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Effect of powdery mildew attack on quality parameters and experimental bread baking of wheat

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ABSTRACT

The research of powdery mildew impact on bread making quality of wheat was conducted on seven divergent wheat cultivars/lines, in factorial treatment designs (T_0 - untreated and T_1 - with fungicide Duett treated variants) at Križevci, Croatia. Test weight, grain protein content, wet gluten, sedimentation value and rheological parameters, as well as experimental bread baking were examined during two years (2000 and 2001).

Two years average test weight and grain protein content readings are significantly lower at untreated (T_0) variants (diff. = 1.01 kg/hl** and 0.5 %** respectively). In wet gluten content there was no significant difference between the two variants, while average sedimentation value was significantly higher at untreated (T_0) variant (diff. = 2.6 ml**). Farinographic indicators of quality (dough development and stability, resistance, degree of softening) as well as indicators of extensograph (energy and resistance) were also better at untreated (T_0) variants.

Dough yield, one of test-baking parameters, was bigger in treated (T_1) variants, while the volume contribution was higher in untreated (T_0) variants. Contrary to expectations, untreated resistant, moderately infected, or even susceptible variants had better quality parameters, offering speculation about eventual negative side-effect of applied fungicide Duett (epoxiconazole 12.5% + carbendazim 12.5%). Due to an interaction between numbers of different factors the speculation should be additionally checked and revised.

Key words: wheat, powdery mildew, bread baking quality.

IZVLEČEK

VPLIV OKUŽBE S PEPELASTO PLESNIJO PŠENICE NA DEJAVNIKE KAKOVOSTI IN REZULTATE POSKUSNE PEKE KRUHA

V Križevcih (Hrvaška), je dve leti (2000 in 2001) potekal poskus s sedmimi sortami/linijami pšenice v faktorskem poskusu (T_0 – netretirana in T_1 – s fungicidom Duett tretirana varianta) za raziskavo vpliva okužbe s pepelasto plesnijo na kazalce pekovske kakovosti pšenice

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(hektolitrska masa, vsebnost beljakovin in vlažnega glutena, sedimentacijska vrednost, reološki parametri in rezultati poskusne peke kruha). Povprečna hektolitrska masa in vsebnost beljakovin sta bili značilno nižji pri netretiranih (T_0) variantah (razlike = 1,01 kg/hl** in 0,5 %**). Glede na vsebnost vlažnega glutena ni bilo značilnih razlik med proučevanimi variantami, medtem ko je bila ugotovljena povprečna vrednost sedimentacije značilno višja pri netretiranih (T_0) variantah (razlika = 2,6** ml). Farinografski pokazatelji kakovosti (razvoj testa, stabilnost, odpor, stopnja mehčanja) kot tudi pokazatelji ekstenzografa (energija in odpor) so bili ugodnejši pri netretiranih variantah. Pri poskusni pripravi kruha in peki je bil nastanek testa večji pri tretiranih (T_1) variantah, medtem, ko je bil volumen kruha večji pri netretiranih (T_0) variantah. V nasprotju s pričakovanji so imele na pepelasto plesen odporne, delno občutljive in občutljive pšenice boljše parametre kakovosti, kar omogoča sklepanje o možnem stranskem negativnem učinku fungicida Duett (epoxiconazol 12.5% + carbendazim 12,5%). Zaradi kompleksnih interakcij številnih dejavnikov vključenih v uravnavanje teh mehanizmov, bi bilo potrebno ta rezultat še dodatno raziskati in preveriti.

Ključne besede: pšenica, pepelasta plesen, pekarska kakovost.

1 INTRODUCTION

Improved agronomic practices in wheat production, primarily higher population density and higher nitrogen application, created favorable conditions for pathogen development and higher crop sensitivity to diseases. Powdery mildew of wheat (*Erysiphe graminis* D.C. f.sp. *tritici* E. Marchal; synonym = *Blumeria graminis* D.C. f.sp. *tritici* March.) is a common disease in northwest region of Croatia. Its negative impact on grain yield is well documented. Depending on severity and time of attack powdery mildew reduce supply of photosynthesis and nitrogen re-translocation from leaves, negatively affects development of root system and leaf assimilation on area, affects all three yield components, and finally the grain yield (Fried et al., 1976; Carver and Griffiths, 1981; Gair et al., 1983; Kišpatić, 1984; Bowen et al., 1991; Henry and Kettlewell, 1996; Cvjetković, 2003; Samobor et al., 2005; etc.). According to time and severity of disease attack, the extent of yield losses can be predicted mathematically (Large 1954, Large and Doling 1962, 1963, Johnson et al., 1979).

Strong attack of powdery mildew has negative impact on test weight and thousand kernel weight (Bowen et al., 1991, Samobor et al., 2005). There are a few data available about mildew impact on other bread making quality parameters, and *some information are even conflicting*. Flour yield is related to test weight. Everts et al. (2001) report reduced flour yield of soft wheat cv. Saluda in the presence of powdery mildew infection. Lower amount of grain protein and resulting increase quality of soft wheat cv. Chancellor was reported by Johnson et al. (1979). More recently, increased level of grain protein and lower bread making quality of bread wheat was reported (Gooding et al., 1994), and also in cool, wet weather pre-maturity α-amylase activity can be reduced as a result of faster grain drying and faster crop senescence.

As a result of mutations and gene recombination during sexual phase of reproduction in fungus *Erysiphe graminis* the number of virulent physiological races/pathotypes are increasing permanently. The physiological race/pathotype is a genotype of pathogen that attacks only certain group of cultivars (Niks et al., 1993); or the race/pathotype is defined as a segregant of pathogen, that provokes different reactions within host genotypes (Fehr, 1987). But reports about race/pathotype related effect of

disease attack on wheat quality was not found. In Croatia, the identification of races/pathotypes started in1960's. At the beginning only 18 virulent races/pathotypes were determined (Špehar, 1968), while in 1990's number of races reported for regions of northwest Croatia and Slovenia increased to 61 (Korić, 1991 and 1994). Races 46, 51, 75 and 85 with 6-10 virulent genes were reported as the most common and the most virulent. Today 48 genes for resistance to powdery mildew located on 32 loci and 16 different chromosomes are determined (Xiu-Quiang and Röder, 2004) but there were no reports about its pleiotropic effect on bread making quality.

The purpose of this research was to determine the effects of powdery mildew (*Erysiphe graminis* D.C. f.sp. *tritici*) attack on parameters of wheat (*Triticum aestivum* ssp. *vulgare*) bread-making quality.

2 MATERIALS AND METHODS

Based on earlier investigations (Samobor and Jošt, 1999; Samobor et al. 2005) seven divergent wheat cultivars/lines were selected (Tab. 1) and tested during two years (2000-2001) at Križevci (46^0 01' N – 16^0 32' E), Croatia. The two factorial randomized block design were used including untreated -T_0 and with fungicide Duett treated -T_1 variants. Fungicide treatment at T_1 variants were performed once in 2000, and twice in 2001: at steam elongation and before heading (Feekes-Large scale 6-8 and 10.1). Only the two very susceptible cultivars (Žitarka and Široka) were treated three times in 2001. The final reading of disease attack was done at heading (Feekes-Large scale 11).

The intensity of disease attack was measured on Brooks scale (1-5) and height of infection on Saari-Prescott scale (0-9). Besides the powdery mildew attack, test weight, grain protein content, wet gluten content, sedimentation value, rheological parameters and experimental baking were determined on both untreated, infected (T_0) and treated, protected (T_1) variants. The readings for each year, and two years average are presented in tables.

Table 1. Origin and some characteristic of selected cultivars/lines

No.	Cultivar/line	Origin	HMW glutens	Remark
1	KS92WGRC21	USA	N 7+9 5+10	Resistant, good quality
2	Divana	Croatia	2* 7+9 5+10	Tolerant, very good quality
3	4572.07	New Zealand	N 7+9 5+10	Tolerant, acceptable quality
4	Droria	Romania	N 7+8 5+10	Susceptible, good quality
5	C00223	Argentina	1 7+9 5+10	Susceptible, good quality
6	Žitarka	Croatia	1 7+8 2+12	Susceptible, accept. quality
7	Široka	Croatia	1 7+9 2+12	Very susceptible, low quality

3 RESULTS AND DISCUSSION

The bread-making quality of wheat is a complex character that can be defined by many parameters; all of them are in interaction with the environmental factors (genotype vs. macro and micro nutrients availability, climate, severity of diseases attack, crop yield, etc.).

In the year 2001, due to more humid climatic conditions (795.0 mm rainfalls), the powdery mildew attack was a little stronger, while the year 2000 was rather dry (565.9 mm rainfalls) with low disease severity.

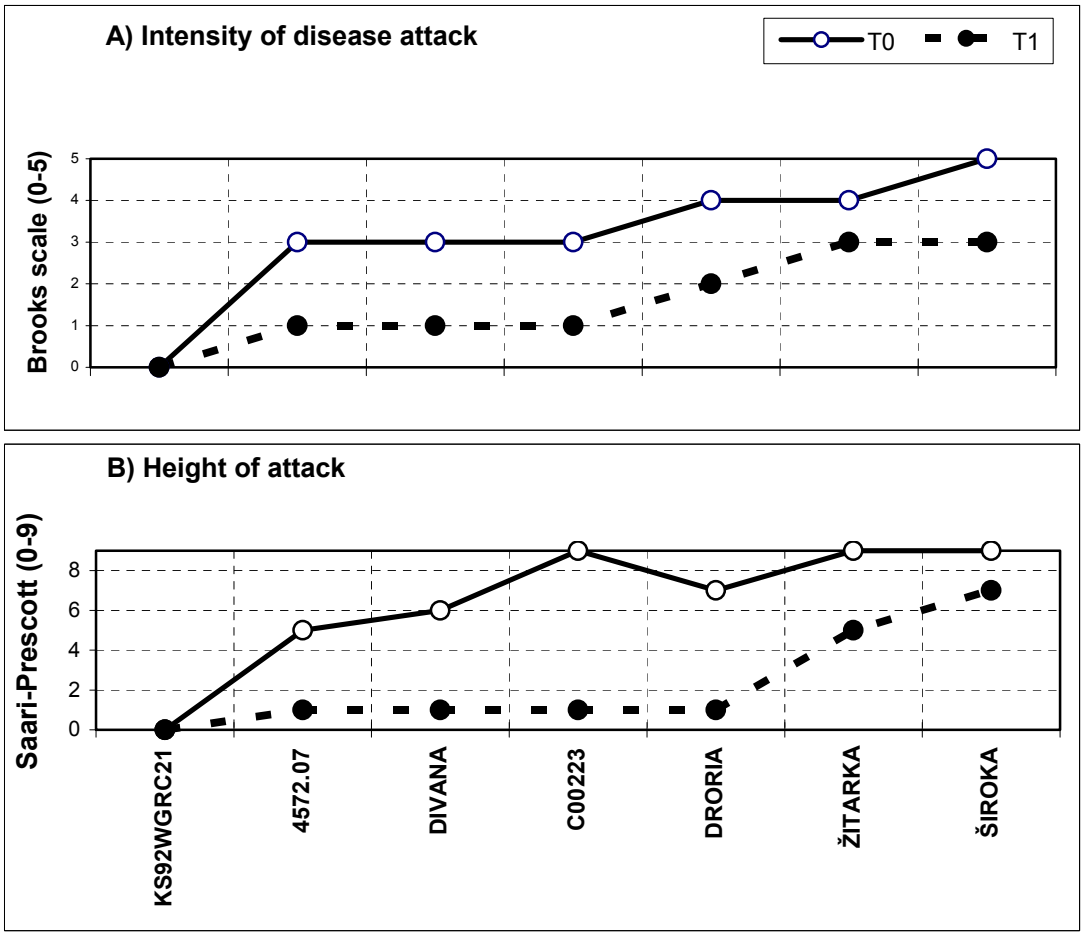

Fig. 1. Powdery mildew attack: intensity (Brooks) and height (Saari-Prescott) for seven cultivars/lines grown at Križevci, in 2001

The powdery mildew attack for seven divergent cultivars/lines grown in 2001 was shown in Fig.1. Only line KS92WGRC21 was completely resistant in both years of research. Other entries could be classified as tolerant (Divana and 4572.07), susceptible (Žitarka, C00223, Droria) and very susceptible (Široka). Differences between untreated (T_0) and with fungicide treated (T_1) variants were highly significant. (Tab.2)

Test weight and grain protein content are common and at elevators widely used parameters of wheat grain quality. Treated variants (T_1) had significantly higher average test weight and grain protein content, but in wet gluten content there was no significant difference between the two variants (T_1 and T_0). (Tab.2) However, sedimentation value, as the more valuable parameter of wheat bread baking quality, had opposite readings.

Table 2. Differences in average readings of powdery mildew (*E. graminis* ssp. *tritici*) attack and quality parameters between $\mathbf{T_0}$ and $\mathbf{T_1}$ of seven wheat cultivars/lines, grown at Križevci in two years (2000 and 2001)

No.	Parameter	Treatment **	2000	2001	Average	Difference ***
1	Powdery mildew attack (Brooks, Saari-Prescott)*	$\mathbf{T_1}$	1 , 1	1 , 1	1 , 1	> 2**, 4 **
		$\mathbf{T_0}$	2 , 3	3 , 6	3 , 5	
2	Test weight (kg/hl)	$\mathbf{T_1}$	82.50	79.78	81.14	> - 1.01 **
		$\mathbf{T_0}$	81.64	78.62	80.13	
3	Grain protein content (%)	$\mathbf{T_1}$	12.43	13.99	13.21	> - 0.33 **
		$\mathbf{T_0}$	12.10	13.66	12.88	
4	Wet gluten content (%)	$\mathbf{T_1}$	23.99	26.39	25.19	> - 0.1
		$\mathbf{T_0}$	24.00	26.14	25.07	
5	Sedimentation value (ml)	$\mathbf{T_1}$	45.93	43.09	44.51	> 2.6 **
		$\mathbf{T_0}$	48.20	45.94	47.07	

* Attack intensity (Brooksu 1-5), height of infection (Saari-Prescott 0-9)

** $\mathbf{T_1}$ = treated with fungicide Duett, $\mathbf{T_0}$ = untreated

*** Significant difference at p=0.05 (*) and p=0.01 (**)

Significantly higher average value was in untreated (T_0) variant (diff. = 2.6** ml). While grain protein content tells us about amount of proteins, sedimentation value tells us more about protein quality, and this fact can explain the sudden changes. This is confirmed by farinographic indicators of quality. Only average water absorption was higher in treated variant (T_1), because it depends upon the amount of protein. While all other indicators, except of course - degree of softening which is negatively correlated with bread making quality, had higher values in untreated (T_0) variants (dough development time, stability, resistance and quality number). Two of extensigraphic parameters (energy and resistance) were also better in untreated (T_0) variants, while extensibility is higher in treated (T_1) variant. (Tab.3; Figs. 2 and 3).

Amylolitic activity measured by Hagberg-Pertten falling-number or by amylograph was generally slightly higher in treated (T_1) variant. As amylolitic activity should not be too high or too low the impact on quality would depend upon characteristic of particular genotype. In treated (T_1) variant, genotype with too low amylolitic activity would have improved this quality parameter, and opposite.

Finally, test baking gives the best illustration of flour quality. While treated variants (T_1) had on average slightly higher dough yield (results of higher water absorption due to higher protein content) in the bread yield there were no differences between variants and in the volume yield on average untreated (T_0) variant was superior. (Tab.3; Fig.4)

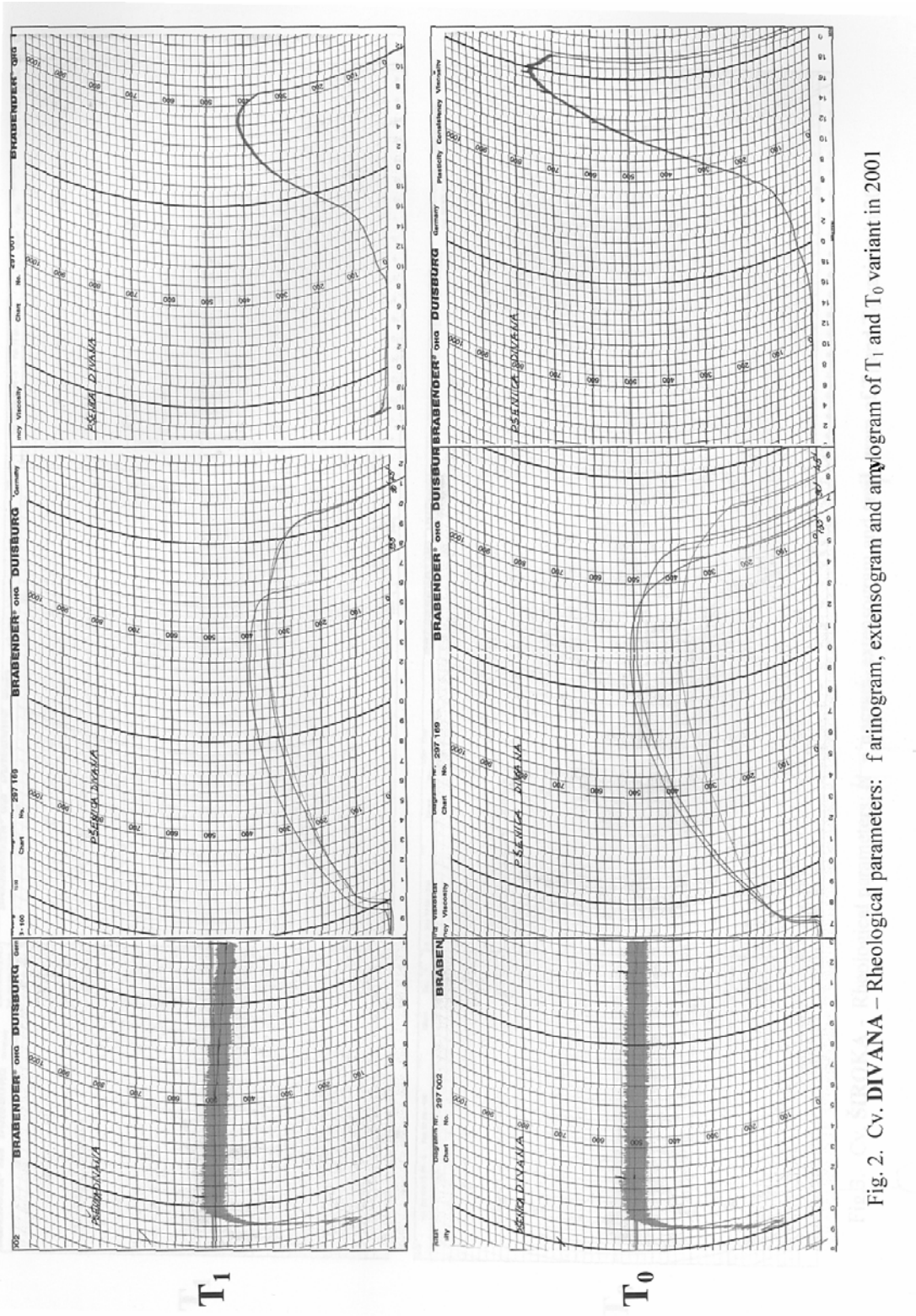

Fig. 2. Cv. **DIVANA** – Rheological parameters: farinogram, extensogram and amylogram of T_1 and T_0 variant in 2001

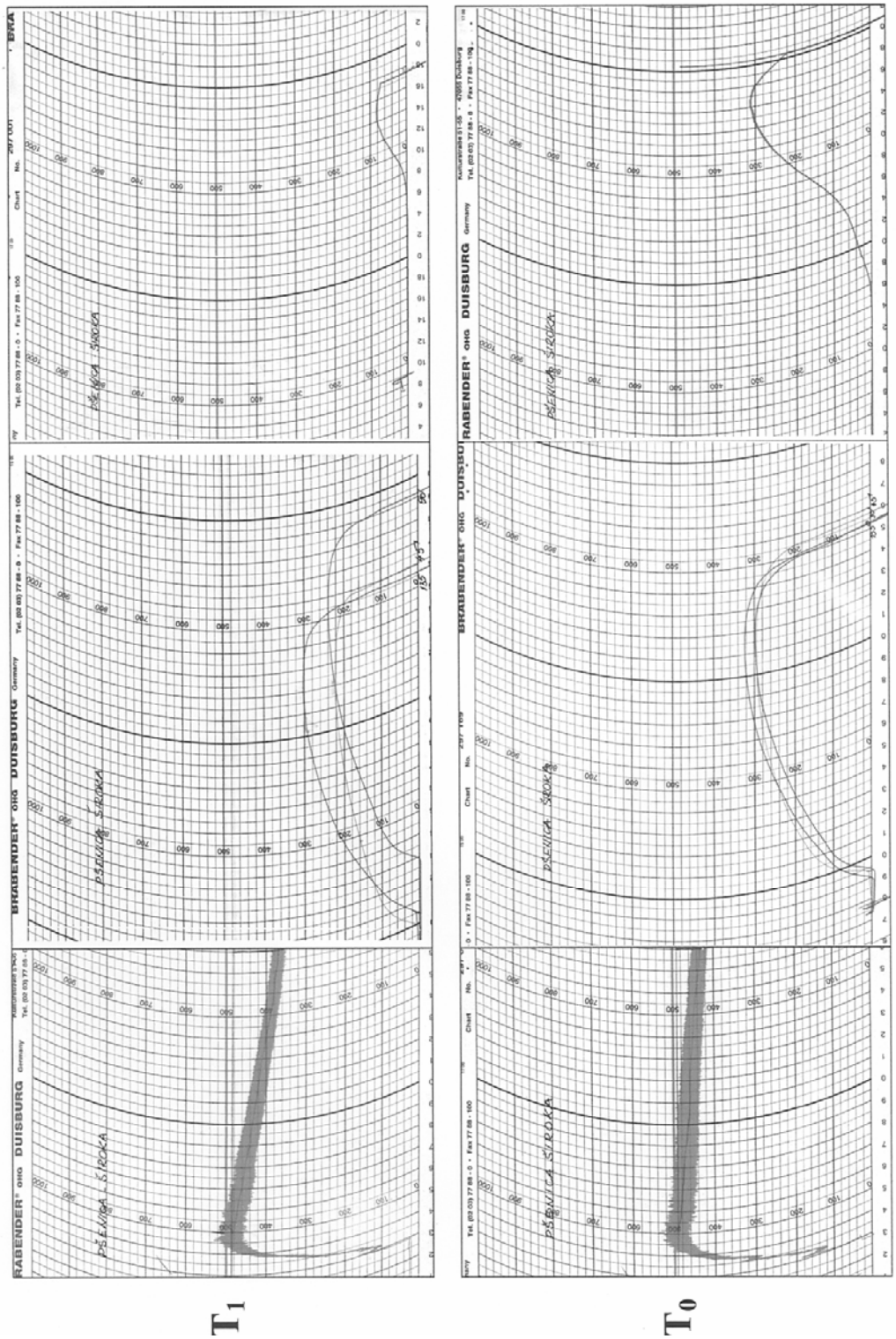

Fig. 3. Cv. **ŠIROKA** - Rheological parameters: farinogram, extensogram and amylogram of T_1 and T_0 variant in 2001

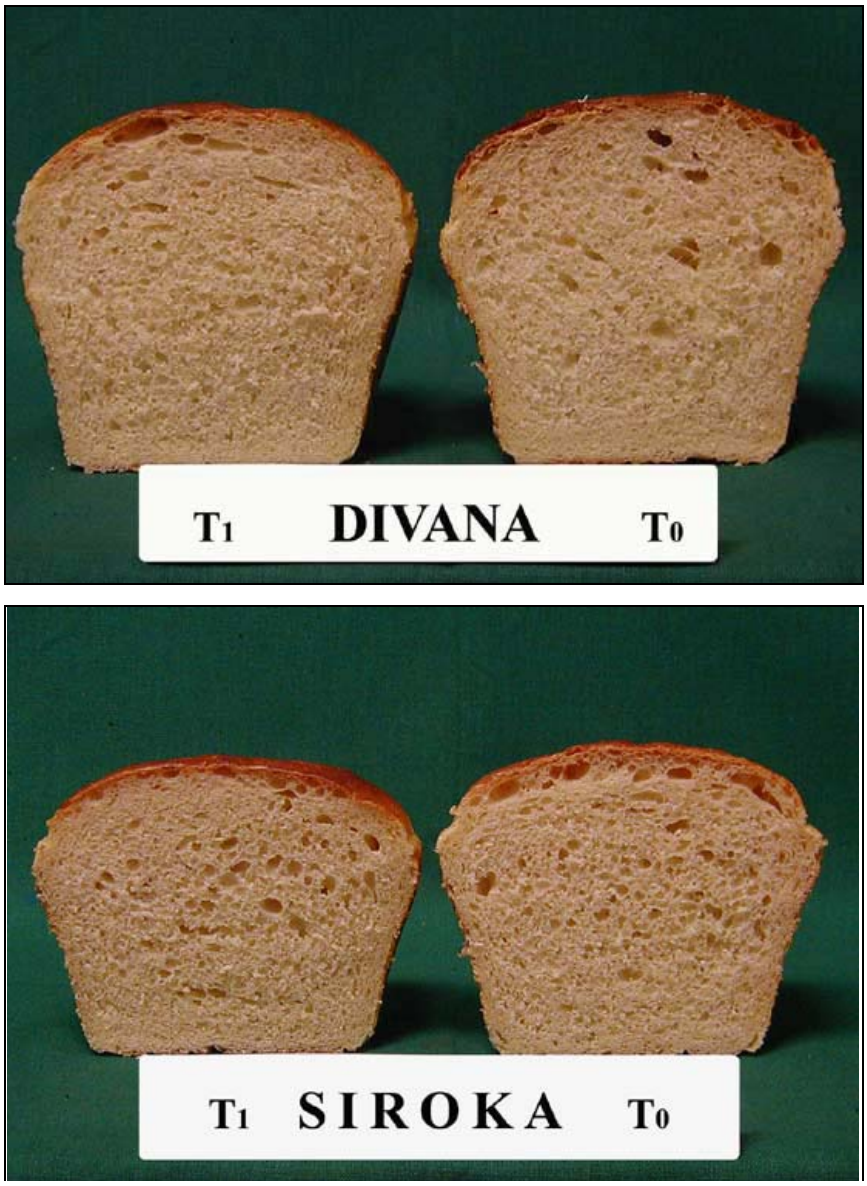

Fig.4. Bread loaf cross-section of treated (T_1) and untreated (T_0) variant of cv. Divana and cv. Široka, grown in 2001.

Table 3. Difference between $\mathbf{T_0}$ and $\mathbf{T_1}$ in rheologycal and test bread baking parameters for seven cultivars/lines tested at Križevci, Croatia, in two years (2000 and 2001)

No.	Parameter	Treatment *	2000	2001	Average readings	Difference
1	**Farinograph**					
1.1	Water absorption (%)	$\mathbf{T_1}$	64.3	62.6	63.5	> 0.7
		$\mathbf{T_0}$	64.3	61.2	62.8	
1.2	Dough development (min)	$\mathbf{T_1}$	3.36	2.36	2.88	> -0.54
		$\mathbf{T_0}$	4.20	2.64	3.42	
1.3	Stability (min)	$\mathbf{T_1}$	0.50	0.64	0.57	> -0.77
		$\mathbf{T_0}$	1.10	1.57	1.34	
1.4	Resistance (min)	$\mathbf{T_1}$	3.86	3.00	3.43	> -1.27
		$\mathbf{T_0}$	5.29	4.10	4.70	
1.5	Degree of softening (FU)	$\mathbf{T_1}$	91	99	94.3	> 21.4
		$\mathbf{T_0}$	76	69	72.9	
1.6	Quality number	$\mathbf{T_1}$	58.1	55.1	56.6	> -5.7
		$\mathbf{T_0}$	62.0	62.5	62.3	
2	**Extensograph** (135 mn)					
2.1	A Energy (sqcm)	$\mathbf{T_1}$	70.39	76.17	73.28	> -2.21
		$\mathbf{T_0}$	59.97	91.00	75.49	
2.2	B Extensibility (min)	$\mathbf{T_1}$	165.71	158.29	162.00	> 1.86
		$\mathbf{T_0}$	157.14	163.14	160.14	
2.3	C Resistance (EU)	$\mathbf{T_1}$	237.14	261.43	249.29	> -2.86
		$\mathbf{T_0}$	209.29	295.00	252.15	
2.4	D Max. resistance (EU)	$\mathbf{T_1}$	325.71	367.86	346.79	> -5.71
		$\mathbf{T_0}$	277.14	427.86	352.50	
2.5	Proportion C/B (EU/min)	$\mathbf{T_1}$	1.47	1.71	1.59	> 0.0
		$\mathbf{T_0}$	1.34	1.84	1.59	
3	**α-amylase activity**					
3.1	Falling number (Hagberg-Perten)	$\mathbf{T_1}$	329	262	296	> 22
		$\mathbf{T_0}$	337	299	318	
4	**Bread parameters**					
4.1	A) Dough yield (g) at 14% v.b.	$\mathbf{T_1}$	164.8	166.8	165.8	> 4.2
		$\mathbf{T_0}$	164.7	158.5	161.6	
4.2	B) Bread yield (g) at 14% v.b.	$\mathbf{T_1}$	155.4	157.3	156.4	> 0.3
		$\mathbf{T_0}$	155.5	156.6	156.1	
4.3	C) Volume yield (cm^3) at 14% v.b.	$\mathbf{T_1}$	416.2	430.5	423.4	> -5.8
		$\mathbf{T_0}$	431.5	426.8	429.2	
4.4	D) Bread shape: h/d	$\mathbf{T_1}$	0.89	0.93	0.91	> 0.0
		$\mathbf{T_0}$	0.94	0.89	0.92	

*$\mathbf{T_1}$ = with fungicide Duett treated, and $\mathbf{T_0}$ = untreated variant

There have been numerous reports about negative effects of powdery mildew attack on grain protein content and test weight of wheat. Our results also verify earlier discoveries. We were also expecting similar impact of powdery mildew on other quality parameters of wheat but to our surprise our investigations generally detected

better quality parameters in untreated (T_0) variants. Since very divergent genotypes were included in investigation, from resistant to very susceptible wheat, and also from excellent to poor quality genotypes, the results generally could be taken as representative for wheat. As, in both years, completely resistant wheat line KS92WGRC21 had better quality parameters in untreated variant, the speculation could be made about negative side effect of the used fungicide (Duett) on quality parameters. Even the untreated variants of genotypes susceptible to powdery mildew had better quality performances and that corroborated our speculations. However, due to very complex polygenic mechanism of resistance as well as some complex and polygenic mechanism of bread quality these speculations should be additionally checked and revised.

4 CONCLUSIONS

The more or less infected wheat (T_0 variant) that was untreated with fungicide Duett displayed generally better bread baking quality parameters (except test weight, grain protein content and dough yield) in comparison with treated (T_1) variant. There are certain speculations about the possible negative side effect of applied fungicide Duett based on obtained readings. For validity these speculations should be additionally checked.

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