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Determination of The Effect of Nitrogenous Fertilization on Grain Quality Characterıstics in Wheat

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Abstract

This research was carried out in the Tevekli Neighborhood rural area of Van Tusba District in the summer growing season of 2020 to determine the effects of four nitrogenous fertilizer doses (0 kg da^{-1} N, (N0: control), 8 kg da^{-1} N (N8), 12 kg da^{-1} N (N12) and 16 kg da^{-1} N (N16)) on some physiological properties (ash, moisture, starch, protein, cellulose and oil) of local (Bahare and Kose) and commercial (Seri-82 and Cemre) bread wheat varieties. The research was designed according to the split-plot design in randomized blocks with three replications, with N doses in the main plots and varieties in the subplots. During the heading period, live plant leaves were measured with the Normalised Difference Vegetation Index (NDVI) sensor, and leaf observations were made. According to the research results; the differences between the other characteristics examined except for grain moisture data were statistically significant ($P<0.05$). According to the interactions, the highest values were obtained from N12 x Cemre (0.320) and N16 x Kose in the same group in NDVI data, N0 x Bahre (1.036 %) and N12 x Bahare in the same group in ash ratios, N12 x Seri (44.704 %) and N12 x Cemre and N16 x Cemre in the same group in starch ratios, N12 x Bahare (15.901 %) in protein ratios, N16 x Kose (4.019 %) in cellulose ratios and N0 x Cemre (2.592 %) in oil ratios and five interactions in the same group. No statistically significant effect of N doses was observed on other examined traits except grain moisture and protein ratios. The grain moisture ratio was obtained from the highest N0 dose (8.788 %), and the protein ratio was obtained from other doses except N0. The effect of varieties on other properties except ash and oil contents in grain was found to be statistically insignificant ($P>0.05$). Bahare local variety had high values in ash ratio and commercial varieties had high values in oil ratio. It is thought that low rainfall and high temperatures during the season effectively obtained low results.

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1. Introduction

Due to its high adaptability, a very large area worldwide is used in wheat farming. Due to this feature, it is evaluated as the raw material of foods used as staple foods in many countries. 20 % of the world's food and 53 % of Türikye's food is produced from wheat (Anonymous, 2017). Developing countries, in particular, meet 21% of their daily calorie needs and 20 % of their protein needs from wheat (Jones et al., 2020; Karaman et al., 2023; Balkan et al., 2023). Local varieties are considered to be very valuable genetic material used in breeding studies. Local varieties that continue to be cultivated in rural areas of the Van Lake Basin have the opportunity to be evaluated as a very valuable gene pool (Altuner et al., 2020).

While characteristics such as thousand-grain weight, hectoliter weight, grain color, and hardness in wheat are used to determine physical quality, the amounts of protein, dry matter, ash, oil, cellulose, and starch in the grain are also used as indicators of chemical quality (Erken, 2022). In particular, protein ratio is considered bread wheat's most important quality indicator. According to the Turkish Food Codex, the lowest protein ratio in bread wheat has been determined as 10.5 % (Menderis, 2006). However, high moisture in the grain reduces the commercial value of wheat, makes storage difficult and promotes germination. For this reason, a 14.6 % moisture level in wheat grain is considered critical (Unal, 2002). Wheat endosperm consists of 28.4 % cellulose and 23.7 % flour (Gartaula et al., 2018).

Physiological properties significantly affect yield and quality in wheat. The inclusion of these properties in breeding studies has become widespread in recent years. In this respect, some devices have been developed to measure physiological properties without damaging the structure of plants. SPAD meter, thermal camera and Normalized Difference Vegetation Index device (NDVI) are some of them (Bayhan et al., 2021). NDVI is one of the spectral index devices widely used to measure grain yield in living plants without the need for cutting (Cabrera-Bosquet et al., 2011). NDVI measurements are based on the principle of measuring the difference in the absorption response of near-infrared reflected and red light in the parts with high leaf density in the chlorophyll. NDVI data taken especially in the flowering and grain filling stages show a significant correlation with grain yield (Mkhabela et al., 2011).

This study aimed to determine the NDVI values and some physiological quality traits such as protein, ash, cellulose, moisture, and starch in the grains of four bread wheat varieties, two of which were local, grown with four different nitrogen fertilization doses in the 2020 summer growing season.

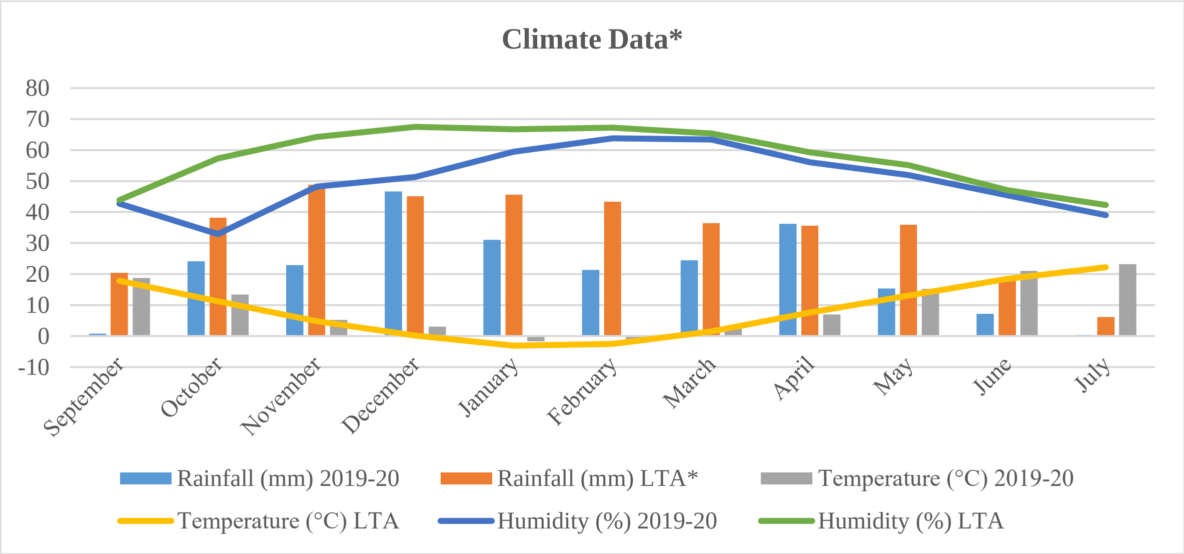
2. Materials and Methods

2.1. Herbal material

Four types of summer-natured bread wheat seeds were used in the experiment. Seri-82 from commercial varieties was provided by the Eastern Mediterranean Agricultural Research Institute and Cemre from the GAP International Agricultural Research Institute. Bahare from local varieties was provided from the Bitlis rural area and Kose from the Mus rural area.

2.2. Climate and soil characteristics of the research area

The research was carried out in the rural area of the Tevekli Neighborhood of Tusba District, Van during the 2020 summer growing season. The precipitation, temperature and relative humidity values of the season and the long-term average (LTA) are given in Figure 1. Accordingly, it is seen that the highest precipitation was received in December, January, and April during the growing season and the season total was 230.3 mm, while the LTA precipitation total was 374.2 mm and the season total was 140 mm lower than this value. It is understood that the average temperature during the season was 9.7 °C, UYO was 8 °C and a growing season with an average temperature 1.7 °C higher than LTA was. It is understood that there was no significant difference between the relative humidity values (Anonymous, 2020).



LTA* Long-term average of rainfall

Figure 1. Experimental area research season and long-term average climate values (Anonymous, 2020)

Data on soil properties of the research area are given in Table 1. According to the analysis results of soil samples taken from 0-20 cm and 20-40 cm depths, it is understood that the trial soils have a loamy texture, a pH around 7-90-7.96 and neutral, and a structure weak in terms of lime and organic matter.

Table 1. Some physical and chemical properties of the research area soils*.

Depth (cm)	Texture	pH	Clay (%)	Electrical conductivity/salt (dS m^{-1})	Organic matter (%)
0 - 20	Loamy	7.90	1.29	0.16	0.44
20 – 40	Loamy	7.96	1.25	0.17	0.42

*Soil analyses results of the Van YYU Agriculture Faculty Labratuary.

2.3.Conducting the research and sample analyses

The research was established in the summer season of 2020 and the plot dimensions were determined as 5 x 1.2 = 6m². Nitrogenous fertilizer (N) was planted in the main plots and varieties in the sub-plots; with 450 seeds m^{-2} calculation were sown. Nitrogenous fertilizer was applied to the main plots with four fertilizer doses of 0 kg da^{-1} N (control), 8 kg da^{-1} N, 12 kg da^{-1} N, and 16 kg da^{-1} N in the form of NH4SO4 with 21% N content, 4 kg da^{-1} together with planting. Phosphorus (P_2O_5) was given in the form of 7 kg da^{-1} TSP at the same time as sowing. The remaining N fertilizer was applied as 46 % urea (CO $(NH_2)_2$) (Gucdemir, 2006). In the pre-tillering, stemming, and heading periods, limited irrigation was applied three times (Akdogan and Soylu, 2018). The trial was established on 48 plots with three replications according to the randomized block split-plot design. In the afternoon, measurements were made with the Normalized Difference Vegetation Index (NDVI) sensor without damaging the leaves of the plants during the heading period (Kilicaslan et al., 2020; Bayhan et al., 2021). In the Dicle University Faculty of Agriculture Laboratory, to determine the grain physiological properties such as protein ratio, starch ratio, moisture ratio, oil ratio, cellulose ratio and ash ratio as a percentage, the grains were determined without being subjected to grinding process with the FOSS brand XDS model Near Infrared Reflection (NIR) device (FOSS, Eden Prairie, North America) according to the AOAC 992–23 method

(Kilicaslan et al., 2020; Anonymous, 1990). Statistical analyzes of the data were performed using the CoSTAT (ver. 6.303) computer analysis program and the multiple comparison of the difference between the means was carried out according to the LSD (0.05 %) test.

3. Results and Discussion

The results obtained regarding the features examined in the research are shown in Table 2.

Table 2. Effects of nitrogen fertilization on NDVI and quality traits in wheat varieties*

N** Dose	Varieties	NDVI		Ash (%)		Moisture (%)		Starch (%)		Protein (%)		Cellulose (%)		Oil (%)	
N0	Bahare	0.210	ab	1.036	a	8.519		42.251	ab	11.798	b	3.716	b	1.549	ab
	Cemre	0.227	ab	0.383	b-d	8.822		43.221	ab	13.526	ab	3.220	c	2.592	a
	Kose	0.263	ab	0.551	a-d	8.724		43.653	ab	13.673	ab	3.046	cd	1.554	ab
	Seri-82	0.297	ab	0.517	a-d	9.082		43.655	ab	13.667	ab	2.920	d	2.546	a
N8	Bahare	0.213	ab	0.848	ab	8.485		41.740	ab	14.731	ab	3.242	c	1.218	ab
	Cemre	0.260	ab	0.328	cd	7.862		43.152	ab	15.014	ab	3.071	cd	1.948	ab
	Kose	0.263	ab	0.782	ab	8.280		40.152	b	15.383	ab	3.124	cd	1.506	ab
	Seri-82	0.227	ab	0.657	a-c	7.857		41.722	ab	13.762	ab	3.534	bc	2.132	a
N12	Bahare	0.260	ab	0.849	a	8.334		41.735	ab	15.901	a	3.314	bc	1.018	b
	Cemre	0.320	a	0.248	d	8.555		44.343	a	15.591	ab	4.037	a	2.533	a
	Kose	0.200	b	0.647	a-c	8.293		41.902	ab	15.541	ab	3.190	cd	1.392	ab
	Seri-82	0.230	ab	0.396	b-d	8.638		44.704	a	14.868	ab	2.937	d	2.461	a
N16	Bahare	0.220	ab	0.730	ab	8.268		42.059	ab	15.431	ab	3.441	bc	1.247	ab
	Cemre	0.260	ab	0.435	b-d	8.323		44.225	a	15.566	ab	2.978	c	1.653	ab
	Kose	0.303	a	0.571	a-c	8.534		42.107	ab	14.181	ab	4.019	a	1.897	ab
	Seri-82	0.177	b	0.480	b-d	8.060		43.050	ab	14.280	ab	3.100		2.100	a
C.V. (%)		26.009		32.857		5.821		4.996		10.989		19.595		31.989	
N Average	N0	0.249		0.621		8.788	**A**	43.196		13.166	B	3.228	A	2.059	
	N4	0.240		0.653		8.121	**C**	41.691		14.723	A	3.243	A	1.702	
	N8	0.252		0.535		8.456	**B**	43.171		15.477	A	3.370	A	1.850	
	N16	0.240		0.555		8.298	**BC**	42.860		14.864	A	3.385	A	1.724	
LSD (0.05)		0.054		0.193		0.220		1.976		1.389		0.609		0.583	
Variety Average	Bahare	0.225		0.865	**A**	8.402		41.946		14.467		3.429	A	1.258	**B**
	Cemre	0.266		0.347	**C**	8.393		43.735		14.923		3.326	A	2.180	**A**
	Kose	0.257		0.638	**B**	8.458		41.954		14.695		3.346	A	1.587	**B**
	Seri-82	0.232		0.514	**B**	8.409		43.283		14.145		3.124	A	2.311	**A**
LSD (0.05)		0.061		0.163		0.413		1.799		1.348		0.546		0.494	

*No statistically significant difference exists between the data shown with the same letter in the same column. There is a statistically significant (P<0.05) difference between the data shown with different lower and upper case letters in the same column. **N0: Control (0 kg da^{-1} N), N8: 8 kg da^{-1} N, N12: 12 kg da^{-1} N, N16: 16 kg da^{-1} N

3.1. NDVI

The NDVI measurement results of the varieties, N doses, and interactions used in the study are shown in Table 2. Accordingly, based on N dose averages, fertilizer doses did not have a statistically significant (P>0.05) effect on NDVI results. NDVI values varied between 0.240-0.252 according to fertilizer doses. There was also no statistically significant difference between NDVI data according to varieties. NDVI values of varieties were determined between 0.225-0.266. The effect of N doses and variety interactions (N x V) on NDVI data was statistically significant (P<0.05). Accordingly, NDVI values varied between 0.177-0.320. According to the interactions, the highest NDVI value was taken from N16 x Kose interactions in the same group as N12 x Cemre and the lowest from N12 x Kose interactions in the same group as N16 x Seri-82. High NDVI data is considered an indicator of healthy plant development (Kizilgeci et al., 2019). In a study conducted with some bread and advanced wheat genotypes and measurements taken during the heading period (Bayhan et al., 2021), it was determined that NDVI values varied between 0.53-0.67 and the trial average was 0.61. In a study conducted to determine the effects of some physiological traits on quality and yield traits in some triticale genotypes (Kizilgeci et al., 2017), it was determined that the NDVI values taken during the heading period were between 0.72-0.77 in the Mardin location and 0.77-0.81 in the Diyarbakır location. In another study (Kizilgeci and Yildirim, 2019), it was determined that the NDVI data taken during the heading period varied between 0.42-0.85. The data obtained in these studies are higher than our results. NDVI values are affected by many factors such as measurement phase and range, sensor height, environment, and growing conditions (Kizilgeci et al., 2017). The desired high chlorophyll content in plants is a trait that has a positive effect on yield in breeding programs (Bayhan et al., 2019; Albayrak et al., 2020).

3.2. Ash

The ash amounts determined in the grain of the varieties used in the study, N doses, and interactions are shown in Table 2. According to the table, no statistically significant difference was observed between the ash amounts in the grain-based on the N fertilizer averages ($P>0.05$). Accordingly, the ash amounts in the grain varied between 0.535-0.653 %. The differences between the ash amount in the grain according to the average of the varieties were found to be statistically significant ($P<0.05$). Accordingly, the ash amounts in the grain varied between 0.347-0.865 %. According to the variety averages, the highest ash amounts in the grain were determined in the Bahare local variety and the lowest in the Cemre variety. The differences between the ash amount in the grain according to the N fertilizer doses and variety interactions were found to be statistically significant ($P<0.05$). According to the interactions, the ash amounts in the grain were between 0.248-1.036 %. Accordingly, the highest ash ratios in the grain were obtained from the N0, N12 x Bahare local variety and other interactions in the same group, and the lowest from the N12 x Cemre interaction. In a study conducted for three years in Yozgat ecological conditions (Mut et al., 2017), the ash ratios of 14 bread wheat varieties were determined to be 1.59 % in the first year, 1.68 % in the second year, and 1.87 % in the third year, varying according to the climate effect. In another study conducted on 11 barley varieties in Gumushane conditions (Sirat and Bahar, 2020), the ash ratio was determined between 2.00-2.31% according to the two-year average results. In Edirne conditions, the raw ash average of 6 bread wheat was determined between 1.14-1.62% (Erken, 2022). The findings obtained in our study are lower than these results. Water loss due to high temperature is also effective in the increase in the ash ratio in the grain (Egesel et al., 2009). Grain ash content varies depending on genotype, environment, and maintenance conditions (Anjum et al., 2014; Mahla et al., 2015).

3.3. Moisture

Data on grain moisture content are shown in Table 2. Accordingly, the effect of N doses on grain moisture content was statistically significant ($P<0.05$). According to N doses, grain moisture content varied between 8.121-8.788 %. Grain moisture content was taken from the highest N0 (control) dose and the lowest N8 dose. The effect of varieties on grain moisture content was statistically insignificant ($P>0.05$). According to varieties, moisture content varied between 8.393-8.458 %. The effect of interactions on grain moisture content was statistically insignificant ($P>0.05$). According to interactions, grain moisture content varied between 7.857-9.082 %. In a two-year study conducted in Gumushane conditions (Sirat and Bahar, 2020), the two-year average moisture content of 11 barley varieties was found to be between 9.21 % and 9.88 %. In another study conducted in Edirne conditions, the moisture content of 6 bread wheat was determined to be between 10.20 % and 15.30 % (Erken, 2022). The findings obtained in our study are lower than these results. Low or ideal moisture content is accepted as one of the indicators of quality in barley. While very low grain moisture in cereals causes increased transportation losses, the commercial value and storage life of those with ideal moisture increases. The moisture content of cereals varies depending on climatic conditions, ripening period, storage type, and conditions (Kun, 1996; Sencar et al., 1997). 14.6 % moisture content is seen as the upper limit for Turkish wheat (Unal, 2002).

3.4. Starch

Data on starch content in grains of the varieties, N doses, and interactions used in the study are shown in Table 2. Accordingly, the effect of N doses and varieties on starch content in grains was statistically insignificant (P>0.05). Starch content was determined between 41.691-42.860 % according to N doses and 41.946-43.735 % according to varieties. Differences between starch content in grains according to interactions were found to be statistically significant (P<0.05). Starch content in grains of interactions occurred between 40.152-44.225 %. Accordingly, the highest starch content was obtained from N12 x Seri-82, N12 x Cemre, and N16 x Cemre from the same group, and the lowest from N8 x Kose interactions. In a study conducted in Diyarbakir conditions using 4 commercial varieties and 16 advanced bread wheat lines, starch ratios were determined between 61.36 % and 63.73 % and it was stated that there was a negative relationship between starch ratio and protein ratio in the grain (Bayhan et al., 2021). In a similar study (Mut et al., 2015), starch ratios in the grain were determined between 61.6 % and 65.0 %. In another study, the average starch ratios of 11 barley varieties were found between 52.61 % and 58.60 % (Sirat and Bahar, 2020). The findings obtained in our study are lower than these data. The reason for this is shown to be the change in starch ratio in the grain under the influence of genotype and ecological factors (Mahla et al. 2015).

3.5. Protein

Data on protein content in the grain of varieties, N doses, and interactions are shown in Table 2. Accordingly, the effect of N doses on protein content in grain was found to be statistically significant (P<0.05). Protein ratios varied between 13.166-15.477 % according to N doses. Protein contents were obtained at the lowest N0 (control) dose and the highest N12 dose. The remaining N doses were also in the highest group. The differences between protein amounts in grain according to varieties were found to be statistically insignificant (P>0.05). Accordingly, protein contents were determined between 14.145-14.923 %. The differences between protein amounts in grain according to interactions were statistically significant (P<0.05). Accordingly, protein ratios in grain were determined between 11.798-15.901 %. The highest protein ratios were obtained from N12 x Bahare and the lowest from N0 x Bahare interactions. In a study conducted with 4 commercial and 16 advanced wheat varieties in Diyarbakır conditions (Bayhan et al., 2021), protein ratios were determined between 13.73-18.43 %. In another study conducted in Diyarbakır conditions (Kizilgeci et al., 2019), protein ratios varied between 14.36-16.48 %. In a study conducted with 14 bread wheat in Yozgat conditions, the protein ratio was 12.8 % according to the three-year average. The findings obtained in our study are similar to these results. It has been stated that the protein ratio in the grain varies under the influence of genotype, ecology, and maintenance conditions. It has also been reported that high protein increases grain hardness, the ratio in the grain varies between 8-18 % (Christen, 2009) and sometimes up to 25 % (Gooding and Davis, 1997) and positively affects other quality characteristics in the grain.

3.5. Cellulose

The cellulose contents of varieties, N doses, and interactions in grain are shown in Table 2. Accordingly, N doses and varieties did not have a statistically significant effect on cellulose contents in grain (P>0.05). Cellulose rates in grain varied between 3.228-3.385 % according to N doses and 3.124-3.429 % according to varieties. The differences between cellulose amounts in grain according to interactions were found to be statistically significant (P<0.05). Accordingly, cellulose contents in grain varied between 2.920-4.037 %. The highest cellulose rates in grain were detected in N16 x Kose interactions in the same group with N12 x Cemre and the lowest in N12 x Seri-82 interactions in the same group with N0 x Seri-82. In Edirne conditions, the crude cellulose ratios of 6 bread wheat were determined between 1.75-3.01 % (Erken, 2022). The results obtained in our research are higher than these data. On the other hand, in a study conducted in Harran Plain conditions (Yildiz and Tari, 2018), the cellulose amounts in barley were found between 6.1-7.2 %. The findings obtained in our research are lower than those of the data.

3.6. Oil

Data on the oil contents of varieties, N doses, and interactions in grain are shown in Table 2. Accordingly, the effect of N doses on oil amounts was found to be statistically insignificant (P>0.05). Oil contents varied between 1.702-2.059 % according to N doses. The effects of varieties on oil contents were determined to be statistically significant (P<0.05). The oil contents of varieties varied between 1.258-2.311 %. The highest oil content was determined in Seri-82, which is in the same group as Cemre, and the lowest in Kose, which is in the same group as Bahare. The effect of the interactions on oil content in the grain was determined to be statistically significant (P<0.05). According to the interactions, oil contents varied between 1.018-2.592 %. The highest oil content in the grain was determined in other interactions in the same group as N0 x Cemre and the lowest in the N12 x Bahare interaction. In a study conducted in Yozgat conditions (Mut et al., 2017), the three-year oil content average of 14 varieties was found to be 1.61 %. In Edirne conditions, the crude oil ratio was found to be between 1.08-2.39 % according to the averages of 6 bread wheat (Erken, 2022). In Gumushane conditions, the two-year average of 11 barley varieties was found to be between 1.36-2.01 % (Sirat and Bahar, 2020). The findings obtained in our research are similar to these. It has been reported that the oil ratio is affected by genotype, environment, and maintenance conditions (Ereifej et al., 2007; Barteczko et al., 2009).

4. Conclusion

According to the research examining the effects of nitrogenous fertilizer doses on NDVI and grain quality traits of local and commercial wheat varieties during the 2020 summer growing season: Nitrogenous fertilization significantly influenced the protein ratio in grain but had a limited effect on other quality traits. Commercial varieties demonstrated superior performance in grain oil content, while the Bahare variety showed high ash, starch, and protein ratios at a fertilization dose of 12 kg da^{-1}. Given the critical role of protein ratio in determining grain quality, our findings suggest that an 8 kg da^{-1} nitrogenous fertilization dose is the most suitable dose for the trial conditions to obtain the highest protein ratio economically.

Declaration of Author Contributions

The authors declare that they have contributed equally to the article. All authors declare that they have seen/read and approved the final version of the article ready for publication.

Declaration of Conflicts of Interest

All authors declare that there is no conflict of interest related to this article.

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