Estimation of genetic parameters and prediction of gains for DFT1-Ribeirão popcorn population

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ABSTRACT

In order to evaluate the potential for improvement of DFT1- Ribeirão popcorn populations by estimating the genetic parameters and prediction of gains with selection among half-sib families, 121 half-sib families extracted from that population were evaluated . The lattice was used with two replications. Elevated grain yield and acceptable popping expansion (PE) were observed. Additive genetic variance was significant for most of the evaluated characters, including productivity and PE. The narrow sense heritabilities were 67.84% (grain yield) and 60.97% (PE). The DFT–Ribeirão population produced 4918.0 kg/ha and 20 mL/g PE, which can be reduced to 4724.0 kg/ha and PE 23 mL/g in the next cycle. Ten families were selected based on PE and proportion of lodge plants (PLP). A 35% decrease in PLP, 9.58% gain in PE and 2.67% decrease in grain yield are expected in the base population. It may be concluded that DFT1–Ribeirão population shows additive genetic variability of the principal characters and adequate mean grain yield; popping expansion limitations and lodge plant and ear disease percentages. In the next cycle, the population will show a reduced lodge percentage, and increased PE, maintaining the same grain yield, thus having a potential to be used in popcorn breeding programs.

KEY WORDS: Half-Sibs, lattice, independence elimination level.

INTRODUCTION

Brazil imports popcorn from the United States and Argentina, in spite of the edaphoclimatic conditions adapted for cultivation. Brazilian popcorn consumption has gradually increased, thus it is necessary to develop cultivars adapted to the Brazilian conditions and popcorn with quality similar or superior to that of imported cultivars. Therefore, the use of local populations is fundamental in popcorn improvement programs in tropical regions, since they are adapted to the ordinary stresses in these places.

The potential of improvement for popcorn populations can be evaluated by estimating the components of genetic variance provided through experimental testing methods used (Hallauer and Miranda Filho, 1981). Many authors reported improvement of popcorn populations. Lira (1983) applied the among and within selection method with half-sib families (‘modified ear-to-row’) and Linares (1987) used the reciprocal recurrent selection in half-sib families to estimate genetic parameters and improve local popcorn populations. Zanette (1989) used diallel analysis to evaluate genetic variability in the following six F2 hybrid populations : P 203, P 405, P 410, P 608, P 609 and P 62174, originated from the University of Iowa, USA. Andrade (1996) estimated the components of genetic variance of local Brazilian popcorn populations using diallel analysis. Pacheco et al. (1998) estimated genetic parameters in CMS 42 and CMS 43 popcorn populations. Pereira and Amaral Filho (2001) applied the nested design to estimate the genetic components of a Brazilian popcorn population. Granate et al. (2001) used selection indices to compare the predicted gains of the CMS 43 population using166 half-sib families.

Among the methods employed in corn improvement, the selection method among and within families has presented the best results, being mainly used by breeders for estimating variance components. This method, as well as the others used in maize, can be applied in popcorn improvement. According to Lonnquist (1964), the selection method among and within half-sib families increase of the frequency of favorable genes without elevating endogamy and the precision of the within population selection, without requiring manual pollination, besides being easy and inexpensive.

This work aimed to estimate genetic components and predict gains to evaluate the potential for improvement of DFT1-Ribeirão popcorn population.

MATERIAL AND METHODS

This work was conducted at the Experimental Station of the Universidade Federal de Viçosa, in Coimbra, Minas Gerais, Brazil.

The improvement method used was the selection among half-sib families, adapted by Lonnquist (1964). DFT1-Ribeirão, an open-pollinated variety, originated from crosses between indigenous composites and exotic cultivars, after three cycles of half-sib selections of ears and type of grains.

A sample of the original population was set in the ground on April, 1998, in a field isolated in time and space from other maize crops. A total of 121 half-sib families were selected by applying the half sib selection considering disease incidence, prolific plants and, type and color of kernel and ear.

The half-sib families and in-between checks were evaluated in 1998. The checks consisted of the simple hybrid IAC 112, the three way cross Zélia and the open-pollinated variety RS 20. The experimental design was an 11x11 lattice , with two replicates. Each progeny was evaluated in a five m long, two-row plot, spaced 0.9 m between rows and 0.20 meter between plants within rows.

The fertilizers used for sowing were 500 kg/ha of 4-14-8 (N-P-2O5-K2O). The estimated population was 55 thousand plants/hectare and 30 kg/ha of N applied 21 days after emergence.

The characters were final stand (FS), plant height (PH, m), prolific plant (PRL), grain yield (GY, kg/4.5 m^2), number of tassel ramifications (NTR), proportion of lodge plants (PLP), proportion of diseased ears (PDE) and popping expansion (PE, mL/g). Popping expansion is the ratio of volume after popping and weight of 30 mL non-popped kernel. PE was evaluated in a hot air electric popper without oil. The kernels were placed in the popper after it reached the temperature of 100°C. The volume of the expanded popcorn was measured in a graded beaker in 1000 mL.

The analysis of variance of the lattice with an adjusted treatment was performed according to the linear model suggested by Cochran and Cox (1957). It was assumed that all effects were random. For PE evaluation, the lattice structure was disregarded and a trial was arranged in a randomized block design with 109 progenies and two replications. The expected mean squares were obtained according to Viana (1993) and the variance components were estimated. Selection was carried out by adopting independent elimination levels for PE and PLP.

The progenies selected were recombined and a selection among plants within progenies was conducted to obtain new progenies to start another cycle.

Statistical analyses were performed using the GENES program (Cruz, 1997).

RESULTS AND DISCUSSION

The confirmation of significant genetic variability among progenies for ST, PH, GY, NTR, PLP, and PE characters by the test F with 5% probability is shown in (Table 1). The genetic variability among half-sib progenies suggests the existence of an addictive genetic variance in the base population for these characters, indicating likely genetic gains by the selection methods. In this case, variability of the final stand was not randomized, since lower germination and greater plant mortality in some

Table 1. Mean Square of Analysis of variance for final stand (ST), plant height (PH, m), prolificacy (PRL), grain yield (GY, kg/4.5m^2), number of tassel ramification (NTR), percentage of lodge plants (PLP), percentage of disease ears (PDE) and, popping expansion (PE, mL/g) in popcorn cultivars in a half-sib experiment in Coimbra, MG.

	Mean Square								
FV	D.F.	ST	HP	PRL	GY	NTR	PLP	PDE	PE [1/]
Replicates	1	13.4	1.53	0.04	4.33	6.70	0.03	0.12	-
Bl/rep (n.aj.)	20	26.3	0.09	0.15	0.48	8.49	0.17	0.001	-
Progenies (aj.)	120	29.4 [2/]	0.03 [2/]	0.07 [ns]	0.4 [2/]	8.12 [2/]	0.07 [2/]	0.01 [ns]	16.3 [2/]
Error	100	11.1	0.01	0.05	0.13	3.56	0.03	0.02	6.33
Mean		22.1	2.1	1.63	2.21	15.6	28.4	17.7	19.7
CV(%)		14.6	6.04	14.1	16.1	12.4	66.0	61.5	12.8
Lattice efficiency (%)		7	35	13	21	2	55	5.3	-

[1/] (PE) D.F. = 108; [2/, ns] significant and non-significant, by the F test, respectively.

treatments, as compared to others, probably due to genetic and non- environmental causes, since the corresponding ears were harvested and stored similarly. Genetic variability among progenies was not significant in PRL and PDE.

Table 2 shows that the variation index value (θ) was close to 1.0, but the GY estimation value was higher. According to Vencovsky and Barriga (1992), variation index values close to 1.0 show a favorable condition for selection, i.e., easiness to get gains by selection.

Plant height heritability was 60.47%, a value close to that (63%) found by Pereira and Amaral Júnior (2001).The heritability values were also considered intermediate to the other characters, i.e., the selection based on these characters tends to be efficient. Ear height has a significant additive genetic correlation with plant height. Pacheco et al. (1998) obtained heritabilities of 31.9% and 36.5% to ear height for CMS 42 and CMS 43 popcorn populations, respectively.

Gy presented the highest heritability (67.84%) regarding family average level (h^2), markedly contrasting to that (17.85%) found by Pereira and Amaral Júnior (2001), using another Brazilian popcorn population. Pacheco et al. (1998) found ear weight heritabilities of CMS 42 and CMS 43 populations of 27.4 and 49.2%, respectively. PE heritability was 60.97%, a value close to those found by Lira (1983), 58.77% and Pacheco et al. (1998), 57.6 % for the CMS 42 population and 60.1% for the CMS 43 population. Pereira and Amaral Júnior (2001) found a heritability value of 82.72% for PE.

Table 3 shows character averages for the DFT1-Ribeirão population. DFT1-Ribeirão population plant height was intermediary to that of RS 20 and IAC 112 cultivars, and it may be considered commercially adequate. The high average for GY reflected the great potential of this population. The check, cv. Zélia, showed the highest grain yield (5,400.0 kg/ha). The grain yield average in this work was superior to those found by Lira (1983), Linares (1987), Andrade (1996), Pereira and Amaral Júnior (2001) and Nunes (2002), who used local populations similar to that discovered by Galvão et al. (2000), who used popcorn hybrids at the same experimental station.

Although superior to the minimum accepted for trading (15 mL/mL), DFT1-Ribeirão Population PE was inferior to the elite cultivar average , indicating the need for improvement, as normally verified in local popcorn populations. Check cultivars showed a similar PE value of 28 mL/g. These values are very close to that found by Nunes (2002) who used nine cultivars at four sowing dates during two years, and

Table 2. Estimates of genetic parameters for plant height (PH, m), grain yield (GY, kg/4.5m^2), number of tassel ramification (NTR), percentage of lodge plants (PLP) and popping expansion (PE, mL/g) in popcorn cultivars in half-sib experiment in Coimbra, MG[1/].

Parameters	PH	GY	NTR	PLP	PE
$\hat{\theta}$	0.8605	1.0853	0.8151	0.7587	0.8837
$\hat{\sigma}^2_A$	0.0460	0.5881	9.9605	0.0812	19.7738
H^2 (%)	60.47	67.84	56.19	54.54	60.967
SG (%)	0.329	-2.667	1.125	-35.939	9.583

[1] variation index $\theta = CV_g/CV$, CV_g, genetic coefficient of variation and additive genetic variance (σ^2_A), heritabilities in restrict sense in family mean level (H^2) and selection gain (GS%), based on independent elimination level.

Table 3. Means for plant height (PH, m), grain yield (GY, kg/4.5m^2), popping expansion (PE, mL/g), number of tassel ramification (NTR), percentage of lodge plants (PLP) and prolificacy (PRL), in the base population (DFT1 (C_0)), breeding population (DFT1 (C_1)) and check cultivars IAC 112, RS 20 and Zélia.

	PH (m)	GY (kg/ha)	PE (mL/g)	NTR	PLP (%)	PRL
DFT1 (C_0)	2.06	4918	20	15.49	28.44	1.63
DFT1 (C_1)	2.07	4724	23	15.80	9.70	1.58
IAC 112	2.23	5300	28	15.40	10.34	1.71
RS 20	1.78	2867	28	17.60	40.73	1.23
ZÉLIA	2.03	5400	28	13.60	9.65	1.57

the same type of popper for PE evaluation. Comparing PE values found in different works must be carefully made since the instruments used for PE evaluation and the units used to determine it can be of different types, rendering the comparison invalid (Matta et al., 2000).

The DFT1 popcorn population showed a higher percentage of lodge plants than the checks, IAC 112 and Zélia. The NTR was similar between the checks and DFT1, but these values are greater to popcorn cultivars than those found to ordinary maize cultivars. The average PRL was 1.63 ears/plant, thus it can be considered to be a prolific population. The PDE value was 17.7%, considered above the commercial standard.

Due to the negative additive genetic correlation (-0.3064) between GY and PE (Coimbra et al., 2001), a selection index that allowed simultaneous gains for these characters could not be found. As the average of GY was satisfactory, this character was not included in the index, thus, minimum level for PE character (20.48) and maximum level to PLP (18.87%), which were arbitrarily fixed, were considered using the independent elimination level.

Ten progenies were selected for recombination and within each one 20 plants were selected, obtaining 200 progenies or half-sib families for the next cycle. In the next cycle, the GY may reduce to 2.67% of base population and, genetic gain of 9.58% to PE using this strategy selection. Even so, the grain yield must maintain to a satisfactory level (tables 2 and 3). A small increase tendency may be observed in plant and number of tassel ramifications. PLP is estimated to have a significant reduction (35.9%). A PE gain and a low PLP are expected to occur when using this selection method.

The genetic parameters are probably over-estimated since the selection was performed only in one environment, and it was impossible to isolate the variance component of genotype x environment interaction. However, because this population is recommended for the region where the selection was performed, there will not be great consequences and gain will be optimum.

CONCLUSIONS

The DFT1-Ribeirão population shows an additive genetic variability for the principal characters of agronomic interest, presenting potential to be use in improvement programs.

The DFT1-Ribeirão population shows an adequate value to PE, high average of grains productivity and limitations for plants lodge and proportion of diseased ears.

Using selection, a reduction of the number of lodge plants, an increase for PE and maintenance to high grain yield will be expected.

ACKNOWLEDGEMENTS

The authors thank CAPES for financial support, Dr. Devanir Mitsuyiki Murakami for proving the popcorn population, the Coimbra Experimental Station employees and the students of Agronomy of Programa Milho ®, Universidade Federal de Viçosa.

RESUMO

Estimação de parâmetros genéticos e predição de ganhos para a população de milho-pipoca DFT1-Ribeirão

Com o objetivo de avaliar o potencial para melhoramento da população de milho-pipoca DFT1-Ribeirão por meio da estimação de parâmetros genéticos e predição de ganhos com seleção entre famílias de meios-irmãos, foram avaliadas 121 famílias extraídas desta população. Utilizou-se o látice com duas repetições. A variância genética aditiva foi significativa para a maioria dos caracteres avaliados, inclusive para produção de grãos e CE. As herdabilidades no sentido restrito foram de 67,84% para a produção de grãos e de 60,97 para CE. A população DFT1-Ribeirão produziu 4.918,0 kg/ha e CE de 20 mL/g e para o próximo ciclo, provavelmente produzirá 4.724,0 kg/ha e CE com 23 mL/g. Foram selecionadas 10 famílias com base em CE e proporção de plantas acamadas (PPA). Espera-se redução de 35% na PPA, aumento de 9,58% para CE e redução de 2,67% na produtividade de grãos em relação à população base. Conclui-se que a população DFT1–Ribeirão apresenta variabilidade genética aditiva para os principais caracteres, valor adequado para produtividade de grãos, valores limitados para capacidade de expansão, porcentagem de plantas acamadas e porcentagem de espigas doentes; no próximo ciclo, esta população apresentará redução de porcentagem de plantas acamadas, aumento da capacidade de expansão e manutenção da produtividade de grãos; a população apresenta potencial para uso em programas de melhoramento de milho-pipoca.

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Received: May 17, 2001;

Accepted: December 17, 2001.