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Influence of nitrogen fertilisation on the technological quality of wheat

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SUMMARY

Wheat is one of the most grown crops around the world. Its primary use is in the production of bread, bakery, and confectionery. The provision of essential nutrients, mainly nitrogen, plays a pivotal role in the growth and development of wheat. The wheat varieties used in the experiment are Alföld and Mv Ménrót. The rates of nitrogen used in the experiment are: 0, 200, 400, 600, 800, and 1000 kg N ha^{-1}. The aim of this study is to evaluate the effect of nitrogen fertilisation on technological quality of wheat and to find the appropriate fertiliser rate to reduce pollution. The results indicate that nitrogen fertilisation did not show a significant effect on thousand kernel weight and test weight. However, nitrogen fertilisation significantly affected protein content, gluten content, Zeleny sedimentation index, and the falling number. The higher the nitrogen fertilisation the better the technological quality parameters of the wheat. The protein content, gluten content, Zeleny sedimentation index and the falling number were the lowest at 0 kg N ha^{-1} followed by 200 kg N ha^{-1} then 400 kg N ha^{-}1 and the highest at 600 kg N ha^{-1}.

Keywords: *wheat; nitrogen; fertilization; technological parameters*

INTRODUCTION

Triticum aestivum L., commonly referred to as wheat, is ubiquitously cultivated as a cereal crop in diverse geographical locations and environmental conditions across the globe. Wheat is mainly used to produce bread, bakery, and confectionery products such as cakes, noodles, pasta, and biscuits. Furthermore, it is used in the production of animal feed, biofuel, and ethanol. Wheat flour is mainly composed of starch (about 75–85%) and protein (about 10%) and it is derived from the endosperm of the wheat kernel. Hence, the two main factors that affect flour quality are protein and starch. The protein content and the starch content of the wheat kernel are influenced by a multitude of factors, such as genetics, environmental conditions, nutrient availability, irrigation, and fertilisation (Guarienti et al., 2004; Rozbicki et al., 2015; Savill et al., 2018). The technological quality of wheat, essential for the production of bread and wheat-derived products, can be evaluated based on several parameters such as protein content, gluten content, falling number, Zeleny sedimentation index, test weight, and thousand kernel weight according to the studies of Guarienti et al. (2004), Min et al. (2017), Hellemans et al. (2018), and Xue et al. (2019).

Technological wheat quality parameters may be affected by wheat genotype, environment, and crop management practices such as fertilisation, irrigation, plant growth regulators, and control of pests and diseases (Rekowski et al., 2021; Ferreira et al., 2021a; Faria et al., 2022). The optimal growth and development of wheat plants depend on the application of important mineral elements. The application of fertilisers has been reported to augment both the yield and quality of wheat grains and flour, as evidenced by studies conducted by Xue et al. (2016), Ma et al. (2019), and Guerrini et al. (2020). Nitrogen is among the vital nutrients supplied by fertilisation, which crops require in significant quantities, as shown by studies conducted by Bazzo et al. (2016), Souza et al. (2021), and Marinho et al. (2022). The importance of nitrogen for *Poaceae* plant species, especially wheat, is widely agreed upon. Nitrogen is a crucial nutrient for wheat due to its indispensable role as a constituent of the cell wall, chlorophyll, nucleic acids, and important biomolecules such as ATP, NADH, and NADPH. Additionally, nitrogen takes part in essential metabolic pathways and reactions that are vital for plant sustenance. The application of nitrogen fertilisation significantly enhances the tillering process in wheat plants, resulting in a notable increase in the density of productive spikes per unit area. Alternatively, the shortage of nitrogen in wheat may produce an adverse impact on leaf and tiller generation (Neumann et al., 2009), thereby leading to a decline in the quantity of productive spikes and frequently causing a reduction in grain yield (Xue et al., 2019; Ferreira et al., 2021b; Souza et al., 2021; Lollato et al., 2021). Wheat crops that receive optimal fertilisation and nutrition, particularly in the form of nitrogen, are known to generate grains that exhibit superior morphological quality and substantial nutritional value. This desirable outcome renders such grains apt for consumption, trade, and utilization by the food industry. This assertion is supported by scientific evidence presented in works by Pataco et al. (2015), Souza et al. (2021), and Lollato et al. (2021).

The aim of this study is to evaluate the effect of nitrogen fertilisation on technological quality of wheat and to find the appropriate rate of nitrogen fertiliser in order to reduce pollution and environmental impact of fertilisation. Because high nitrogen fertiliser rates lead to increased nitrate leaching contributing to the pollution and the eutrophication of ground and surface waters.

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MATERIALS AND METHODS

This study was carried out in the 2022 growing season at the experimental field and research facilities of the Hungarian University of Agriculture and Life Sciences (MATE). The experimental field is in a hilly area (47°35'42.5"N 19°22'10.7"E, 210 m above sea level) with a brown forest (Chromic Luvisol) soil type and a climate close to the average of the country. The experimental field was cleaned up, plowed, rototilled, and the seedbed was made before sowing. Plot machines were used to sow and harvest the plots. The rate of sowing was 450 to 500 seeds per square meter. Weeds were controlled by herbicides and wheat pests were controlled by pesticide application.

The experiment used a split-plot design, with the main plots consisting of several wheat cultivars and the subplots consisting of various nitrogen doses. Each plot had a 5 m^2 area and was spaced 50 cm apart horizontally and 30 cm apart vertically. Three replications were done for each treatment. The used wheat cultivars were Alföld and Mv Ménrót. Nitrogen fertiliser was applied in the form of granular ammonium nitrate (NH_4NO_3) with 34% content of the active ingredient. Nitrogen fertiliser was applied once at the heading stage (April). The doses of nitrogen in the application were: 200, 400, 600, 800, and 1000 kg N ha^{-1}. As a control, nitrogen topdressing-free plots were used. Near-infrared (NIR) spectroscopic equipment Mininfra Scan-T Plus version 2.02 was used to measure protein content, gluten content, and Zeleny sedimentation index. The falling number was measured with Perten 1400 system (ICC method No. 107/1 1995). Test weight was measured with the Chondrometer Hectoliter grain tester (ISO 7971-3:2019). Thousand kernel weight and test weight were measured with the KERN EMS and the Sartorius MA-30 precision scales. Analysis of variance (ANOVA) module of the IBM SPSS V.21 software at a 5% significance level with subsequent Tukey's test were used to perform the statistical evaluation of the results.

RESULTS AND DISCUSSION

The study was carried out to test the influence of nitrogen fertilisation on the following wheat quality parameters: protein content, gluten content, test weight, thousand kernel weight, falling number, and Zeleny sedimentation index and to detect the appropriate rate of nitrogen fertilisation to reduce its pollution and environmental impact. Precipitation (mm) and temperature (°C) data was taken from the World Weather Online® meteorological service for the anthesis (May), maturation (June) and harvesting (July). The rainfall was 24.6 mm in May, 30.2 mm in June and 33 mm in July. The temperature was 18 °C in May, 24 °C in June and 26 °C in July. The environmental conditions were not optimal for the wheat quality parameters.

Thousand kernel weight and test weight

In Mv Ménrót, nitrogen fertilisation did not show a significant effect on thousand kernel weight (F = 1.414, P = 0.288) and test weight (F = 1.473, P = 0.269) *(Figures 1* and *2, Table 2).*

In Alföld, nitrogen fertilisation did not show a significant effect on thousand kernel weight (F = 3.030, P = 0.054) and test weight (F = 2.953, P = 0.058) *(Figures 1* and *2, Table 2).*

Figure 1. **Effect of nitrogen fertilisation (kg N ha^{-1}) on thousand kernel weight (g)**

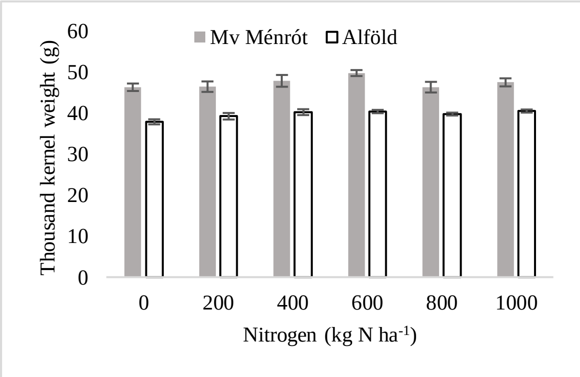
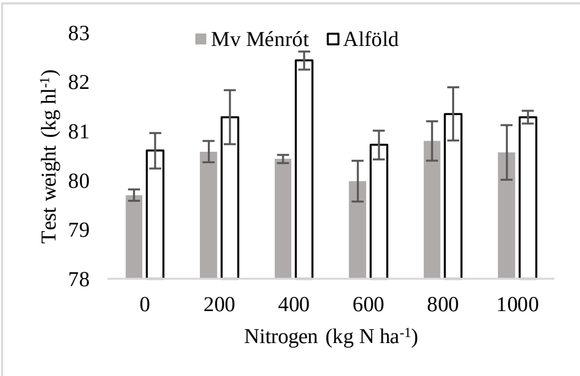


Figure 2. **Effect of nitrogen fertilisation (kg N ha^{-1}) on test weight (kg hl^{-1})**



Protein content

In Mv Ménrót, nitrogen fertilisation significantly affected protein content (F = 80.969, P = 0.000) *(Table 2).* Protein content was 10.02% at 0 kg N ha^{-1}, 16.63% at 200 kg N ha^{-1}, 17.47% at 400 kg N ha^{-1}, 18.73% at 600 kg N ha^{-1}, 19% at 800 kg N ha^{-1}, and 18.5% at 1000 kg N ha^{-1} *(Table 1).*

In Alföld, nitrogen fertilisation significantly affected protein content (F = 64.941, P = 0.000) *(Table 2).* Protein content was 9.72% at 0 kg N ha^{-1}, 15.93% at 200 kg N ha^{-1}, 17.83% at 400 kg N ha^{-1}, 18.8% at 600 kg N ha^{-1}, 19.43% at 800 kg N ha^{-1}, and 19.63% at 1000 kg N ha^{-1} *(Table 1).*

Protein content increased with increasing nitrogen dose. Protein content was the lowest at 0 kg N ha^{-1} followed by 200 kg N ha^{-1} then 400 kg N ha^{-1} and the highest at 600 kg N ha^{-1} after which further increase of

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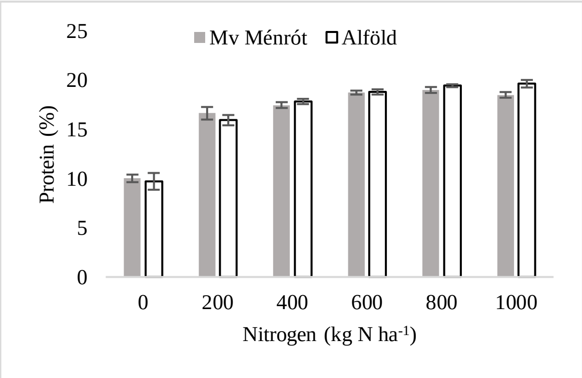
nitrogen rate did not give a significant increase (*Figure 3*).

Figure 3. **Effect of nitrogen fertilisation (kg N ha^{-1}) on protein (%)**



Gluten content

In Mv Ménrót, nitrogen fertilisation significantly affected gluten content (F = 83.882, P = 0.000) *(Table 2).* Gluten content was 19.33% at 0 kg N ha^{-1}, 38.13% at 200 kg N ha^{-1}, 40.43% at 400 kg N ha^{-1}, 43.9% at 600 kg N ha^{-1}, 44.6% at 800 kg N ha^{-1}, and 43.27 % at 1000 kg N ha^{-1} *(Table 1).*

In Alföld, nitrogen fertilisation significantly affected gluten content (F = 72.897, P = 0.000) (*Table 2*). Gluten content was 19.63% at 0 kg N ha^{-1}, 36.03% at 200 kg N ha^{-1}, 41.53% at 400 kg N ha^{-1}, 43.63% at 600 kg N ha^{-1}, 45.8% at 800 kg N ha^{-1}, and 45.6% at 1000 kg N ha^{-1} *(Table 1).*

Gluten content increased with increasing nitrogen dose. Gluten content was the lowest at 0 kg N ha^{-1} followed by 200 kg N ha^{-1} then 400 kg N ha^{-1} and the highest at 600 kg N ha^{-1} after which further increase of nitrogen rate did not give a significant increase *(Figure 4).*

Table 1. **Descriptive statistics of thousand kernel weight (g), test weight (kg hl^{-1}), gluten (%), protein (%), Zeleny sedimentation index (ml) and falling number (s) affected by nitrogen fertilisation (kg N ha^{-1})**

			Mean	Std. Deviation	Std. Error	Minimum	Maximum
Mv Ménrót	Thousand kernel weight	0	46.24	1.57	0.91	45.03	48.02
		200	46.39	2.21	1.28	44.05	48.44
		400	47.80	2.48	1.43	45.59	50.49
		600	49.70	1.27	0.73	48.28	50.71
		800	46.27	2.24	1.29	43.68	47.61
		1000	47.44	1.70	0.98	45.80	49.19
		Total	47.31	2.07	0.49	43.68	50.71
	Test weight	0	79.70	0.20	0.12	79.50	79.90
		200	80.58	0.38	0.22	80.15	80.80
		400	80.43	0.14	0.08	80.35	80.60
		600	79.98	0.72	0.41	79.45	80.80
		800	80.80	0.69	0.40	80.40	81.60
		1000	80.57	0.96	0.55	79.70	81.60
		Total	80.34	0.63	0.15	79.45	81.60
	Gluten	0	19.33	1.86	1.07	17.20	20.60
		200	38.13	3.20	1.85	35.30	41.60
		400	40.43	1.06	0.61	39.30	41.40
		600	43.90	0.98	0.57	42.80	44.70
		800	44.60	1.21	0.70	43.20	45.30
		1000	43.27	1.58	0.91	41.90	45.00
		Total	38.28	9.14	2.15	17.20	45.30
	Protein	0	10.02	0.67	0.38	9.26	10.50
		200	16.63	1.11	0.64	15.60	17.80
		400	17.47	0.51	0.30	16.90	17.90
		600	18.73	0.35	0.20	18.40	19.10
		800	19.00	0.52	0.30	18.40	19.30
		1000	18.50	0.50	0.29	18.00	19.00
		Total	16.73	3.24	0.76	9.26	19.30
	Zeleny sedimentation index	0	30.63	3.14	1.81	27.10	33.10
		200	65.03	4.84	2.79	61.30	70.50
		400	68.77	0.61	0.35	68.10	69.30
		600	73.53	0.93	0.54	72.90	74.60
		800	74.93	1.67	0.97	73.00	75.90
		1000	72.87	1.75	1.01	71.10	74.60
		Total	64.29	16.01	3.77	27.10	75.90

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Table 1. continued

			Mean	Std. Deviation	Std. Error	Minimum	Maximum
	Falling number	0	327.67	16.04	9.26	311.00	343.00
		200	419.00	7.21	4.16	411.00	425.00
		400	419.67	5.13	2.96	414.00	424.00
		600	481.00	15.62	9.02	471.00	499.00
		800	475.33	7.57	4.37	470.00	484.00
		1000	495.33	35.81	20.67	454.00	517.00
		Total	436.33	60.39	14.23	311.00	517.00
Alföld	Thousand kernel weight	0	37.83	1.07	0.62	36.66	38.75
		200	39.18	1.38	0.80	38.06	40.73
		400	40.19	1.24	0.72	39.01	41.48
		600	40.33	0.70	0.40	39.55	40.90
		800	39.72	0.60	0.35	39.02	40.08
		1000	40.45	0.65	0.38	39.70	40.85
		Total	39.62	1.25	0.29	36.66	41.48
	Test weight	0	80.60	0.62	0.36	79.90	81.10
		200	81.28	0.95	0.55	80.35	82.25
		400	82.43	0.32	0.18	82.25	82.80
		600	80.72	0.51	0.29	80.40	81.30
		800	81.35	0.94	0.54	80.60	82.40
		1000	81.28	0.23	0.13	81.05	81.50
		Total	81.28	0.82	0.19	79.90	82.80
	Gluten	0	19.63	3.46	2.00	16.60	23.40
		200	36.03	1.37	0.79	35.10	37.60
		400	41.53	2.11	1.22	39.20	43.30
		600	43.63	1.78	1.03	41.60	44.90
		800	45.80	0.72	0.42	45.20	46.60
		1000	45.60	1.67	0.96	44.10	47.40
		Total	38.71	9.56	2.25	16.60	47.40
	Protein	0	9.72	1.48	0.85	8.38	11.30
		200	15.93	0.91	0.52	15.10	16.90
		400	17.83	0.46	0.27	17.30	18.10
		600	18.80	0.46	0.26	18.30	19.20
		800	19.43	0.25	0.15	19.20	19.70
		1000	19.63	0.67	0.38	19.20	20.40
		Total	16.89	3.60	0.85	8.38	20.40
	Zeleny sedimentation index	0	32.87	6.65	3.84	26.10	39.40
		200	62.40	2.52	1.46	60.30	65.20
		400	71.57	3.90	2.25	67.70	75.50
		600	74.07	2.24	1.29	71.50	75.60
		800	76.93	0.80	0.46	76.10	77.70
		1000	76.77	2.42	1.40	74.20	79.00
		Total	65.77	16.23	3.83	26.10	79.00
	Falling number	0	324.00	2.65	1.53	321.00	326.00
		200	379.67	17.21	9.94	360.00	392.00
		400	380.33	8.50	4.91	372.00	389.00
		600	476.33	16.65	9.61	463.00	495.00
		800	502.67	18.48	10.67	492.00	524.00
		1000	493.67	37.85	21.85	450.00	517.00
		Total	426.11	71.84	16.93	321.00	524.00

0: no nitrogen
200: the nitrogen dose was 200 kg N ha^{-1}
400: the nitrogen dose was 400 kg N ha^{-1}
600: the nitrogen dose was 600 kg N ha^{-1}
800: the nitrogen dose was 800 kg N ha^{-1}
1000: the nitrogen dose was 1000 kg N ha^{-1}

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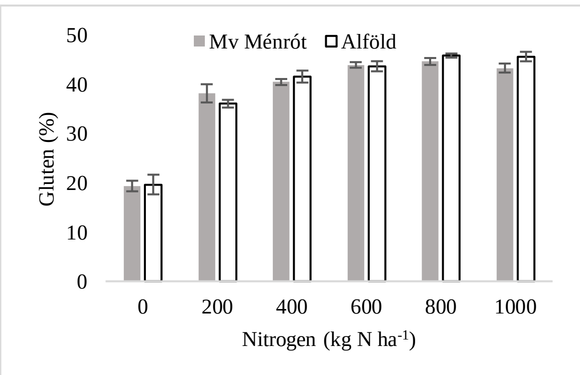
Table 2. **Analysis of variance for thousand kernel weight, test weight, gluten, protein, Zeleny sedimentation index and falling number affected by nitrogen fertilisation**

			Sum of Squares	*df*	Mean Square	*F*	*Sig.*
Mv Ménrót	Thousand kernel weight	Between groups	27.133	5	5.427	1.414	.288
		Within groups	46.062	12	3.838		
		Total	73.194	17			
	Test weight	Between groups	2.603	5	.521	1.473	.269
		Within groups	4.242	12	.353		
		Total	6.844	17			
	Gluten	Between groups	1380.084	5	276.017	83.882	.000
		Within groups	39.487	12	3.291		
		Total	1419.571	17			
	Protein	Between groups	173.625	5	34.725	80.969	.000
		Within groups	5.146	12	.429		
		Total	178.772	17			
	Zeleny sedimentation index	Between groups	4276.929	5	855.386	127.132	.000
		Within groups	80.740	12	6.728		
		Total	4357.669	17			
	Falling number	Between groups	58151.333	5	11630.267	36.357	.000
		Within groups	3838.667	12	319.889		
		Total	61990.000	17			
Alföld	Thousand kernel weight	Between groups	14.821	5	2.964	3.030	.054
		Within groups	11.739	12	.978		
		Total	26.560	17			
	Test weight	Between groups	6.344	5	1.269	2.953	.058
		Within groups	5.157	12	.430		
		Total	11.501	17			
	Gluten	Between groups	1503.103	5	300.621	72.897	.000
		Within groups	49.487	12	4.124		
		Total	1552.589	17			
	Protein	Between groups	212.713	5	42.543	64.941	.000
		Within groups	7.861	12	.655		
		Total	220.574	17			
	Zeleny sedimentation index	Between groups	4325.907	5	865.181	67.123	.000
		Within groups	154.673	12	12.889		
		Total	4480.580	17			
	Falling number	Between groups	82878.444	5	16575.689	40.984	.000
		Within groups	4853.333	12	404.444		
		Total	87731.778	17			

df: degree of freedom; Sig.: significance; Significance level = $P < 0.05$

Figure 4. **Effect of nitrogen fertilisation (kg N ha^{-1}) on gluten (%)**



Zeleny sedimentation index

In Mv Ménrót, nitrogen fertilisation significantly affected Zeleny sedimentation index ($F = 127.132$, $P = 0.000$) *(Table 2)*. Zeleny sedimentation index was 30.63 ml at 0 kg N ha^{-1}, 65.03 ml at 200 kg N ha^{-1}, 68.76 ml at 400 kg N ha^{-1}, 73.53 ml at 600 kg N ha^{-1}, 74.93 ml at 800 kg N ha^{-1}, and 72.87 ml at 1000 kg N ha^{-1} *(Table 1)*.

In Alföld, nitrogen fertilisation significantly affected Zeleny sedimentation index ($F = 67.123$, $P = 0.000$) *(Table 2)*. Zeleny sedimentation index was 32.87 ml at 0 kg N ha^{-1}, 62.40 ml at 200 kg N ha^{-1}, 71.57 ml at 400 kg N ha^{-1}, 74.07 ml at 600 kg N ha^{-1}, 76.93 ml at 800 kg N ha^{-1}, and 76.77 ml at 1000 kg N ha^{-1} *(Table 1)*.

Zeleny sedimentation index increased with increasing nitrogen dose. Zeleny sedimentation index

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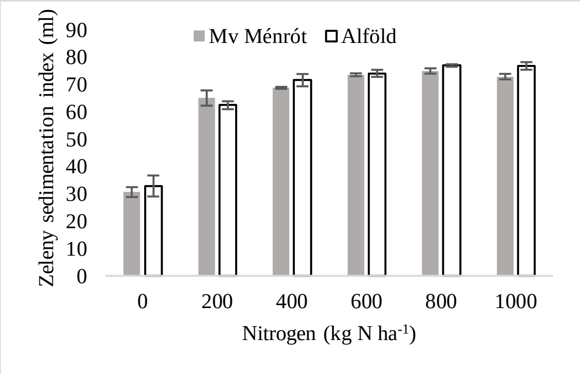
was the lowest at 0 kg N ha^{-1} followed by 200 kg N ha^{-1} then 400 kg N ha^{-1} and the highest at 600 kg N ha^{-1} after which further increase of nitrogen rate did not give a significant increase *(Figure 5)*.

Figure 5. **Effect of nitrogen fertilisation (kg N ha^{-1}) on Zeleny sedimentation index (ml)**



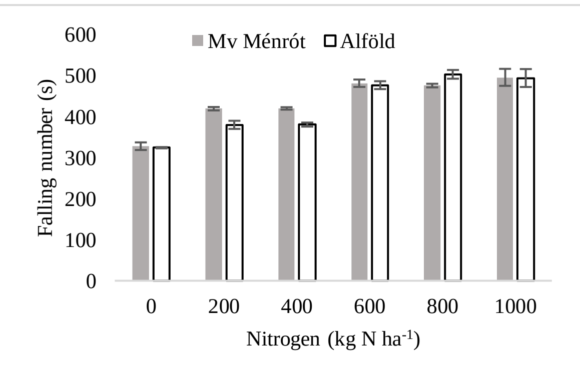
Falling Number

In Mv Ménrót, nitrogen fertilisation significantly affected the falling number ($F = 36.357$, $P = 0.000$) *(Table 2)*. The falling number was 327.67 s at 0 kg N ha^{-1}, 419 s at 200 kg N ha^{-1}, 419.67 s at 400 kg N ha^{-1}, 481 s at 600 kg N ha^{-1}, 475.33 s at 800 kg N ha^{-1}, and 495.33 s at 1000 kg N ha^{-1} *(Table 1)*.

In Alföld, nitrogen fertilisation significantly affected the falling number ($F = 40.984$, $P = 0.000$) *(Table 2)*. The falling number was 324 s at 0 kg N ha^{-1}, 379.67 s at 200 kg N ha^{-1}, 380.33 s at 400 kg N ha^{-1}, 476.33 s at 600 kg N ha^{-1}, 502.67 s at 800 kg N ha^{-1}, 493.67 s at 1000 kg N ha^{-1} *(Table 1)*.

The falling number increased with increasing nitrogen dose. The falling number was the lowest at 0 kg N ha^{-1} followed by 200 kg N ha^{-1} then 400 kg N ha^{-1} and the highest at 600 kg N ha^{-1} after which further increase of nitrogen rate did not give a significant increase *(Figure 6)*.

Figure 6. **Effect of nitrogen fertilisation (kg N ha^{-1}) on falling number (s)**



In our study, nitrogen fertilisation had no statistically significant influence on thousand kernel weight and test weight. However, it had a statistically significant influence on protein content, gluten content, and Zeleny sedimentation index. The higher the nitrogen dosage the higher those quality parameters were. Protein content, gluten content and Zeleny sedimentation index were the lowest at 0 kg N ha^{-1} followed by 200 kg N ha^{-1} then 400 kg N ha^{-1} and the highest at 600 kg N ha^{-1} after which further increase of nitrogen rate did not give a significant increase. High grain protein content is necessary for bread wheat cultivars because bread quality is strongly connected with wheat grain protein content (Gooding et al., 1991). Increasing nitrogen application rate at tillering stage and/or at flowering stage generally increases grain protein content. Nakano et al. (2008) indicated that nitrogen application at flowering stage is more effective than nitrogen application at tillering stage for increasing grain protein content. Nitrogen fertilisation has been shown to improve protein content, gluten content, and Zeleny sedimentation index (Pechanek et al., 1997; Ralcewicz and Knapowski, 2004; Győri, 2006; Szaframska et al., 2008; Cesevicien and Masauskien, 2009; Kismányoky and Tóth, 2010; Rakszegi et al., 2016). The outcomes garnered from our experimentation concerning the protein content, gluten content, and Zeleny sedimentation index of the wheat grain samples appear to exhibit a degree of concordance with prior investigations (Pollhamer, 1981; Vida et al., 1996; Pepó, 2010) which also indicate that nitrogen fertilisation had a high positive effect on the examined wheat kernel quality parameters. Horváth et al. (2014) also demonstrated that increasing nitrogen fertilisation levels had a positive effect on the protein and gluten content of wheat grain. Szentpétery et al. (2005) discovered that increasing fertiliser dose applications had a favorable impact on the protein content and gluten content. Pepó et al. (2005) found a significant correlation between fertilisation and gluten content. According to Ozturk and Aydin (2004) and Horvat et al. (2006), nitrogen application is important for protein content and gluten content. In addition, they observed a high positive correlation between protein content and Zeleny sedimentation index. Nitrogen fertiliser rates boosted the grain protein concentration, according to Guerrini et al. (2020), who studied the effects of nitrogen fertilisation in Italian wheat genotypes. A positive impact of nitrogen fertilisation on the content of gluten in harvested grains of a Brazilian wheat genotype was also confirmed by Pinnow et al. (2013). Stankowski et al. (2004), Zecevic et al. (2004), Varga et al. (2007), Szaframska et al. (2008), and Souza et al. (2021) found that nitrogen fertilisation had a significant positive influence on protein content, gluten content, and Zeleny sedimentation index.

European flour mills employ the falling number as a grain quality assessment to estimate the alpha-amylase activity in wheat grain used for breadmaking (Perten, 1964). Nitrogen fertilisation had a statistically significant influence on the falling number in our study. The nitrogen fertiliser rate significantly increased the falling number. The higher the nitrogen dosage the

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higher the falling number was. The falling number was the lowest at 0 kg N ha^{-1} followed by 200 kg N ha^{-1} then 400 kg N ha^{-1} and the highest at 600 kg N ha^{-1} after which further increase of nitrogen rate did not give a significant increase. This finding is consistent with the conclusions made by Teesalu and Leedu (2001), Ralcewics and Knapowski (2004), and Stankowski et al. (2004), who reported that nitrogen fertiliser rates affect the falling number. According to the findings of Cesevičiené and Mašauskiené (2007), an increased application of nitrogen resulted in a considerably more pronounced augmentation in the falling number of wheat compared to that of the reduced application of nitrogen. Varga et al. (2007), on the other hand, found that certain wheat cultivars in Croatia were unable to exhibit a substantial increase in the falling number parameter in response to heightened levels of nitrogen fertilisation. Eguchi et al. (1969) reported that nitrogen topdressing sometimes delayed maturity and was associated with a decrease in grain quality. Brun (1982) also observed that high nitrogen fertiliser application can decrease the falling number. This could be due to damp conditions around the ear promoting germination and thus increasing alpha-amylase activity. It has been postulated by Stewart (1984) that the application of nitrogen fertilisers may potentially impede growth and development of the plant and exert a consequential impact on the preservation of an elevated falling number. Pushman and Bingham (1976) demonstrated a contrary observation to Brun's research by providing evidence that increased nitrogen application resulted in decreased alpha-amylase activity.

CONCLUSIONS

Nitrogen fertilisation was studied to evaluate the following wheat quality parameters: protein content, gluten content, test weight, thousand kernel weight, falling number, and Zeleny sedimentation index and to find the appropriate rate of nitrogen fertiliser to reduce pollution due to fertilisation. The results indicate that nitrogen fertilisation did not show a significant effect on thousand kernel weight and test weight. However, nitrogen fertilisation significantly affected protein content, gluten content, Zeleny sedimentation index, and the falling number. The higher the nitrogen fertilisation the higher the value of the wheat quality parameters. The protein content, gluten content, Zeleny sedimentation index and the falling number were the lowest at 0 kg N ha^{-1} followed by 200 kg N ha^{-1} then 400 kg N ha^{-1} and the highest at 600 kg N ha^{-1} after which further increase of nitrogen rate did not give a significant increase. Nitrogen fertilisation up to 600 kg N ha^{-1} enhanced the quality of the wheat yield. Nitrogen fertilisation above 600 kg N ha^{-1} did not further increase the quality of the wheat yield.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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