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Determination of the Promising Advanced Bread Wheat Lines in Terms of Quality Traits in the Thrace Region

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Abstract

This study was carried out in Tekirdağ-Hayrabolu and Edirne locations in order to investigate some advanced bread wheat lines in terms of some quality traits under the conditions of Thrace Region during 2020-2021 wheat growing period. The study also aimed to identify promising advanced bread wheat lines with product quality suitable for the Thrace Region, which are suitable for registration and have gene source potential. In the experiments, 10 advanced bread wheat lines (NZFE 197, NZFE 199, NZFE 200, NZFE 201, NZFE 202, NZFE 204, NZFE 209, NZFE 213, NZFE 215 and NZFE 218) and 5 standard bread wheat varieties (Gelibolu, Selimiye, Rumeli, NKÜ Lider and Esperia) were used as materials. The experiments were conducted in a randomized complete block design with 3 replications. Protein ratio, wet gluten content, gluten index, zeleny sedimentation value and delayed sedimentation value were investigated in the study. It was determined that protein ratio 11.95%-14.98, wet gluten content 26.83-34.83 %, gluten index 85.33-96.00 %, zeleny sedimentation value 33.17-55.50 ml and delayed sedimentation value 42.33-69.83 ml were varied. The best results after our standard varieties were obtained from advanced lines. In conclusion, it can be said that NZFE 204 and NZFE 213 advanced lines for quality traits are promising variety candidates for Thrace Region. These lines were taken into registration experiments for re-testing.

Research Article

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1. Introduction

Wheat (*Triticum* ssp.) is a strategic crop plant that is the most cultivated among the cereal species both in the world and in Türkiye. It is the staple food of about 50 countries in the world today due to its wide adaptability, its ability to be grown in many different climatic conditions, the high nutritional value of its grain, and the ease of transportation, storage and processing. It is also a cereal species that plays an important role in the nutrition of more than 35 % of the world's population (Khakwani et al., 2011). Türkiye ranks among the prominent wheat-consuming countries in the world with a wheat consumption of approximately 177 kg per capita (TUIK, 2021). Of Türkiye's 23.9 million hectares of agricultural land, 49% is allocated to cereals. Among cereals, wheat is the most important genus with a ratio of 60 % (FAO, 2022).

Today, the world's population is rapidly increasing, while cultivation areas are rapidly decreasing due to errors in cultural processes such as tillage, irrigation, fertilization, erosion, industrialization and urbanization. Estimates show that the world population will be 9.7 billion in 2050 and 11.2 billion in 2100 (Anonymous, 2015). The only solution to produce the wheat required by the world population is to increase the yield per unit area. Therefore, yield increase has been the primary target in wheat breeding studies to present day and yield increase has been achieved in new varieties (Yağdı, 2002). However, the production of quality grain and quality flour has been a major problem in recent years. Quality wheat imports are needed to supply quality flour (Karaman et al., 2012).

Grain quality in bread wheat is controlled by a large number of genes and the degree to which each trait is affected by the environment is different. On the other hand, the interaction between grain yield and quality traits may occur at different levels (Kılıç et al., 2014). Quality parameters in wheat are significantly dependent on grain protein content and protein content is significantly affected by genotype and environment (Koca et al., 2011). However, there is generally a negative relationship between grain yield and protein content in wheat, and while grain yield increases, protein content and flour quality are negatively affected. Güngör et al. (2022) also determined that protein ratio, Zeleny sedimentation value and gluten content were negatively related with grain yield in wheat. In wheat breeding studies until today, obtaining high-yielding varieties has been determined as the primary target and quality has remained in the second rank (Karaman et al., 2012). Most of the quality wheat required by flour and bakery product industrialists is met through imports in our country. For this purpose, depending on the years, payments between 689 million dollars-1.2 billion dollars are paid (Gençtan et al., 2020). Therefore, the combination of grain yield and quality should be one of the most important breeding targets in wheat (Karaman et al., 2012). By determining the changes in yield and quality under different environmental conditions, it is possible to evaluate lines that are stable in terms of desired yield and quality characteristics and whose performance is better than the existing standard varieties as variety candidates (Yazar et al., 2013).

In this study, 10 bread wheat advanced lines developed by Tekirdağ Namık Kemal University, Faculty of Agriculture, Department of Field Crops were tested with 5 commercial bread wheat varieties grown in Thrace Region at two different locations (Tekirdağ-Hayrabolu and Edirne) in terms of some quality traits and it was aimed to determine promising advanced lines with superior traits.

2. Materials and Methods

2.1. Materials

A total of 15 bread wheat genotypes, including 10 bread wheat advanced lines developed by Tekirdağ Namık Kemal University (TNKU), Faculty of Agriculture, Department of Field Crops and 5 commercial bread wheat varieties grown in Thrace Region, were used as material in the study. The advanced lines and varieties used in the study are given in Table 1.

Table 1. The advanced lines and varieties used in the study

Advanced Lines	Pedigree/Registration year	Origins
NZFE 197	Harmankaya / Flam85//Flemenko / Bez	TNKU Agricultural Faculty
NZFE 199	Lira/IBWSN4//Litera/3/Sana/Çetinel	TNKU Agricultural Faculty
NZFE 200	Nina / Esperia//Flemenko / Flam85	TNKU Agricultural Faculty
NZFE 201	Esperia/Lira//Musik/3/F80/Sbosna/4/Bez/Sbosna/5/Dropia	TNKU Agricultural Faculty
NZFE 202	GK Hunyad/GK Tisza	TNKU Agricultural Faculty
NZFE 204	Flemenko / Musik//Flemenko / Flam85	TNKU Agricultural Faculty
NZFE 209	Sana / Krasunia//Nina / Esperia	TNKU Agricultural Faculty
NZFE 213	Renan/Lira//Garcia/3/Lira/IBWSN4/4/Music	TNKU Agricultural Faculty
NZFE 215	GK Ati/Capo//GK Tisza	TNKU Agricultural Faculty
NZFE 218	Flemenko / Flam85//Flemenko / Golia	TNKU Agricultural Faculty
Varieties		
Gelibolu	2005	Türkiye
Selimiye	2009	Türkiye
Rumeli	2012	Türkiye
NKU Lider	2016	Türkiye
Esperia	2011	Italy

2.2. Soil and climate properties of the experimental areas

The experiment was conducted in two different locations in the farmers' fields of Hayrabolu District of Tekirdağ Province and Sarayakpınar Village of Edirne Province during the 2020-2021 wheat growing period. Some climatic data obtained from Tekirdağ and Edirne Meteorological Stations for the 2020-2021 wheat growing period are given in Table 2.

Table 2. Some climate data of Tekirdağ and Edirne provinces during the 2020-2021 growing period

Months	Provinces	Precipitation (mm)		Mean temperature ^{0}C	
		Monthly	Long-term	Monthly	Long-term
October-2020	Tekirdağ	51.8	55.2	18.2	15.2
	Edirne	64.0	56.7	17.2	14.2
November-2020	Tekirdağ	1.2	81.3	11.6	11.4
	Edirne	6.6	68.8	9.2	9.3
December-2020	Tekirdağ	38.7	86.2	10.1	7.2
	Edirne	92.6	75.2	8.4	4.5
January-2021	Tekirdağ	127.8	69.9	7.8	4.4
	Edirne	201.4	62.9	5.9	2.0
February-2021	Tekirdağ	53.5	54.7	7.3	5.3
	Edirne	55.4	50.8	6.7	5.2
March-2021	Tekirdağ	45.3	55.6	7.0	6.8
	Edirne	44.2	46.2	6.5	7.1
April-2021	Tekirdağ	43.6	42.9	10.7	11.5
	Edirne	76.6	49.9	11.2	12.7
May-2021	Tekirdağ	57.6	37.6	17.5	16.6
	Edirne	65.0	49.2	18.5	17.9
June-2021	Tekirdağ	54.7	37.8	20.8	28.9
	Edirne	82.2	48.9	21.5	22.0
Total	Tekirdağ	474.2	521.2	-	-
	Edirne	688.0	508.6	-	-
Mean	Tekirdağ	-	-	12.3	11.9
	Edirne	-	-	11.7	10.5

It is noteworthy that the total precipitation (474.2 mm) received during the wheat growing season at the Tekirdağ location where the experiment was conducted was 47 mm lower than the long-term average (521.2 mm) (Table 2). The amount of precipitation received in April and May, which includes the heading and grain filling periods in wheat, is very effective on yield and quality. It is understood that the precipitation received in April (43.6 mm) was similar to the long-term mean (42.9 mm) and the precipitation received in May (57.6 mm) was 20.0 mm higher than the long-term mean (37.6 mm). The average temperature during the wheat growing season at Tekirdağ location was measured as 12.3 ºC, 0.4 ºC above the long-term average (Table 2).

From Table 2, it is understood that the total precipitation received during the wheat growing season at Edirne location (688.0 mm) was 179.4 mm higher than the long-term mean (508.6 mm). When the amount of precipitation received in April and May, which include the heading and grain filling periods at Edirne location, it is observed that the precipitation received in April (76.6 mm) is 26.7 mm higher than the long-term average (49.9 mm) and the precipitation received in May (65.0 mm) is 15.8 mm higher than the long-term average. The mean temperature during the wheat growing season at Edirne location was measured as 11.7 ºC, 1.2 ºC above the long-term average (Table 2).

According to the results of the analysis of the soil samples of the experimental areas where the field experiments were carried out in Edirne Commodity Exchange Soil Laboratory, it is understood that the soil of the experimental area in Tekirdağ location is clay-loamy, neutral, limeless, high in phosphorus, sufficient in calcium, magnesium, potassium, manganese and zinc, high in iron and low in organic matter. It was determined that the soil of the experimental area in Edirne location was clay-loamy, slightly acid, limeless, high in phosphorus, sufficient in calcium, magnesium, potassium, manganese and manganese, high in iron, low in zinc and low in organic matter.

2.3. Methods

Field experiments were established in Tekirdağ-Hayrabolu location on November 13, 2020 and in Edirne location on November 14, 2020 with 3 replications according to the randomized block experiment design. The seeds of the bread wheat advanced lines and varieties used in the experiment were sown by a parcel sowing machine in plots consisting of 6 rows of 6 meters and each row was 0.17 m apart. Sowing density was 500 seeds m^{-2}. In the experiment, 4 kg da^{-1} of pure nitrogen and 4 kg da^{-1} of pure phosphorus as 20.20.0 compound fertilizer at the sowing stage, 9.2 kg da^{-1} of pure nitrogen as urea fertilizer (46 % nitrogen) at the tillering stage and 3.9 kg da^{-1} of pure nitrogen as calcium ammonium nitrate fertilizer (26 % nitrogen) at the stem elongation stage were applied. Weeds were controlled chemically in the experimental area. 50 g L^{-1} Pinoxaden +12.5 g L^{-1} Cloquintocet-mexyl and 452.42 g L^{-1} (300 g a.e. L^{-1}) 2,4-D EHE + 6.25 g L^{-1} Florasulam were used to prevent narrow-leaved and broad-leaved weeds, respectively.

In the study, protein ratio (%), wet gluten content (%), gluten index (%), Zeleny sedimentation value (ml) and delayed sedimentation value (ml) were investigated. These investigated traits were measured by Near Infrared (NIR) spectroscopy (Thermo Fisher Scientific).

2.4. Statistical analysis

After checking the homogeneity of variance in the data obtained from the experiment, variance analysis (ANOVA) was performed by combining the locations according to the randomized complete block design. The statistical significance of the differences between the mean values of the investigated traits was determined according to the least significant difference (LSD) test using JUMP 5.0 package program (Düzgüneş et al., 1987).

3. Results and Discussion

The results of ANOVA showed that the protein ratio (PR), wet gluten content (WGC), gluten index (GI), zeleny sedimentation value (ZSV) were affected by location, genotype and location x genotype interaction, but delayed sedimentation value (DSV) was affected by genotype and location x genotype interaction. Data on the investigated characteristics are given separately below.

3.1. Protein ratio

In terms of protein ratio, location, genotype and location x genotype interactions were found statistically significant at 0.01 level. Table 3 shows that the mean protein content of the genotypes varied between 11.95-14.98 %. The highest mean protein content was measured in Rumeli standard variety, followed by Esperia standard variety (14.40 %) and NZFE 213 advanced line (14.32 %). The lowest protein ratio was determined in NZFE 200 advanced line, followed by NZFE 201 (12.40 %) and NZFE 218 (12.43 %) advanced lines. The mean protein ratio of standard varieties was determined as 13.91 %. Among the advanced lines, NZFE 213 (14.32 %) had a higher protein ratio than the mean of the standard varieties and NZFE 204 (13.92 %) had a protein ratio similar to the mean of the standard varieties (Table 3). In the study, it was determined that the mean protein ratio of Edirne location (14.47 %) was higher than the mean protein ratio of Hayrabolu location (12.47 %) (Table 3). In the location x genotype interaction, the mean protein ratio varied between 10.97-16.33 %. The highest mean protein ratio was determined in Rumeli standard variety at Edirne location, followed by Esperia standard variety at the same location with 15.46 %. The lowest average protein ratio was found in NZFE 200 and NZFE 201 advanced lines with the same value at Hayrabolu location, followed by NZFE 218 advanced line at Hayrabolu location with 11.20 % (Table 3).

Table 3. Mean values and significance groups for PR

Genotyps	Locations		
	Edirne	**Hayrabolu**	**Mean**
NZFE 197	15.03 bc	12.17 k	13.60 cd
NZFE 199	14.63 bcd	12.60 ıjk	13.62 cd
NZFE 200	12.93 g-k	10.97 l	11.95 g
NZFE 201	13.83 def	10.97 l	12.40 fg
NZFE 202	14.53 cd	12.70 ıjk	13.62 cd
NZFE 204	15.03 bc	12.80 h-k	13.92 bc
NZFE 209	14.43 cde	12.57 ıjk	13.50 cd
NZFE 213	14.96 bc	13.67 efg	14.32 b
NZFE 215	13.83 def	12.40 jk	13.12 d
NZFE 218	13.66 efg	11.20 l	12.43 fg
Gelibolu	13.23 f-j	12.47 jk	12.85 ef
Rumeli	16.33 a	13.63 e-h	14.98 a
NKÜ Lider	14.66 bcd	13.07 f-j	13.87 bc
Esperia	15.46 b	13.33 f-ı	14.40 ab
Selimiye	14.43 cde	12.47 jk	13.45 cd
MSV	14.82	12.99	13.91
Mean	14.47 A	12.47 B	
LSD	Location (L): 0.218**	Genotyp (G): 0.596**	LxG: 0.836**

PR: Protein ratio, MSV: Mean of standard varieties, *: significant at %5 level, **: significant at %1 level

It is known that protein amount and composition are the most important factors determining grain quality in wheat and protein amount varies depending on genetic structure, cultivation techniques and environmental factors (Miadenow et al., 2001). In our research, it was determined that there were significant differences between the mean protein ratio values obtained from the locations where the experiments were conducted. This may be due to the different climatic characteristics of the locations. Our results are in accordance with the results of Naneli et al. (2015), Karaman and Aktaş (2020), Öztürk (2022), Sirat (2022), Erdem and Sakin (2023) who determined that the protein ratio in wheat varies according to years and locations. The differences between the mean protein content of bread wheat genotypes were also significant. This may be due to the different genetic characteristics of the bread wheat genotypes used in the study. Our results obtained as genotype mean for protein ratio were similar to the results of Öztürk et al. (2009) (11.7-15.2%), Koca et al. (2011) (110-16.1%) and Güçlü (2015) (10.82-17.37%).

3.2. Wet gluten content

In study, the effect of location, genotype and location x genotype interaction on the wet gluten content was statistically significant at 0.01 level. The mean wet gluten content of the genotypes varied between 26.83-34.83 % (Table 4). The highest mean wet gluten content was determined in NZFE 213 advanced line, followed by Rumeli with 34.17 %, Selimiye standard variety with 33.83 % and NZFE 202 advanced line. The lowest wet gluten content was determined in NZFE 200 advanced line, followed by NZFE 218 (27.33 %) and NZFE 201 (28.17 %) advanced lines in the same statistical group. The mean wet gluten content of standard varieties was determined as 32.56 %. Among the advanced lines, NZFE 202 and NZFE 213 had higher wet gluten content than the mean of standard varieties (Table 4). In our study, the mean wet gluten content of Edirne location (36.36%) was higher than Hayrabolu location (26.44%) (Table 4). In the location x genotype interaction, the mean wet gluten content varied between 21.66-40.33 %. The highest mean wet gluten content was found in Rumeli standard variety at Edirne location, followed by Selimiye standard variety at the same location in the same statistical group with 40.00%. The lowest mean wet gluten content was found in NZFE 201 advanced line at Hayrabolu location, followed by NZFE 200 and NZFFE 218 advanced lines at Hayrabolu location with 22.33 % (Table 4).

Table 4. Mean values and significance groups for WGC

Genotypes	**Locations**		
	Edirne	**Hayrabolu**	**Mean**
NZFE 197	37.33 a-d	23.66 lmn	30.50 cd
NZFE 199	35.33 cde	29.33 ghı	32.33 bc
NZFE 200	31.33 gh	22.33 mn	26.83 e
NZFE 201	34.66 def	21.66 n	28.17 e
NZFE 202	38.66 ab	29.00 hıj	33.83 ab
NZFE 204	36.33 bcd	26.00 jkl	31.17 c
NZFE 209	36.00 bcd	26.00 jkl	31.00 cd
NZFE 213	38.00 abc	31.66 fgh	34.83 a
NZFE 215	36.33 bcd	28.00 ıjk	32.17 bc
NZFE 218	32.33 efg	22.33 mn	27.33 e
Gelibolu	32.33 efg	25.33 klm	28.83 de
Rumeli	40.33 a	28.00 ıjk	34.17 ab
NKÜ Lider	38.00 abc	29.33 ghı	33.67 ab
Esperia	38.33 abc	26.33 ı-l	32.33 bc
Selimiye	40.00 a	27.66 ıjk	33.83 ab
MSV	37.79	27.33	32.56
Mean	36.36 A	26.44 B	
LSD	Location (L): 0.829**	Genotype (G): 2.271**	LxG: 3.191**

WGC: Wet gluten content, MSV: Mean of standard varieties, *: significant at %5 level, **: significant at %1 level

The amount of wet gluten, which is an indicator of protein quality in wheat, generally varies according to genotype, cultivation techniques and climatic conditions during the maturing period. In our study, significant differences were observed between the mean wet gluten content obtained from the locations where the experiments were conducted. This may be due to the different ecological characteristics of the locations. Our results are consistent with the results of Bilgin (2001), Işık (2011), Güçlü (2015) and Albayrak et al. (2020), who determined that the amount of wet gluten in wheat varies according to years and locations. The differences between the mean wet gluten content of bread wheat genotypes were found to be statistically significant. This may be due to the different genetic characteristics of the bread wheat genotypes. Our findings obtained as the genotype mean for wet gluten content were similar to the mean wet gluten content values obtained by Yağdı (2002) (22.3-38.0%), Aktar (2011) (25.0-37.1%), Kurt (2012) (25.05-36.30%) and Öztürk (2022) (25.4-38.6%).

3.3. Gluten index

The differences between the means of location, genotype and location x genotype interactions for gluten index were found statistically significant at 0.01 level. The mean gluten index values of the genotypes varied between 85.33-96.00 %. The highest mean gluten index was determined in Esperia standard variety, followed by NZFE 197 (95.33 %) and NZFE 200 (95.00 %) advanced lines. The lowest gluten index was obtained from NZFE 215 advanced line, followed by

NZFE 202 advanced line (88.00 %). In the study, the mean gluten index of standard varieties was determined as 93.90 %. It was noticed that the advanced lines except NZFE 199, NZFE 202 and NZFE 215 had higher gluten index than the mean of the standard varieties (Table 5). When the locations were compared, it was observed that the mean gluten index value of Edirne location (91.76 %) was lower than that of Hayrabolu location (94.80 %) (Table 5). In location x genotype interaction, mean gluten index values varied between 76.66-96.00 %. The highest average gluten index value was measured in Rumeli and Esperia standard varieties at Hayrabolu location, Esperia standard variety at Edirne location, followed by NKÜ Lider standard variety at Hayrabolu location with 95.67 %. The lowest mean gluten index was found in NZFE 215 advanced line at Edirne location, followed by NZFE 202 advanced line at Edirne location with 83.00 % (Table 5).

Table 5. Mean values and significance groups for GI

Genotypes	**Locations**		
	Edirne	**Hayrabolu**	**Mean**
NZFE 197	95.33 ab	95.33 ab	95.33 ab
NZFE 199	92.00 cde	94.67 ab	93.33 cd
NZFE 200	95.33 ab	94.67 ab	95.00 abc
NZFE 201	94.33 a-d	95.00 ab	94.67 a-d
NZFE 202	83.00 f	93.00 b-e	88.00 e
NZFE 204	95.00 ab	94.33 a-d	94.67 a-d
NZFE 209	93.66 a-d	95.33 ab	94.50 bcd
NZFE 213	95.00 ab	94.67 abc	94.83 abc
NZFE 215	76.66 g	94.00 a-d	85.33 f
NZFE 218	94.33 a-d	93.67a-d	94.00 bcd
Gelibolu	91.66 de	94.67 abc	93.17 cd
Rumeli	91.66 de	96.00 a	93.83 bcd
NKÜ Lider	91.66 de	95.67 ab	93.67 bcd
Esperia	96.00 a	96.00 a	96.00 a
Selimiye	91.66 e	95.00 ab	92.83 d
MSV	92.53	95.46	93.90
Mean	91.76 B	94.80 A	
LSD	Location (L): 0.726**	Genotype (G): 1.989**	LxG: 2.794**

GI: Gluten index, MSV: Mean of standard varieties, *: significant at %5 level, **: significant at %1 level

Gluten index value in wheat is a quality parameter used to determine gluten quality and it is desired to be between 60-90 % in bread wheat flours (Elgün et al., 2002). In our study, it was determined that the effect of locations on gluten index was significant. Similar to our findings, Işık (2011), Kurt (2012), Bilgin et al. (2015) and Öztürk (2022) emphasized that gluten index in wheat varies according to years and locations. In our study, the differences between the mean gluten index of the bread wheat genotypes were also found to be significant. This may be a result of the different grain quality of bread wheat genotypes. Gluten index values obtained as genotype mean for gluten index were similar to the mean gluten index values obtained by Kahraman et al. (2008).

3.4. Zeleny sedimentation value

As a result of the analysis of variance performed for the Zeleny sedimentation values obtained in our study, it was determined that the differences between the means of location, genotype and location x genotype interactions were statistically significant at 0.01 level. The mean Zeleny sedimentation values of the genotypes varied between 33.17-55.50 ml (Table 6). NKÜ Lider variety had the highest mean Zeleny sedimentation value, followed by Rumeli (55.17 ml) and Esperia (55.00 ml) standard varieties in the same statistical group. The lowest Zeleny sedimentation value was determined in NZFE 218 advanced line, followed by NZFE 199 (36,17 ml) and NZFE 215 (38,33 ml) advanced lines. The mean Zeleny sedimentation value of the standard varieties was determined as 51.33 ml. It was observed that none of the advanced lines had a higher Zeleny sedimentation value than the mean of the standard varieties. Table 6 shows that the mean Zeleny sedimentation value of Edirne location (46.69 ml) is higher than the mean Zeleny sedimentation value of Hayrabolu location (43.51 ml). When the location x genotype interaction was evaluated, it is observed that the mean Zeleny sedimentation values varied between 33.00-61.33 ml. The highest mean Zeleny sedimentation value was measured in Esperia standard variety at Edirne location, followed by NKÜ Lider (59.66 ml) and Rumeli (57.66 ml) standard varieties in the same statistical group. The lowest mean Zeleny sedimentation value was determined in NZFE 218 advanced line (33.00 ml), which had the same value at both locations, followed by NZFE 199 advanced line at Edirne location with 35.66 ml (Table 6).

Table 6. Mean values and significance groups for ZSV

Genotypes	Locations		
	Edirne	**Hayrabolu**	**Mean**
NZFE 197	48.33 c-g	46.66 f-ı	47.50 b
NZFE 199	36.66 mno	35.66 no	36.17 fg
NZFE 200	42.33 ı-l	40.00 k-n	41.17 cde
NZFE 201	44.66 g-j	39.66 k-n	42.17 cd
NZFE 202	38.33 lmn	40.33 j-m	39.33 def
NZFE 204	50.33 b-f	47.33 e-h	48.83 b
NZFE 209	43.00 h-k	42.33 ı-l	42.67 c
NZFE 213	53.00 b	48.00 d-g	50.50 b
NZFE 215	37.33 mno	39.66 k-n	38.33 ef
NZFE 218	33.00 o	33.33 o	33.17 f
Gelibolu	42.66 ı-l	42.33 ı-l	42.50 cd
Rumeli	57.66 a	52.66 bc	55.17 a
NKÜ Lider	59.66 a	51.33 b-e	55.50 a
Esperia	61.33 a	48.66 b-g	55.00 a
Selimiye	52.33 bcd	44.66 g-j	48.50 b
MSV	54.72	47.92	51.33
Mean	46.69 A	43.51 B	
LSD	Location (L): 1.190**	Genotype (G): 3.258**	LxG: 4.578**

ZSV: Zeleny sedimentation value, MSV: Mean of standard varieties, *: significant at %5 level, **: significant at %1 level

Zeleny sedimentation test in wheat is a method used to estimate protein quality and bread volume. It is known that the effect of genetics on sedimentation value is higher than the environment, and that flours with high gluten value and good quality have high sedimentation values (Özsoy et al., 2023). Also, Naneli et al. (2015), Karaduman et al. (2015), Karaman and Aktaş (2020) reported that Zeleny sedimentation value in wheat is affected by environmental changes. Similarly, in our study, the differences between locations in terms of Zeleny sedimentation value were found significant. The mean Zeleny sedimentation values obtained as the mean of the genotypes in our study were similar to the mean Zeleny sedimentation values obtained by Öztürk (2022).

3.5. Delayed sedimentation value

In the study, as a result of the analysis of variance, it was determined that the differences between genotype and location x genotype interactions for delayed sedimentation value were statistically significant at 0.01 level, while the differences between locations were not statistically significant. In the study, the mean delayed sedimentation values of the genotypes varied between 42.33-69.83 ml (Table 7). The highest mean delayed sedimentation value was measured in Rumeli standard variety, followed by Esperia standard variety in the same statistical group with 69.00 ml. The lowest delayed sedimentation value was determined in NZFE 218 advanced line, followed by NZFE 199 advanced line (43,67 ml) in the same statistical group. The mean delayed sedimentation value of the standard varieties was determined as 63.26 ml. Among the advanced lines, only NZFE 204 (62.83 ml) had a delayed sedimentation value similar to the average of the standard varieties. In our study, the mean delayed sedimentation values of both locations were similar to each other and there was no statistically significant difference between them (Table 7). In the location x genotype interaction, mean delayed sedimentation values varied between 41.33-70.00 ml. The highest mean delayed sedimentation value was measured in Rumeli standard variety at Hayrabolu location, followed by Rumeli (69,66 ml) and Esperia (69,66 ml) standard varieties at Edirne location and Esperia (68,33 ml) standard variety at Hayrabolu location. The lowest average delayed sedimentation value was found in NZFE 199 advanced line at Hayrabolu location, followed by NZFE 215 advanced line at Edirne location with 41.66 ml (Table 7).

Table 7. Mean values and significance groups for DSV

Genotypes	Locations		
	Edirne	**Hayrabolu**	**Mean**
NZFE 197	63.33 cde	57.67 ghı	60.50 bc
NZFE 199	46.00 opq	41.33 s	43.67 fg
NZFE 200	45.33 pqr	55.67 hıj	50.50 d
NZFE 201	54.66 ıjk	47.33 nop	51.00 d
NZFE 202	50.33 lmn	53.00 jkl	51.67 d
NZFE 204	64.00 bcd	61.67 def	62.83 b
NZFE 209	45.33 pqr	49.00 m-p	47.17 e
NZFE 213	59.33 fgh	60.00 efg	59.67 c
NZFE 215	41.66 rs	49.67 l-o	45.67 ef
NZFE 218	43.00 qrs	41.67 rs	42.33 g
Gelibolu	51.66 klm	50.67 lmn	51.17 d
Rumeli	69.66 a	70.00 a	69.83 a
NKÜ Lider	59.66 efg	66.67 abc	63.17 b
Esperia	69.66 a	68.33 a	69.00 a
Selimiye	67.67 ab	58.67 fgh	63.17 b
MSV	63.66	62.86	63.26
Mean	55.42	55.42	
LSD	Location (L): - Genotype (G): 2,689** LxG: 3,778**		

DSV: Delayed sedimentation value, MSV: Mean of standard varieties, *: significant at %5 level, **: significant at %1 level

Delayed sedimentation value in wheat is used to determine the damage caused by the sunn pest and the wheat stink bug. If the delayed sedimentation values obtained are lower than the Zeleny sedimentation values, it indicates their damage. In our research, it was observed that the mean delayed sedimentation values obtained from the locations were similar and both locations had a higher delayed sedimentation value than the Zeleny sedimentation values. This result shows that there was no damage from the sunn pest during the wheat growing period in the locations where the research was carried out. The differences between the mean delayed sedimentation values of bread wheat genotypes were found to be significant. This may be due to the fact that the bread wheat genotypes had different genetic characteristics in terms of grain quality. The mean delayed sedimentation values of the genotypes were higher than the delayed sedimentation values obtained by Bilgin (2001), Işık (2011) and Kurt (2012). This may be due to the fact that the bread wheat genotypes used in the studies had different genetic characteristics and that the damage caused by the sunn pest was different in the years and locations where the studies were carried out.

4. Conclusions

This study was carried out in Tekirdağ-Hayrabolu and Edirne locations in order to investigate some advanced bread wheat lines in terms of some quality traits under the conditions of Thrace Region. As a result of the study, it can be said that NZFE 204 and NZFE 213 are promising advanced lines that can be variety candidates for Thrace Region which has the potential of gene source in terms of quality traits. These lines were taken into registration experiments for re-testing; at the same time, they were transferred to the crossing garden to be used as parents in crossing studies.

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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