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Using haploid plants for the creation of high yield populations in maize

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Haploid breeding is of interest to maize breeders, which by chromosome doubling of haploids will reduce the expense and time for the production of homozygous lines.

However, there are some papers in which a wider use of haploid/doubled-haploid plants in breeding work is being discussed (Bouchez and Gallais, 2000; Rober, Gordillo and Geiger, 2005; Bordes et.al., 2006). The main point of the papers is that at the haploid level, due to the absence of allelic gene interactions, selection for favorable genes with non-allelic effects might be more effective in comparison with the diploid level.

Chalyk and Rotarenco used this feature of haploids in a scheme of recurrent selection to improve seed productivity of two synthetic populations - SA and SP (Chalyk and Rotarenco, 1999; Chalyk and Rotarenco, 2001). The selection was carried out by ear size in haploid plants. After three cycles of haploid recurrent selection, the values of the seed productivity and other quantitative traits in both diploid populations were significantly increased (Rotarenco, Chalyk and Eder, 2004).

During the last years, the fourth cycle of such recurrent selection has been carried out in the SP population. Thus, the seed productivity of this population (SPC4) reached a rather high level and, in our opinion, it might be comparable to F1 hybrids.

The main purpose of our work was to compare the SPC4 population (FAO – 330) with three simple hybrids that are widely used in local maize production: Moldavian 291, Porumbeni 295 and Porumbeni 359. The F2 progenies of these hybrids, and an interpopulation hybrid (SPC4xSAC3), were also included in the estimation. The trial was conducted in three replications in Fundulea, Romania. Each genotype was grown in a two-row plot with a length of 7.8 meters. Plant density was 50, 000 plants per hectare. After flowering, two plant traits, plant height and ear height, were measured. Ear length, number of seed rows and seed productivity were estimated after the drying of the ears. Because of drought, the seed productivity of the estimated genotypes was much lower (about 40%) in comparison with favorable years. Nevertheless, the results obtained can be used according to the goal of the experiment. The results are presented in the Table 1.

Table 1. Seed productivity and parameters of ear and plant traits in estimated genotypes.

Traits	Genotypes							
	Population SPC4	Interpopulation hybrid SPC4xSAC3	Moldavian 291	Porumbeni 295	Porumbeni 359	Moldavian 291 F2	Porumbeni 295 F2	Porumbeni 359 F2
Seed productivity, gr/plant	101.6±3.9	102.2±3.3	121.3±4.1^^^	122.8±5.0^^^	104.0±4.4	95.5±4.0	94.2±4.7	96.2±3.6
Ear length,cm.	18.9±0.3	18.4±0.2	20.1±0.1^^^	18.7±0.2	18.1±0.2**	17.1±0.2***	17.2±0.3***	17.0±0.2***
Number of seed rows, no.	16.9±0.2	16.4±0.2	14.6±0.2***	15.5±0.2***	14.8±0.2***	14.8±0.2***	15.4±0.2***	14.5±0.2***
Plant height, cm.	222.1±2.6	239.9±2.2^^^	225.4±2.8	191.7±2.0***	185.1±2.1***	202.4±2.3***	181.4±2.4***	181.2±1.5***
Ear height, cm.	90.2±1.8	96.6±1.5^^	79.2±1.1***	68.5±1.0***	71.7±1.1***	75.1±1.3***	65.6±1.4***	73.8±1.0***

^ - the excess over the SPC4 population; ^^, ^^^ significant difference at 0.01 and 0.001 probability level, respectively
* - the excess of the SPC4 population; **, *** significant difference at 0.01 and 0.001 probability level, respectively

Two hybrids, Moldavian 291 and Porumbeni 295, exceeded the SPC4 population for seed productivity. There were no significant differences between the population and the F2 progenies of the hybrids for this trait. Ear length was significantly greater in the Moldavian 291 hybrid, whereas the SPC4 population exceeded all the simple hybrids and their F2 progenies in the number of seed rows.

Most likely, the excess of the seed productivity of the two F1 hybrids over the population was caused by their superiority in size of seeds (weight of 1,000 seeds); however, an estimation of this parameter was not carried out.

The values of seed productivity and ear traits in the interpopulation hybrid did not differ significantly from the SPC4 population. However, this hybrid significantly exceeded the population for the plant traits. In other words, there was no heterosis for the ear traits, whereas a rather high heterosis for the plant traits.

As was previously revealed, the SPC4 population significantly exceeded the SAC3 population for seed productivity and other quantitative traits. Therefore, the SPC4 population can be considered the best parent in the interpopulation hybrid SPC4xSAC3.

The influence of allelic gene interactions, dominance and overdominance, could be the reason for the high heterosis for plant traits in the interpopulation hybrid. At the same time, these gene interactions did not have a significant influence on the ear traits and consequently on the seed productivity of this hybrid.

The improvement of a heterogeneous population per se occurs due to an increase of the frequency of favorable genes with non-allelic effects (Hallauer and Miranda, 1986). Based on the results obtained, it can be concluded that the selection among haploids is a very efficient and relatively quick way to increase the frequency of favorable genes with non-allelic effects in a population.

We plan the further improvement of the SPC4 population. However, because of the decrease of genetic variability in the population, there is a large chance that further improvement will not be as efficient as it was during the four cycles of haploid recurrent selection. Therefore, a new germplasm with favorable genes will be introduced into the population. For the estimation and selection of this germplasm haploid plants will also be used.

In our opinion, haploidy might be a very useful tool for the improvement of synthetic populations. High yield populations could be widely used both as an initial material in breeding work and in production.