

GENETIC ANALYSIS OF AN EARLY OPEN POLLINATED VARIETY OF CORN

F. CASAÑAS, L. BOSCH, F. NUEZ

Summary

Lately, open pollinated varieties of corn have been displaced by double and single hybrids. However these varieties are of considerable economic importance in Spain. In the North West region a great deal of open pollinated subpopulations very adapted to different altitudes are being cultivated. Most of them are characterized by early maturing cycle and high endogamy. This type of variety has been much less studied than the intermediate or late maturing varieties such as those coming from the United States. The objective of the research was to contribute to the knowledge of these early varieties.

KEY WORDS: Early open pollinated corn; Variance components; Heritability; Genetic advance.

INTRODUCTION

In the north of Spain and specially in the north west, many open pollinated varieties of corn are still being cultivated nowadays. These materials, most of them of flint grain, have suffered a pressure of selection destined mainly to adapt them to particular environmental conditions, without paying much attention to the effect that this process had on yield. The peculiar type of agricultural exploitation developed in this zone, with small fields and scarce exchange of genetic material among farmers, has originated a great quantity of subpopulations,

with a high endogamy, a low production, and very much adapted to the different microenvironments (specially to different heights)(Moreno, 1980).

The abundancy of short cycle varieties among these materials keeps them far away from the most studied from a genetic point of view (the northamerican ones), wich tend to middle and long cycles (Lindsey et al., 1962; Chopra, 1964; Sprague, 1964; Compton et al., 1965; Eberhart et al., 1966; Hallauer and Wright, 1967; Chi et al., 1969, among others). So, we find ourselves in front of a material of peculiar history, near unknown from the genetical structure point of view, and that has started to be included into programs to obtain flint inbreds that combine well with the american dent ones (Moreno, 1979, 1980 and 1981; Moreno and Losada, 1980). Moreover, these varieties have for themselves a considerable economic importance into the country.

Through this work we pretend to contribute to the genetic knowledge of these early varieties by analyzing a presumably representative one of them. Eventually we also pretend an evaluation of the possibilities to use these materials as starting point for breeding programs.

#### MATERIAL AND METHODS

The elected variety came from Asturias (north of Spain), and was cultivated about 700 m over sea level. It was a short cycle and flint material, with a diversity of grain colors ranging from yellow to intense garnet. A representative sample of the variety was picked up to stablish full-sibs and half-sibs families, following the matting design proposed by Comstock and Robinson (1948).

Later, 235 families were studied distributed as follows: 73 half-sibs families, constituted each one by three families of full-sibs; and 8 half-sibs families, constituted each one by two families of full-sibs.

The planting was made following a completely randomized design, with 20 plants representatives of each full-sibs family. Planting density was about 42.000 plants/ha. On each plant the following traits were controlled: a) Days to pollen shedding b) Nodes to the ear, c) Total nodes, d) Number of ears, e) Dry weight of the ears (yield).

The variance analysis of each trait was made by means of a nested design, where the plant effect (pl) was jerarquizado to female (f), and this last to male (m). The variance components  $\sigma_m^2$ ,  $\sigma_f^2$  and  $\sigma_{pl}^2$  were estimated through the method proposed by Anderson and Bancroft (1952). The additive genetic variance was estimated following the expression  $\sigma_A^2 = 4 \sigma_m^2$  and the non additive genetic variance by the expression  $\sigma_D^2 = 4(\sigma_f^2 - \sigma_m^2)$ . Genotypic variance was the addition of both. From phenotypic variance  $\sigma_P^2 = \sigma_m^2 + \sigma_f^2 + \sigma_{pl}^2$ , and  $\sigma_A^2$  values, we have estimated the heritability values of each trait ( $\hat{h}^2 = \sigma_A^2 / \sigma_P^2$ ). The response of the variety to selection (R) per unit of intensity of selection (i) has been estimated following the expression  $R/i = \hat{h}^2_p$  (Falconer, 1960).

Finally, and with the object of calculating the correlations among traits we made the covariance analysis for each pair of traits, following an identic model to the one described for the variance analysis, although substituting the mean squares by the mean crossed products. The errors of the estimates were calculated through the methods proposed by Kempthorne (1957) for the heritability, and by Tallis (1959) and Mode and Robinson (1959), for the correlations.

## RESULTS

All the variances of the different factors through which genetical variances were estimated appeared as significatives ( $p < 0.01$ ) except for the number of ears ( $p > 0.05$ ) (Table 1).

### Situation of Table 1

In Table 2 are exposed the phenotypical and genotypical correlations between the different pairs of traits that presented significative genetic variance. In Table 3 environmental correlations are shown.

### Situation of Tables 2 and 3

## DISCUSSION AND CONCLUSIONS

The high earliness of the studied variety makes this trait the most interesting at least from the point of view of the genetical structure of corn populations. The results in Table 1 indicate very similar values of  $\sigma_A^2$  and  $\sigma_D^2$  for the days to pollen shedding which contrasts with the best part of estimates made in other varieties and where the additive genetic variance is larger than the non additive (Robinson et al., 1955; Lindsey et al., 1962; Compton et al., 1965). Nevertheless, these differences can be attributed to the different earliness of the materials as the varieties studied by the mentioned authors are of much longer cycle than the one presented here. If we accept that in the majority of loci the alleles determining earliness are dominant (Daniel, 1973; Rood and Major, 1980 and 1981), the situation could be explained by a difference in gene frequencies. The variety here studied, after having suffered a selection pressure tending to shorten its cycle in order to become adapted to increasing heights, would have accumulated a large quantity of alleles determining earliness, that is to say, dominant alleles. Such a situation, with a high frequency of dominant alleles is reflected in high values of  $\sigma_D^2$  with respect to  $\sigma_A^2$ , even supposing complete additivity among loci (Kempthorne, 1957).

The traits nodes to the ear and total nodes, behave in a very similar way, probably due to the high genotypic correlation they present (Table 2). The dominant genetic variance appears not lower than the additive one in both cases ( $\sigma_D^2/\sigma_A^2 = 1.57$  and 1.67 respectively). Few works present estimates of the genetic variances with respect to these traits in open pollinated varieties, but the results got by means of inbreds and hybrids indicate a predominance of the additive genetic variance on the non additive (Bonaparte, 1977; Harville and Josephson, 1979), which does not coincide with our results. A possible explanation to this fact could be the genotypic correlation that the number of nodes keeps with the days to pollen shedding (Table 2). Thus, the expression of the number of nodes variances would be partially subjected to the variances of the days to pollen shedding.

In spite of the fact that bibliography shows a predominance of the varieties in which the estimations of  $\sigma_D^2$  are inferior than the ones of  $\sigma_A^2$  for grain yield (Hallauer and Miranda, 1981 find a mean of  $\sigma_D^2/\sigma_A^2 = 0.796$  from 37 references), the cases in which  $\sigma_D^2 > \sigma_A^2$  are not uncommon (Gevers, 1960; Williams et al., 1965; Chi et al., 1969; Toit, 1979). The high  $\sigma_D^2$  cannot be attributed in our variety to the accumulation of dominant genes for yield, as the dominance to high production has been repeatedly pointed out (Rojas and Sprague, 1952; Stuber and Moll, 1971; Martin and Hallauer, 1976; Moreno and Dudley, 1981; Piovarcy, 1975), which contrasts with the scarce average yield of the variety (Table 1). This predominance of  $\sigma_D^2$  on  $\sigma_A^2$  cannot be attributed either to the genotypic correlation of this trait with the days to pollen shedding, as it is very low (Table 2).

There is a likely explanation of these results that implies also the trait number of nodes with which the yield keeps a considerable genotypic correlation (Table 2). In the group of Spanish varieties among which this is found, there has been detected the presence of a large number of deleterious recessive alleles that in heterozygosity would behave in a not additive way with the rest of the genotype, and meaning an epistatic component

that in the analytical design used here remains included into  $\sigma_D^2$ . This would increase the estimates of the dominant variance concerning the number of nodes, and specially the yield.

The trait number of ears presents a very low phenotypic variance (0.033), being  $\sigma_A^2$  and  $\sigma_D^2$  not significatives. The variety appears thus as monomorphic for this trait.

The low phenotypic correlations that all the traits keep with the days to pollen shedding (Table 2), and specially the negative correlation with yield, can be explained observing the negative environmental correlations shown in Table 3, and reflecting on the physiology of the plant. As a matter of fact a situation of stress makes longer the days from planting to pollen shedding, and reduces the vegetative development (Larson and Hanway, 1977), which would be translated in a negative environmental correlation between days to pollen shedding and vegetative traits. The negative effect of the environmental correlations would reduce the high genotypic correlations that would result in very low values of phenotypic correlations, and even negatives in the most extreme cases as yield.

We can thus conclude that the differences among the studied variety and the more known long cycle materials can be reasonably explained as a consequence of the adaptation process to short cycle produced while these materials were cultivated at increasing height, together with the few representatives of the population employed as founders of the next generation (5 to 12 ears per field according to Moreno, 1980) that would reduce the genetic variance. Another important aspect would be that due to the lack of selection pressure, these populations keep high quantities of deleterious recessive alleles, that specially affect the yield and the plant size. The accumulation of dominant genes for earliness produced during the adaptation process to short cycle would be responsible of the considerable  $\sigma_D^2$  detected for this trait, while the deleterious alleles by including its effect in the estimates of the dominant variance, would tend to magnify it in the yield and number of nodes.

We want finally to point out that the low responses to selection shown by all the traits (Table 1) does not suggest this material to be a good starting point for breeding programs, although it could be a source of adaptation genes to very particular conditions.

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Table 1.- Main genetic parameters of the variety for the different traits.  
(R/i = response to selection per unity of intensity of selection).

Trait	Mean phenotypic value	$\sigma_A^2$	$\sigma_D^2$	$\hat{h}^2$	R/i
Days to pollen shedding	45.4	1.714	1.716	$0.19 \pm 0.07$	0.58
Nodes to the ear	4.8	0.091	0.142	$0.16 \pm 0.06$	0.12
Total nodes	9.1	0.206	0.346	$0.22 \pm 0.08$	0.21
Number of ears	1.03	0.0008	0.0044	-	-
Ear weight (gr/plant)	81.7	122.5	194.0	$0.14 \pm 0.06$	4.22

Table 2.- Phenotypic and genotypic correlations. Estimates of genotypic correlations are above and right of the diagonal, and estimates of phenotypic correlations are below and left of the diagonal.

	Days to pollen shedding	Nodes to the ear	Total nodes	Ear weight
Days to pollen shedding		$0.37 \pm 0.11$	$0.46 \pm 0.10$	$0.17 \pm 0.12$
Nodes to the ear	$0.11 \pm 0.02$		$0.81 \pm 0.04$	$0.30 \pm 0.11$
Total nodes	$0.19 \pm 0.02$	$0.71 \pm 0.01$		$0.47 \pm 0.09$
Ear weight	$-0.13 \pm 0.02$	$0.23 \pm 0.02$	$0.31 \pm 0.02$	

Table 3.- Environmental correlations.

	Days to pollen shedding	Nodes to the ear	Total nodes	Ear weight
Days to pollen shedding		$-0.06 \pm 0.08$	$-0.07 \pm 0.11$	$-0.31 \pm 0.08$
Nodes to the ear			$0.64 \pm 0.05$	$0.18 \pm 0.07$
Total nodes				$0.16 \pm 0.09$
Ear weight				

CASAÑAS, F., BOSCH, L., NÚEZ, F: Genetická analýza ranných otevřeně opylovatelných druhů kukuřice.

V poslední době byly otevřeně opylovatelné druhy kukuřice nahrazeny dvojitými a jednoduchými hybridy. Ovšem, tyto hybridy mají ve Španělsku velký ekonomický význam. V severozápadní oblasti jsou kultivovány ve značném rozsahu otevřeně opylovatelné subpopulace, velmi adaptabilní k různým nadmořským výškám. Většina z nich je charakterizována ranným dozrávacím cyklem a vysokou endogamií. Tento typ hybridu byl mnohem méně studován než středně nebo pozdně dozrávající hybridy původem ze Spojených států. Smyslem výzkumu bylo přispět k získání poznatků o těchto ranných hybridech.

КАСАÑАС, Ф., БОШ, Л., НУЭЗ, Ф: Генетический анализ ранних открыто опыляемых видов кукурузы.

В последнее время были открыто опыляемые виды кукурузы заменены двойными и простыми гибридами. Однако, эти гибриды имеют в Испании большое экономическое значение. В северозападной области культивируются в значительной мере открыто опыляемые субпопуляции с большой способностью приспосабливаться к неодинаковой высоте над уровнем моря. Большинство из них характеризуется ранним циклом созревания и высокой эндогамией. Этот тип гибрида изучался в гораздо меньшей мере, чем средне- и поздно созревающие гибриды, происходящие из Соединенных Штатов. Целью исследований было внести вклад в дело получения сведений об этих ранних гибридах.

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