table 4. Means of grain quality traits at fresh corn harvest

Traits[1]	BRS Vivi	SWB 551	AG 1051
Chromatographic component L*[2]	83.1	75.6	83.1
Carbohydrates (mg $100g^{-1}$)	13.9	14.4	8.5
Total energy (kcal)	74.5	75.2	51.1
Unhusked ear weight (g)	308.26	316.48	420.15
Husked ear weight (g)	195.85	207.68	275.05
Mean grain weight per ear (g)	93.77	116.09	152.78
% grain weight / ear weight	29.00	38.95	31.95
Crude fiber (mg $100g^{-1}$)	1.94	1.72	2.04
Ether extract (mg $100g^{-1}$)	1.0	0.9	0.9
Total carotenoids (mg g^{-1})	26.10	24.92	25.11
β-carotene (mg g^{-1})	0.15	1.30	0.15

[1] Source: Adapted from Pinho et al. (2008) and Pinho at al. (2011)
[2] Color lightness from 100 (white) to 0 (black).

than common corn seeds (Netto et al. 2007). The initial germination pattern in seed lots of hybrid BRS Vivi can be good, since the field emergence of a fresh seed lot was 86% and seed vigor in the accelerated aging test 88%. However, it is worth mentioning that the percentage of emergence and vigor may change according to the storage period and seed conditions.

The single-cross hybrid BRS Vivi was tested and is recommended for the Brazilian Southeast and Midwest regions and the state of Paraná. The availability of this single-cross hybrid widens the genetic base of sweet corn, since for the development not only sweet corn, but also common corn parents were included.

Basic Seed Production

Seed production will be based on licenses for seed companies granted by Embrapa.

CONCLUSIONS

The release of a new sweet corn cultivar expands the product offer on the Brazilian market and widens the narrow genetic base of sweet corn in Brazil.

REFERENCES

Brewbaker JL (1977) Hawaiian Supersweet #9 corn. **HortScience 12**: 355.

Brewbaker JL and Banafunzi N (1975) Hawaiian Supersweet #6 corn. **HortScience 10**: 427.

Guia Veja (2013) Revolução na quitanda **Revista Veja 2321**: 108-110.

Netto DAM, Andrade RV, Padilha L, Oliveira AC, Gama EEG and Teixeira FF (2007) **Maturação fisiológica de milho doce e sua relação com a qualidade de sementes das sementes**. Embrapa Milho e Sorgo, Sete Lagoas, 24p. (Boletim de Pesquisa e Desenvolvimento, 3).

Pinho L, Paes MCD, Gloria, MBA, Almeida AC and Costa CA (2008) Qualidade de milho verde cultivado em sistemas de produção orgânico e convencional. **Revista Brasileira de Milho e Sorgo 7**: 279-290.

Pinho L, Paes MCD, Gloria, MBA, Almeida AC and Costa CA (2011) Color and chemical composition and of green corn produced under organic and conventional conditions. **Ciência e Tecnologia de Alimentos 31**: 366-371.

Pereira Filho IA and Cruz JC (2002) **Cultivares de milho para o consumo verde**. Embrapa Milho e Sorgo, Sete Lagoas, 7p. (Circular Técnica, 15).

Teixeira FF, Guimarães LLM, Guimarães PEO, Pacheco CAP, Parentoni SN and Silva AR (2011) Pré-melhoramento do milho. In Lopes MA, Fávero AP, Ferreira MAJF, Faleiro FG, Folle SM and Guimarães EP (eds.) **Pré-melhoramento de plantas**. Embrapa Informação Tecnológica, Brasília, p. 571-614.

Tracy WF (2001) Sweet corn. In Hallauer AR (ed) **Specialty corns.** CRC Press, Boca Raton, p. 155-197.

Yousef GG and Juvik JA (2002) Enhancement of seedling emergence in sweet corn by marker-assisted backcrossing of beneficial QTL. **Crop Science 42**: 96-104.