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APTITUDE OF IMPROVED HALF-SIB PROGENIES FOR GREEN CORN PRODUCTION

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Abstract: The objectives of this study were to evaluate improved half-sib progenies with an aptitude for green maize production in terms of agronomic adaptation and ear yield potential. The experiment was installed in the 2017/2018 harvest without a randomized block design with three replications. Two commercial controls (variety CatiVerde 02 and hybrid AG 1051) were used with 98 half-sib progenies. The genotypes were formulated to optimize the agronomic characteristics of plant height, male and female cycles, and ear insertion height. At stage R3 (milky grain), ears were harvested to evaluate commercial ear length, commercial ear diameter, the total number of ears, the total number of commercial ears, the percentage of commercial ears, the average mass of commercial ears, and productivity of commercial ears. From the analysis of variance, the genetic parameters were estimated by the mathematical expectation of the mean squares of the sources of variation. A principal component analysis (PCA) was performed, followed by genotype grouping by genetic dissimilarity using the UPGMA method. The resulting genetic parameters demonstrated high variability among progenies, indicating potential genetic gain with artificial selection. The PCA enabled 30 half-sib progenies to be selected, highlighting the P-32, which stood out with an average yield of 14,230 kg ha^{-1}. The UPGMA clustering method revealed five genetically different groups and eight divided progenies. The results clearly demonstrated the existence of favorable genetic variability among the progenies of corn half-sibs, making them well suited to green corn production for fresh consumption.

Keywords: *Zea mays* L, recurrent selection, genetic parameters, ear yield.

Introduction

Commercial exploitation of the corn crop, including the production of green corn, is widespread in Brazil. Across the country, consumption occurs diversely in natura or as an ingredient for manufacturing cakes, ice cream, mush, and many other food products, industrialized or not. Despite the tradition of green corn consumption, Brazil does not stand out internationally, with the United States, Nigeria, and Mexico being the main world producers (Conab, 2018).

Green corn is consumed throughout the year in most population centers, with the highest volume of consumption occurring during the period from December through March. This national demand contributes to the need for a significant increase in resilient and sustainable green corn production, making diversification a high-potential viable option that adds value for small rural farms engaging primarily in family labor. In addition, the benefits of this promising type of cultivation have led many traditional producers of corn for grain, beans, and coffee to opt for agricultural diversification in their exploitation of green corn in natura (Bahia Filho, 2002).

With the expansion of the market and commercial requirements and low availability of cultivars adapted for the production of green corn in natura, with most existing corn genotypes primarily intended for grain production, there is a need to develop specific green corn cultivars. Until recently, the same cultivars used in grain production were used for the production of green corn, even the corn cultivars used in the production of silage, as they possess grain and ear characteristics close to the Brazilian market requirements for green corn in natura (Fornasieri Filho, 2007).

Successful artificial selection in breeding programs is based on the existence of genetic variability within a population. Methodically selecting superior and divergent genotypes for traits of interest can increase the frequency of favorable alleles and serve to maintain genetic variability (Freitas Junior, 2009). For the improvement of green corn, it is necessary to select individuals with commercial ear high yield potential and a series of associated qualitative characteristics.

Using these genotypes in crossbreeding schemes, involving recurrent selection cycles between and within half-sib progenies, is an interesting alternative to obtain improved varieties with an aptitude for green corn production. It will allow family farmers to have access to genotypes with a high standard of quality. Additionally, farmers specializing in green corn production will be afforded access in the future to new open-pollinated varieties with agronomic adaptation and aptitude for the production of green corn in natura through the genetic breeding program of special corns at State University of Ponta Grossa.

Material and methods

The experiment was carried out in Ponta Grossa – PR, at the Fazenda Escola “Capão da Onça” of the State University of Ponta Grossa (25°5'3512” south latitude and 50°3'5016” west longitude, with an average altitude of 869 m), in the 2017/2018 summer crop. The climate of the region, according to Köppen's classification, is of the humid subtropical type (Cfb), and the soil is classified as Typical Dystrophic red Latosol (RLd) (Embrapa, 2006).

The experimental design used was randomized blocks, with three replications, where 100 genotypes were evaluated, involving 98 half-sib progenies and two commercial controls (CatiVerde 02 CATI-SP variety and AG 1051 Agroceres hybrid), which are recommended officially for the production of green corn. Due to the high number of treatments (genotypes) to be evaluated at the green corn stage (R3), the blocks were installed with a 15-day sowing interval to optimize the respective agronomic evaluations and the suitability for green corn production. Sowing was carried out mechanically using a Semeato plot seeder/fertilizer, model PS-8. The experimental plot consisted of two lines 4 m in length with 0.9 m in between. According to the corn crop's technical recommendations, the base/cover fertilization and the cultural treatments (control of weeds and insects) were carried out.

Plant material

The genetic basis of the half-sib progenies began in the 1997/1998 harvest with the manual pollination of the Ita and Piranão varieties with the Peruvian variety Gigante Blanco Urubamba. Subsequently, two cycles of mass selection were carried out, and the resulting seeds were sown manually in the 2000/2001 crop, in six strips consisting of two rows, which were alternated with the double hybrids D 170 and AG 1051 for the artificial crossing. The seeds from the best ears produced in the crossing were used in two cycles of mass selection, harvesting from the best plants that had healthy ears, were longer, larger in diameter, well stuffed, containing from 8 to 12 well-defined rows, and consisting of grains that were long, wide and thick; all criteria that are also associated with green corn aptitude.

To obtain the progenies, on January 11, 2004, 35 half-sib progenies were sown. Each progeny consisted of a single row of plants, 20 m ha^{-1} long, spaced 0.90 m apart, with a population of approximately 45,000 plants ha^{-1}. From January 20, 2005, pollinations were carried out between plants of all progenies of Germanic brothers, obtaining about 1,500 ears. At field maturation point, 1,053 ears were visually pre-selected based on examining the ears length and diameter husk and health. In the laboratory, they were husked and measured in terms of length, diameter, mass, and number of rows per ear, and after threshing in terms of cob diameter, number, and mass of grains per ear. From each row, between four and eight ears were selected, using as criteria the longest with the largest diameter and grain mass, resulting in 369 progenies.

Due to the small space available for the storage of seeds, 120 seeds were separated from each ear selected, kept in a cold chamber until sowing, with half-sib being used to implant the progeny test and the remainder for the recombination of superior progenies. Tests of the progenies were carried out in the 2005/2006 harvest, consisting of 179 and 190 pre-selected progenies. During the tests, 97 progenies were selected, and, in the last years, these progenies went through two cycles of random mating, with one line of implantation for each progeny. These mating gave rise to 328 progenies of potential half-sibs, which remained stored in a cold chamber. Subsequently, an initial laboratory selection was carried out in 2017, seeking certain characteristics (grain weight, color, and size). This is where the 98 half-sib progenies used in this agronomic competition experiment in the 2017/2018 crop were obtained.

Half-sib progeny assessments

The progenies of corn half-sibs were evaluated for the following agronomic traits: male cycle (MC): number of days from emergence until 70% of the plants emitted the tassel; female cycle (FC): number of days from emergence until 70% of the plants emitted the main ear stigmas; plant height (PH): measurement from the soil surface to the beginning of the tassel branching in meters, based on the evaluation of four random plants per plot; and ear insertion height (EIH): measurement from the soil surface to the ear insertion base in meters, based on the evaluation of four random plants per plot.

To evaluate the characteristics related to the suitability for the production of green corn, at least three collections were carried out every two days from the 25th day after the female flowering date, which is equivalent to the milky grain stage (R3). The ears collected were evaluated for: average length of commercial ears (LCE) in cm; average diameter of commercial ears (DCE) in cm; the total number of ears (TNE) in n° ha^{-1}; the total number of commercial ears (TNCE) in n° ha^{-1}; percentage of commercial ears (%CE); and commercial ear yield per hectare in tons (CEY) in kg ha^{-1}. The classification of commercial ears was in accordance with the following parameters: ear length $\geq$ 15 cm, ear diameter greater than 3 cm, and absence of flaws/damage in the formation of grains in the ears (Conab, 2018).

Statistical analysis

The data on agronomic characteristics and suitability for green corn production were initially subjected to analysis of variance, followed by an estimation of genetic parameters through the mathematical expectation of the mean squares of the analysis of variance for half-sib progenies corn according to Vencovsky and Barriga (1992).

The multivariate analysis of the principal components (PCA) was performed using the princompfunction and the grouping of genotypes by the UPGMA method based on the Mahalanobis (1936) generalized square distance (D2). All the analyses were performed using the R-3.4.0 software (R Core Team, 2017).

Results and discussion

Analysis of variance and estimation of genetic parameters

The results of the analysis of variance showed a significant effect ($p \leq 0.05$) for all corn genotype characteristics evaluated (Table 1). The differences between the half-sib progenies include the presence of genetic variability in this set of genotypes for adaptive traits and aptitude for green corn production. The coefficients of variation were of low magnitude, ranging from 1.32 (MC) to 14.46% (CEY), being considered adequate for field experiments (Table 1).

The heritability coefficient directly indica-tes the heritable proportion of the total variability, and the approximation of this parameter helps the breeder in choosing the method and the intensity of selection to be used, as well as in estimating the genetic gain to be obtained through artificial selection (Carvalho et al., 1981).

Table 1. Summary of the analysis of variance and estimation of genetic parameters for the variables plant height (PH), ear insertion height (EIH), male cycle (MC), female cycle (FC), commercial ear length (CEL), commercial ear diameter (CED), the total number of ears (TNE), total number of commercial ears (TNCE), percentage of commercial ears (%CE), average mass of commercial ears (MASS), and productivity of commercial ears (CEY) as a function of half-sib progenies. Ponta Grossa, 2021.

Source of Variation	Mean Square											
	GL	PH (m)	EIH (m)	MC (days)	FC (days)	CEL (cm)	CED (cm)	TNE (no ha^{-1})	TNCE (no ha^{-1})	%CE	MASS (g)	CEY (kg ha^{-1})
Block	2	0.32	0.18	0.81	70.56	0.52	0.00	62220220.17	151118.73	111.63	190.61	600774.76
Genotypes	99	0.07*	0.05*	14.94*	12.56*	1.34*	0.08*	122175721.06*	115115445.03*	109.17*	673.81*	7045902.85*
Error	198	0.01	0.01	0.92	1.22	0.51	0.05	33876039.54	31567697.39	39.8	456.82	2141722.65
Average		2.79	1.76	72.77	79.99	17.21	4.94	51277.75	43812.42	85.55	231.57	10122.62
CV (%)		2.95	4.99	1.32	1.38	4.14	4.48	11.35	12.82	7.37	9.23	14.46
Genetic Parameters												
$\hat{\sigma}_p^2$		0.02	0.02	4.98	4.19	0.45	0.03	40725573.69	3837185.01	36.39	224.6	2348634.29
$\hat{\sigma}_g^2$		0.02	0.02	4.68	3.78	0.28	0.01	29433560.51	27849249.22	23.13	72.33	1634726.73
$\hat{\sigma}_e^2$		0.00	0.00	0.31	0.41	0.17	0.02	11292013.18	10522565.8	13.27	152.27	713907.55
$\hat{h}_{bs}^2$		90.62	86.65	93.87	90.27	62.32	44.89	72.27	72.58	63.55	32.2	69.6
CV_g		5.29	7.35	2.97	2.43	3.07	2.34	10.58	12.05	5.62	3.67	12.63
CV_e		2.95	4.99	1.32	1.38	4.14	4.48	11.35	12.82	7.37	9.23	14.46
$\hat{b}$		1.79	1.47	2.26	1.76	0.74	0.52	0.93	0.94	0.76	0.4	0.87

$\hat{\sigma}_p^2$: phenotypic variance; $\hat{\sigma}_g^2$: genotypic variance; $\hat{\sigma}_e^2$: environmental variance; $\hat{h}_{bs}^2$: heritability in broad sense; CV_g: genetic coefficient of variance; CV_e: environmental coefficient of variance; $\hat{b}$: b coefficient

From the estimates of the genetic parameters, it was possible to determine that the estimated values of heritability in the broad sense ($\hat{h}^2_{bs}$) ranged from 32.2 for the average mass of commercial ears (MASS) to 93.9% for the male cycle (MC), with values above 60% for nine of the evaluated characteristics: plant height (AP), ear insertion height (EIH), male cycle (MC), female cycle (FC), commercial ear length (CEL), the total number of ears (TNE), the total number of commercial ears (TNCE), percentage of commercial ears (%CE), and yield of commercial ears per hectare (CEY) (Table 1). The estimates of heritability in the broad sense ($\hat{h}^2_{bs}$) were higher when evaluating a set of progenies of corn half-sibs, which estima-ted heritability in the broad sense ($\hat{h}^2_{bs}$) from 17.4 for the percentage of commercial ears (%CE) to 73.5% for the cycle female (FC). Similarly, Silva et al. (2016) evaluated 96 half-sib progenies from Creole corn germplasm for suitability for green corn production, and estimated heritability coefficients above 55% for the variables male, female cycle, and the number of grain rows per ear.

Dagla et al. (2015), evaluating 45 sweet corn hybrids, estimated heritability coefficients that were lower when compared to the progenies coefficients, at 61.2% for yield and 57.3% for ear length. For the phenotypic variables plant height, ear insertion height, number of grain rows, and variables related to chemical composition, the authors observed heritability coefficients above 60%. Additionally, the results of this experiment were similar to those found by Suhaisini et al. (2016), who evaluated the genetic variability present in a set of 50 sweet corn hybrids through 18 variables related to plant architecture, yield, photosynthetic efficiency, and grain chemical composition. Nine variables showed heritability coefficients above 75%, and the variables photosynthetic efficiency, total sugars, non-reducing sugars, plant height, dry and fresh ear weight, and ear insertion height obtained the highest estimates, reaching 97.4%.

The $\hat{b}$ quotient, expressed as the ratio between the coefficient of genetic variation (CV_g) and the coefficient of environmental variation (CV_e), can also help the breeder to conduct the breeding program. According to Cruz et al. (2004), when the estimate is ≥ 1, it indicates experimental precision in data collection and a very favorable situation for artificial selection.

Most of the variables linked to ear yield are controlled by a large number of genes and are influenced by environmental conditions. Thus, the determination of the magnitude of the genotypic and phenotypic variation coefficients indicates the variability contained in the population and can be used to predict the expected gains with artificial selection (Bello et al., 2012). The estimates of the b quotient in this experiment produced values very close to 1 for most of the analyzed variables. For TNE, TNCE, and CEY, the $\hat{b}$ quotient values were 0.93, 0.94, and 0.87 respectively, with emphasis on the variables PH (1.79), EIH (1.47), MC (2.26), and FC (1.76), which presented values greater than 1. These results indicate a very favorable condition for artificial selection (Table 1).

Principal component analysis

Of the 11 phenotypic characteristics measured in 100 corn genotypes (98 half-sib progenies and two commercial controls) from the field experiment, it was possible after the analysis of the primary components to reduce the dimension of the initial variables into two principal components (PC's), which explained 49.8% of the total phenotypic variance of the studied variables (Table 2).

Table 2. Estimate of the eigenvalues (λj) associated with the principal components, relative importance (λj %), and the total accumulated phenotypic variance (%). Ponta Grossa, 2021.

Components	Λj	λj (%)	% accumulated variance
PC1	1.72	26.95	26.95
PC2	1.58	22.81	49.76
PC3	1.41	18.02	67.78
PC4	1.10	11.02	78.80
PC5	0.99	8.85	87.65
PC6	0.93	7.78	95.43
PC7	0.46	1.93	97.36
PC8	0.39	1.41	98.77
PC9	0.36	1.16	99.93
PC10	0.08	0.05	99.98
PC11	0.05	0.02	100.00

The percentage of accumulated phenotypic variance in the first two components was considered adequate, taking into account the high number of characteristics evaluated, as well as a large number of half-sib progenies being evaluated, being much higher than several works reported in the specialized literature (Daher et al., 1997; Strapasson et al., 2000; Barbosa et al., 2005).

According to the percentage of explained variance for each component, it can be seen that the first and second components had estimated eigenvalues of 26.9% and 22.8%, respectively (Table 2).

The results of the eigenvectors in PC1 showed that the characteristics CEY (-0.562), TNCE (-0.506), and TNE (-0.424) were associated with the yield potential of green corn, being the ones that most influenced the formation of PC1 (Table 3). These variables represent 75% of the total relative importance of PC1. In this case, genotypes with higher scores in PC1 will have higher yield potential for green corn ears.

Table 3. Eigenvectors of the first two main components and the relative importance of each phenotypic variable for the formation of the main component. Ponta Grossa, 2021.

Variable	PC1		PC2	
	Eigenvectors	%	Eigenvectors	%
PH (m)	0.106	1.1236	-0.437	19.0969
EIH (m)	0.089	0.7921	-0.482	23.2324
MC (dias)	0.126	1.5876	-0.462	21.3444
FC (dias)	0.177	3.1329	-0.421	17.7241
CEL (cm)	-0.125	1.5625	-0.034	0.1156
CED (cm)	-0.211	4.4521	0.186	3.4596
TNE (espigas ha^{-1})	-0.424	17.9776	-0.225	5.0625
TNCE (espigas ha^{-1})	-0.506	25.6036	-0.222	4.9284
%CE (%)	-0.261	6.8121	-0.047	0.2209
MASS (g)	-0.228	5.1984	0.172	2.9584
CEY (kg ha^{-1})	-0.562	31.5844	-0.137	1.8769

(%) relative importance of the variable for the formation of the main component, (PH) plant height, (EIH) ear insertion height, (MC) male cycle, (FC) female cycle, (CEL) commercial ear length, (CED) commercial ear diameter, (TNE) total number of ears, (TNCE) the total number of commercial ears, (%CE) percentage of commercial ears, (MASS) average mass of commercial ears, and (CEY) commercial ears yield.

For PC1, it is observed that the P-32 progeny was superior in performance compared to the others, with an ear yield of 14,230 kg ha^{-1}, the total number of ears of 62,473 ha^{-1}, the total number of commercial ears of 60,743 ears ha^{-1}, and percentage of commercial ears of 97.23% (Figure 1). For PC2, the highest eigenvector coefficients were obtained for characteristics related to agronomic adaptation such as EIH (-0.482), MC (-0.462), PH (-0.437), and FC (-0.421) associated with the morphology and phenology of the plant corn (Table 3). These variables represent 82% of the total relative importance of PC2. The commercial controls CatiVerde 02 and AG 1051 showed inferior performance in relation to the set of progenies selected from the scores of PC1 (Figure 1).

In terms of simultaneous selection of phenotypic characteristics, several indices have been proposed over the last few years, with efficiency being variable according to the objectives of the breeding program (Arnhold and Silva, 2009). Based on the scores obtained from the principal component analysis, it was possible to select genotypes with the greatest suitability to produce a set of phenotypic variables of interest (Ceron and Sahagun, 2005).

For selecting the best half-sib progenies with an aptitude for the production of green corn, based on the principal components analysis, it was decided to consider the distribution of genotypes in relation to PC1. In this component, the CEY, TNCE, and TNE characteristics contributed the most to the total accumulated variance, reflecting the progenies ear yield potential. It was possible to select 30 half-sib progenies through PC1, including the P-32 that stood out among the others.

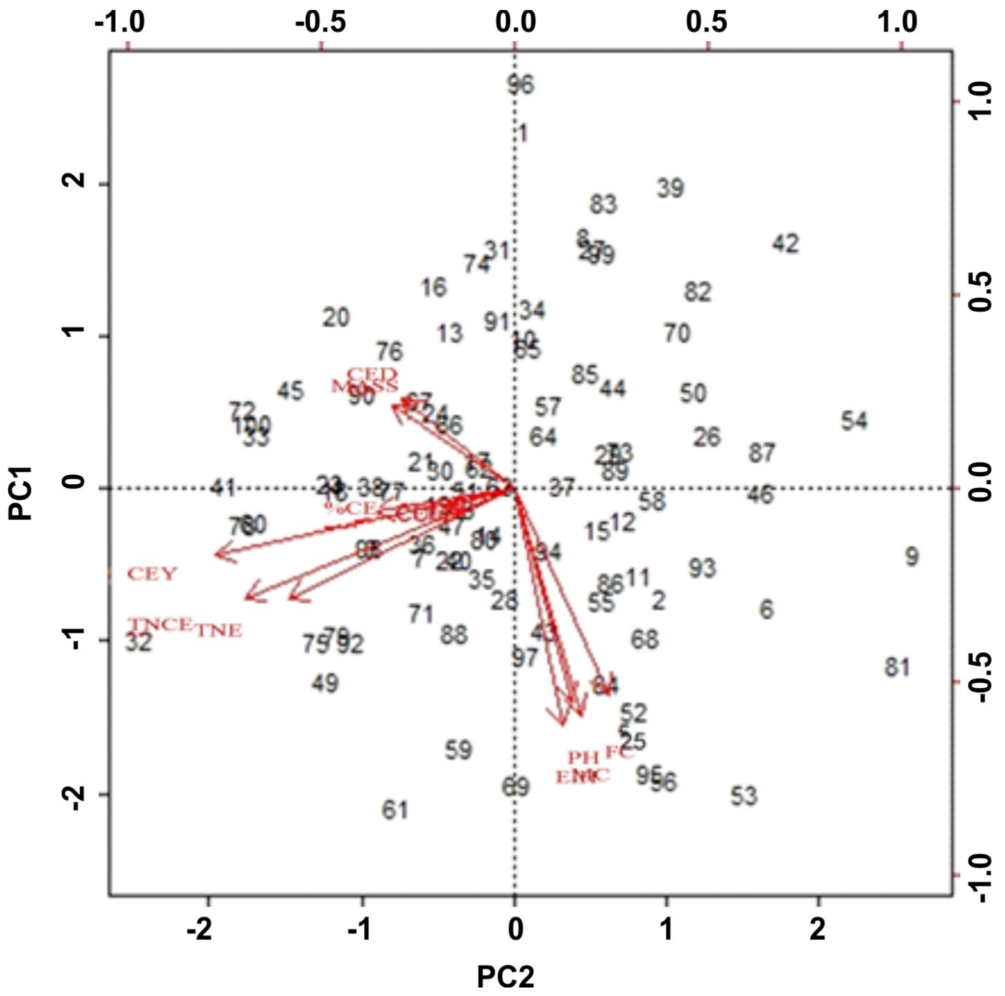

Figure 1. Genotype scores (half-sib progenies and controls) for the first two main components. Ponta Grossa, 2021.

The results achieved in this work confirm that multivariate analyses allow the grouping of highly correlated characteristics, reducing them to a few variables with minimal loss of information (Ceron and Sahagun, 2005), and allow the selection of superior genotypes from a set of phenotypic variables without the need to previously establish economic weights for the variables under the effect of artificial selection.

Grouping of genotypes by the UPGMA method

The cluster analysis of corn genotypes by the UPGMA method from the Mahalanobis generalized square distance data (D2) enabled the formation of genotype groups according to the dissimilarity index (Figure 2). To determine the number of groups, Mojena (1977) method was applied, which consists of a calculation procedure based on the relative size of the fusion levels or distances in the dendrogram. Using the constant k = 1.25, a cutoff point was determined in the dendrogram at 38% dissimilarity (Figure 2). From the cutoff point, it was possible to visualize the formation of five genetically different groups and eight isolated half-sib progenies, a result consistent with the topology observed in the dendrogram generated by the UPGMA method (Figure 2).

G1 and G5 comprised the largest number of half-sib progenies, 52 and 21 respectively, representing 73% of the studied genotypes. In G2, seven progenies (7%) were grouped into five progenies (5%), and G4 was composed of five progenies of half-sib (5%), in addition to the two commercial controls (CatiVerde02 and AG 1051). Additionally, eight isolated half-sib progenies (P-9, P-27, P-51, P-54, P-57, P-60, P-61 and P-95) were observed (Table 4).

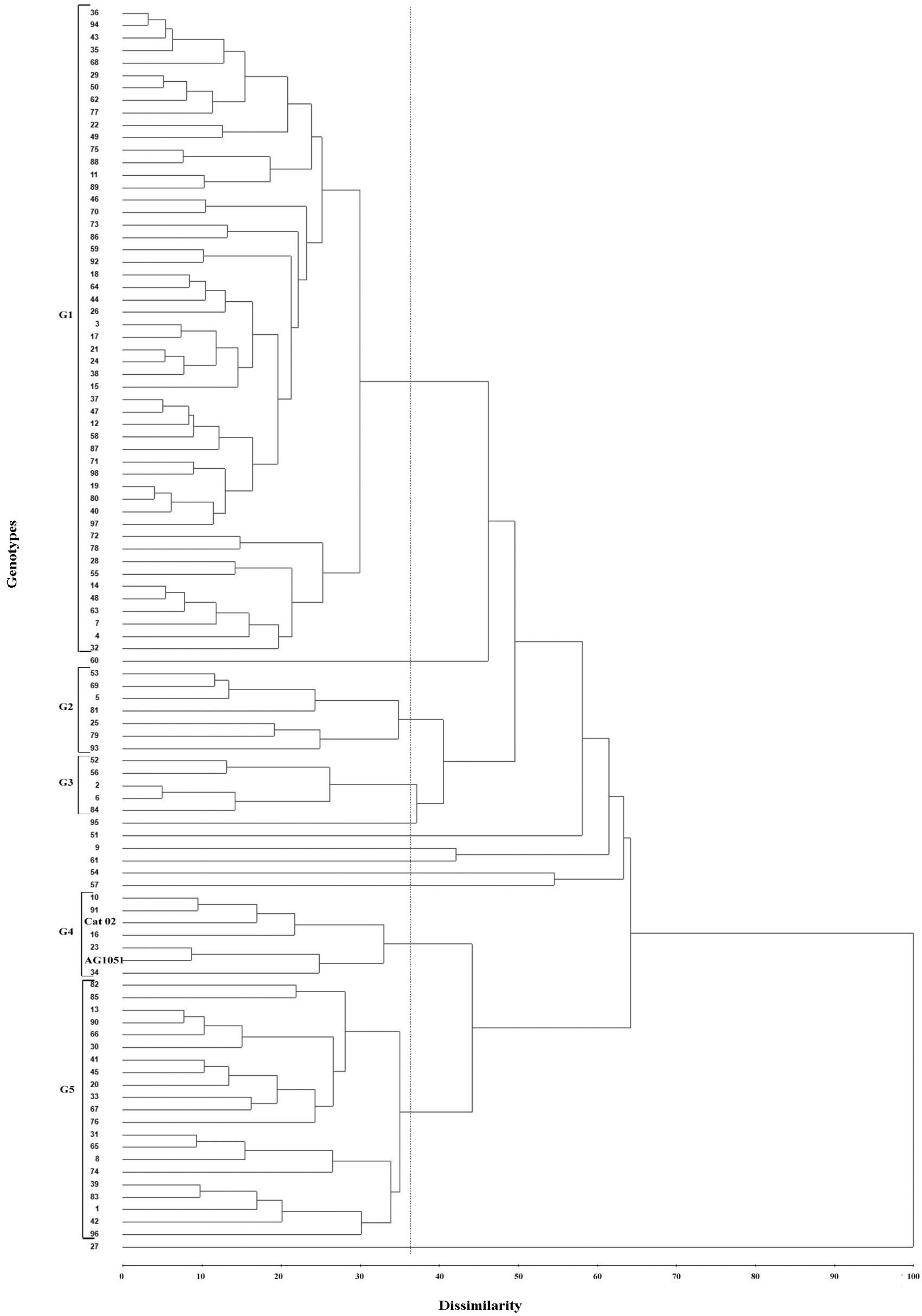

Figure 2. Grouping of 100 corn genotypes (progenies and controls) using the UPGMA method from the generalized square distance of Mahalanobis (D2). Ponta Grossa, 2021

Table 4. Average performance of the 11 phenotypic variables for each group of genotypes and isolated progenies obtained by the UPGMA grouping method. Ponta Grossa, 2021.

Groups	no	PH (m)	EIH (m)	MC (dias)	FC (dias)	CEL (cm)	CED (dias)	TNE (no ha^{-1})	TNCE (n°ha^{-1})	%CE (%)	MASS (g)	CEY (kg ha^{-1})
1	52	2.84	1.79	73.00	80.00	17.30	4.94	51,778.56	44,893.38	87.01	234.33	10,475.98
2	7	3.01	2.01	74.00	82.00	17.06	4.87	53,151.26	41,783.38	81.27	226.17	9,484.01
3	5	2.94	1.74	77.00	83.00	16.45	4.85	46,348.91	43,331.71	87.84	224.03	9,210.53
4	7	2.50	1.48	73.50	80.00	16.42	4.87	54,056.83	43,771.04	88.83	222.73	10,061.73
5	21	2.71	1.70	70.00	77.50	17.18	4.98	49,263.47	40,873.02	85.04	235.13	10,139.73
P-9	1	2.73	1.81	76.00	84.00	17.64	4.79	47,685.19	30,092.59	62.26	220.75	6,530.09
P-27	1	2.92	1.75	66.50	78.50	16.66	5.21	45,345.93	35,869.45	77.89	251.88	8,883.87
P-51	1	2.97	1.78	74.00	80.50	17.94	5.53	46,647.03	41,877.10	89.84	243.07	10,182.38
P-54	1	2.82	1.69	71.00	81.00	16.86	4.58	41,493.06	32,986.11	79.20	205.86	6,904.51
P-57	1	2.62	1.55	74.00	83.50	19.11	4.88	41,737.05	38,382.13	91.75	255.14	9,794.36
P-60	1	2.86	1.77	69.50	78.50	17.85	5.05	64,434.52	55,828.37	85.63	219.94	12,064.24
P-61	1	2.79	1.83	76.50	85.50	17.07	4.79	63,649.59	53,772.52	84.36	227.51	12,116.30
P-95	1	2.92	1.97	79.00	83.00	17.05	4.97	54,687.50	41,666.67	76.93	224.58	9,388.02

(no) the number of genotypes, (PH) plant height, (EIH) ear insertion height, (MC) male cycle, (FC) female cycle, (CEL) commercial ear length, (CED) ear diameter commercial, (TNE) total number of ears, (TNCE) total number of commercial ears, (%CE) percentage of commercial ears, (MASS) average mass of commercial ears, and (CEY) commercial ears yield.

From the phenotypic means of the 11 variables studied in the groups generated by the UPGMA method, it can be seen that the progenies of G1 showed a high commercial pattern, high percentage of commercial ears (87%), average mass of commercial ears (234.33 g), and average yield ha^{-1} of 10,475.98 kg ha^{-1} reaching a maximum yield of 14,230 kg ha^{-1} (P-32). This maximum yield is much higher than the productivity desired in the improvement programs aimed at producing green corn in natura (12,000 kg ha^{-1}).

Progenies from G2 showed an average length and diameter of commercial ears at 17.06 cm and 4.87 cm, respectively, but the percentage of commercial ears of G2 was 81.27%, which is considered high. Coincidentally, the progenies that comprised the G3 also showed a high percentage of commercial ears (87.84%) (Table 4).

In G4, the averages of the progenies, together with the two commercial controls (CatiVerde 02 and AG 1051), showed positive prominence of favorable adaptive traits suitable for the production of green corn. This group also showed low ear insertion height (1.48 m), precocity for the male cycle (73.5 days), a high percentage of commercial ears (88.83%), and an ear yield of 10,061.73 kg ha^{-1}. Hypothetically, it was expected that the two commercial controls would have a low height of ear insertion and a high percentage of commercial ears. This is due to the greater homogeneity of these genotypes in relation to the progenies of half-sibs that are still under the effect of cycles of artificial selection (Table 4).

The 21 half-sib progenies grouped in G5 had higher average precocity of male (70 days) and female (77.5 days) cycles, a length, and diameter of commercial ears of 17.18 cm and 4.98 cm, respectively, and a high percentage of commercial ears (85.04%), with an average mass of commercial ears (235.13 g) and ear yield (10,139.73 kg ha^{-1}) (Table 4). This group stood out for presenting desirable characteristics regarding agronomic adaptation associated with an aptitude for green corn production.

Regarding the isolated half-sib progenies, the P-51 progeny stood out for the characteristics associated with the commercial aspect of the ear, demonstrating greater length (17.94 cm), diameter (5.53 cm), and average ear mass (243.07 g), in addition to the high percentage of commercial ears (89.84%) and a yield of 10,182.3 kg ha^{-1}. Progenies P-60 and P-61 were notable for having the highest average ear yields at 12,064.2 ha^{-1} and 12,116.3 kg ha^{-1}, respectively. Additionally, P-60 showed precocity for the male (69.5 days) and female (78.5 days) cycle (Table 4).

Considering the minimum characteristics required for the commercialization of green corn in natura, for all half-sib progenies evaluated, measurements of length and diameter consistently exceeded standards, producing averages greater than 16 cm and 4 cm, respectively, which favor the acceptance of the product by the green corn consumer market (Table 4).

The literature indicates that populations under selection with low genotype divergence reduce the likelihood of broadening favorable genetic variability through recombination of selected individuals (Souza et al., 2002). By choosing groups with greater divergence, heterosis can be explored more efficiently through crossings between contrasting individuals (Rotili et al., 2012). Thus, in this experiment, half-sib progenies with high genetic divergence could be used in crossing schemes aimed at increasing the genetic variability.

Conclusion

Existence of favorable genetic variability among the progenies of corn half-sibs, making them well suited to green corn production for fresh consumption.

Genotypes from G1 stood out for presenting the best characteristics of interest and for containing a significant number of potential genotypes (52) similar to P-32. Together with G1, the three highlighted half-sib progenies (P-51, P-60, and P-61) could be used in the recombination step.

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