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EXPECTED AND REALIZED GAINS IN THE CMS-39 MAIZE POPULATION AFTER THREE CYCLES OF HALF-SIB FAMILY SELECTION*

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ABSTRACT

The CMS-39 maize population synthesized by the National Center of Research for Maize and Sorghum (CNPMS/EMBRAPA) was submitted to half-sib family selection for grain yield. Populations representing the original cycle (C_0), and cycles I, II, and III, were evaluated in randomized complete blocks with ten replications in Sete Lagoas, Lavras, Ribeirão Vermelho, and Santo Antônio do Amparo, Minas Gerais State, Brazil. The purpose was to evaluate the observed gain from selection and to compare it with the gain expected based on parameter estimates at each selection cycle. The realized gain per cycle, reported as the average for the four cycles was 3.6%. This value was smaller than the average expected gain per cycle, which was 7.2%. The main reasons for the non-agreement of these estimates are discussed.

INTRODUCTION

Even though in maize culture has the largest amount of genetic and phenotypic parameter estimates available, comparisons between expected and realized gains have been made in few situations and often with contradictory results. Good agreement between expected and realized gains has been reported by Vencovsky (1968), Gardner

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(1977) and Compton and Bahadur (1977), whereas a marked discrepancy between these estimates has been reported by Burton *et al.* (1971) and by Penny and Eberhart (1971).

The maize population CMS-39 was submitted to several cycles of recurrent half-sib family selection (Aguiar, 1986; Pacheco, 1987; Arriel, 1991). The experimental results permit the determination of the magnitude of parameter estimates and of expected genetic gain in relation to realized gain.

MATERIAL AND METHODS

The maize population CMS-39 was synthesized by the National Center of Research on Maize and Sorghum (CNPMS) from the hybridization of 55 materials. These materials consisted of single, double and intervarietal hybrids, and also of some free-pollinated varieties which gave outstanding results in the National Maize Trial.

CMS-39 populations representing the original cycle (C_0) and cycles I, II and III were evaluated using half-sib families. The populations of cycles I, II and III were obtained by Aguiar (1986), Pacheco (1987) and Arriel (1991), respectively.

The populatisons representing the different cycles were tested in randomized complete blocks with then replications during the 1990/91 agricultural year in the municipalities of Sete Lagoas, Lavras, Ribeirão Vermelho, and Santo Antônio do Amparo, all in the state of Minas Gerais. The experimental plots consisted of four 5-m long rows spaced 1.0 m apart, planted at a density of five plants per linear meter. The plants were treated as recommended for maize crops. Grain yield data per plot were obtained with 14.5% humidity.

Grain yield data obtained in the four experiments were submitted to analysis of variance per location and to joint analysis of variance.

The response to selection was analyzed according to the linear regression model of Steel and Torrie (1980):

$$Y_i = m + bX_i + \varepsilon_i,$$

where Y_i is the mean yield observed in cycle i, m is the overall mean, b is the linear regression coefficient which represents the selection gain per cycle, X_i is selection cycle i (i = 0, 1, 2, 3), and ε_i is the experimental error associated with the observed mean i.

RESULTS AND DISCUSSION

Individual analyses of variance for kernel weight (kg/ha) showed differences between selection cycles in the trials conducted at Lavras and Ribeirão Vermelho (Table I).

At all locations, mean grain yield was high, ranging from just over 6.000 to more than 6.600 kg/ha (Table I).

Table I - Summary of analysis of variance of grain yield data (kg/ha) obtained at Sete Lagoas, Lavras, Ribeirão Vermelho and Santo Antônio do Amparo (MG), 1990/91.

S.V.	d.f.	MS(x 10^{-3})			
		Sete Lagoas	Lavras	R. Vermelho	S.A. Amparo
Cycles	3	714.80	1828.86*	1208.42*	461.80
Error	27	507.88	610.88	496.21	639.77
Means (kg/ka)		6245.46	6628.17	6099.28	6024.55
C.V. (%)		11.41	11.79	11.55	13.30

*F test significant at the 5% level of probability.

The results of joint analysis of variance showed significance ($P < 0.01$) for location and cycle (Table II). The same was not observed for the cycle x location interaction, indicating that the cycles tested showed concordant behavior over locations. The response to selection cycles was linear (Table III).

Table II - Summary of joint analysis of variance of grain yield data (kg/ha) obtained at Sete Lagoas, Lavras, Ribeirão Vermelho and Santo Antônio do Amparo (MG), 1990/91.

S.V.	d.f.	MS (x 10^{-3})
Locations (L)	3	5,132.9**
Cycles (C)	(3)	3,278.9**
Linear	1	9,278.0**
Deviation	2	412.3
C x L	9	311.7
Mean error	108	563.7
Mean		6,246.87
C.V. (%)		12.02

**F test significant at the 1% level of probability.

Table III - Mean grain yield (kg/ha) observed during the various selection cycles, 1990/91.

Cycles	Locations				Means	
	Sete Lagoas	Lavras	R. Vermelho	S. Antônio Amparo	Observed	Expected
0	5959.0	6014.0	5671.0	5760.0	5851.0	5928.0
1	6076.0	6900.0	6013.0	5943.0	6233.0	6140.0
2	6457.0	6661.0	6216.0	6266.0	6400.0	6352.0
3	6489.0	6938.0	6497.0	6088.0	6503.0	6564.0
m	5950.0	6248.0	5697.0	5818.0		5928.0
b	197.0 ± 100.8	253.0 ± 100.5	268.0 ± 99.6	131.0 ± 113.1		212.0 ± 53.1
GS (%)	3.3	4.0	4.7	2.3		3.6

m, Expected mean for the original population; b, realized gain per selection cycle ± standard error; GS (%), percent gain in relation to the original population mean.

Observed means and means estimated by regression, as well as percent gain realized by selection are presented in Table III. The regression coefficient corresponding to realized gain per selection cycle was 212 kg/ha. When compared to the mean of the original cycle, this gain was 3.6% per cycle and consequently per year since recombination was performed in the winter and therefore the two generations of each cycle were produced within a single year.

From the estimates of expected gain by half-sib family selection of population CMS-39, obtained by Aguiar (1986) in the first selection cycle (10.3%), by Pacheco (1987) in the second cycle (4.0%) and by Arriel (1991) in the third cycle (7.3%), the mean expected gain per cycle was calculated as 7.2%. This value was double the realized gain per cycle.

Commenting about the lack of agreement between expected and realized gain, Hallauer and Miranda Filho (1988) pointed out the following causes; a) sampling or estimate error, and b) genotype x environment interaction effects. The sampling error may occur in the recombination lot. If problems occur, especially at flowering time, recombination may be deficient in one or more cycles, obviously contributing to the lack of correspondence between the synthesized population and the population that should be obtained by selection.

In trials carried out to determine realized gain, the material tested may not be a representative sample of the population, with the consequent occurrence of another type of sampling error. This error can be reduced by using many replications and larger plots than those traditionally employed. This error probably did not occur here since the

populations were tested at four locations and in 10 replications per location. Furthermore, 50 plants were used, i.e., 500 plants per experiment, a number which is sufficient to represent the population of each cycle.

In the case of variances, the errors are expected to be more pronounced because the deviations are squared. Thus, an overestimate of additive genetic variance may cause expected gain to be higher than realized gain. In population CMS-39, the errors associated with the estimate of additive genetic variance were 13%, 39% and 26% of the estimate for cycles I, II and III, respectively. This may explain at least in part the differences between realized and expected gain.

An error in gain estimate may also occur when the standardized selection differential is used (i). This occurs when family means do not perfectly fit a normal distribution. This fact may be particularly serious when a smaller number of families is evaluated. The mean frequency distributions reported by Aguiar (1986), Pacheco (1987) and Arriel (1991) showed a good fit to normal distribution. Thus, this factor probably did not contribute to the discrepancy observed in this case.

The major factor affecting in the agreement between expected and realized gain should then be genotype x environment interaction. Families are tested in one year and selection cycles are tested in another year. In tropical regions in particular, climatic conditions are quite variable and even within the same agricultural year there is interaction between genotypes and sowing season (Souza, 1989; Oliveira, 1990). Since during the last few years the amount and distribution of rainfall has been quite irregular in Minas Gerais State, interaction between agricultural year and genetic material is expected. This interaction reflects on the agreement between realized and expected gain. Unfortunately, there is no way of quantifying this effect.

Half-sib family x environment interaction was detected at each selection cycle, although selection cycle x location interaction was not observed (Table I). However, the families were selected on the basis of mean performance in the various environments, which must have attenuated this effect.

CONCLUSION

Mean realized gain by selection of half-sib families of the maize population CMS-39 was 3.6%. This value was of a lower magnitude than mean expected gain for three selection cycles, which was 7.2%.

RESUMO

A população de milho criada pelo Centro Nacional de Pesquisa de Milho e Sorgo (CNPMS/EMBRAPA) foi submetida à seleção de famílias de meio irmãos para produção de grãos. As populações

representantes do ciclo original (C_0) e ciclos I, II e III foram avaliadas em um delineamento de blocos casualizados com 10 repetições em Sete Lagoas, Lavras, Ribeirão Vermelho e Santo Antônio do Amparo, Estado de Minas Gerais, Brasil. O propósito foi avaliar o ganho observado da seleção e compará-lo com o ganho esperado baseado na estimativa de cada ciclo de seleção. O ganho realizado por ciclo para produção de grãos, obtido como médio para os quatro ciclos foi 3,6%. Este valor foi menor que o ganho médio esperado por ciclo, 7,2%. As principais razões pela discordância dessas estimativas são discutidas.

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