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Impact of climatic conditions on rheological parameters in several Romanian winter wheat varieties

Authors: Cristina Mihaela Marinciu, Cătălin Lazăr, Gabriela Şerban (NARDI Fundulea), Mihai Tilihoi (ARDS Valul lui Traian), Gabriela Păunescu (University of Craiova-ARDS Caracal), Cecilia Bănăţeanu (ARDS Livada), Beniamin-Emanuel Andraş (ARDS Livada), Cristina Melucă (ARDS Teleorman), Iustina Lobontiu (RDSCB Târgu-Mureş), Zsuzsa Domokoş (RDSCB Târgu-Mureş), Simona Florina Isticioaia (ARDS Secuieni), Andreea Sabina Pintilie (ARDS Secuieni), Andreea Enea (ARDS Secuieni), Emanuela Marcu (ARDS Brăila), Cornelia Tican (NIRDPSB Braşov)

Introduction

Wheat is characterized by its excellent baking properties, resulting from the unique properties of the gluten protein fraction, which gives the dough a firm but extensible and elastic character. However, the ongoing climate change has become a challenging factor for the wheat cereal industry in recent years. On the one hand, intensely hot and dry summers have led to a decline in wheat yields. On the other hand, the wheat protein quality and amounts (in particular gluten) have been observed to vary greatly depending on the climatic conditions (Gagliardi et al. 2020, Rumler et al 2023).

Wheat yield and end-use quality depend on the variety, environment, and their interaction, and, thus, they reflect the interregional and year-to-year differences and the climatic conditions (M. Hadnađev et al, 2013). Heat stress during grain filling has been reported to be one of the factors that can affect the dough properties and quality characteristics of wheat. (Labuschagne et al, 2009).

Material and method

Nine winter wheat cultivars, released at NARDI Fundulea, namely: Glosa, FDL Miranda, Otilia, Pitar, Ursita, Voinic, FDL Abund, FDL Consecvent, FDL Columna, were evaluated under conventional conditions in 9 research centers: NARDI Fundulea, the University of Craiova, ARDS Valu lui Traian, ARDS Livada, ARDS Teleorman, ARDS Braila, RDSCB Târgu-Mureş, ARDS Secuieni, NIRDPSB Braşov, during three seasons: 2021, 2022, 2023. In 7 of the 9 research centers, the varieties were tested under two different nitrogen supply conditions, namely with and without fertilization in the spring. Rheological parameters were assessed using the Reomixer device.. In our study we analyzed three parameters: initial slope ("initslope") describing the water absorption phase; peak height ("peakheight") reflecting dough strength or elasticity and one calculated parameter, the estimated bread volume (BV). We also analyzed protein % by Infratec grain analyzer FOSS 1241. The agrometeorological data were analyzed for each location and year: the amount of precipitation, minimum and maximum temperatures, the number of days with temperatures below 14ºC and the number of days with temperatures above 24ºC during the grain formation period (May and June).

The ANOVA procedure was performed for average values for each rheological parameters in each testing center. There were calculated correlations between rheological parameters and agrometeorological data.

Results and discussions

The bread volume was significantly influenced by the minimum temperatures in June for the *FDL Abund* and *Voinic* varieties. Additionally, the number of days with temperatures above 24°C significantly affected the bread volume in *Glosa*, *FDL Miranda* and *Otilia* varieties (table 1).

The dough strength (*peakheight*) was significantly influenced by the minimum temperatures of June in *FDL Abund*, *Ursita* and *Voinic* (figure 1*)* varieties and the maximum temperatures of May and June in *FDL Miranda* and *Otilia* varieties. The water absorption was significantly influenced by the maximum temperatures of May and June in *Otilia* (figure 2) variety, by the minimum temperatures of May in *Pitar* variety, by the minimum temperature of June in *Ursita* variety. The average values of quality parameters showed significant differences between the testing centers (table 2).

Table 1. Correlation coefficients between climatic factors and bread volume for nine wheat varieties, under both fertilized conditions

	FDL ABUND	FDL ABUND	FDL COLUMNA	FDL COLUMNA	FDL CONSECVENT	FDL CONSECVENT	GLOSA	GLOSA	FDL MIRANDA	FDL MIRANDA	OTILIA	OTILIA	PITAR	PITAR	URSITA	URSITA	VOINIC	VOINIC
BREAD VOLUME	NEFERT	FERT	NEFERT	FERT	NEFERT	FERT	NEFERT	FERT	NEFERT	FERT	NEFERT	FERT	NEFERT	FERT	NEFERT	FERT	NEFERT	FERT
Precipitation of May	-0.13	0.11	0.18	0.45	0.19	0.16	-0.04	0.17	-0.11	-0.02	0.08	0.28	0.00	0.20	-0.10	-0.01	0.04	0.05
Precipitation of June	-0.24	0.21	0.01	0.40	-0.03	0.06	-0.28	-0.15	-0.45	-0.13	-0.13	-0.07	-0.23	0.22	-0.34	-0.12	-0.11	0.09
Maximum temperature of May	0.20	0.31	0.15	0.07	0.16	0.30	0.14	0.34	0.44	0.48	0.19	0.42	0.19	0.23	0.18	0.17	0.28	0.02
Maximum temperature of June	-0.08	0.17	0.04	0.23	0.12	0.24	0.04	0.41	0.43	0.38	0.10	0.44	0.06	0.20	0.05	0.25	0.07	0.03
Minimum temperature of May	0.09	-0.12	-0.13	-0.40	0.02	-0.15	-0.01	-0.34	-0.02	-0.06	-0.05	-0.13	-0.04	-0.34	-0.04	-0.12	0.02	-0.33
Minimum temperature of June	0.53*	0.20	0.39	-0.11	0.37	0.22	0.33	-0.24	0.34	0.12	0.29	-0.01	0.38	0.14	0.33	-0.11	0.54*	-0.27
Day with temperature <14°C in May	-0.38	0.10	-0.17	0.34	-0.27	-0.06	-0.32	0.17	-0.13	0.16	-0.14	-0.02	-0.21	0.24	-0.15	0.20	-0.29	0.41
Day with temperature <14°C in June	-0.43	-0.06	-0.19	0.28	-0.25	-0.09	-0.26	0.16	-0.25	-0.09	-0.18	-0.01	-0.24	0.02	-0.21	-0.04	-0.35	0.19
Day with temperature>24°C in May	0.20	0.32	0.24	0.29	0.26	0.36	0.25	**0.49***	0.63**	0.39	0.22	0.48*	0.24	0.31	0.26	0.16	0.28	0.07
Day with temperature>24°C in June	-0.06	-0.08	-0.18	-0.21	-0.09	-0.04	0.03	0.25	0.28	0.21	-0.02	0.08	0.03	-0.09	0.15	0.20	-0.06	-0.12

** = significant at P<1%; * = significant at P<5%;

Table 2. ANOVA for protein % and bread volume

	Protein %			Bread volume		
	2021	2022	2023	2021	2022	2023
Fundulea F	13.80***	15.04***	16.00***	884^{ns}	1011**	1101***
Valu lui Traian F	12.84^{ns}	11.76^{000}	13.51^{ns}	755	781^{00}	728^{ns}
Livada F	13.36^{ns}	12.59^{00}	13.79*	930*	843^{ns}	894^{ns}
Caracal F	12.27^{0}	14.53**	12.12^{ns}	808^{ns}	1010**	752^{ns}
Teleorman F	-	14.99***	13.42^{ns}	-	1036***	922^{ns}
Tbrgu-Mures F	-	12.27^{000}	14.40***	-	780^{00}	908^{ns}
Brasov F	15.97***	-	-	1050***	-	-
Secuieni F	14.34***	-	14.28**	926*	-	893^{ns}
Fundulea N0	11.94^{00}	15.16***	11.51^{0}	751^{ns}	983**	689^{0}
Valu lu Traian N0	10.37^{000}	11.58^{000}	10.43^{000}	600^{000}	788^{00}	988*
Caracal N0	11.15^{000}	13.94^{ns}	11.68	694^{00}	958^{ns}	732^{ns}
Brasov N0	14.99***	-	-	1072***	-	-
Secuieni N0	11.34^{000}	-	8.15^{000}	608^{000}	-	482^{000}
Teleorman N0	-	15.33***	12.23^{ns}	-	1066***	842^{ns}
Tbrgu-Mures N0	-	10.68^{000}		-	653^{000}	-
Braila F	-	-	12.80^{ns}	-	-	912^{ns}
DL 5%	0.6	0.6	1	82.00	77.00	117

*** = significant at P<5%; ** = significant at P<1%; * = significant at P<5%; ns = insignificant for P<5%

Figure 1. Correlation between minimum temperature of June and dough strength (*peakheight*) at *Voinic* variety

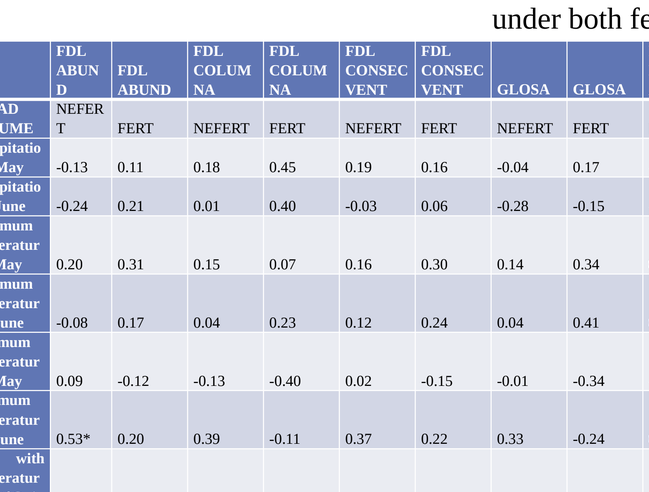

Figure 2. Correlation between maximum temperature of May and water absorbtion (*initslope*) at *Otilia* variety

Figure 3. Mixograph of *Voinic* variety tested at Fundulea, in 2022, under fertilized conditions

BV = 1025

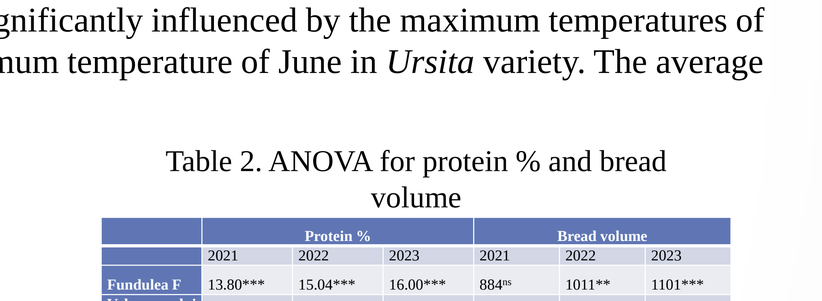

Figure 4. Mixograph of *Voinic* variety tested at Târgu-Mureş, in 2022, under fertilized conditions

BV = 799

Conclusions

The quality parameters analyzed were more or less influenced by the climatic conditions. The analyzed climatic conditions influenced the quality parameters differently, depending on each wheat variety. The average values of quality parameters showed significant differences between the testing centers.

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