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The meiotic index in hexaploid triticale. Direct and indirect ways to improve it

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Abstract — The starting point in the chain of events concerning fertility is the meiotic division. Thus, to improve the meiotic performance of triticale is a sure biological way of promote its evolution. Sixty F_2 — derived families were evaluated during 1997 (F_2 :.$_3$) and 1998 (F_2 :$_4$), in order to measure the direct and indirect responses to selection for the improved percentage of normal tetrads, or meiotic index, in hexaploid triticale. A significant direct response to selection in respect to the meiotic index was observed, but not indirectly through spikelet fertility. However, we have found that there is the possibility for selection at the end of the reproductive process (i.e. per spikelet fertility) without a negative effect on the percentage of normal tetrads.

Key words: hexaploid triticale, meiotic index, direct response to selection, indirect improve

ment

INTRODUCTION

The starting point of the chain of events concerning fertility is the meiotic division. Triticale *(Triticosecale* Wittmack), a man made species where "bread" or "pasta" wheat and rye genomes are the constituents, shows cytological disorders common in those organisms where evolution is not completed; consequently disturbance during the meiotic process may be responsible for a reduced fertility (SZPNIAK DE FERREIRA 1983), in reference to the number of seeds produced by a plant, spike or spikelet. Because of this, to improve meiotic and fertility performance in triticale is a biological way to promote its evolution. Two different ways of acting on the gene frequencies of the primary character determinants are available, directly to them and indirectly; moreover, two conditions are needed in the indirect option, the heritability of the secondary character must be higher than the primary, and obviously both must be associated (FALCONER 1960). Taking into account of these considerations, spikelet fertility can be used to improve the meiotic performance of those new materials where two or more genomes are involved. In this context, one of the most studied meiotic irregularities is the presence of micronuclei in the tetrads (OCHOA DE SUAREZ *et al.* 1987; FALCAO *et al.* 1990; MANERO DE ZUMELZU *et al.* 1995) where several studies have demonstrated the existence of variability which may be useful for plant breeding purposes (MANERO DE ZUMELZU *et al.* 1992, 1995, 1998; ORDONEZ *et al.* 1997). Published data with respect to spikelet fertility and percentage of normal tetrads heritability estimates, showed either low or similar values and the relationship between them is open to discussion (MAICH *et al.* 1998). In summary, to obtain optimal reproductive performance through viable descendants, under specific environmental conditions, is a paramount purpose for any organism, when fertility, as final product, is attained through several biological steps where meiosis plays an essential role. To improve each reproductive step is nature and man common purpose, some of wich steps are directly changed through their gene frequency determinants but other not yet, i.e. the cytological ones.

Consequently an integral hypothesis may be drawn: "meiosis is at the begining of the reproductive process and, at the end of it, fertility takes its place; each of these steps may be improved directly or indirectly through the other one, depending of their heritabilities and their

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relationships". Thus, the object of the present study was to measure the direct and indirect responses to selection for the percentage of normal tetrads, or meiotic index, in hexaploid triticale.

MATERIALS AND METHODS

A F_2 population originated from Don Frank per Tarl varietal cross was cultivated under low plant densities (25 seeds m^{-2}) during 1996. Two hundred fifty F_2 plants were analysed according their meiotic index (MI), as percentage of normal tetrads, and spikelet fertility (Fe) through the number of seeds per spikelet. Three immature spikes were taken in order to determine the percentage of normal tetrads, analysing 100 tetrads per plant. To estimate spikelet fertility, a sample of three mature spikes was taken from each F_2 plant, using the number of seeds to spikelet per spike ratio. A disruptive selection intensity of 6% was applied over both frequency distributions obtaining, in each case, two groups of fifteen F_2 plants. The 60 F_2 derived families were evaluated during 1997 ($F_{2:3}$) and 1998 ($F_{2:4}$); one row plots 5 m long 0.20 m apart were used, utilizing 50 seeds m^{-2} when the $F_{2:3}$ families were evaluated and 200 seeds m^{-2} in the $F_{2:4}$ generation. In both generations, the percentage of normal tetrads was determined analysing five immature spikes per family. Statistical analysis was performed considering separately and together the 1997 and 1998 results. A Duncan's Multiple Range Test was used in order to determine the least significant differences between means.

RESULTS AND DISCUSSION

Significant statistical differences (P 0.05) between group mean values were obtained during 1997 (Table 1). The meiotic index mean value corresponding to the families originated from the plant group with the high meiotic indexes, differed with respect to that pertaining to the low meiotic indexes group. With respect to the material selected in function of spikelet fertility, mean differences were significant between the high fertility group versus the low meiotic index one, but not among the mean values corresponding to the high and low fertility groups. For the meiotic index, a direct response to selection was obtained, but not indirectly.

TABLE 1 — Meiotic index (MI) mean values corresponding to four groups of F_2 derived lines in hexaploid triticale selected disruptively (high and low) in function of the meiotic index (MI) and spikelet fertility (Fe) and evaluated under field conditions during two years (1997 and 1998)

	Selection criteria			
	MI		Fe	
	high	low	high	low
1997	60.07 (a)	41.47 (b)	55.36 (a)	47.98 (ab)
1998	44.22 (a)	38.47 (a)	38.27 (a)	31.46 (a)
1997-1998	52.15 (a)	39.97 (b)	46.81 (ab)	39.72 (b)

Means in a file with different letter are significantly different at $P \leq 0.05$ (Duncan's Multiple Range Test).

With respect to the evaluation performed in 1998, not significant statistical differences between group mean values were found (Table 1). According to the 1998 results, the meiotic index, as direct selection criterion in order to improve it and spikelet fertility as the indirect one failed to give a significant response to selection.

Analysing both years together, as in the 1997 results, mean differences were highly significant (P 0.01); the high meiotic index group had a higher meiotic index mean value than that observed in the low meiotic and low fertility groups. In contrast, the meiotic index mean value observed in the high fertility group was not significant superior than that found in the low fertility group.

In conclusion, a significant direct response to selection with respect to the meiotic index was observed, but not indirectly through the spikelet fertility; similar results were obtained by MERKER (1971) and HSAM and LARTER (1973) who demonstrated the absence of a significant relation between spike fertility and meiotic index. However, the absence of significant mean differences between the high meiotic index and high spikelet fertility groups highlights the possibility for selection at the end of the reproductive process (i.e. spikelet fertility) without having a negative effect on the percentage of the normal tetrads.

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