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Effect of a fungicide treatment on yield and quality parameters of new varieties of durum wheat *(Triticum turgidum* L. ssp. *durum)* and bread wheat *(Triticum aestivum* L.) in western Andalusia

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Abstract

Five durum wheat varieties (*Triticum turgidum* L. spp. *durum*) and five bread wheat varieties (*Triticum aestivum* L.) have been tested in yield trials located in Jerez de la Frontera (Cádiz) in 2000-2001 and 2001-2002. The statistical design consisted of random blocks. Effects of fungicide treatment with epoxiconazol on yield, kernel weight, hectolitric weight, proteins and vitrosity percentage, falling number, baker strength and extensibility were studied. A high incidence of the foliar pathogenic agents *Septoria tritici* and *Puccinia triticina* was detected. A high correlation was obtained between the severity level of both diseases of durum wheats and their productivity. The quality factors kernel weight and hectolitric weight of durum wheats were altered by fungicidal effects. No statistical correlation was observed among the parameters studied in bread wheat.

Key words: *Septoria tritici, Puccinia triticina,* AUDPC, productivity, epoxiconazol.

Resumen

Efecto del tratamiento con fungicida sobre la productividad y calidad del trigo duro *(Triticum turgidum* L. ssp. *durum)* y trigo blando *(Triticum aestivum* L.) en Andalucía occidental

Durante las campañas agrícolas 2000-2001 y 2001-2002 cinco variedades de trigo duro (*Triticum turgidum* L. ssp. *durum)* y cinco de trigo blando (*Triticum aestivum* L.) fueron analizadas según un diseño en bloques al azar con cuatro repeticiones en Jerez de la Frontera (Cádiz). Se investigó el efecto del tratamiento fungicida con epoxiconazol sobre la productividad, peso de mil semillas, peso por hectólitro, porcentaje de proteínas y de vitrosidad, índice de caída de Hagberg, fuerza panadera y extensibilidad/tenacidad. Se constató una elevada incidencia de los patógenos foliares *Septoria tritici* y *Puccinia triticina*, obteniéndose una elevada correlación entre el nivel de infección de ambas enfermedades sobre trigo duro y su productividad. El peso de mil semillas y el peso por hectólitro de trigos duros son factores de calidad en los que se detectó una correlación significativa con la aplicación o no de fungicidas. No se constató correlación significativa entre los parámetros estudiados en el caso de trigos blandos.

Palabras clave: *Septoria tritici, Puccinia triticina,* AUDPC, rendimiento, epoxiconazol.

Introduction

Current methods to fight against fungal diseases in cereals, with the help of new fungicides, are based on etiological and epidemiological knowledge of the diseases, the productive potential of the crop, the type of response and the degree of susceptibility of the variety, presence of the disease, plant phenological status and climatological factors, especially those associated with humidity (López Bellido, 1991).

The main leaf diseases that affect wheat crop are leaf rust (*Puccinia triticina*), yellow rust (*Puccinia striiformis*), septoria (*Septoria tritici* and *Stagonospora nodorum*), powdery mildew (*Blumeria graminis f. spp. tritici*), *Pyrenophora tritici-repentis* and white mould (*Fusarium nivale*) (Martínez Moreno, 2002).

Disease control studies in durum wheat *(Triticum turgidum* L. ssp. *durum)* and bread wheat crops (*Triticum aestivum* L.) emphasize the importance of having detailed knowledge about crop planting and

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growth. These diseases have been favored in recent years by the fact that large areas have been dedicated to few, often genetically related, varieties, short crop rotations and a high seed density.

In Andalusia, large economic losses are mainly due to rust epidemics (usually *Puccinia triticina*) and septoriasis (mainly *Septoria tritici*). Conditions that favor development of these diseases usually coincide with conditions that favor crop growth and their main effects are to reduce yield and quality in years with the highest productive potential (Urbano, 2001).

Chemical control of diseases is a technique that has been widely used since 1960 with the introduction of carbendazime and related products, with some systemic activity, and the use of mixtures of chemicals from this group with maneb or mancoceb at the start of the 1970's. Later, another group of fungicides that inhibits ergosterol biosynthesis was developed, which included the triazols. To guarantee fungicide protection in this study the active material epoxiconazol was used, included in the triazol family. In mediterranean conditions, with important oscillations in crop yield, and where leaf epidemics do not occur every year or in all areas, it is difficult to justify routine fungicidal treatment. In countries with high productivities, practical manuals have been written indicating the treatment threshold, taking into account the phenological condition of the crop and disease development, the susceptibility of the variety, its potential yield and environmental conditions (Stuckey and Hershman, 1988). However, treatments with fungicides should not be systematic and whether they are used or not should be decided on the basis of the risks and conditions of the crop.

Diseases of wheat leaves and their repercussions on crop yield and quality have been studied in different crop regions. In the wheat growing area of Argentina, Galich *et al.* (1986, 1987) found that late infections, with spike formation, of *Septoria tritici* and *Puccinia triticina* produced variable losses in thousand kernel weight. Afterwards, Simon *et al.* (1996) also recorded variable losses in thousand kernel weight with late infections of septoria. Bancal *et al.* (1998) studied the effect of natural epidemics of wheat rust in France and verified the reduction in grain weight and wheat crop yield due to leaf diseases. Dimmock and Gooding (2002) studied the effect of different leaf diseases on bread wheat in the United Kingdom and their repercussions on grain yield and protein. Several authors have demonstrated that diseases of fungal origin reduce wheat yield and quality in mediterranean regions (Cherif *et al.*, 1994; Casulli, 1998; Ramdani *et al.*, 2000; Nsarellah *et al.*, 2000; Yahyaoui *et al.*, 2000, 2002).

Environmental conditions in western Andalusia over the last six years have resulted in the appearance of leaf diseases in wheat crops. Hence, in 1994-1995 strong powdery mildew attacks were detected and many farmers applied fungicidal treatments in spite of low yields. In 1995-1996, conditions were ideal for a septoria epidemic followed by a late attack of leaf rust (Urbano, 2001). In 1996-1997 there was a strong initial epidemic of septoria interrupted by climatological conditions consisting of a long drought after periods of abundant rainfall (RAEA, 1997). This was followed by a heavy attack of leaf rust. During 1998-1999 a pronounced powdery mildew epidemic was detected (RAEA, 1998). From 1999 to 2002, septoria and leaf rust have been found to be almost generalized (RAEA, 2000, 2001, 2002). All these findings explain the reasons for carrying out trials aimed at establishing the incidence of the main leaf diseases that affect a group of varieties of durum and bread wheat in western Andalusia, with and without fungicidal treatment, and their repercussions on yield and on the main quality parameters of both species.

Material and methods

During the seasons 2000-2001 and 2001-2002, agronomical trials were carried out with and without fungicidal treatment in the Agricultural Research and Training Center «Rancho de la Merced», in Jerez de la Frontera (Cádiz), belonging to the Agricultural Research Department of the Andalusian Regional Council.

Tilling methods were those included in the protocol established for cereal experiments in this center for a flat, uniform, unirrigated plot, with a frank clay soil and a sunflower crop rotation. Five varieties of durum wheat (*Triticum turgidum* L. spp. *durum)* and five of bread wheat (*Triticum aestivum* L.) were studied, in a randomized block statistical design with an experimental plot size of 10 m × 1.2 m and four repeats.

The plant material studied included 6 new varieties from the firm Agrovegetal, S.A.: Don Manuel, Don Rafael and Don Sebastián for durum wheats and Escacena, Olvera and Écija for bread wheats, obtained from the CIMMYT (International Maize and

Wheat Breeding Center, Mexico) Breeding Program; commercial controls for reference, Don Pedro and Yavaros C-79 (durum wheats) and Yecora and Cartaya (bread wheats) were used.

Fungicidal treatment of leaf diseases consisted of two applications of 12.5% epoxiconazol (commercial name: Lovit, Basf España), each with a dose of 1 L ha^{-1}. Treatment was started when the crop was in stage 25 of the code of Weber and Bleiholder (1990) and Lancashire *et al.* (1991) (tillering) and was repeated when the crop was in stage 39 of the same code (flag leaf). Treatments were applied in two repeat experiments and the remaining plots did not receive fungicidal protection.

The incidence of leaf diseases was studied over the whole crop cycle by estimating the parameter AUDPCs (standard area under disease progress curve) (Urbano, 2001). These assessments were carried out every fortnight from February to May to obtain data relating to disease severity, that was estimated by measuring the percentage of live leaf area affected by the pathogen. The AUDPCs was calculated by the formula:

$$AUDPCs = [\ \%\ disease + \%\ disease_{\ i+1})_{\ *}\ 0.5_{\ *}$$
$$*\ no.\ days\ interval)]\ /\ no.\ days\ total$$

The experimental plots were harvested after phenological stage 89 of the code of Weber and Bleiholder (1990) and Lancashire *et al.* (1991) (complete maturity). Grain yield was estimated from the harvested production. For the grain, the main quality parameters were determined in the Agricultural Food Produce Laboratory of Córdoba, Department of Agriculture and Fisheries, Andalusia Regional Council. For durum wheats, the grain was analyzed [thousand kernel weight (g), grain water contents (%), weight per hectoliter (kg hl^{-1})] and analysis of milled product [protein (%), Hagberg's falling number (s), beta-carotenes (ppm)]. Also, for bread wheats the grains were analyzed [thousand kernel weight (g), water contents of grain (%), weight per hectoliter (kg hl^{-1})] and analysis

Table 1. Parameter AUDPCs of *Septoria tritici* and *Puccinia triticina* for varieties of durum and bread wheat with and without fungicidal tratment during the seasons 2000/2001 and 2001/2002 in Jerez de la Frontera (Cádiz)

Varieties	AUDPCs *Septoria tritici*				AUDPCs *Puccinia triticina*			
	2000/2001		2001/2002		2000/2001		2001/2002	
	T	NT	T	NT	T	NT	T	NT
Durum wheats								
Yavaros C-79	0a	20.2a	4.9a	29.1a	1.6a	27.7a	0a	8.9a
Don Pedro	0a	24.3a	3.7a	27.7a	0.6a	22.7a	0a	17.1a
Don Manuel	0a	22.9a	3.7a	32.7a	0.3a	27.7a	0a	19.1a
Don Rafael	0a	23.0a	6.2a	23.9a	1.0a	25.2a	0a	19.0a
Don Sebastián	0a	12.3a	1.2a	23.9a	3.2a	25.2a	0a	16.5a
Mean durum wheats	0B	20.5A	3.9B	27.5A	1.3B	25.7A	0B	16.1A
Standard deviation	0	4.8	1.8	3.7	1.1	2.1	0	4.2
Error	0	2.2	0.8	1.6	0.5	0.9	0	1.9
Bread wheats								
Cartaya	0a	3.1ab	0a	0b	0a	1.9ab	0a	0a
Yécora	0a	4.1ab	5.1a	8.8a	0a	3.8a	0a	0a
Escacena	0a	10.9a	2.5a	10.2a	0a	0.6ab	0a	0a
Olvera	0a	2.1b	3.8a	3.8ab	0a	1.6ab	0a	0a
Écija	0a	3.1ab	0a	10.2a	0a	0b	0a	0a
Mean bread wheats	0B	4.7A	2.3B	6.6A	0B	1.6A	0A	0A
Standard deviation	0	3.5	2.3	4.5	0	2.1	0	0
Error	0	1.6	1.0	2.0	0	0.6	0	0

T: treated with 12.5% epoxiconazol. NT: not treated. Values followed by the same lower-case letter in the same column and by the same capital letter in the same row and year correspond to no significant difference at $P \leq 0.05$ according to Duncan's test.

of milled grain [protein (%), Hagberg's falling number (s), Chopin's alveogram: L (extensibility), P (persistence), P/L and W (baker strength)].

The results were analyzed by the programs STATISTIX 1.0 (Analytical software, 1996) and SPSS (Lizasoain and Joraisti, 1999).

Results

The years 2000/2001 and 2001/2002 were characterized by a high incidence of leaf pathogens *Septoria tritici* and *Puccinia triticina* in the study area. The results obtained for the parameter AUDPCs of *Septoria tritici* and *Puccinia triticina* on durum and bread wheat in experiments with and without fungicidal treatment are shown in Table 1.

Yield results (Table 2) revealed a mean yield increase in the range of 2070-2580 kg ha^{-1} in durum wheats and 651-1410 kg ha^{-1} for bread wheats treated with fungicide compared to untreated crops.

Table 2. Grain yield (kg ha^{-1}) of durum wheat and bread wheat during 2000/2001 and 2001/2002

Varieties	2000/2001		2001/2002	
	T	NT	T	NT
Durum wheats				
Yavaros C-79	8,450a	5,750a	7,813a	5,323a
Don Pedro	8,900a	6,350a	6,958a	6,088a
Don Manuel	9,050a	5,100a	7,883a	4,883a
Don Rafael	8,700a	6,500a	7,185a	4,478a
Don Sebastián	7,400a	5,900a	6,665a	5,435a
Mean durum wheats	8,500A	5,920B	7,301A	5,231B
Standard deviation	655	553	533	606
Error	293	247	238	271
Bread wheats				
Cartaya	8,050abc	6,800ab	7,028a	6,185a
Yécora	6,650c	6,100b	7,870a	5,920a
Escacena	9,800a	7,550a	7,525a	7,840a
Olvera	7,450bc	6,150b	6,025b	5,485a
Écija	9,400ab	7,700a	7,593a	7,355a
Mean bread wheats	8,270A	6,860B	7,208A	6,557A
Standard deviation	1,319	753	727	997
Error	590	336	325	446

T: treated with 12.5% epoxiconazol. NT: not treated. Values followed by the same lower-case letter in the same column and species and by the same capital letter in the same row and year correspond to no significant difference at $P \leq 0.05$ according to Duncan's test.

Table 3. Multiple linear estimation between grain yield factors (kg ha^{-1}) and AUDPCs of *Septoria tritici* and *Puccinia triticina* for durum wheat and bread wheat

Durum wheats	$m_2 = -22.9$	$m_1 = -83.3$	$b = 8068$
	$se_2 = 24.9$	$se_1 = 23.2$	$se_b = 246.6$
	$R^2 = 0.75$***	$se_y = 733.8$	
	$F = 26.0$	$df = 17$	
	$ss_{reg} = 28045016$	$ss_{resid} = 9153041$	
Bread wheats	$m_2 = -356.8$	$m_1 = -45.0$	$b = 7517$
	$se_2 = 263.1$	$se_1 = 66.5$	$se_b = 345.2$
	$R^2 = 0.13^{N.S.}$	$se_y = 1103$	
	$F = 1.2$	$df = 17$	
	$ss_{reg} = 2972539$	$ss_{resid} = 20711289$	

Significance levels: *** ($p \leq 0.001$); N.S. ($p > 0.1$). m, b: regression line coefficient and constant; se: standard error for the m coefficient; se_b: standard error for the constant b; R^2: coefficient of determination; se_y: standard error for estimation of y; F: Snedecor's coefficient; df: degrees freedom; ss_{reg}: sum of squares regression; ss_{resid}: residual sum of squares.

Multiple linear regression between yield parameters of durum wheat and bread wheat and the incidence of diseases caused by septoria and leaf rust during the years studied revealed statistical significance for durum wheats but no significance for bread wheats. These results are shown in Table 3.

Quality analysis of the durum and bread wheat samples in the experiments are recorded in Table 4.

Statistical analysis of quality parameters obtained for the durum wheat samples of the experiment revealed significant differences in the multiple linear regression of the parameter hectolitric weight and AUDPCs of *Septoria tritici* and *Puccinia triticina* (Table 5).

Multiple linear regression of thousand kernel weight in durum wheat and the AUDPCs of *Septoria tritici* and *Puccinia triticina* established that changes observed in this quality parameter were due to the infection caused by the pathogens (Table 6).

Hagberg's falling number and protein percentages were only slightly reduced in plots not treated with fungicide, obtaining a determination coefficient $R^2 = 0.224$ ($p \leq 0.1$) and $R^2 = 0.362$ ($p \leq 0.05$) respectively. There were no significant differences between treated and untreated plots for the other quality parameters studied.

Statistical analysis of the quality parameters obtained for samples of bread wheat in experiments did not reveal significant differences in any of the parameters studied.

Table 4. Effect of epoxiconazol treatment on the quality of durum wheat and bread wheat varieties during the seasons 2000/2001 and 2001/2002

Varieties	2000/2001		2001/2002		2000/2001		2001/2002		2000/2001		2001/2002		2000/2001		2001/2002		2000/2001		2001/2002	
	T	NT	T	NT	T	NT	T	NT	T	NT	T	NT	T	NT	T	NT	T	NT	T	NT
Durum wheat	**Thousand kernel weight (g)**				**Weight per hectoliter (kg hl^{-1})**				**Protein (%)**				**Vitrosity (%)**				**Falling number (s)**			
Yavaros C-79	50.85b	41.9ab	42.8a	39.2ab	85.4b	83.1bc	86.1ab	81.3b	12a	11.7ab	11.3ab	11.6a	89a	92a	88a	88a	335a	423a	442a	479a
Don Pedro	48.65b	42.6ab	43a	40ab	86ab	84.8ab	84.9bc	83.3ab	12a	10.8b	11ab	10.4a	83.5a	72.5b	88.5a	81.5a	432a	420a	503a	441a
Don Manuel	42.15c	35.65b	40.7a	36.4b	85.5ab	82.3c	84c	81.5b	12.2a	11.8a	10.1b	11a	85a	87.5a	73.5a	88.5a	417a	399a	470a	476a
Don Rafael	54.45a	41.5ab	49.4a	36.3b	87a	85.5a	87a	83ab	12.5a	11.8a	11.7ab	11.5a	86a	83ab	84.5a	88a	435a	410a	471a	493a
Don Sebastián	53.7a	45.9a	48.1a	44.3a	85.7ab	81.7c	85.7abc	84.5a	14.1a	11.2ab	12a	11.2a	95a	76b	90.5a	75.5a	448a	400a	468a	471a
Mean durum wheat	50A	41.5B	44.8A	39.2A	85.9A	83.5B	85.5A	82.7B	12.6A	11.4A	11.2A	11.1A	87.7A	82.2A	85A	84.3A	413A	410A	471A	472A
Standard deviation	4.94	3.7	3.74	3.27	0.64	1.62	1.15	1.33	0.88	0.44	0.73	0.47	4.55	8.02	6.78	5.7	45.2	11.06	21.65	19.16
Error	2.2	1.66	1.67	1.46	0.29	0.72	0.51	0.59	0.39	0.2	0.33	0.21	2.03	3.58	3.03	2.55	20.2	4.94	9.68	8.57
Bread wheat	**Thousand kernel weight (g)**				**Weight per hectoliter (kg hl^{-1})**				**Protein (%)**				**Baker's strength (W)**				**Extensibility/tenacity (P/L)**			
Cartaya	42.6a	38.5c	38.8cd	35.6b	83.9a	82.5b	83b	80.9b	12.1a	11.3a	10.7bc	10.9ab	128b	95b	128c	159c	0.72b	0.91a	0.72b	0.83ab
Yécora	42.1a	41.5b	46.1a	46.3a	83.5a	83.3ab	85a	85.3a	12.3a	11.6a	11.6b	11.3ab	158b	103b	268a	248b	0.99b	1.76a	0.96a	1.05a
Escacena	42.5a	39.8bc	41.6b	40.2ab	85.5a	83.1ab	85.4a	83.5a	12.1a	10.6a	10.2c	10.1b	160b	118b	187b	183bc	1.06b	0.78a	1.04a	0.98ab
Olvera	44.7a	44.9a	37.4d	37.5b	84.9a	84.7a	81.8b	83.3a	13.7a	11.9a	12.6a	12.3a	210ab	218a	309a	335a	2.57a	1.7a	1.02a	1.07a
Écija	42.7a	38.1c	40.6bc	40.2ab	84.9a	83.7ab	84.6a	84.4a	13.4a	11.4a	11bc	10.9ab	310a	135b	216b	229b	0.8b	0.75a	0.72b	0.69b
Mean bread wheat	42.9A	40.5A	40.9A	39.9A	84.5A	83.5A	84A	83.5A	12.7A	11.4A	11.2A	11.1A	193A	134A	222A	231A	1.23A	1.18A	0.89A	0.92A
Standard eviation	1.02	2.7	3.32	4.04	0.82	0.82	1.51	1.65	0.77	0.48	0.92	0.8	71.6	49.5	70.3	68.2	0.76	0.5	0.16	0.16
Error	0.45	1.23	1.48	1.8	0.36	0.36	0.67	0.73	0.34	0.22	0.41	0.36	32	22.1	31.45	30.5	0.34	0.22	0.07	0.07

T: treated with 12.5% epoxiconazol. NT: not treated. Values followed by the same lower-case letter in the same column and by the same capital letter in the same row for each parameter and year studied indicate no significant difference at $P \leq 0.05$ according to Duncan's test.

Table 5. Multiple linear estimation between the factors hectolitric weight of grain (kg hl^{-1}) and AUDPCs of *Septoria tritici* and *Puccini triticina* for durum wheat

$m_2 = -0.03$	$m_1 = -0.09$	$b = 85.8$
$se_2 = 0.04$	$se_1 = 0.04$	$se_b = 0.43$
$R^2 = 0.54$**	$se_y = 1.29$	
$F = 9.88$	$df = 17$	
$ss_{reg} = 32.75$	$ss_{resid} = 28.18$	

Significance level: ** ($p \leq 0.01$).

Discussion

The parameters AUDPCs of *S. tritici* and *P. triticina* obtained in both years revealed the efficacy of the treatment with epoxiconazol. A different response was also observed in the incidence of diseases in both durum and bread wheats.

S. tritici revealed a specialization against the host species, with higher levels of infection in durum wheat than in bread wheat. Previous studies (Urbano, 2001) have shown that monopicnicdial isolates of *S. tritici* obtained from durum wheat varieties from the cereal growing region of Jerez de la Frontera (Cádiz) presented a higher virulence profile (50% virulent and 50% avirulent) for a collection of differential varieties than those obtained for bread wheat varieties in the same area (more than 80% avirulent isolates) for the same differential varieties. These results do not agree with those obtained in other mediterranean regions. In Israel and Morocco, the frequency of resistance genes is greater in durum wheats than in bread wheats (Burleigh *et al.*, 1991; Eyal, 1981; Saadaoui, 1987). Other experiments carried out in Andalusia obtained results similar to those recorded in Israel and Morocco when they found durum wheats to be more resistant to septoriasis (Montes and Marin, 1984). This could be explained by the change in species grown in western Andalusia in favor of durum wheat and to the detriment of bread wheat in recent years (Pérez, 1998).

Table 6. Multiple linear estimation between the factors thousand kernel weight (g) and AUDPCs of *Septoria tritici* and *Puccini triticina* for durum wheat

$m_2 = 0.04$	$m_1 = -0.37$	$b = 48.21$
$se_2 = 0.13$	$se_1 = 0.12$	$se_b = 1.32$
$R^2 = 0.55$**	$se_y = 3.92$	
$F = 10.29$	$df = 17$	
$ss_{reg} = 315.6$	$ss_{resid} = 260.7$	

Significance level: ** ($p \leq 0.01$).

Similarly, the severity of the infection due to *P. triticina* was different in durum and in bread wheats. This could be due to the fact that breeding programs over the last few years have been aimed at introducing resistance genes in bread wheats (Martínez Moreno, 2002). The greater susceptibility of durum wheats was confirmed here, as for other cereal growing areas of Mexico, Tunisia and Morocco. The CIMMYT breeding program, therefore, has the priority objective of introducing genes with resistance to leaf rust in durum wheat (Pfeiffer, personal communication).

Reduced yield due to the incidence of fungal diseases was confirmed, corroborating previous results (Nsarellah *et al.*, 2000; Monotti *et al.*, 2001; Zadravec and Babnik, 2001; Dimock and Gooding, 2002). In 75% of cases, variations in productivity of durum wheats could be due to varying severity of leaf rust and septoria owing to the fungicide effect. In contrast, in all the years studied, variations in yield of bread wheats could not be explained by the incidence of diseases although the mean yields were significantly different to those recorded in the first year of the experiment (1410 kg ha^{-1}).

The reduced thousand kernel weight and weight per hectoliter corroborate the results obtained by other authors who report variable losses in thousand kernel weight with late septoria infections in the wheat growing area of Argentina (Galich *et al*., 1986, 1987; Simon *et al.*, 1996) and also in other mediterranean areas (Monotti *et al.*, 2001), showing that these parameters are affected by the incidence of leaf diseases and increase when fungicidal protection is used (Jorgensen *et al.*, 2001).

For protein percentages both in durum and bread wheats, more than 1% higher mean value were observed in the repeat treatments carried out in 2000/2001. However, as for other authors, there were no significant differences between different years studied (McKendry *et al.*, 1995; Dimock and Gooding, 2002).

Vitrosity percentage and Hagberg's falling index measured in durum wheat did not reveal significant differences between mean values with and without fungicidal treatment. Similarly, baker's strength and extensibility/tenacity were not significantly different in bread wheats in any of the two years studied. This could be because in the conditions studied changes in these parameters are independent of the incidence of leaf diseases.

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