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Genotype, environmental and GxE interactions effects on the meiotic index in hexaploid triticale (*Triticosecale* Wittmack)

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SUMMARY

Triticale (*Triticosecale* Wittmack) is an artificial alloploid species adapted to marginal crop areas, including semiarid conditions. Diverse studies have analysed the effects of the genotype and the environment on the meiotic disorders. The objectives of this study were to determine: 1) the existence of genetic variability for the meiotic index; 2) the effect of two moisture regimes on this character; 3) the presence of interaction between both factors. Six triticale varieties were cultivated under two moisture regimes: with and without irrigation. Significant statistical mean differences between the six genotypes studied were observed, but not between water treatments. However, a significant GxE interaction was observed which indicates a differential behaviour of some genotypes according to the irrigation regimes. The data suggest a relation between the meiotic index and the germoplasm origin.

Key words: triticale, cytological disorders, water treatments, GXE interactions.

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RESUMEN

El triticale (*Triticosecale* Wittmack) es una especie aloploide artificial adaptada a zonas de cultivo marginales, incluyendo condiciones de semiaridez. Diversos estudios han analizado el efecto del genotipo y del ambiente sobre las irregularidades meióticas. Los objetivos de este estudio fueron determinar: 1) la existencia de variabilidad genética para el índice meiótico; 2) el efecto de dos regímenes hídricos sobre este carácter; 3) la presencia de interacción entre ambos factores. Seis variedades comerciales de triticale hexaploide fueron sometidas a dos regímenes de humedad: con y sin riego. Se observaron diferencias significativas entre los seis genotipos estudiados, no así entre los regímenes hídricos. Sin embargo, se constataron interacciones genotipo-ambiente significativas, lo que indica un comportamiento diferencial de algunos genotipos según el régimen hí-

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dica un comportamiento diferencial de algunos genotipos según el régimen hídrico de cultivo. Estos resultados sugieren una relación entre índice meiótico y origen del germoplasma.

Palabras clave: triticale, desórdenes meióticos, regímenes hídricos, interacciones GxA.

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Triticale (*Triticosecale* Wittmack) is an artificial alloploid species adapted to marginal crop areas, including semiarid conditions (Stankova & Matsov, 1982; Scovmand *et al.*, 1984; Jessop, 1996). However, the relationships between wheat and rye genomes produce meiotic irregularities which could be reduced in a triticale breeding programe. In order to do so, diverse studies have analysed the effects of the genotype and the environment on the meiotic disorders. The existence of inter and intravarietal genetic variability respect to the percentage of normal microspores have been shown by Manero de Zumelzú *et al.* (1992). Similar results for the meiotic index (MI), or percentage of tetrades without micronuclei, have been reported by other authors (Gustafson & Qualset, 1975; Thomas *et al.*; 1983; Szpiniak de Ferreira, 1983; Ochoa de Suárez et al; 1987). The number of seeds per spike (Sayed, 1982; Abdala & Trethowan, 1990; Trethowan et al, 1990), the duration of the grain filling period (Trethowan *et al.*, 1990), and the grain yield (Abdala & Trethowan, 1990; Pfeiffer *et al.*, 1990) are conspicuous evidences of the environmental effects on the reproductive development. This problem is particularly important in cytological studies. Falçao *et al.* (1990) reported that environmental influence was higher for condensation, bridges and chromosomic breakups, whereas genotypic effects were more relevant for pairing irregularities, laggards and micronuclei. Analysing wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.) and triticale, Reddy (1992) has demonstrated the consequence of high temperatures on micronuclei rate. On the other hand, comparing wheat and hexaploid triticale, Boyd *et al.* (1970) have not demonstrated any temperature effect on meiotic and reproductive stability. Finally, water precipitations are the most important climatic determinants of agriculture in the semiarid regions where triticale has received more attention. Paradoxically, the effects of water stress on their meiotic behaviour is little known. In rice (*Oriza sativa* L.), Namuco & O'Toole (1986) have shown that chromosome abnormalities during the meiotic phases increased when the plant water supply decreased, a significant effect at relatively low levels of leaf water potential, and the meiotic process was suppressed when water supply was extremely low. According to these considerations, it may be inferred that the genetic constitution and the environmental cultivation conditions affect the meiotic index in hexaploid triticale. The objectives of this study were to determine: 1) the existence of genetic variability for the meiotic index; 2) the effect of two moisture regimes on this character; 3) the presence of interaction between both factors.

The experiment was conducted from June to October 1994 at the College of Agriculture Experimental Farm Córdoba National University, located in the central semiarid region of Argentine, where the soil is a silty loam Entic Haplustoll (USDA Soil Taxonomy). Six commercially distributed hexaploid triticale varieties (Don Frank, Quiñé, Tatú, Tehuelche, Venus and Yagán) were sown in three row plots 1.3 m long with 0.2 m row spacing and 100 seeds m2 plant density. Triticale varieties were subjected to two moisture regimes: with and without irrigation. Approximately 30 mm of water were applied at sowing in both treatments for germination and stand establishment. Taking into account an average historic rainfall of 150 mm in the triticale season, and in order to supplement winter cereal water requirements (400 mm), seven irrigations nearly every twenty days until boot stage were supplied to the irrigated trial. The experimental design was a complete randomized block, arranged as a split plot with two replications. Soil moisture regimes (with and without irrigation) were the main plots and the triticale varieties were the sub-plots. The average initial soil water content was 40mm/m and the amount of rainfall during the studied period was 127.7 mm. From each experimental unit five immature spikes were collected and treated according to the technique pro-

Table 1. Variance analysis of the meiotic index for six hexaploid triticale varieties grown under two water regimes (with and without water irrigation).

Source of variation	df	Mean square	P-values
Block	1	0.00120	≥ 0 05
Irrigation	1	0.00260	≥ 0 05
Error (a)	1	0.00034	
Variety	5	0.01695	≤ 0.01
Irrigation x Variety	5	0.00727	≤ 0.01
Error (b)	10	0.00084	
C.V.		6.74%	

posed by Ochoa de Suárez *et al.* (1987). Two hundred tetrades were analyzed in order to determine the meiotic index. Data were resolved using Ryan, Einot, Gabriel and Welsch Multiple Range Test.

Variance analysis (Table 1) revealed significant statistical differences ($P \leq 0.01$) between varieties and variety x water treatment interactions. The mean values of the MI of the six triticale varieties grown under two moisture regimes are given in Table 2 I. In respect to their MI values, triticale varieties were discriminated in two categories, the stable ones with high MI values (Don Frank) and low MI values (Venus) (Table 2 I y II); and the unstable ones, among which Tehuelche, Tatú and Quiñé triticale varieties showed significant statistical differences ($P \leq 0.05$) among water treatments (Table 2 II). While Falçao *et al.* (1990) did not observe genotype x environment interactions with respect to micronuclei rate, in this study, the latter varieties displayed an unstable meiotic behaviour. The Tatú variety, developed by the Centro Internacional del Mejoramiento del Maíz y Trigo (CIMMYT), exhibited the higher percentage of normal tetrades with water irrigation, and the lower percentage without it. A similar tendency showed the Tehuelche variety, developed by the Instituto Nacional de Tecnología Agropecuaria (INTA) in the southern semiarid region of Argentina (Bordenave). With respect to Quiñé, a triticale variety developed by Río Cuarto National University placed in the central semiarid region of Argentina, the higher MI values were observed without water supply

In summary, the hexaploid triticale varieties studied differed in relation to the meiotic index and the data suggest the existence of a relation between meiotic behaviour and germplasm origin, since a change in the moisture environmental conditions of cultivation with respect to the original one, induced disturbances in the meiotic process.

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Table 2. Mean values for the meiotic index for six hexaploid triticale varieties grown under two water regimes (with and without water irrigation).

I

Variety	Mean	
Don Frank	88	a
Tehuelche	87	ab
Yagán	86	ab
Venus	76	bc
Tatú	76	bc
Quiñé	74	c

N° of means in the comparison	2	3	4	5	6
LSD	10.3	11.3	11.9	11.9	12.5

II

Variety	Without		With	
Don Frank	89	a	88	a
Tehuelche	85	a	89	b
Yagán	84	a	89	a
Venus	76	a	76	a
Tatú	69	a	83	b
Quiñé	80	a	68	b

Means with the same letter (vertical in I and horizontal in II) are not significantly different at 5% for Ryan, Einot, Gabriel and Welsch Multiple Range Test.

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