

# Maize synthetics from a mixture of single, three-way, and double cross hybrids using inbreeding coefficients and mean predictions

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## Abstract

Equations for inbreeding coefficient and mean prediction were calculated for a synthetic made with a mixture of single, three-way, and double cross hybrids. As inbreeding and mean predictions for the three types of hybrids was already known, corresponding results for inbreeding and mean prediction for the hybrid mixture were obtained with relative ease.

**Keywords:** *Zea mays* L, synthetics, inbreeding coefficient, mean prediction

## Introduction

The prize of maize hybrid seed in underdeveloped countries is frequently very high, sometimes reaching 20% or more of crop production costs. This makes farmers create maize synthetics using seed from hybrids. It is important, therefore, to understand the genetic characteristics of these types of synthetics regarding their inbreeding coefficient and predicted yield.

## Review of Literature

There are  $m$  plants for all three hybrids. The inbreeding coefficient of the single, three-way, and double cross synthetics are, respectively:  $1/2s$  (Márquez-Sánchez, 2007) and Sahagún-Castellanos and Villanueva-Verduzco (1997);  $(m+3)/8tm$ , and  $(m+1)/4dm$  (Márquez-Sánchez 2008, 2010). Thus, the inbreeding of the three-way synthetic is the average of the inbreeding of the single and double cross synthetics.

On the other hand, the predicted yield of a synthetic made with a number of  $n$  hybrids of the same kind, each with  $m$  plants is (Marquez-Sánchez 2008, 2010):

$$\begin{aligned} Y(\text{SYNTH})_1 &= \\ [nmS_1 + nm(m-1)C' + nm^2(n-1)C]/n^2m^2 &= \\ [S_1 + (m-1)C' + m(n-1)C]/nm &= \\ S_1/nm + C'/n - C'/nm + C - C/n &= \\ C - (C - C')/n - (C' - S_1)/nm &\quad (1) \end{aligned}$$

In the first row,  $S_1$  are  $m$  selfed lines in each of the  $n$  hybrids,  $C'$  are  $nm(m-1)$  crosses among plants of the same hybrid, and  $C$  are  $nm^2(n-1)$  crosses among plants from different hybrids.

## Materials and Methods

There are  $s$  single cross hybrids,  $t$  three-way cross hybrids, and  $d$  double cross hybrids, each with  $m$  plants. The sum of  $s$ ,  $t$ , and  $d$  is equal to  $n$ . Thus,

the total in hybrid mixture is:  $[(s+t+d)m]^2 = (s+t+d)^2m^2 = n^2m^2$ . Knowing the inbreeding and the general prediction of the three types of hybrids, allows obtaining inbreeding and yield prediction for the synthetic resulting from the hybrid mixture.

## Results

### Inbreeding of hybrid mixture synthetic

The literature review indicates that  $m$  is included in three-way and double cross synthetics and not in the single cross synthetic, whose inbreeding is independent of  $m$ ; thus  $m$  in the denominator of  $(1/2s)$  in the following equation should be excluded. The inbreeding of the mixture synthetic is:

$$\begin{aligned} F(\text{SYNTHETIC})_1 &= \\ [1/(s+t+d)^2][s^2(1/2s) + t^2(m+3)/(8tm) + \\ d^2(m+1)/(4dm)] &= \\ [1/(s+t+d)^2][s/2 + t(3+m)/(8m) + \\ d(m+1)/(4m)] &\quad (2) \end{aligned}$$

Equation 2 should also include correlations among the three types of hybrids; if the assumption is that the hybrids are unrelated such correlations are equal to zero.

Now, we can prove Equation 1 by calculating inbreeding for every type of synthetic, and then comparing inbreeding with the respective formulae from the literature review. Thus, for the single cross synthetic:  $(1/s^2)(s/2) = 1/2s$ ; for the three-way cross synthetic:  $(1/t^2)t(m+3)/(8m) = (m+3)/(8tm)$ ; and for the double cross synthetic:  $(1/d^2)d(m+1)/(4m) = (m+1)/(4dm)$ .

### Yield prediction of the hybrid mixture synthetic

Table 1 shows the hybrid mixture under random pollination. The diagonal includes the three types of synthetics with frequencies  $s^2$  for the single-hybrid synthetic,  $t^2$  for the three-way hybrid synthetic, and  $d^2$  for the double-hybrid synthetic. The values outside the diagonal are the crosses among the three types

of hybrids with their respective frequencies: 2st(HS x HT), 2sd(HS x HD), and 2td(HT x HD).

According to Equation 1 the mean predictions for the three types of synthetics are:

$$\begin{aligned} Y_s &= S - (S - S')/s - (S' - S_{1s})/sm \\ Y_t &= T - (T - T')/t - (T' - S_{1t})/tm \\ Y_d &= D - (D - D')/d - (D' - S_{1d})/dm \end{aligned} \quad (3)$$

where S, T, and D stand by C; S', T', and D' stand by C'; and S<sub>1s</sub>, S<sub>1t</sub>, and S<sub>1d</sub> stand by S<sub>1</sub> lines, in Equation 1. Additionally, we have the terms for the products among the pairs of hybrids, that is: 2st(HS x HT), 2sd(HS x HD) and 2td(HT x HD), where HS, HT and HD mean the actual yields of the single, three-way and double cross hybrids, respectively, and, as mentioned before  $sm + tm + dm = nm$ .

According to Equations 1 and 3 the yield of the mixture synthetic is:

$$\begin{aligned} Y(\text{SYNTHETIC})_1 &= \\ &[1/(s + t + d)^2]\{[Y_s + Y_t + Y_d] + \\ &[2st(\text{HS x HT}) + 2sd(\text{HS x HD}) + \\ &2td(\text{HT x HD})]/n^2m^2\} = \\ &[S_s - (S_s - S'_s)/s - (S'_s - S_{1s})/sm] + \\ &[T_t - (T_t - T'_t)/t - (T'_t - S_{1t})/tm] + \\ &[D_d - (D_d - D'_d)/d - (D'_d - S_{1d})/dm] + \\ &[2st(\text{HS x HT}) + 2sd(\text{HS x HD}) + \\ &2td(\text{HT x HD})]/n^2m^2 \end{aligned}$$

**Table 1** - A synthetic made from random mating of a mixture of s single hybrids, t three-way hybrids, and d double hybrids.

Type of Hybrid and numbers	Type of hybrid and numbers		
	HS (s)	HT (t)	HD (d)
HS (s)	(SINT HS) (s <sup>2</sup> )	(HS x HT) (st)	(HS x HT) (sd)
HT (t)	(HT x HS) (ts)	(SINT HT) (t <sup>2</sup> )	(HT x HD) (td)
HD (d)	(HD x HS) (ds)	(HD x HT) (dt)	(SINT HD) (d <sup>2</sup> )

## Conclusions

Synthetics with a mixture of several types of hybrids can be made with relatively high yields for low income farmers. The farmer will use as many types of hybrids as he wants, but has to consider that the higher the number of hybrids mixed, the lower the yield of the synthetic.

## Discussion

Both the inbreeding coefficient and the prediction of the hybrid mixture synthetic may be calculated as the respective average mean, weighted by the number of each type of hybrid and by the number of plants per hybrid.

Given that this is a theoretical study, the farmer does not care how many hybrids of each type are included; it must be enough for the farmer to understand that: the higher the number of hybrids, the lower synthetic's inbreeding, resulting in lower yield.

## References

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