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Article

Comparison of sweetness in ear corn with different genetic background and incorporation of the shrunken2 gene

Alexander López-Hernández[1]
Leobigildo Córdova-Téllez[1]
Amalio Santacruz-Varela[1§]
J. Jesús García-Zavala[1]

[1]Postgraduate College-*Campus* Montecillo. Highway Mexico-Texcoco km 36.5, Montecillo, Texcoco, State of Mexico. CP. 56230. Tel. 595 8045900. (alexander.lopez.fito@gmail.com; lcordova@colpos.mx; zavala@colpos.mx).

[§]Corresponding author: asvarela@colpos.mx

Abstract

The production of super sweet ear in Mexico focuses on the use of commercial hybrids, since there are no native races with this characteristic, for this reason the following research was proposed with the objectives: a) introduce a sweetness gene in native ear corn populations; and b) determine its effect on agronomic characteristics, quality and consumer acceptance. The following native collections of ear corn were used: C-Pue-185 (Cacahuacintle), Hgo-428 (Chalqueño) and Hgo-416 (Elotes Cónicos) infiltrated with the shrunken2 gene (sh2) and with different proportions of genetic background of native corn, the commercial hybrids A7573, Cherokee and Sweeter93 were used as controls. Experiments were established in the localities of Montecillo, Texcoco, State of Mexico and San Felipe, Teotlalcingo, Puebla, in 2021, using a randomized complete block design with three repetitions. Characteristics of morphology, of yield and a sensory test were recorded. The population Hgo-428sh2F1 with genetic background 50% native + 50% super sweet was the best in terms of total soluble solids (TSS) with 16.5 ºBrix. In the sensory test, the same population Hgo-428sh2BC1F1 stood out, with genetic background of 75% native + 25% super sweet. The population formed by Hgo-428 (Chalqueño) was identified as outstanding in total soluble solids and ear flavor. The commercial hybrid A7573 stood out in morphological characteristics. The original native populations Hgo-428 (Chalqueño) and C-Pue-185 (Cacahuacintle) were equal to the best commercial control A7573 in terms of sliced fresh grain yield (SFGY). The incorporation of the super sweet gene (sh2) negatively affected all the characteristics evaluated.

Keywords: *Zea mays* L, native races, shrunken2 gene.

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Introduction

Within the genetic diversity of corn (*Zea mays* L.), there are ear corns of sweet grain, considered as vegetables, due to the intensive care they require and the added value they possess. Different varieties of sweet corn vary greatly in taste, texture, and nutrition (Yang *et al*., 2021). Currently, sweet corn is widespread in various countries and intended exclusively for human consumption, either fresh as ears or industrially processed as canned food (Enciso *et al*., 2012), in addition, in food science it is studied for the use of analog cheese for spreading (Aini *et al*., 2019), extracts for cooking and beverages with high levels of carbohydrates and proteins (Revilla *et al*., 2021).

The main difference between sweet corn and non-sweet corns is that the former has a recessive gene present in its genome, whose function is to delay or prevent the complete transformation of the grain sugar into starch (Montoro and Ruiz, 2017), for this reason, corn homozygous for this gene has a higher concentration of sugar when consumed fresh (Revilla *et al*., 2021). In the present work, native germplasm that is used for the production of ears in the high valleys of Mexico was used: Elotes Cónicos, Chalqueño and Cacahuacintle (Sierra-Macías *et al*., 2016), these populations are frequently used in central Mexico for this purpose, which represents an opportunity to select the best outstanding native population for ear production (Ortiz-Torres *et al*., 2013).

This research consisted of introducing a sweetness gene in native populations for ear use and determining its effect on agronomic characteristics, quality characteristics and acceptance by the consumer, in order to increase their value for the benefit of producers and consumers, by providing farmers with the opportunity to sow super sweet ears as a production alternative.

Materials and methods

Genetic material

Three collections of ear corn from high valleys were used: Cacahuacintle (C-Pue-185), Chalqueño (Hgo-428) and Elotes Cónicos (Hgo-416) (Table 1), to which the shrunken2 gene (sh2) was incorporated as described below: the segregating population Shrunken-2 Hi sh2 SYN 2k of the International Maize and Wheat Improvement Center (CIMMYT, for its acronym in Spanish) was used as a donor of the sh2 gene and this genotype was manually crossed with the three races of corn from the High Valleys of Mexico in spring-summer (SS) of 2016.

Table 1. Corn genetic materials used for evaluation.

Race	Collection/commercial name/genealogy	Genetic background	Color	Texture of endosperm
Cacahuacintle	C-Pue-185	100% Native	White	Mealy
	C-Pue-185sh_2F_1	50% Native + 50% Sweet		
	C-Pue-185$sh_2BC_1F_1$	75% Native + 25% Sweet		

Race	Collection/commercial name/genealogy	Genetic background	Color	Texture of endosperm
Elotes Cónicos	Hgo-416	100% Native	Blue	Semi-Crystalline
	Hgo-416sh$_2$F$_1$	50% Native + 50% Sweet		
	Hgo-416sh$_2$BC$_1$F$_1$	75% Native + 25% Sweet		
Chalqueño	Hgo-428	100% Native	Cream White	Semi-Toothed
	Hgo- 428sh$_2$F$_1$	50% Native + 50% Sweet		
	Hgo-428sh$_2$BC$_1$F$_1$	75% Native + 25% Sweet		
Controls	A7573	100% Normal	White	Toothed
	Cherokee	100% Normal	White	Semi-crystalline
	Golden Sweeter 93	100% Super Sweet	Yellow	Sweet

The sowing was carried out on two dates: on the first date the three populations and the donor were sown, five days later a second date of the donor was sown to ensure flower synchrony. Because the sh2 gene is expressed in a homozygous recessive condition, in SS of 2017 self-fertilizations of F1 plants were performed to detect ears with sweet grains in the F2.

In SS of 2018, the sweet phenotypes (F2) of each of the F1 crosses were sown to perform the first backcross (BC1) towards the recurrent populations. In SS of 2020, the F1 plants obtained in 2016, with genetic background 50% recurrent + 50% of the donor, and the F1 crosses obtained in 2018, the result of the first backcross BC1, with genetic background 75% recurrent + 25% of the donor were sown and self-fertilized to identify the sweet genotypes again. In 2021, the F2:3 plus three commercial ear corn hybrids were sown as controls.

Experimental sites

The experiments were established on May 14, 2021 in the locality of San Felipe Teotlalcingo, Puebla, Mexico (19° 13’ 48” north latitude and 98° 31’ 07” west longitude at 2 400 m), with climate type C (w1) (w)(x’) s, semi-cold subhumid with rains in summer, with average annual temperature between 5 and 12 °C, average annual precipitation of 900 mm and on May 25 of the same year in Montecillo, Texcoco, State of Mexico (19° 28’ 02” north latitude and 98° 54’ 24” west longitude at 2 250 m), climate type Cb (w0) (w) (i’) g, temperate with long cool summer, average annual temperature between 12 and 18 °C and average annual precipitation of 637 mm (García, 1998).

Experimental design and unit

The experimental design was in randomized complete blocks with three repetitions and the experimental unit in a plot of six furrows of 5 m in length and 0.8 m of separation, with 11 bushes of two seeds at a distance of 0.5 m between them for normal grain materials, and 11 bushes with four seeds at a distance of 0.5 m between them for genotypes with the sh2 gene to prevent failures in germination, due to the unfavorable physical and physiological condition of genotypes with sweet endosperm.

Management of experiments

The sowing was done manually, in stage V3 it was thinned to two plants per bush, which reduced the population density to 50 000 plants ha^{-1}. Fertilization was carried out before sowing with the following formula: 180N-60P-0K, half nitrogen and all phosphorus were applied at the sowing and the rest of the nitrogen at 45 days after sowing. The sources were urea and diammonium phosphate. Weed control was performed with Atrazine at doses of 2 kg ha^{-1} in 200 L of water, and Dicamba + Atrazine at doses of 2 L ha^{-1} in 300 L of water.

There was the presence of the chafer (*Macrodactylus* sp.) pest, which was controlled with Chlorantraniliprole + Lambdacyhalothrin at doses of 100 ml ha^{-1} in 200 L of water. The experiments were conducted under irrigation. Harvesting was done manually at 28 days after female flowering, seven days later than recommended by (Shelton and Tracy, 2015).

Variables evaluated

Plant vigor (VIG) was recorded by a visual rating with a scale of 1 to 9, where 1 corresponds to the least vigorous plants and 9 to the most vigorous plants; female flowering (FF, days) as the number of days elapsed from the date of sowing until 50% of the population showed the emergence of receptive stigmas approximately 2 or 3 cm long in the main immature ear, ear height (EH, cm) it was measured in a representative plant of the experimental unit as the distance from the base to the insertion node of the main ear.

All the bracts were removed from five ears from plants with full competence and the following data were recorded: ear length (EL, cm), it was measured from the basal part of the ear to the apical part, grain filling (EAFI, cm) it was measured from the basal part of the ear until reaching the part occupied with grains, without considering aborted grains, only the grains that were in complete rings around the ear, ear diameter (ED, cm) it was measured in the middle part with a digital vernier (Mitutoyo CD-6 CS; Miyutoyo Corporation, Kanagawa, Japan).

Count of the number of rows (NR), female structure was divided and half of the basal part was used to carry out the count of the rows of the ear, yield of ear without husks (YEWH, t ha^{-1}) it was determined at the time of harvest with a digital scale (Ohaus, Scout Pro, Ohaus Corporation, Parsippany, New Jersey, USA), sliced fresh grain yield (SFGY, t ha^{-1}), for this, it was separated from the ear and manually sliced with a knife, then weighed on an Ohaus Scout Pro digital scale.

YEWH and SFGY data were adjusted to moisture content of 70% (Rice and Tracy, 2013; Meneses *et al*., 2017) and at a density of 50 thousand ears ha^{-1} (potentially marketable pieces), total soluble solids (TSS, ºBrix) an extract was obtained from the homogeneous mixture of sliced grains of 20 ears in the stage of consumption harvested in the morning. The determination was performed in triplicate with a digital refractometer (Atago Pal-1®, Tokyo, Japan) in 300 µl of the fresh extract.

Sensory test (EF)

In the sensory test, the methodology to study the taste and preference of consumers proposed by Severiano (2019) was applied, before an untrained panel of 25 people (women and men of three age groups, < 30, 30-50 and > 50 years). The ear was prepared by cooking 0.5 kg of grain in the consumption stage (*esquite*) of each experimental unit. The cooking was carried out immediately after harvest with simple bottled water for 1 h in a novacero enameled steel pot, 22 cm of 5 L (CINSA) and an electric burner of 60 hz, 1 700 w, 127 v (Timco, PE-02, Mexico) with the same level of regulation.

The samples were presented to the group of panelists at the typical temperature of consumption (≈ 45 ºC) in plastic cups of 30 ml with 20 g of cooked ear. The tasting order of the samples for each person was random and between the evaluation of each sample, the panelists consumed simple bottled water to wash tongue and palate.

Each sample was evaluated for taste on a hedonic scale of nine points, where 9 represented I like it extremely, 8 I like it very much, 7 I quite like it, 6 I like it slightly, 5 I am indifferent, 4 I dislike it slightly, 3 I quite dislike it, 2 I dislike it very much and 1 I dislike it extremely (Paucar-Menacho *et al*., 2016), with the variant that a nine-point linear graphic scale was used, in which the panelists marked on the line a point or diagonal at the level of preference of the sample, then it was measured with a ruler and the value of that mark was recorded.

Statistical analysis

A combined general analysis of variance was performed for each variable. To identify the best populations, a comparison of means was carried out with the Tukey test ($p \leq 0.05$) and the matrix of Pearson's correlation between the variables evaluated was calculated. All data analyses were performed with the statistical package SAS® 8.0 (SAS Institute, 1999).

Results and discussion

Combined analysis of variance

In the source of variation, localities, statistically significant differences were found ($p \leq 0.01$) for the variables plant vigor (VIG), female flowering (FF), ear height (EH), ear diameter (ED), yield of ear without husks (YEWH), sliced fresh grain yield (SFGY) and total soluble solids (TSS) (Table 2). This indicates that the evaluation localities discriminate differently and it is attributed to the fact that they are divergent in terms of climatic, soil conditions, geographical location and the conduct of experiments, particularly in each of them.

Table 2. Mean squares of the combined analysis of variance of ear corns evaluated in two localities.

SV	DF	VIG (1-9)	FF (d)	EH (cm)	EL (cm)	EAFI (cm)	ED (mm)	NR	YEWH (t ha^{-1})	SFGY (t ha^{-1})	TSS (ºbrix)	EF
Loc (L)	1	4.5 **	1845.32**	18915.12**	0.67 ns	0.02ns	81.19**	0.55 ns	46.81 **	13.56 **	20.23 **	0.007ns
Rep/Loc	4	0.95 ns	0.57 ns	64.33ns	1.8 ns	1.39ns	2.97 ns	0.38 ns	0.65 ns	0.32 ns	0.48 ns	0.52ns
Gen (G)	11	26.87**	181.54**	6178.45**	21.77**	29.7**	68.86**	23.55**	40.24 **	8.13 **	44.64 **	3.41 **
G × L	11	1.37 **	5 **	275.15 **	1.79*	2.89**	2.79 ns	0.91 ns	1.68 **	0.63 **	1.84 **	0.54 *
Error	44	0.42	1.51	100.28	0.81	0.95	2.23	0.74	0.51	0.21	0.36	0.21
CV (%)		12.26	1.24	14.93	4.92	6.76	3.53	6.99	8.86	11.50	4.91	9.46

SV= source of variation; DF= degrees of freedom; VIG= plant vigor; FF= female flowering; EH= ear height; EL= ear length; EAFI= ear filling; ED= ear diameter; NR: number of rows; YEWH= yield of ear without husks; SFGY= sliced fresh grain yield; TSS= total soluble solids; EF= ear flavor; * and **= statistical significance with $p\leq 0.05$ and $p\leq 0.01$, respectively, ns= not significant.

In the source of variation, genotypes, statistically significant differences ($p\leq 0.01$) were found for all variables, which means that at least one of them is different from the rest of the genotypes; therefore, there is variability between them, the differences found are largely attributed to the genetic diversity shown by the experimental populations, as different races were involved, as well as to the genetic background product of the crosses made for the formation of the populations evaluated, likewise the presence of the Sh2 gene, which has a marked influence on the phenotypic expression of the materials.

With respect to the interaction of genotypes by localities, statistical significance ($p\leq 0.01$) was detected for most of the variables, from which it follows that there are relative differences between the behavior of genotypes across localities; that is, there is unequal behavior of experimental populations when going from one environment to another. For the variables ED and NR, no statistical significance was found, indicating absence of interaction with the environments.

In this study, genetic variability was detected in the populations evaluated, which allows making the selection of the best according to their good agronomic attributes and stability across environments; nevertheless, for the latter case, it is necessary to resort to methodologies that explore, quantify and interpret this interaction. This is important to avoid developing programs specific to each environment, when the ear quality of the corn is highly affected by the environment.

Selection of outstanding genotypes

Total soluble solids (TSS) readings ranged from 8.83 to 16.53 ºBrix (Table 3), the population Hgo-428sh2F 1 stood out with genetic background 50% native + 50% donor with 16.53 ºBrix. The lowest value was for the normal ear population Hgo-416 (Elotes Cónicos), with 8.83 ºBrix, this coincides with the results obtained by Coutiño *et al*. (2015) with the native variety Paloma in Villaflores Chiapas (8.8 ºBrix).

Table 3. Means of genotypes and commercial controls for morphological and quality variables of ear.

Genotype	Quality		Morphological							Yield	
	TSS (ºBrix)	EF	VIG (1-9)	FF (d)	EH (cm)	EL (cm)	EAFI (cm)	ED (cm)	NR	YEWH (t ha^{-1})	SFGY (t ha^{-1})
Hgo-428sh2F_1	16.53a	5.97ab	5c	100.5c	46.5ef	16.25e	11.81d	39.1e-g	12.13 b-d	6fg	3.07de
Hgo-428sh2BC_1F_1	14.74b	6.08a	2.5f	102.16bc	64.33de	17.71 c-e	13.83bc	40.72 d-f	11.86 b-d	6.14fg	3.42d
Hgo-416sh2BC_1F_1	14.35bc	4.79cb	3.5d-f	100.16c	58.83de	16.05e	11.22d	37.79fg	9.03f	5.16g	2.4e
C-Pue185sh2BC_1F_1	14.02bc	5.68ab	2.66ef	99.83c	56.5de	17.25de	13.15cd	42.33cd	11.31 c-e	7.43ef	3.63cd
C-Pue-185shF_1	13.96bc	4.79cb	4.66cd	99.83c	45.16ef	16.83e	12.60cd	41.02de	12.95bc	6.51fg	3.17de
Sweeter 93	13.81bc	5.93ab	4cd	95d	22.33g	18.89 b-d	15.45ab	42.16cd	14.83a	8.28de	4.66b
Hgo-416sh2F_1	13.44 c	4.96 a-c	3.83 c-e	100.4c	34fg	16.62e	12.32cd	37.39g	10.58 d-f	5.23g	2.43e
Hgo-428(Chalqueño)	10.7d	4.21cd	6.83b	103.66b	135.5a	19.83b	15.91a	44.25bc	12.46bc	9.02cd	5.13ab
A 7573	9.37e	3.94cd	8ab	108.5a	68.5d	22.45a	17.26a	48.77a	15a	13.82a	5.92a
Cherokee	9.13e	3.11d	8.16a	89.33e	71.66cd	19.5bc	17.26a	45.67b	15.2 a	10.83b	4.74b
C-Pue-185 (Cacahuacintle)	8.95e	4.37c	7.66ba	94.16d	110.33b	19.82b	16.8a	45.5b	13.06b	10.25bc	5.33ab
Hgo-416 (Elotes Cónicos)	8.83e	4.34c	7.16ab	90.5e	90.83bc	19.08bc	16.05a	42.73 b-d	10ef	8.25de	4.42bc
DHS	1.2	1.18	1.3	2.45	19.84	1.79	1.94	2.97	1.72	1.42	0.92

Means with the same letter in each column are statistically equal (Tukey, $p \leq 0.05$). TSS= total soluble solids; EF= ear flavor; VIG= plant vigor; FF= female flowering; EH: ear height; EL= ear length; EAFI= ear filling; ED= ear diameter; NR= number of rows; YEWH= yield of ear without husks; SFGY: sliced fresh grain yield. HSD= honest significant difference.

In ear flavor (EF) the same population stood out, but with different genetic background; that is, 75% native + 25% donor, so it follows that, in relation to the quality of ear, the population Hgo-428 (Chalqueño) can be a good candidate in the commercialization of ear with the super sweet gene. In morphological characteristics, the non-sweet genotypes A7573, AS-Cherokee, Hgo-428 (Chalqueño), C-Pue-185 (Cacahuacintle), Hgo-416 (Elotes Cónicos) stood out in all aspects.

The commercial hybrid A7573 stood out in most variables, such as VIG, FF, EL, EAFI, ED and NR. In a similar study, Sánchez *et al*. (2013) also found the hybrid A7573 as a genotype outstanding in length and diameter of ear in two trials in the humid tropics zone for ear production; in addition, they mentioned that, in studies carried out by other authors, for the hybrid A-7573, under irrigation conditions, ear lengths between 24 and 31 cm and diameters of 4.1 to 5.5 cm were recorded, values very close to those obtained in this research. With respect to sliced fresh grain yield, the normal native populations Hgo-428 (Chalqueño) and C-Pue-185 (Cacahuacintle) were statistically equal ($p \leq 0.05$) to the commercial control A7573 and numerically superior to Sweeter 93. Zaluski *et al*. (2021) considered grain yield, yield of shucked ears and number of commercial ears as key traits for the identification of promising super sweet corn genotypes. Valdivia-Bernal *et al*. (2010) found that the Jala landrace was outstanding in ear yield compared to the hybrid A7573.

This encourages us to continue making efforts in the process of backcrosses to recover the characteristics of the initial populations, but with the variant of the sweetness gene incorporated. In ear flavor, the best material, according to the panelists, was Hgo-428sh2BC1F1, followed by Hgo-428sh2F1, Sweeter 93 and C-Pue185sh2BC1F1, materials that are within the group of super sweets, with ear flavor values of 6.08, 5.97, 5.93 and 5.68, respectively.

Pearson's correlations

The pairs of variables EAFI vs EL, YEWH vs EL, ED and SFGY vs EAFI, ED, YEWH presented statistically significant, positive correlations ($p \leq 0.01$), with values of r> 0.8 (Table 4). The closer to 1 the correlation coefficient between variables, the greater the association between them, although this does not necessarily imply causal relationships (Roy-García *et al*., 2019). If the ear is intended to be marketed in full piece; that is, without slicing, it is desirable to focus selection efforts on materials with greater length and diameter of ear.

Table 4. Pearson's correlation coefficients between variables of 12 ear corn genotypes evaluated in two localities.

	VIG	FF	EH	EL	EAFI	ED	NR	YEWH	SFGY	TSS	EF
VIG	1										
FF	-0.11ns	1									
EH	0.39^{**}	-0.35^{**}	1								
EL	0.64^{**}	-0.004ns	0.35^{**}	1							
EAFI	0.67^{**}	-0.2ns	0.39^{**}	0.87^{**}	1						
ED	0.56^{**}	-0.24ns	0.5^{**}	0.75^{**}	0.76^{**}	1					
NR	0.36^{**}	-0.04ns	-0.01ns	0.52^{**}	0.5^{**}	0.62^{**}	1				
YEWH	0.6^{**}	-0.24ns	0.45^{**}	0.84^{**}	0.79^{**}	0.93^{**}	0.61^{**}	1			
SFGY	0.54^{**}	-0.3^{*}	0.53^{**}	0.79^{**}	0.81^{**}	0.88^{**}	0.56^{**}	0.9^{**}	1		
TSS	-0.77^{**}	0.1ns	-0.44^{**}	-0.66^{**}	-0.77^{**}	-0.56^{**}	-0.27^{*}	-0.61^{**}	-0.59^{**}	1	
EF	-0.67^{**}	0.19ns	-0.4^{**}	-0.33^{*}	-0.37^{**}	-0.37^{**}	-0.16ns	-0.44^{**}	-0.29^{*}	0.69^{**}	1

VIG= plant vigor; FF= female flowering; EH= ear height; EL= ear length; EAFI= ear filling; ED= ear diameter; NR= number of rows; YEWH= yield of ear without husks; SFGY= sliced fresh grain yield; TSS= total soluble solids; EF= ear flavor; * and **= statistical significance with $p \leq 0.05$ and $p \leq 0.01$, respectively; ns= not significant.

In genetic improvement programs, yield is one of the variables to which greater importance is attributed when generating and advancing new products to the market, for this reason, the significant correlation found in sliced fresh grain yield (SFGY) with ear diameter (r= 0.88^{**}) and with ear yield without husk (r= 0.9^{**}) is highlighted. Both features can be used as indirect selection criteria to improve yield.

The yield of whole ear without husk showed a high correlation ($r= 0.87^{**}$) with ear length. Borroel *et al*. (2018) found a significant correlation of yield with ear diameter (r= 0.9) and with ear length (r= 0.77), data very similar to those found in this research. There is a significant negative correlation ($p\leq 0.01$) of TSS with VIG, EH, EL, EAFI, ED, YEWH and SFGY of $r= -0.77^{**}$, $r= -0.44^{**}$, $r= -0.66^{**}$, $r= -0.77^{**}$, $r= -0.56^{**}$, $r= -0.61^{**}$ and $r= -0.59^{**}$, respectively.

The incorporation of the super sweet gene sh2 tends to drastically affect some morphological characteristics, especially the vigor, germination and development of the seedling, which represents problems specific to sweet and super sweet corns for the management of their germplasm, since the mutations that gave rise to these varieties have important implications on the physiology of germination, by having blocked the metabolic pathway of synthesis of starch, polysaccharide that represents the main reserve substance of the seed in the case of corn (Montoro and Ruiz, 2017); therefore, during backcross cycles, it is of utmost importance to make selection for these variables.

Sensory evaluation

According to the data obtained in the sensory evaluation, the content of soluble solids (ºBrix) in the grains was related to consumer preference, since there is a significant positive correlation ($p\leq 0.01$) with total soluble solids ($r= 0.69^{**}$), which indicates that the panelists liked the sweet materials more, a result that coincides with what was found by Coutiño *et al*. (2010), who pointed out that sweet corns with a high content of total soluble solids are the most preferred for consumption in ear, but does not fully coincide with the findings of Osorio-Saenz *et al*. (2019), who found that the consistency of the grain also has an influence on the consumer.

Genome recovery by backcrossing

The methodology of genetic improvement by backcrosses to incorporate the sweetness gene to native materials with ear characteristics is efficient, since it was possible to incorporate and maintain the gene, in addition to recovering to a large extent the morphological characteristics of the populations of interest (Figure 1). The recovery of characteristics can be seen as the backcross cycles progress. In this regard, Ayodeji *et al*. (2019) indicated that new populations of super sweet corn can be generated through backcrossing and selection for that trait. For commercial production, it is necessary to sow in isolated lots to avoid crosses with non-sweet corns.

For the populations Hgo-428 (Chalqueño) and C-Pue-185 (Cacahuacintle), there are characteristics that are recovered quickly, but they are not the same for each population. In the population Hgo-428 (Chalqueño), a higher percentage of recovery is obtained for the variables EH, EL, EAFI and ED with 13.16%, 7.36%, 12.69% and 3.66%, respectively, for each cycle of backcross applied, but not for the variables YEWH and SFGY.

These variables in the population C-Pue-185 of the Cacahuacintle race are recovered faster with 8.97% and 8.63%, respectively. The characteristics that were quickly fixed for both populations were EL, EAFI, ED and NR, where the latter was the one that was 100% recovered from the first cross. These characteristics can be potentially exploited in genetic improvement programs, adequately characterizing the initial populations and exerting selection pressure to identify and quickly fix these characteristics from the first backcross cycles.

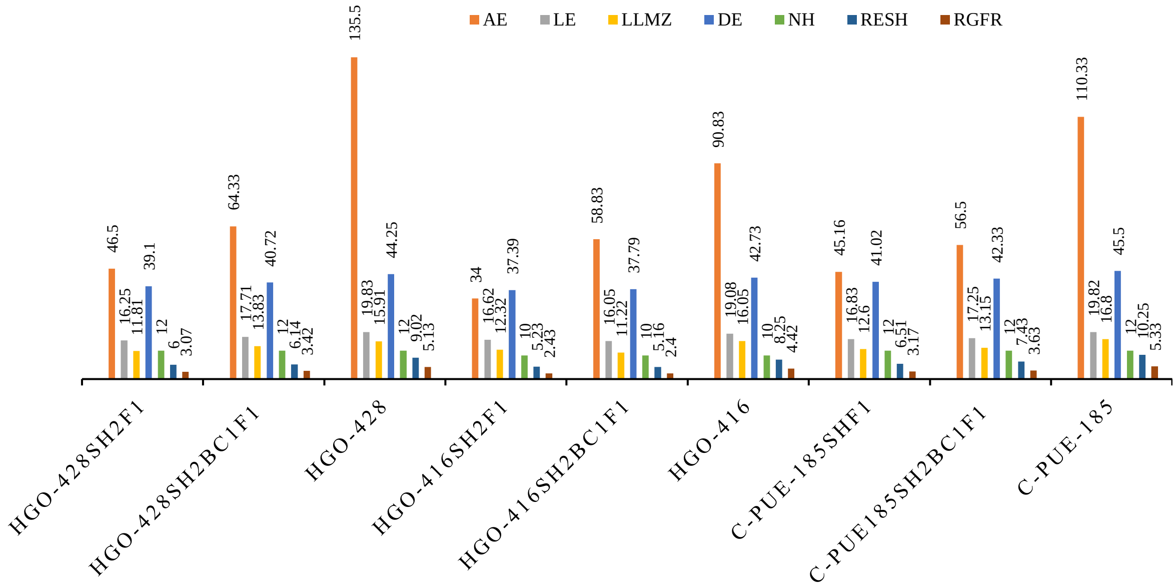

Figure 1. Percentage of recovery of the different variables by backcrossing with respect to the original populations. AE= ear height (EH); LE= ear length (EL); LLMZ= ear filling (EAFI); DE= ear diameter (ED); NH= number of rows (NR); RESH= yield of ear without husk (YEWH); RGFR= sliced fresh grain yield (SFGY).

Conclusions

There is genetic variability between populations for the variables plant vigor (VIG), female flowering (FF), ear height (EH), ear length (EL), ear filling (EAFI), yield of ear without husk (YEWH), sliced fresh grain yield (SFGY), total soluble solids (TSS) and ear flavor (EF), but not for ear diameter (ED) and number of rows (NR), which favors the identification of the best populations for ear production. The population Hgo-428sh2F1 with genetic background 50% native + 50% donor was the best with respect to TSS.

In ear flavor (EF), the same population Hgo-428sh2BC1F1 stood out, but with genetic background 75% native + 25% donor, followed by Hgo-428sh2F1, Sweeter 93 and C-Pue185sh2BC1F1. The population formed by Hgo-428 (Chalqueño) was identified as the best in quality and can be an excellent candidate for the commercialization of super sweet ear. The commercial ear corn hybrid A7573 stood out in most of the variables plant vigor (VIG), female flowering (FF), ear length (EL), ear filling (EAFI), ear diameter (ED) and number of rows (NR).

The normal native populations Hgo-428 (Chalqueño) and C-Pue-185 (Cacahuacintle) were equal to the best commercial control A7573 in terms of sliced fresh grain yield, and Hgo-428 stood out over the commercial ear con control in the sweetness of their ears, which encourages us to continue with the process of backcrosses to recover the characteristics of the initial populations, but that the sweetness variant is included as an added value.

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