ARTICLE

Genetic variability and recurrent selection in corn population with potential for green corn production

Crop Breeding and Applied Biotechnology
21(4): e38332149, 2021
Brazilian Society of Plant Breeding.
Printed in Brazil
http://dx.doi.org/10.1590/1984-70332021v21n4a58

Maraiza Lima Costa[1], Willame dos Santos Candido[2], Jefferson Fernando Naves Pinto[1], Caíque Machado e Silva[3], Bruna Elaine de Almeida Silva[1] and Edésio Fialho dos Reis[1*]

Abstract: *The present study selected progenies, aiming at the production of green corn, by methods of intrapopulation recurrent selection with subsequent recombination, generating open-pollinated populations. To this end, in the 2017/2018 second season, progenies from the PMVJ01 population (originated from the recombination of progenies of the TG-02R2 x AG1051 cross) were evaluated, using PMVJ01 and the hybrid AG1051 as controls. The following parameters were evaluated: flowering, heights, green ear yield, husk cover, ear diameter and length, mass yield, ear shape, number of rows on the ear, alignment of rows, color of kernels, and husk width and length. Genetic parameters were estimated, and the gain was predicted with the selection of 20% of the progenies, using the index of Mulamba and Mock in four selection procedures and a fifth by multivariate method. Genetic variability was found in the population, which allows advances in the selection process. After recombination, two of the populations generated showed potential for use as open-pollinated cultivar.*

Keywords: *Predicted gain, selection index, grain yield of green ears, Zea mays L.*

INTRODUCTION

Corn (*Zea mays* L.) is one of the most important cereals worldwide and, in Brazil, has relevant importance in human and animal diets, besides the important social function, since it is a source of income and jobs for small producers and family farmers; it is one of the main inputs in animal production and integrates several culinary dishes. Among the various forms of use is green corn.

The nutritional, economic and social importance of green corn was highlighted by Grigulo et al. (2011) and Dovale et al. (2011), as well as the growing demand for its production; since this vegetable is appreciated and used in different parts of the country and in different forms: fresh, in typical dishes and even in the canning industry, which has been arousing the interest of producers. However, producers face a series of challenges, such as the scarcity of quality and affordable seeds. Faced with these difficulties, the need to develop specific cultivars for the production of green corn, which serve the consumer market and, at the same time, meet the producers' purchasing capacity, is evident (Shiferaw et al. 2011, Silva et al. 2020).

In view of this scenario, breeding uses key methods in the identification of superior genotypes and, in cases where the goal is to improve a population,

***Corresponding author:**
E-mail: edesioreis@ufj.edu.br
ORCID: 0000-0002-8000-3513

Received: 15 May 2021
Accepted: 22 November 2021
Published: 20 December 2021

[1] Universidade Federal de Jataí, Campus Jatobá, Cidade Universitária, 75.801-615, Jataí, GO, Brazil
[2] Universidade Federal do Piauí, Campus Universitário Ministro Petrônio Portella, 64.049-550, Teresina, PI, Brazil
[3] Universidade Federal de Viçosa, Departamento de Agronomia, Campus Universitário, 36.570-900, Viçosa, MG, Brazil

recurrent selection is one of the most used. This method consists of concentrating favorable alleles to the detriment of unfavorable ones and thus obtaining a population with an average higher than the average of the original population and, above all, without reducing its genetic variability (Hallauer et al. 2010, Amaral Júnior et al. 2013).

Given the need to gather a large number of traits in a population, especially in the case of green corn, breeding uses strategies such as simultaneous selection involving several traits, which allows the generation of a resultant composed of the combination of the set of genotypes based on the traits indicated by the breeder (Lima et al. 2018). In this context, the use of estimates of genetic parameters combined with selection indices contributes to a greater chance of success in obtaining promising genotypes (Rodrigues et al. 2011). Among the selection indices, the index of Mulamba and Mock (1978) allows the simultaneous combination of a set of traits predetermined by the breeder and the prediction of genetic gains that guide him in the selection process (Freitas et al. 2013).

Thus, the objective of this study was to generate open-pollinated populations which meet the specificities of the green corn production chain, as an alternative for small producers and family farmers.

MATERIAL AND METHODS

The experiment was composed of 167 half-sib families of the open-pollinated population PMVJ01 originated from the recombination of progenies of the cross between the population TG02R2 and the commercial hybrid AG1051. The population TG02R2 originates from the synthetic variety TG-02 (Miranda Filho et al. 2012) which, in previous experiments of the Plant Improvement Program of the Federal University of Goiás – Regional Jataí, underwent two cycles of recurrent selection aiming at the production of grains. The commercial hybrid AG1051 is widely cultivated by producers in the Midwest region for green corn production.

One hundred and sixty seven half-sib families of the PMVJ01 population were evaluated, along with the controls PMVJ01 and AG1051, in the 2017/2018 second season at the experimental farm of the Federal University of Goiás – Jataí Regional Unit (lat 17º 53’ S, long 52º 43’ W, alt 700 m asl). The controls were included for use as a reference in the experiment, but they were not included in the analysis of variance and parameter estimation. The experiment was established in a 13 x 13 lattice scheme with two replicates, in which the plots were represented by 4-m-long rows spaced by 0.9 x 0.2 meters and, after emergence, the stand was adjusted to 20 plants per row.

Fertilization was performed according to the results of soil chemical analysis, as recommended by Vergutz and Novais (2015). Two herbicide applications were performed after the initial desiccation to control the weeds present in the area, and one insecticide application was performed after seed treatment to control *Spodoptera frugiperda*.

The following traits were evaluated in the field: female flowering (FF) in GDU (unit of accumulated heat from the planting date until 50% of the plot showed visible stigma style); male flowering (MF) in GDU (unit of accumulated heat from the planting date until 50% of the plot was releasing pollen); plant height (PH) in meters (average of 5 plants); and ear height (EH) in meters (average of 5 plants).

Harvest was carried out when the ears reached the green corn stage (phenological stage R3), around 20 to 25 days after flowering (Pereira Filho 2002). Each plot was completely harvested and the following traits were evaluated, considering the total per plot: number of ears (NEar); number of ears with caterpillars (NE); unhusked ear weight (UEW) in kg and husked ear weight (HEW) in kg; considering 5 random ears per plot - husk cover (HC), where lower scores represent better husk cover (CIMMYT 1999); ear length (EL) in cm; ear diameter (ED) in cm; useful ear length (UL) in cm (average length of five random ears after removing the part without kernels); useful ear weight (UW) in kg (considering the five ears of the UL); number of rows on the ears (NR); alignment of rows on the ear (AL), where lower scores represent more straight alignment (Santos et al. 2005); ear shape (ES), where the highest scores represent the cylindrical shape of the ears (Santos et al. 2005); color of kernels (CLR), where lower scores represent lighter grain colors (Albuquerque et al. 2008) and mass yield (MY), in kg, considering the five useful ears, extracted with an electric grater (Botini, 001652/35. RME.02 model). Five ears still unhusked were evaluated for husk width (HW) in cm and husk length (HL) in cm.

All statistical analyses were performed using the computer program Genes (Cruz 2016). Analysis of variance was performed (Vencovsky and Barriga 1992); genetic parameters were estimated for half-sib families (Vencovsky and Barriga 1992, Cruz et al. 2012), and 20% of the best progenies were selected based on the rank sum index of Mulamba and Mock (1978), using four selection strategies, resulting in four groups of progenies for recombination, taking into account two commercial objectives and two others based on visual and production aspects, with weights and selection direction according to Table 1.

In addition to the four strategies mentioned, a fifth strategy was generated using the UPGMA clustering method based on the dissimilarity measurements obtained by the Mahalanobis generalized distance method (Cruz et al. 2014). This selection strategy made it possible to simultaneously use all the evaluated traits and to obtain the clustering of 24 progenies closer to the control hybrid (AG1051), widely used for green corn production.

After identification of the progenies, based on the five selection strategies, the recombination was performed, generating the five populations. These populations were tested in the 2018/2019 second season in a randomized block design with four replicates using the hybrid AG1051 as a control. The plots were composed of four 5-m-long rows, spaced by 0.9 x 0.2 m and, after emergence, the stand was adjusted to 25 plants per row.

Fertilization was performed according to the results of soil chemical analysis, as recommended by Vergutz and Novais (2015). Two herbicide applications were performed after the initial desiccation to control the weeds present in the area, and one insecticide application was performed after seed treatment to control *Spodoptera frugiperda.*

Table 1. Selection strategies with weights and desired direction

Strategies	Traits	Weights	Desired direction of selection
I	UW	02	Increase
	MY	03	Increase
	HW	02	Increase
	NE	02	Decrease
II	ED	02	Increase
	EL	02	Increase
	UL	02	Decrease
	NR	02	Increase
	AL	01	Decrease
	HC	01	Decrease
	ES	02	Increase
	NE	01	Decrease
III	UW	02	Increase
	HEW	02	Increase
	ED	01	Increase
	EL	05	Decrease
	NR	03	Decrease
	AL	01	Increase
	CLR	01	Increase
	NE	02	Decrease
IV	ED	02	Increase
	EL	02	Increase
	MY	01	Increase
	NR	02	Increase
	NE	03	Decrease

NE: number of ears with caterpillar, HC: husk cover, AL: alignment of rows on the ear, ES: ear shape, CLR: color of kernels, NR: number of rows on the ear, HEW: husked ear weight (kg), UW: useful weight of ears (kg), MY: mass yield (kg), EL: ear length (cm), ED: ear diameter (cm), UL: useful ear length (cm) and HW: husk width (cm).

The plots were identified in the pre-flowering period and, with the beginning of flowering, the following traits were evaluated: female flowering, in GDU; male flowering, in GDU; plant height in meters; ear height in meters. The useful plot (2 central rows) was harvested when the ears reached the green corn stage, around 20 to 25 days after flowering (phenological stage R3) (Pereira Filho 2002), and the following traits were evaluated: number of ears; unhusked ear weight in kg; husked ear weight in kg; number of marketable ears (length greater than or equal to 15 cm and diameter greater than or equal to 4 cm); weight of marketable ears in kg; and number of ears attacked by caterpillars. Considering 5 random ears per plot, the following traits were evaluated: husk cover, according to CIMMYT (1999); ear length in cm; ear diameter in cm; number of rows on the ears; alignment of rows on the ears, according Santos et al. (2005); ear shape, according Santos et al. (2005); color of kernels, according Albuquerque et al. (2008); and mass yield in kg.

Analysis of variance was performed according to Vencovsky and Barriga (1992), and Tukey test was applied at 5% probability level to establish a comparison between populations and with the hybrid control.

RESULTS AND DISCUSSION

The analysis of variance showed a significant difference ($p \leq 0.05$) among the 167 genotypes evaluated, for most traits, except for husk cover, alignment of rows, ear shape and useful length of the ears, in addition to husk width. This result suggests the existence of genetic variability in the PMVJ01 population, thus allowing the exploration of this variability, in order to improve the population with cycles of recurrent selection and prospects of gains in traits of interest.

The coefficients of variation (Table 2), for most traits, had low magnitude (below 10%), indicating good experimental accuracy and, therefore, reliability in the estimation of genetic parameters to be used to predict gains and, consequently, greater efficiency in the selection (Scapim et al. 1995, Fritschi-Neto et al. 2012, Berilli et al. 2013).

Table 2. Means of corn half-sib families ($\bar{X}_0$), of the control AG1051 ($\bar{X}_H$) and estimates of genetic variance among families (σ^2_G), mean phenotypic variance (σ^2_F), heritability based on the mean of families (h^2_m), experimental coefficient of variation (CV_e), genetic coefficient of variation (CV_g) and variation index (θ)

	Genetic Parameters							
Traits	$\bar{X}_0$	$\bar{X}_H$	σ^2_G	σ^2_F	h^2_m	CV_e (%)	CV_g (%)	θ
MF	947.042	944.300	174.780	259.680	67.310	1.380	1.400	1.010
FF	969.605	969.800	321.368	430.911	74.580	1.530	1.850	1.210
PH	2.244	2.375	0.002	0.010	23.040	5.500	2.130	0.390
EH	1.352	1.530	0.002	0.006	36.520	6.430	3.450	0.540
NE	5.173	2.500	2.793	5.489	50.890	45.030	32.410	0.720
HC	1.587	2.200	0.032	0.160	20.120	31.720	11.260	0.350
AL	1.959	1.800	0.005	0.055	9.370	16.030	3.650	0.230
ES	2.029	2.000	0.004	0.019	19.560	8.560	2.980	0.350
CLR	2.568	2.400	0.069	0.142	48.210	14.950	10.200	0.680
NR	15.041	16.600	0.313	0.642	48.830	5.390	3.720	0.690
UEW	5.254	6.021	0.099	0.201	49.220	8.590	5.980	0.700
HEW	2.898	3.456	0.052	0.112	46.960	11.860	7.890	0.665
UW	0.850	0.825	0.085*	0.335*	25.270	13.180	5.420	0.411
MY	0.465	0.490	0.068*	0.206*	32.950	17.660	8.750	0.495
EL	17.997	19.100	0.452	0.973	46.450	5.670	3.730	0.660
ED	4.402	4.500	0.011	0.040	26.030	5.540	2.320	0.420
UL	14.502	15.800	0.035	0.961	3.670	9.380	1.290	0.140
HW	21.880	22.750	0.321	1.709	18.800	7.610	2.590	0.340
HL	23.043	23.100	0.688	1.258	54.730	4.630	3.600	0.780

*: Values multiplied by 10^3. MF: male flowering (GDU), FF: female flowering (GDU), PH: plant height (m), EH: ear height (m), NE: number of ears with caterpillar, HC: husk cover, AL: alignment of rows on the ear, ES: ear shape, CLR: color of kernels, NR: number of rows on the ear, UEW: unhusked ear weight (kg), HEW: husked ear weight (kg), UW: useful weight of five ears (kg), MY: mass yield of five ears (kg), EL: ear length (cm), ED: ear diameter (cm), UL: useful ear length (cm), HW: husk width (cm) and HL: husk length (cm).

The means of the progenies were close to the means of the control hybrid (AG1051) (Table 2) for the traits male flowering, female flowering, ear shape, ear diameter and husk length. For husk cover, when compared to the means of the control AG1051 (Table 2), the set of progenies proved to be more appropriate than the hybrid AG1051, since lower means indicate ears better covered by the husk according to the scale of CIMMYT (1999). For ear height, the mean of the progenies was lower than that of the hybrid AG1051, which is favorable, as it reduces lodging.

The estimates of heritability (h^2_m) of progenies for male flowering and female flowering (Table 2) denote representativeness of the genetic value by the phenotypic value. Heritability values at the level of progeny means (Table 2) obtained for plant height and ear height, genetic coefficient of variation and variation index were relatively low, similar to those obtained by Faluba et al. (2010), studying the genetic potential of the UFV 7 population for improvement.

The traits related to production (unhusked ear weight, husked ear weight and mass yield) showed means slightly lower than those of the hybrid AG1051 (12.7%, 16.2% and 5%, respectively). However, the significant difference between the progenies, together with the values of CV_g (%), mean heritability (h^2_m) close to 50% and the variation indices close to the unit (Table 2), especially for the first two traits, indicate the possibility of success in the selection because, together, these parameters are indicators of selection efficiency.

It is important to note the combination between the parameters (h^2, CV_e, CV_g), and especially the variation index Θ, which can suggest ease and efficiency in the selection to improve these characteristics. This is because, in addition to the heritability greater than 50%, highlighting the greater representation of the genetic value in the phenotypic value, the values of θ close to or greater than the unit, as observed for the traits male flowering, female flowering, number of ears with caterpillars, color of grains, number of rows, weights with and without husk, ear length and husk length, indicate a favorable situation for selection (Vencovsky and Barriga 1992, Cruz et al. 2012).

According to Pereira Filho (2002) and Rodrigues et al. (2011), ears must have a color ranging from cream to yellow, with diameter greater than 3 cm and length greater than 15 cm, which corroborates the results found in the present study (Table 2), in which the average was greater than 4 cm for ear diameter and reached 18 cm for length, similar to the values reported by Paiva Júnior et al. (2001), Santos et al. (2005) and Ferreira et al. (2009).

Although the performance of the progenies for these traits is within the indicated standards, the selection for length is still justified by the lower means compared to the performance of the AG1051 hybrid, as well as for number of rows. Thus, the values of h^2_m and variation index (Table 2) reinforce that the selection on these traits can be performed efficiently. Such traits are of fundamental importance for the commercialization of green corn, as they influence the consumer's judgment about the quality of the product (Pereira Filho 2002, Rodrigues et al. 2011).

Table 3. Estimated mean productivity for corn half-sib families (HSF) and the control hybrid (AG1051)

	Productivity (kg ha^{-1})		
	UEW	**HEW**	**MY**
HSF	11675.25	6440.53	4018.01
AG1051	13379.99	7679.99	3405.55
Maximum (HSF)	15584.44	10324.44	7982.22
Minimum (HSF)	7660.66	3977.77	1668.88

UEW: unhusked ear weight (kg ha^{-1}), HEW: husked ear weight (kg ha^{-1}) and MY: mass yield (kg ha^{-1}).

The mean values of production of unhusked and husked ears (Table 2) were similar to those obtained by Câmara (2007) when studying green and dry grain productivity in 13 corn cultivars, including double, triple, synthetic and high-productivity compound hybrids. Thus, it is evident that, in the present study, these values did not show discrepancy compared to those observed for the control hybrid AG1051, which evidences the existence of high performance and productive progenies, verified by the maximum and minimum values, within the studied population (Table 3).

Producers and traders of green corn and typical dishes of the city of Jataí - GO, an important trait in production is the mass yield; 60 ears of corn are expected to have an average yield of 6.5 kg of fresh mass, and the hybrid AG1051 meets this expectation, being widely used in the preparation of typical dishes. The average productivity for mass yield of the progenies was similar to the productivity of the hybrid AG1051 (Table 3) and the maximum value obtained reaffirms the existence of progenies with high productive performance in the PMVJ01 population, showing the possibility of selection on this trait because, together with the genetic parameters related to it, it indicates a situation favorable to selection.

For the trait number of ears with caterpillars, all selection strategies (Table 4) showed expected progress in the desired direction, which indicates the possibility of successful selection on this trait. The expected gains were even greater with selection criteria I, which considered the traits useful weight, mass yield, husk width and number of ears with caterpillars, and IV, which considered the traits ear diameter and length, mass yield, number of rows on the ear and number of ears with caterpillars.

Likewise, the negative values for the traits husk cover, row alignment, ear shape and grain color, observed when using the second selection criterion (Table 4), also indicate progress with the selection in the desired direction, since the good cover of the ear reduces the possibility of depreciation of the product by pests, and the straight alignment of rows on the ear, its cylindrical shape and the light color of the grains are traits preferred by consumers (Pereira Filho 2002, Rodrigues et al. 2011). In this context, when proposing a selection criterion, one must consider the one that provides the best expected gains in the desired direction for the greatest number of traits possible.

Criterion I also revealed the best gains for the traits related to production, unhusked ear weight, husked ear weight, useful ear weight, fresh mass yield and husk width (Table 4), as expected, since these were considered directly in this criterion because they were components related to the production of sweet corn cake. Criteria II and III did not take into account mass yield, which contributed to their less favorable performance.

Considering the gains estimated in the first selection criterion (Table 4), it would be possible to increase the means of productivity (Table 3), from 11675.25 to 12119.25 kg ha^{-1} in unhusked ear weight, since the predicted gain for the criterion is 3.803%, from 6440.53 to 6709.55 kg ha^{-1} in husked ear weight, with predicted gain of 4.177% and from 4018.01 kg ha^{-1} to 4274.80 kg ha^{-1} in fresh mass yield, considering the predicted gain of 6.391%.

For husk cover and ear shape, the selection criterion II obtained the best gains (Table 4), which was also expected since the physical aspects of the unhusked and husked ears were considered. For alignment of rows, the highest predicted gain was achieved with criterion III and, for the color of kernels, the greatest gain is expected when using criteria V and

Table 4. Estimates of expected gain by the selection of corn half-sib families (GS %) for four selection criteria using the selection index of Mulamba and Mock (1978) and for the selection criterion which used the UPGMA clustering (criterion 5)

	GS (%)				
Trait	**Criterion I**	**Criterion II**	**Criterion III**	**Criterion IV**	**Criterion V**
MF	0.655	0.117	-1.459	0.852	0.077
FF	0.376	-0.315	-1.901	1.446	1.588
PH	0.503	0.491	0.253	0.359	0.140
EH	0.407	0.679	0.654	0.702	-0.116
NE	-10.610	-9.888	-9.270	-16.667	-2.986
HC	1.423	-0.417	0.426	0.886	0.436
AL	0.129	-0.495	-1.068	0.297	-0.420
ES	-0.247	-0.294	0.283	0.112	0.159
CLR	-0.186	-1.236	-4.817	0.319	-4.944
NR	1.012	1.730	0.368	1.088	1.170
UEW	3.803	2.579	2.653	2.920	0.469
HEW	4.177	2.783	3.222	3.333	1.398
UW	3.299	1.955	1.802	2.473	0.993
MY	6.391	2.916	2.140	4.185	1.166
EL	0.767	1.850	1.277	1.467	0.893
ED	1.175	0.568	0.344	1.126	0.475
UL	0.119	0.238	0.110	0.138	0.029
HW	0.844	0.387	0.066	0.485	-0.092
HL	0.115	0.893	0.871	0.035	0.232

MF: male flowering (GDU), FF: female flowering (GDU), PH: plant height (m), EH: ear height (m), NE: number of ears with caterpillar, HC: husk cover, AL: alignment of rows on the ear, ES: ear shape, CLR: color of kernels, NR: number of rows on the ear, UEW: unhusked ear weight (kg), HEW: husked ear weight (kg), UW: useful weight of ears (kg), MY: mass yield (kg), EL: ear length (cm), ED: ear diameter (cm), UL: useful ear length (cm), HW: husk width (cm) and HL: husk length (cm).

III. For the latter, a gain is calculated directly, because this trait was considered as an important aspect in the selection of ears for fresh consumption (Pereira Filho 2002).

For ear length, better gains were observed using the criteria II, III and IV, being higher for the first. These criteria considered ear length directly in the selection, which makes it possible to affirm that the selection for this trait can be easily performed. For ear diameter, the criteria I and IV stood out, achieving greater gains. For useful length, number of rows, and husk length, criterion II predicts a better performance for these traits after selection.

The Tukey test at 5% probability level for the five populations (five selection criteria) after the recombination is presented in Table 5, which shows the similarity between the five populations and the control hybrid, since a significant difference was detected between them only for unhusked ear weight, husked ear weight, number of marketable ears and weight of marketable ears.

The population generated by criterion V was inferior to the hybrid for all four traits that showed significant difference, which leads to the conclusion that the UPGMA clustering method had lower efficiency in the selection of progenies with good production performance. This is consistent with what was observed in the expected gain, confirming that it was not a good selection procedure.

Populations I and IV did not show a significant difference at 5% probability level by Tukey test in comparison to the control hybrid AG1051, which confirms the existence of progenies with good production performance that composed these populations and also demonstrates the efficiency of the selection method, based on the Selection Index of Mulamba and Mock (1978), as also observed by Berilli et al. (2013), Freitas et al. (2013) and Candido et al. (2020). This behavior is in line with the prediction of gains, since strategies I and IV showed better gain expectations for traits related to production components. The performance of strategies II and III may be associated with the use of quantitative traits in the process of selection.

Populations II and III performed worse than the hybrid AG1051 for the traits unhusked and husked ear weights (population II) and weight of marketable ears (population III) (Table 5), which is justified by the method of selection,

Table 5. Means of 18 traits evaluated in five populations promising for green corn, obtained by selection and recombination, and the commercial control AG1051

Traits	Populations I		II		III		IV		V		AG1051	
MF	947.37	a	940.31	a	933.12	a	936.46	a	940.31	a	918.35	a
FF	954.29	a	964.95	a	936.59	a	957.48	a	954.44	a	964.80	a
PH	2.01	a	1.96	a	2.03	a	1.98	a	1.97	a	2.09	a
EH	1.31	a	1.27	a	1.30	a	1.30	a	1.25	a	1.37	a
NE	2.00	a	1.85	a	2.00	a	1.85	a	1.95	a	2.65	a
HC	3.34	a	3.10	a	2.70	a	3.15	a	3.45	a	2.60	a
AL	2.05	a	2.00	a	2.10	a	2.10	a	2.40	a	2.25	a
ES	2.15	a	2.20	a	2.00	a	2.05	a	2.10	a	2.10	a
CLR	1.00	a	1.00	a	1.25	a	1.25	a	1.00	a	1.25	a
NR	15.25	a	18.00	a	18.75	a	16.75	a	14.75	a	20.25	a
UEW	5.15	ab	4.57	ab	4.49	ab	5.22	ab	3.46	b	8.06	a
HEW	4.98	ab	4.76	b	5.08	ab	4.89	ab	4.61	b	6.03	a
UW	2.98	ab	2.90	b	3.15	ab	3.02	ab	2.84	b	3.65	a
MY	0.89	ab	0.82	ab	0.80	b	0.96	ab	0.63	b	1.66	a
EL	17.05	a	18.20	a	18.65	a	16.75	a	17.00	a	17.90	a
ED	4.25	a	4.20	a	4.20	a	4.10	a	4.00	a	.35	a
UL	14.70	a	15.90	a	14.80	a	14.90	a	15.20	a	16.10	a
HW	0.38	a	0.42	a	0.42	a	0.40	a	0.32	a	0.50	a

MF: male flowering (GDU), FF: female flowering (GDU), PH: plant height (m), EH: ear height (m), NE: number of ears with caterpillar, HC: husk cover, AL: alignment of rows on the ear, ES: ear shape, CLR: color of kernels, NR: number of rows on the ear, UEW: unhusked ear weight (kg), HEW: husked ear weight (kg), UW: useful weight of ears (kg), MY: mass yield (kg), EL: ear length (cm), ED: ear diameter (cm), UL: useful ear length (cm), HW: husk width (cm) and HL: husk length (cm).

which directly considered the traits related to the physical aspects of the ears (alignment, shape, length, diameter, etc.) and production with a view to fresh consumption (number of rows, alignment, color, etc.), respectively.

The productivity of unhusked and husked ears, in the green stage, with the projection of the production of plots (Table 5) per hectare, ranged from 5.12 t ha^{-1} (population V) to 5.64 t ha^{-1} (population III) and from 3.15 t ha^{-1} (population V) to 3.49 t ha^{-1} (population III), respectively. In the hybrid AG1051, the productivity of unhusked and husked ears was 6.03 t ha^{-1} and 3.65 t ha^{-1}, respectively. Similar results were obtained by Moraes et al. (2010), when studying commercial cultivars of green corn in São Paulo, and by Rodrigues et al. (2018), with unhusked ear productivity ranging from 5 to 8 t ha^{-1} and husked ear productivity ranging from 3 to 5 t ha^{-1} in the 2014/15 season. As it is the first cycle of recurrent selection, aiming at the production of green corn, the results were promising, in addition to the possible use of the best populations for green corn production, with new cycles of recurrent selection.

The study revealed promising results in the first selection cycle, indicating the possible use of the best populations in new cycles of recurrent selection for the production of green corn. The selection criteria based on the index of Mulamba and Mock (1978) were more suitable for predicting gains and populations I and IV showed better estimates of gains for traits related to production, after recombination, with behavior similar to that of the control hybrid.

REFERENCES

Albuquerque CJB, Von Pinho RG, Borges ID, Souza Filho AX and Fiorini IVA (2008) Desempenho de híbridos experimentais e comerciais de milho para produção de milho verde. **Ciência e Agrotecnologia 32**: 768-775.

Amaral Júnior TA, Gonçalves LSA, Freitas Júnior SP, Candido LS, Vittorazzi C, Pena GF, Ribeiro RM, Silva TRC, Pereira MG, Scapim CA, Viana AP and Carvalho GF (2013) UENF 14: a new pop corn cultivar. **Crop Breeding and Applied Biotechnology 13**: 218-220.

Berilli APCG, Pereira MG, Trindade RS, Costa FR and Cunha KS (2013) Response to the selection in the 11th cycle of reciprocal recurrent selection among full-sib progenies of maize. **Acta Scientiarum Agronomy 35**: 435-441.

Câmara TMM (2007) Rendimento de grãos verdes e secos de cultivares de milho. **Revista Ceres 54**: 87-92.

Candido WS, Machado SC, Costa ML, Silva BEA, Miranda BL, Pinto JFN and Reis EF (2020) Selection indexes in simultaneous increment of yield components in topcross hybrids of green maize. **Pesquisa Agropecuária Brasileira 55**: e01206.

CIMMYT (1999) **Managing trials and reporting data for CIMMYT's international maize testing program**. CIMMYT, México, 20p.

Cruz CD (2016) Genes software – extended and integrated with the R, Matlab and Selegen. **Acta Scientiarum. Agronomy 38**: 547-552.

Cruz CD, Carneiro PCS and Regazzi AJ (2014) **Modelos biométricos aplicados ao melhoramento genético**. Editora UFV, Viçosa, 668p.

Cruz CD, Regazzi AJ and Carneiro PCS (2012) **Modelos biométricos aplicados ao melhoramento genético**. Editora UFV, Viçosa, 514p.

Dovale JC, Fritsche-Neto R and Silva PSL (2011) Selection index of maize cultivars with twice fitness: baby corn and green corn. **Bragantia 70**: 781-787.

Faluba JF, Miranda GV, Delima RO, Souza LV, Debem EA and Oliveira AMC (2010) Potencial genético da população de milho UFV 7 para o melhoramento em Minas Gerais. **Ciência Rural 40**: 1250-1256.

Ferreira R, Gardingo JR and Matiello RR (2009) Seleção de progênies de irmãos germanos destinadas à produção de milho-verde. **Scientia Agraria 10**: 023-030.

Freitas ILJ, Amaral Júnior AT, Viana AP, Pena GF, Cabral PS, Vittorazzi C and Silva TRC (2013) Ganho genético avaliado com índices de seleção e com REML/BLUP em milho-pipoca. **Pesquisa Agropecuária Brasileira 48**: 1464-1471.

Fritsche-Neto R, Vieira RA, Scapim CA, Miranda GV and Rezende LM (2012) Updating the ranking of the coefficients of variation from maize experiments. **Acta Scientiarum Agronomy 34**: 99-101.

Grigulo ASM, Azevedo VH, Krause W and Azevedo PH (2011) Behavior of genotypes of corn in the expenditure in nature in Tangará da Serra, state of Mato Grosso, Brazil. **Bioscience Journal 27**: 603-608.

Hallauer AR, Carena MJ and Miranda Filho JB (2010) **Quantitative genetics in maize breeding**. Springer, New York, 664p.

Lima VJ, Freitas Júnior SP, Souza YP, Silva CS, Farias JEC, Souza RF, Chaves MM and Feitosa JV (2018) Genetic gain capitalization in the first cycle of recurrent selection in popcorn at Ceará's Cariri. **Revista Brasileira de Ciências Agrárias 13**: e5556.

Miranda Filho JB, Reis EF, Oliveira AS and Rodrigues LO (2012) Desenvolvimento de sintéticos de milho para o sudoeste de Goiás, In **Congresso nacional de milho e sorgo**. ABMS, Sete Lagoas, p. 2710-2716.

Moraes ARA, Junior EUR, Gallo PB, Paterniani MEAGZ, Sawasaki E, Duarte AP, Bernini CS and Guimarães OS (2010) Desempenho de oito cultivares de milho verde na safrinha, no estado de São Paulo. **Revista Brasileira de Milho e Sorgo 9**: 79-91.

Mulamba NN and Mock JJ (1978) Improvement of yield potential of the Eto Blanco maize (*Zea mays* L.) population by breeding for plant traits. **Egyptian Journal of Genetics and Cytology 7**: 40-51.

Paiva Júnior MC, Von Pinho RG, Von Pinho EVR and Resende SG (2001) Desempenho de cultivares para a produção de milho verde em diferentes épocas e densidades de semeadura em Lavras-Mg. **Ciência e Agrotecnologia 25**: 1235 –1247.

Pereira Filho IA (2002) **O cultivo do milho verde**. Embrapa, Sete Lagoas, 217p.

Rodrigues F, Von Pinho RG, Albuquerque CJB and Von Pinho ÉVR (2011) Índice de seleção e estimativa de parâmetros genéticos e fenotípicos para características relacionadas com a produção de milho-verde. **Ciência e Agrotecnologia 35**: 278-286.

Rodrigues FP, Melo GS, Resende CLP, Mrojinski F, Mendes RC and Silva MA (2018) Aptidão de híbridos de milho para o consumo *in natura.* **Revista de Ciências Agrárias 41**: 484-492.

Santos IC, Miranda GV, Melo AV, Mattos RN, Oliveira LR, Lima JS and Galvão JCC (2005) Comportamento de cultivares de milho produzidos organicamente e correlações entre características das espigas colhidas no estádio verde. **Revista Brasileira de Milho e Sorgo 4**: 45-53.

Scapim CA, Carvalho CGP and Cruz CD (1995) Uma proposta de classificação dos coeficientes de variação para a cultura do milho. **Pesquisa Agropecuária Brasileira 30**: 683-686.

Shiferaw B, Prasanna BM, Hellin J and Banziger M (2011) Crops that feed the world 6. Past successes and future challenges to the role played by maize in global food security. **Food Security 3**: 307.

Silva CM, Candido WS, Almeida PHS, Costa ML, Silva BEA, Pinto JFN and Reis EF (2020) Yield potential of green maize from partially inbred lines in top crosses. **Australian Journal of Crop Science 14**: 140-149.

Vencovsky R and Barriga P (1992) **Genética biométrica no fitomelhoramento**. Editora USP, Ribeirão Preto, 496p.

Vergutz L and Novais RF (2015) Recomendação de corretivos e adubação. In Borem A, Galvão JCC and Pimentel MA (eds) **Milho: do plantio a colheita**. Editora UFV, Viçosa, p. 107.