EFFECT OF DIFFERENT LEVELS OF FERTILIZERS AND FORECROPS ON RHEOLOGICAL PROPERTIES OF WINTER WHEAT

Zoltán Magyar [1] – Péter Pepó [1] – Ernő Gyimes [2]

[1] University of Debrecen, Kerpely Kálmán Doctoral School
[2] University of Szeged, Faculty of Engineering, Institute of Food engineering
e-mail: magyarzoltan93@gmail.com

ABSTRACT
During our experiments in 2017/2018 crop year at Látókép Experimental Farm of University of Debrecen we studied the effect of different forecrops (sweet corn, sunflower) and increased dosages of artificial fertilizers (control, $N_{90}PK$, $N_{150}PK$) on rheological properties of wheat. Both levels of artificial fertilizers significantly improved valorigraphic water absorption (WA), quality number (VQN) and dough-stability (DST), moreover alveographic L and W value. Applying artificial fertilizers valorigraphic mixing-tolerance (DMT) and dough softening (DS) values were decreased significantly comparing to the control ones. Sweet corn as a forecrop had significantly favourable effect on VQN, DDT, DST, DS and DMT; promylographic ductility; alveographic L values comparing to sunflower. Fertilizing x forecrop interaction affected in a significant way the DMT and P/L value. In addition, fertilizing x cultivar interaction had significant effect on alveographic L, promylographic ductility and ratio. Using Pearson's correlation analysis results, fertilizer dosages were in strong positive correlation with VQN and DDT; alveographic L and W. The alveographic W was in strong positive correlation with promylographic energy (r=0,842**) and DST (r=0,863**), while the L was in medium positive correlation with promylographic ductility (r=0,744**). Our results proved that, the wheat flour's rheological parameters are significantly affected by fertilizing dose, forecrop and cultivar.

Keywords: wheat, rheological parameters, agrotechnical elements, valorigraph, alveograph

INTRODUCTION

Wheat flour is playing a very important role in our daily diet, which is the basic material of many industries, like bakery, confectionary and pasta industry extending to animal feed as well (RAGASITS, 1989). Quality parameters of wheat can be affected by many agrotechnical factors (ERDEI AND SZÁNIEL, 1975). The real quality value of wheat is expressed during processing (POLLHAMERNÉ, 1981), that can be predicted by testing samples with different rheological measurements, like valorigraph, farinograph, alveograph, promylograph or extensograph. Using these techniques kneading properties, water absorption, flexibility and strength of dough can be tested.
The yield and the quality of wheat can be greatly affected by forecrop, which is favourable if it does not exploit nutrient and water supplies of the soil (RAGASITS, 1989). Considering the agrotechnical factors, one of the most important is the proper nutritional supply, which can be achieved by artificial fertilizing (GYŐRI AND GYŐRINÉ, 1998). The usage of artificial fertilizers is affected by the nutrient reactionary properties of the cultivated wheat genotypes (PEPÓ, 2011), as a result the basic condition of economical wheat production is the selection of proper genotype (ÁGOSTON AND PEPÓ, 2005).
Good quality flour means the following for the baking industry: good water absorption capability, appropriate dough elasticity, shape-holding and gas-holding ability (Erdei and Szániel, 1975). Rheological methods can be divided into two groups: 1) static methods, like alveograph, extensograph; 2) dynamic ones, like farinograph and valorigraph (SIPOS *ET AL*., 2007). According to PEPÓ (2002) the average of 4-year data GK Öthalom wheat genotype's VQN was increased by 9, the wet gluten content was increased by 5% with the usage of 120kg NPK fertilizer dosage. The genotype properties had medium significant

effect on WA, QN, DST and DS (TANÁCS AND GERŐ, 2003). DDT and DST were significantly affected by genotype and year effect, stated by ZECEVIC *ET AL*. (2013). Nitrogen fertilizing significantly increased P (MATUZ *ET AL*., 2007), WA and DDT values (LININA *ET AL*., 2014).

Crude protein content had medium correlation with DST (KOPPEL AND INGVER, 2010). Fertilizing had significant correlation with alveographic values (GYŐRI *ET AL*., 2003). According to SIPOS *ET AL*. (2007) L value correlated positively in a significant extent with VQN, WG, CP and extensographic ductility, and negatively with DS. In a 4-year research TÓTH *ET AL*. (2007) declared that VQN had tight correlation with W. The extensographic ductility had tight correlation with WG, CP, QN and W (SIPOS *ET AL*., 2007).

MATERIAL AND METHOD

The experiment was set up at Látókép Experimental Farm of University of Debrecen in the 2017/2018 growing season, which has a chernozem soil type. The area has medium humus content, medium phosphorus and potassium supply and neutral pH. The forecrops of the experiment were sweet corn and sunflower. The effect of three fertilizer levels (control, $N_{90}P_{67,5}K_{79,5}$; $N_{150}P_{112,5}K_{132,5}$) were tested in 10 m^2 plots in 4 repetitions. The 50% of nitrogen and the whole amount of the phosphorus and potassium were applied in autumn, the remaining 50% of the nitrogen fertilizer was applied in spring as top dressing. Following two Hungarian winter wheat genotypes were tested: GK Öthalom and Mv Ispán. First the samples were treated by SLN Pfeuffer sample cleaner, then we conditioned them to 15.5% moisture content, lastly ground into flour with Brabender Quadrumat Senior laboratory mill. Crude protein contents (Kjeldahl method), wet gluten contents (ISO 21415-2:2015), valorigraphic (MSZ ISO 5530-3:1995), promylographic (Egger's Promylograph method) and alveographic (MSZ EN ISO 27971:2015) parameters were defined at the Institute of Food engineering, University of Szeged, Faculty of Engineering. Promylograph method is very similar to extensograph, where we made a 500-consistency dough, we rounded and moulded it, after that we let it to rest. The dough is measured after 45-90-135 minutes resting time.

For processing the results of the measurements IBM SPSS Statistics 22 program's one- and two-way ANOVA (with Tukey and Bonferroni posh-hoc tests) and Pearson's correlation analysis were performed. For graphical representation Python 3.7 version's Seaborn 0.9.0 library was used.

RESULTS

According to our results all the three factors (forecrop, fertilizer and cultivar) had significant effect on the measured rheological parameters. It can be seen, that the main parameters were between 22.73-54.81 (valorigraphic quality number, VQN, *Table 1.*), 107.80-312.73 (alveographic W, *Table 2.*) and 31.50-83.25 (promylographic energy, PE, *Table 3.*), which reflects well the unfavourable year effect of the 2017/2018 growing season. The crude protein was between 7.47-13.14%, the wet gluten content was between 16.06-29.25% (*Table 2.*). The lowest VQN, W and PE values belonged to GK Öthalom (sunflower, control), till then the highest VQN belonged to Mv Ispán (sweet corn, N_{150}PK), W and PE was got by Mv Ispán (sunflower, N_{150}PK).

Both levels of artificial fertilizers significantly improved valorigraphic water absorption (WA), VQN and dough-stability (DST), moreover alveographic L and W (*Figure 1.*) values. Beside these results, fertilizers increased significantly the valorigraphic dough-development time (DDT); alveographic P/L; promylographic ductility (PD), maximum resistance (PMR) and energy (PE) comparing to the control samples, which results correlate well with LININA *et al.* (2014) findings. Applying artificial fertilizers valorigraphic mixing-tolerance (DMT) and dough softening (DS) values were decreased significantly comparing to the control ones.

Table 1. – **The effect of different forecrops and artificial fertilizers on the valographic parameters (Debrecen, 2018)**

Genotype	Forecrop	Treatments	VQN	WA	DDT	DST	DS	DMT	FQN
GK Öthalom	Sweet corn	control	33.09	53.68	1.38	2.63	155.00	107.50	23.25
	Sweet corn	N_{90}PK	44.77	56.38	2.00	7.13	130.00	82.50	39.50
	Sweet corn	N_{150}PK	49.47	57.06	2.25	8.50	117.50	68.75	49.50
	Sunflower	control	22.73	53.76	1.00	2.25	195.00	140.00	17.75
	Sunflower	N_{90}PK	41.73	55.42	1.75	6.25	138.75	82.50	37.00
	Sunflower	N_{150}PK	45.95	56.41	2.00	7.13	133.75	77.50	43.25
Mv Ispán	Sweet corn	control	34.80	58.17	1.13	3.13	145.00	107.50	24.50
	Sweet corn	N_{90}PK	49.60	61.33	2.25	8.00	122.50	67.50	52.25
	Sweet corn	N_{150}PK	54.81	61.75	2.50	8.75	107.50	50.00	61.25
	Sunflower	control	25.52	58.38	1.00	1.88	171.25	128.75	18.75
	Sunflower	N_{90}PK	44.23	61.05	1.63	6.38	131.25	70.00	37.00
	Sunflower	N_{150}PK	50.55	62.51	2.00	7.88	110.00	57.50	47.00

Abbreviation's explanation: VQN= valorigraphic quality number; WA= water absorption; DDT= dough development time; DST= dough stability; DS= dough softening; DMT= dough mixing tolerance; FQN= farinographic quality number

Table 2. – **The effect of different forecrops and artificial fertilizers on the alveographic parameters, protein and wet gluten content (Debrecen, 2018)**

Genotype	Forecrop	Treatments	P	L	P/L	W	WG	CP
GK Öthalom	Sweet corn	Control	63.55	51.43	1.24	119.75	16.65	8.79
	Sweet corn	N_{90}PK	64.53	94.25	0.70	207.63	25.19	12.04
	Sweet corn	N_{150}PK	67.68	108.63	0.63	240.85	28.26	13.14
	Sunflower	Control	73.90	36.60	2.02	107.80	16.65	7.47
	Sunflower	N_{90}PK	62.53	87.38	0.73	175.70	24.72	11.29
	Sunflower	N_{150}PK	62.03	101.18	0.61	200.70	29.25	12.45
Mv Ispán	Sweet corn	Control	89.65	52.38	1.80	167.10	20.69	9.56
	Sweet corn	N_{90}PK	92.18	83.83	1.11	249.15	27.08	12.03
	Sweet corn	N_{150}PK	95.93	87.05	1.11	272.45	28.82	12.84
	Sunflower	Control	116.75	34.40	3.42	132.30	16.06	8.25
	Sunflower	N_{90}PK	109.48	60.63	1.85	238.05	24.80	10.91
	Sunflower	N_{150}PK	117.95	75.33	1.57	312.73	27.59	12.03

Abbreviation's explanation: P= alveographic max. pressure; L= extensibility; P/L= curve's configuration; W= energy; WGC= wet gluten content; CP= crude protein content

Sweet corn as a forecrop had significantly favourable effect on VQN, DDT, DST, DS, DMT, PD and alveographic L value comparing to sunflower. Studying the cultivar effects, that can be stated Mv Ispán had significantly better WA, VQN, DS and DMT value; promylographic ductility resistance (PDR), PMR, PE and rate (PR); alveographic P, W and P/L value. Our measurements confirm *Pepó* (2011) findings, that different genotypes react in a different extent to fertilizer dosages.

Table 3. – **The effect of different forecrops and artificial fertilizers on the promylographic parameters (Debrecen, 2018)**

Genotype	Forecrop	Treatments	PDR	PD	PMR	PE	PR
GK Öthalom	Sweet corn	Control	286.3	93.5	294.5	39.8	3.1
	Sweet corn	$N_{90}PK$	374.0	118.3	455.3	70.3	3.2
	Sweet corn	$N_{150}PK$	382.0	119.3	478.3	72.3	3.2
	Sunflower	Control	211.3	102.5	214.3	31.5	2.1
	Sunflower	$N_{90}PK$	297.5	110.5	326.0	49.8	2.7
	Sunflower	$N_{150}PK$	285.5	113.0	315.0	49.3	2.5
Mv Ispán	Sweet corn	Control	370.3	97.8	394.5	51.8	3.9
	Sweet corn	$N_{90}PK$	332.0	116.5	409.0	61.8	2.9
	Sweet corn	$N_{150}PK$	360.5	123.8	447.5	72.5	2.9
	Sunflower	Control	463.3	82.3	469.0	50.5	5.6
	Sunflower	$N_{90}PK$	400.8	107.5	457.8	64.0	3.8
	Sunflower	$N_{150}PK$	436.3	119.5	556.5	83.3	3.7

Abbreviation's explanation: PDR= promylographic ductility resistance; PD= ductility; PMR= max. resistance; PE= energy; PR= ratio

Table 4. – **Correlation analysis between main quality parameters (Pearson' correlation analysis, Debrecen, 2018)**

	FT	WA	VQN	DDT	DST	DS	PDR	PD	PMR	PE	P	L	W
FT	1												
WA	,479**	1											
VQN	,857**	,579**	1										
DDT	,782**	,445**	,859**	1									
DST	,903**	,534**	,952**	,902**	1								
DS	-,756**	-,576**	-,948**	-,716**	-,839**	1							
PDR	.159	,525**	.229	.048	.185	-,362*	1						
PD	,735**	,362*	,731**	,752**	,785**	-,586**	-.117	1					
PMR	,399**	,652**	,488**	,320*	,457**	-,579**	,936**	.189	1				
PE	,642**	,669**	,727**	,591**	,719**	-,738**	,710**	,588**	,895**	1			
P	-.011	,768**	.070	-.043	.012	-.155	,581**	-.110	,550**	,375**	1		
L	,819**	.184	,794**	,772**	,829**	-,702**	.009	,744**	.247	,528**	-,383**	1	
W	,801**	,797**	,880**	,763**	,863**	-,846**	,393**	,721**	,650**	,842**	,398**	,638**	1

Abbreviation explanation: FT= fertilizer treatments; WA= water absorption; VQN= valorigraphic quality number; DDT= dough development time; DST= dough stability; DS= dough softening; PDR= promylographic ductility resistance; PD= prom. ductility; PMR= prom. max. resistance; PE= prom. energy; P= alveographic max. pressure; L= alv. extensibility; W= alv. energy

Fertilizing x forecrop interaction affected in a significant way the DMT and P/L value. In addition, fertilizing x cultivar interaction had significant effect on alveographic L, promylographic ductility and ratio. Using Pearson's correlation analysis results (*Table 4.*), fertilizer dosages were in strong positive correlation with VQN (0,857**), DST (0,903**), DDT (0,782**), alveographic L (0,819**) and W (0,801**), which results confirm *Győri et al.* (2003) consequences. The alveographic W was in strong positive correlation with VQN (0,880**), promylographic energy (0,842**) and DST (0,863**), while the L was in medium positive correlation with promylographic ductility (0,744**) and DST (0,829**), these results proved the statements of *Tóth et al.* (2007) and *Sipos et al.* (2007).

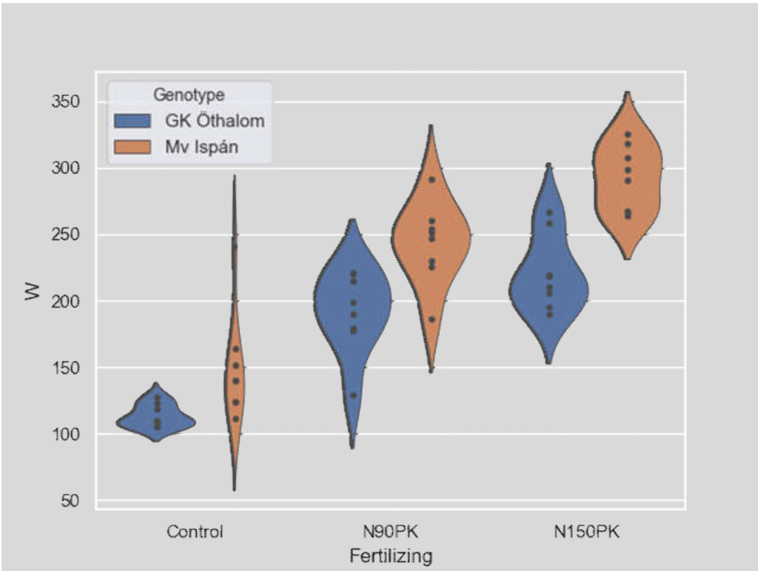

Figure 1. – **Alveographic W in the case of 3 fertilizer doses (Debrecen, 2018)**

CONCLUSIONS

Summarizing our results, the rheological parameters of wheat are significantly affected by fertilizer doses, forecrop and cultivar. On the basis of our researches sweet corn creates much more favourable conditions as a forecrop than sunflower, because the deep root system of sunflower exploits nutrient and water supplies of the soil. In the case of growing wheat for baking use, there is a need to put great emphasis on selecting the right cultivars and agrotechnology practices. In the future we will do the measurements in the next season as well, to extend our research with the year effect.

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