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Heritability of several traits in an early population of maize

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ABSTRACT

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The heritability in the narrow sense of days to pollen shedding, days to silking, plant height, ear height, lodging, kernel moisture, number of ears per plant, number of ear rows, ear length, 1000-kernel weight and yield were estimated in an early population of maize (_Zea mays_ L.) using 40 families of half sibs grown in a blocks-in-replications design for two years. The estimates ranged from 0.13 for kernel moisture to 1.00 for number of ear rows. The heritability for yield was 0.38.

INTRODUCTION

Maize (_Zea mays_ L.) has been grown in Galicia (northwestern Spain) for about 350 years (Pérez García, 1978). At present open pollinated varieties are still grown in an important proportion of its acreage.

In the last few years a considerable genetic erosion has taken place. For instance, in 1984 lines from 'Reid' germplasm accounted for 44% of the total seed produced that year in the United States (Darrah and Zuber, 1986). Considering that the Corn Belt germplasm is the base of most of the varieties grown in the temperate zones of the world, the danger of genetic vulnerability can be very great.

To reduce genetic vulnerability a cooperative program was started at several Research Institutes in Spain with the aim of increasing the genetic basis of the commercial varieties by means of incorporating the local germplasm to the hybrids offered to farmers. The efficient development of such a breeding program is dependent upon the existence of genetic variability and the knowledge of the type of gene action involved (Sprague, 1963).

The genetic study of the Spanish germplasm has recently started at the Estación Experimental de Aula Dei (Alvarez, personal communication) and at the Misión Biológica de Galicia (Ron and Ordás, 1987) with the aim of assessing the amount of genetic variance present in this germplasm as well as the proportion of it that is additive. This will allow to know in advance the genetic gain expected in a selection program.

The objective of this work was to estimate heritability in the narrow sense (i.e. the additive genetic variance divided by the phenotypic variance) in a maize population representative of the open pollinated varieties grown in the highlands of Galicia.

MATERIALS AND METHODS

In 1985 about 60 plants, hereinafter designated as males were randomly chosen from the population 'Maceda'. Each of the male plants was crossed on five random plants, designated as females, from the same population. At harvesting, after discarding poor filled ears, 40 males had produced at least four crossed ears with a reasonable amount of seed, although in most cases the amount of full sib seed was scarce enough as to not allow to plant at least two tests per family. Thus the four full sib families from each male were composited in a half sib family as is explained below.

The 40 half sib families were randomly divided into four blocks of 10 families each and were planted in 1986 and 1987 in the experimental plots of the Misión Biológica de Galicia at Salcedo, near Pontevedra.

A blocks-in-replication design arranged in randomised complete blocks with two replicates was used each year. The experimental plot consisted of 10 hills, each with four kernels, spaced 50 cm apart. The 40 kernels used to plant each half sib family plot were picked taking four random kernels from each full sib family. The separation between rows was 80 cm. When the plants were in the four-leaf stage the hills were randomly thinned to two plants obtaining then a final planting density of approximately 50,000 plants/ha.

In both years data were taken on days to pollen shedding and silking (number of days from seeding to pollen extrusion and silking, respectively, on 50 % or more plants), plant and ear height (centimetres from the base of the stalk up to the top of the tassel and up to the node of the upper ear, respectively) and lodging (proportion of plants broken under the upper ear node or root lodged). At harvesting, data of yield of grain at 14 % moisture were taken on each plot. Besides, two random samples of five ears were taken on each plot. One of the samples was used to estimate moisture content of grain drying in oven at 80°C for a week a random sample of kernels. The other sample, after dried, was used to count the number of kernel rows per ear, the length of the ear in centimetres and the weight in grammes of a random sample of 1000 kernels.

Individual analyses of variance were made for each trait for each year. Before pooling the individual analyses into the combined analysis, Barttlet's tests (Steel and Torrie, 1981) for homogeneity of error variances were carried out. Only the error variances for ear length resulted heterogeneous and then the levels of significance for this trait in the combined analysis must be taken with some caution.

Estimates of heritability in the narrow sense were made following the approach of Jackson (1983) for the case when full sib relationships are ignored and there are multiple progeny per dam (case 3). Assuming that after thinning each plot is formed by five progeny per dam (r=5), the number of progeny per sire (N) will be equal to 20. This brings about a value of Q = 0.21 and of R = (1 + Q) 0.25 = 0.30.

RESULTS AND DISCUSSION

The combined analyses of variance (Table 1) showed that there was significant variation among the half sib families for all the traits studied with the exception of number of ears per plant. This was not a surprising result as the landraces of maize from Galicia have a strong tendency to produce only one ear per stalk and then there is no genetic variability for this trait. This is very likely a logical consequence of the selection carried out by farmers year after year. They pick for seed the best ears in the crib which, obviously, have been produced by the less prolific plants.

The interaction of males within blocks x years was significant only for pollen shedding (Table 1). At any case this interaction was much smaller than the corresponding main effect. The differences among the half sib families, with the exception of pollen shedding, are, then, constant regardless of the environment in which they are measured. The significance of the mean square for males within blocks for ear length was well above the critical level and then, in spite of the heterogeneity of the error variances shown by Barttlet's test, we can be confident of the existance of real differences among the half sib families for this trait, too.

The study of the means (Table 2) shows that the range of number of ears per plant is relatively great (0.68-1.20), although this variation is obviously environmental as pointed out before. All the important traits from the point of view of a future program of improvement of the population (lodging, kernel moisture, number of ear rows, length of ear and yield) show extreme values (Table 2) that look promising.

Table 1.- Mean squares of the pertinent sources of variation for several traits for 40 families of half sibs from a population of maize grown in 1986 and 1987.

Trait	Mean squares		
	Males/blocks	Males/blocks x years	Error
Pollen shedding (days)	3.31**	1.34*	0.69
Silking (days)	5.14**	1.14	1.66
Plant height (cm)	294.72*	85.76	141.28
Ear height (cm)	123.56**	41.52	36.64
Lodging (%)	410.67**	179.84	176.48
Kernel moisture (%)	5.54**	2.07	1.85
No. ears/plant	0.0101	0.0102	0.0091
No. ear rows	3.37**	1.04	0.93
Ear length (cm)	2.09**	1.24	0.83
1000-kernel weight (g)	2204.9**	839.6	689.3
Yield (Mg/ha)	1.09**	0.50	0.39

df=36 for males/blocks and for males/blocks x years
df=72 for error
*, ** Significant at the 0.05 and 0.01 probability levels, respectively

Table 2.- Means, ranges and coefficients of variation for several traits for 40 families of half sibs from a population of maize grown in 1986 and 1987.

Trait	Mean	Range	CV %
Pollen shedding (days)	59.5	56-66	1.9
Silking (days)	60.4	55-66	2.1
Plant height (cm)	190	154-237	6.2
Ear height (cm)	59.1	38.0-80.4	10.2
Lodging (%)	26	0-73	50.4
Kernel moisture (%)	27.0	17.0-35.9	5.0
No. ears/plant	0.97	0.68-1.20	9.8
No. ear rows	14.26	11.6-17.6	6.8
Ear length (cm)	14.95	11.54-19.24	6.1
1000-kernel weight (g)	343	247-439	7.7
Yield (Mg/ha)	4.13	1.8-7.0	15.1

The estimates of heritabilities in the narrow sense (Table 3) ranged from 0.13 for kernel moisture to 1.00 for number of ear rows with standard errors that, although high, can be considered acceptable. Only the errors for pollen shedding and plant height were higher than 40% of the corresponding heritability estimate.

Table 3.- Estimates of heritability in the narrow sense for several traits in a population of maize.

Trait	h^2	$SE(h^2)$
Pollen shedding (days)	0.58	0.24
Silking (days)	0.59	0.18
Plant height (cm)	0.50	0.22
Ear height (cm)	0.89	0.25
Lodging (%)	0.79	0.31
Kernel moisture (%)	0.13	0.05
No. ears/plant	-	-
No. ear rows	1.00	0.31
Ear length (cm)	0.54	0.20
1000-kernel weight (g)	0.64	0.20
Yield (Mg/ha)	0.38	0.13

The general trends of our results are in agreement with those presented in the extensive revision of Hallauer and Miranda (1981) although, in general, we obtained higher values. For instance Hallauer and Miranda (1981) give for yield a heritability of 0.19 as the average of 99 estimates, while our value was 0.38; however, they show a value of 0.62 for kernel moisture while ours is only 0.13. We should not forget that the method we used (Jackson, 1983) produce estimates that are biased upward. We used the computed R to correct heritability estimates for bias, but this is only appropriate in cases where the dominant components of variance are unimportant (Jackson, 1983). We think that given the present status of knowledge of the genetics of maize this assumption can be reasonably accepted.

Other recent estimates (Böhm and Schuster, 1985; Geraldi et al., 1985) of heritability for yield are also lower than ours, while Shahi et al. (1986) at normal planting density show a value of 0.38, exactly the same result obtained by us.

As a result we can conclude that the population used in this study, representative of the landraces grown in the highlands of Galicia (northwestern Spain), show a pattern of genetic variability similar to other germplasm. In addition, the great ranges of variation shown for lodging and yield, as well as the values of heritability for these traits, should make us confident to obtain good genetic gains in a selection program addressed to improve both yield and standability. The low value of heritability for kernel moisture is an indication of a lack of additive genetic variation for this trait. The population is well adapted to the highlands of Galicia, without problems of maturity. The improved populations that would be obtained should also be equally adapted without selecting for maturity.

RESUMEN

En una población precoz de maíz (Zea mays L.) se estimó la heredabilidad en sentido estricto de los caracteres días a floración masculina, días a floración femenina, altura de la planta, altura de inserción de la mazorca, encamado, humedad del grano, número de mazorcas por planta, número de filas de grano, longitud de la mazorca, masa de 1000 granos y rendimiento. Las estimaciones se hicieron mediante 40 familias de medios hermanos que, en un diseño de bloques-en-repeticiones, se ensayaron durante dos años. Las estimaciones obtenidas variaron de 0.13 para humedad del grano a 1.00 para número de filas de grano. El rendimiento tuvo una heredabilidad de 0.38.

REFERENCES

Bóhm, H. and W. Schuster (1985) Untersuchungen zur Heritabilität bei Mais (Zea mays L.). **Z. Pflanzenzüchtg.** 95: 125-134.

Darrah, L.L. and M.S. Zuber (1986) 1985 United States farm maize germplasm base and commercial breeding strategies. **Crop Sci.** 26: 1109-1113.

Geraldi, I.O., J.B. Miranda Fo and R. Vencovsky (1985) Estimates of genetic parameters for tassel characters in maize (Zea mays L.) and breeding perspectives. **Maydica**, 30: 1-14.

Hallauer, A.R. and J.B. Miranda Fo (1981) Quantitative genetics in maize breeding. Iowa State Univ. Press, Ames, Iowa, USA.

Jackson, N. (1983) Effect of ignoring full sib relationships when making half sib estimates of heritability. **Theor. Appl. Genet.** 65: 61-66.

Pérez García, J.M. (1978) Aproximación al estudio de la penetración del maíz en Galicia. En: **La historia social en sus fuentes de protocolo**. Universidad de Santiago de Compostela.

Ron, A.M. de and A. Ordás (1987) Genetic study of non-ear characters in maize. **Plant Breed.** 98: 268-271.

Shahi, J.P and I.S. Singh (1986) Genetic variability for grain yield and its component characters at two plant densities in maize (Zea mays L.). **Z. Pflanzenzüchtg.** 96: 122-129.

Sprague, G. F. (1963) Quantitative genetics in plant improvement. En: K.J. Frey (ed.) **Plant Breeding**. Iowa State Univ. Press, Ames, Iowa, USA.

Steel, R.G.D. and J.H. Torrie (1981) Principles and procedures of statistics. 2nd ed. McGraw Hill Kogakusha.