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EFFECT OF DIFFERENT NITROGEN DOSES AND SEED AMOUNTS ON SPIKE CHARACTERISTICS IN CULTIVATED AND WILD WHEATS

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Abstract: The study was conducted in 2022-2023 and 2023-2024 in the experimental fields of Tekirdağ Namık Kemal University, Faculty of Agriculture, Department of Field Crops. The study was conducted in 3 replications according to the split-plot experimental design using 400-450-500-550-550 seeds m^{-2} and 10-15-20 kg da^{-1} pure nitrogen dose in einkorn, mirabile wheat and NKU Zirve genotypes. In the study, spike length, number of grains per spike and grain weight per spike values of einkorn, mirabile and NKU Zirve wheats were analysed. According to the results of the analyses, it was determined that the number of grains in the spike was higher in mirabile wheat, and the values of spike length and grain weight in the spike were higher in NKU Zirve bread wheat genotypes. In spike length, the highest seed rate average was 8.06 cm in 450 seed m^{-2}, the highest nitrogen dose average was 7.95 cm in 15 kg da^{-1} pure nitrogen application and the lowest nitrogen dose average was 7.73 cm in 10 kg da^{-1} pure nitrogen dose application. In the number of grains in the spike, the highest seed rate average was 43.33 with 450 seeds m^{-2}, the lowest was 38.06 with 550 seeds m^{-2}, and the highest nitrogen dose average was 41.09 with 20 kg da^{-1}. The highest seed rate average of 400 seeds m^{-2} with 1.48 g, the highest nitrogen dose average with 1.43 g at 15 and 20 kg da^{-1}, the lowest nitrogen dose average with 1.39 g at 10 kg da^{-1} pure nitrogen dose application were determined.

Keywords: *Triticum turgidum var. mirabile*, *Triticum monococcum L.*, Sowing norm, Nitrogen dose, Spike, Local wheat

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1. Introduction

Wheat has been the main food source of the people of our country from past to present with the products obtained from wheat, especially bread. Wheat has always been considered valuable, respected and regarded as a sacred product. In our country, only 20 per cent of the existing agricultural areas can be irrigated and the remaining areas are dry farmed. This situation further emphasises the importance of field crops produced by dry farming method. Wheat has gone beyond being only a source of food and has become a strategic product on a global scale. Countries have to carry out economic and strategic international policies on wheat production and supply in order to meet the nutritional needs of their populations. The main reason for this is the vital role that wheat plays in human nutrition on a global scale. It is accepted that the relationship between wheat and humans started about 14 thousand years ago in Southeastern Anatolia, around Urfa; Einkorn, known as the ancestor of wheat, was first cultivated in Karacadağ in Urfa 12 thousand years ago and spread all over the world from there (Zaharieva and Monneveux, 2014). In a study conducted on sowing seed rate in wheat at Tekirdağ and Edirne locations, spike length, number of grains per spike and weight decreased significantly in the 600 seed m^{-2} application with the highest sowing seed rate, while spike length, number of grains per spike and weight were higher in the 300 seed m^{-2} application compared to other sowing seed rate applications (Balkan et al., 2024). In recent years, due to the increasing effect of global climate change, the effects of biotic and abiotic stresses have become more intense in many regions. Increasing temperatures cause more frequent droughts and an increase in diseases and pests. In addition, the increasing desire for healthy nutrition among consumers increases the interest and demand for natural, organic and traditional products, and there are opinions that wild and local plants should be taken into consideration more.

Most of the modern varieties, which have been bred by using different breeding techniques, can reach these yields with high input use. In addition, these modern varieties are easily affected by changing climatic conditions, which may pose risks for sustainable agriculture and sustainable food. Wild plants are genotypes that have adapted to local conditions for many years and are therefore more resistant to abiotic and biotic stresses. These plants have adapted to various climatic conditions through natural selection and

traditional agricultural practices. Increasing demands on food security and sustainability are fuelling renewed interest in local plants and local genetic diversity. Local genotypes can reduce the need for chemical and artificial fertiliser use, which increases environmental sustainability. In a study on local bread wheat populations, it was determined that local bread wheat varieties are important genetic resources in terms of quality and have significant potential for use in breeding programmes (Mut et al., 2024). In a study, pioneer farmer/consumer communities in Çanakkale, Balıkesir and Kars provinces and some community-supported agriculture groups operating in İzmir province in the dissemination of local wheat varieties and bread and other products were examined. As a result of the study, it was found that understanding the production process in consumer groups and identifying problems related to consumption through focus group studies firstly increased the consumption of local wheat products (Yıldız and Özkaya, 2024). Kaydan and Yağmur (2008) examined grain yield and yield components on 16 bread wheat varieties under Van conditions in 2005-2006 and 2006-2007 production periods for two years. They determined that grain yield was positively correlated with yield components such as number of grains per spike and spike length. In a study, yield factors such as number of spike per square metre and number of grains per spike also contributed to the increase in harvest index (Öztürk and Korkut, 2018). In wheat breeding, number of grains per spike is one of the important yield factors considered in selection. Therefore, it is of great importance to increase one or more of these yield elements in order to obtain higher yield from unit area (Toklu and Yağbasanlar, 2005). The aim of this study was to determine the effect of different sowing norms and nitrogen doses on spike traits in wild wheat varieties, mirabile wheat, einkorn wheat and NKU Zirve bread wheat variety developed by combination breeding and to reveal the potential of spike traits for high productivity in agricultural production. It is aimed that the data to be obtained as a result of the study will be the basis for future researches, interpretations, inferences and studies.

2. Materials and Methods

2.1. Materials

In the research, einkorn wheat was obtained from the Central Research Institute of Field Crops, mirabile wheat and NKU Zirve wheat were obtained from Tekirdağ Namık Kemal University, Faculty of Agriculture, Department of Field Crops. Experimental sowing was carried out on 10.12.2022 in 2022-2023 and 10.12.2023 in 2023-2024, and harvesting was carried out on 16.07.2023 and 25.07.2024. The trials, which were planned to form sub-plots of sowing densities (400, 450, 500, 550 seeds m^{-2}) and nitrogen doses (10, 15 and 20 kg da^{-1}), were carried out in two years (2022- 2023 and 2023-2024 growing period) with 3 replications according to the split plots experiment design divided in randomised blocks. In the trials, sowing was done with a plot drill on plots of 6.12 m^{-2} (6 rows of 6 metres in length and 17 cm between row spacing) and 5.1 m^{-2} area was harvested at harvest. Researches revealed that 16 kg da^{-1} pure nitrogen should be applied in wheat cultivation in Thrace Region in order to reach the potential wheat yield of the region (Güçdemir, 2006). From this point of view, 3 different nitrogen doses were applied in the experiment. 5 kg of the nitrogen doses was given to all plots as base fertiliser with 20.20.0 compound fertiliser with sowing. The remaining pure nitrogen applications were applied as top fertiliser in 4 different times by considering the growth and development periods and rainfall on the Zadoks scale (Table 1).

Table 1. Fertilization applicatipons

Applications	Sowing	Beginning of tillering (Zadoks 21)	The End of tillering (Zadoks 25)	The End of the stem elongation (Zadoks 37)
10	5 kg da^{-1} pure N	5 kg da^{-1} pure N	-	-
15	5 kg da^{-1} pure N	6 kg da^{-1} pure N	4 kg da^{-1} pure N	-
20	5 kg da^{-1} pure N	7 kg da^{-1} pure N	4 kg da^{-1} pure N	4 kg da^{-1} pure N

The first top fertilisation was applied at the beginning of tillering (Zadoks 21st period), the second top fertilisation was applied at the end of tillering (Zadoks 25th period) and the third top fertilisation was applied at the end of spike emergence (Zadoks 37th period). Herbicide application was made for weed control. No herbicide application was made on einkorn wheat. Weed control in einkorn wheat was carried out manually.

2.2. Statistical Analyses

The data obtained from the experiment were subjected to analysis of variance using TARIST computer program according to the Split Plots Experimental Design. The mean values of the traits examined in the experiment was compared using Duncan test.

3. Results

3.1. Spike Length

Analysis of variance was performed with the values related to the spike length trait of the genotypes, and when the results of the analysis of variance were analysed, the difference between the averages of year, genotypes, genotype x seed rate interaction, seed rate x nitrogen dose interaction and genotype x seed rate x nitrogen dose interaction was found statistically

significant at 0.01% level, and the difference between seed rate, nitrogen dose and genotype x nitrogen dose interaction was found statistically significant at 0.05% level. Genotype, seed rate, dose averages and significance groups for spike length are given in Table 2.

Table 2. Genotype, seed rate and dose averages and significance for spike length

Genotype	Average	Seed rate	Average	Nitrogen Dose	Average
Einkorn	5.75 b	400	7.85 ab	10	7.73 b
Mirabile Wheat	8.56 a	450	8.06 a	15	7.95 a
NKU Zirve	9.22 a	500	7.83 ab	20	7.86 ab
		550	7.64 b		

The highest spike length was measured in NKU Zirve variety with 9.22 cm, followed by mirabile wheat with 8.56 cm and einkorn wheat with 5.75 cm. Statistically, NKU Zirve and mirabile wheat were in the same group and einkorn wheat was in different statistical group. The highest spike height in different sowing rate was 450 seed m^{-2} with 8.06 cm, followed by 400 and 500 seed m^{-2} sowing seed rate with 7.85 cm and 7.83 cm. In terms of nitrogen doses, the highest spike height was measured with 15 kg da^{-1} with 7.95 cm. The lowest nitrogen dose was 7.73 cm at 10 kg da^{-1} pure nitrogen dose application. The values and significance groups of genotype x seed rate, genotype x dose, seed rate x dose and genotype x seed rate x dose interactions for spike length are given in Table 3.

Table 3. Genotype x seed rate, genotype x dose, seed rate x nitrogen dose and genotype x seed rate x nitrogen dose interaction averages and significance

Genotype	Seed rate	Nitrogen Dose			Genotype x seed rate int.
		10	15	20	
Einkorn	400	5.63 jk	6.28 ıj	6.02 jk	5.78 ef
	450	5.90 jk	6.20 j	6.00 jk	6.03 e
	500	5.40 jk	5.55 jk	5.22 k	5.39 f
	550	5.52 jk	5.70 jk	5.64 jk	5.62 ef
Genotype x Dose int.		5.61 e	5.93 d	5.72 de	
Mirabile Wheat	400	8.37 efg	8.95 c-f	9.07 b-f	8.79 bc
	450	8.73 def	9.58 a-d	9.02 b-f	9.11 abc
	500	8.41 efg	8.94 c-f	8.18 fg	8.51 c
	550	7.71 gh	7.04 hı	8.74 def	7.83 d
Genotype x Dose int.		8.75 b	8.63 b	8.30 c	
NKU Zirve	400	9.06 b-f	9.06 b-f	8.82 c-f	8.98 abc
	450	8.61 ef	8.90 c-f	9.65 abc	9.05 abc
	500	8.81 c-f	10.08 a	9.84 ab	9.57 a
	550	9.56 a-d	9.14 b-e	9.12 b-e	9.27 ab
Genotype x Dose int.		9.27 a	9.29 a	9.10 a	

Genotype x Seed Rate X Nitrogen Dose Int.	Nitrogen Dose		
Seed rate	10	15	20
400	7.69 bc	7.90 abc	7.97 ab
450	7.75 abc	8.19 a	8.22 a
500	7.88 abc	8.19 a	7.41 c
550	7.60 bc	7.83 abc	7.49 bc

In einkorn wheat, the highest spike length was measured at 450 seed m^{-2} seed rate with 6.03 cm, followed by 400 seed m^{-2} seed rate with 5.78 cm and 550 seed m^{-2} seed rate with 5.62 cm. The highest spike length of mirabile wheat genotype was measured at 450 seed m^{-2} seed rate with 9.11 cm, followed by 400 seed m^{-2} seed rate with 8.79 cm and 500 seed m^{-2} seed rate with 8.51 cm. In NKU Zirve wheat genotype, the highest spike length was measured at 500 seed m^{-2} seed rate with 9.57 cm, followed by 550 seed m^{-2} with 9.27 cm and 450 seed m^{-2} seed rate with 9.05 cm. In NKU Zirve bread wheat genotype, the highest spike height was measured at 15 kg da^{-1} pure nitrogen dose with 9.29 cm and the lowest was at 20 kg da^{-1} pure nitrogen dose with 9.10 cm. In mirabile wheat genotype, the highest spike length was 8.75 cm at 10 kg da^{-1} pure nitrogen dose and the lowest was 8.63 cm at 15 kg da^{-1} pure nitrogen dose. In einkorn wheat genotype, the highest spike length was 5.93 cm at 15 kg

da^{-1} pure nitrogen dose and the lowest was 5.61 cm at 10 kg da^{-1} pure nitrogen dose. The highest spike length of 8.22 cm was measured at 450 seed m^{-2} sowing density and 20 kg da^{-1} pure nitrogen application. The lowest spike length of 7.41 cm was measured at 500 seed m^{-2} sowing seed rate and 20 kg da^{-1} pure nitrogen application. These results obtained in the experiment show that the highest spike length is obtained in NKU Zirve bread wheat genotype when 500 seeds m^{-2} and 15 kg da^{-1} pure nitrogen application per decare. The highest spike length was obtained with 450 seeds m^{-2} and 15 kg da^{-1} pure nitrogen application in mirabile wheat, and the highest spike length was obtained with 400 seeds m^{-2} and 15 kg da^{-1} pure nitrogen application in einkorn wheat genotype. When the genotype x seed rate x nitrogen dose interactions were analysed, the highest spike height with 10.08 cm and 9.84 cm was obtained in 500 seed m^{-2} and 15 kg da^{-1} and 20 kg da^{-1} pure nitrogen applications of NKU Zirve genotype, and the lowest spike height with 8.61 cm was obtained in 450 seed m^{-2} and 10 kg da^{-1} pure nitrogen application. The highest spike length of mirabile wheat genotype was 9.58 cm in 450 seed m^{-2} and 15 kg da^{-1} pure nitrogen application, the lowest spike length was 7.04 cm in 550 seed m^{-2} and 15 kg da^{-1} pure nitrogen application. In einkorn genotype, the highest spike length was 6.28 cm in 400 seed m^{-2} and 15 kg da^{-1} pure nitrogen application and the lowest spike length was 5.22 cm in 500 seed m^{-2} and 20 kg da^{-1} pure nitrogen application plots.

3.2 Number grains per spike

The number of grains per spike, which is one of the important main yield factors in wheat, is under the influence of environmental and genetic factors. There is a positive and significant relationship between grain yield and number of grains per spike. During the development of the plant, environmental factors also affect spikelet development, pollination and fertilisation (Polat et al., 2015). It was reported that there is generally a positive interaction between the number of grains per spike and grain yield (Mutlu, 2021). Variance analysis was performed with the values related to the number of grains per spike trait of wheat genotypes, and when the results of variance analysis were analysed, year, genotypes, genotype x seed rate interaction, genotype x nitrogen dose interaction, seed rate x nitrogen dose interaction and genotype x seed rate x nitrogen dose interaction were found statistically significant at 0.01% level. Genotype, seed rate, nitrogen dose averages and significance for the number of grains per spike trait are given in Table 4.

Table 4. Genotype, seed rate and nitrogen dose averages and significance for the number of grains in the spike

Genotype	Average	Seed rate	Average	Nitrogen dose	Average
Einkorn	21.34 b	400	41.38	10	39.86
Mirabile Wheat	50.87 a	450	43.33	15	41.00
NKU Zirve	49.74 a	500	39.83	20	41.09
		550	38.06		

The highest number of grains was counted in mirabile wheat with 50.87 grains, followed by NKU Zirve genotype with 49.74 grains and einkorn wheat with 21.4 grains. The highest seed rate average was 43.33 with 450 seeds m^{-2} and the lowest was 38.06 with 550 seeds m^{-2}. The highest number of grains in the spike was measured in 20 kg da^{-1} application with 41.09 grains. The lowest nitrogen dose average was found in 10 kg da^{-1} pure nitrogen dose application with 39.86 grains. Genotype x seed rate, genotype x nitrogen dose, seed rate x nitrogen dose, seed rate x nitrogen dose and genotype x seed rate x nitrogen dose interaction averages and significance are given in Table 5. In NKU Zirve bread wheat genotype, the highest number of grains per spike was 54.18 at 500 seed m^{-2} seed rate, followed by 450 seed m^{-2} seed rate with 52.20 and 550 seed m^{-2} seed rate with 47.25. In mirabile wheat genotype, the highest number of grains per spike was at 400 seed m^{-2} seed rate with 58.36, followed by 450 seed m^{-2} seed rate with 54.73 and 550 seed m^{-2} seed rate with 45.95. In einkorn wheat genotype, the highest number of grains per spike was 23.07 at 450 seed m^{-2} seed rate, followed by 550 seed m^{-2} seed rate with 20.97 and 500 seed m^{-2} seed rate with 20.87. In NKU Zirve bread wheat genotype, the highest number of grains per spike was measured at 20 kg da^{-1} pure nitrogen dose with 50.41, followed by 15 kg da^{-1} pure nitrogen dose application with 50.38. The highest number of grains in the spike was 53.44 with 10 kg da^{-1} pure nitrogen dose, followed by 50.60 with 15 kg da^{-1} and 48.58 with 20 kg da^{-1} pure nitrogen dose for mirabile wheat. In einkorn wheat genotype, the highest number of grains in the spike was 22.02 with 15 kg da^{-1} pure nitrogen dose, followed by 21.41 with 20 kg da^{-1} pure nitrogen dose. When the genotype x seed rate x nitrogen dose interaction was analysed, the highest number of grains in the spike was obtained with 63.89 grains in 400 seed m^{-2} and 15 kg da^{-1} pure nitrogen application of mirabile wheat. This was followed by 450 and 400 seeds m^{-2} and 20 kg da^{-1} and 10 kg da^{-1} pure nitrogen application with 58.76 and 57.97. The lowest number of grains per spike was 18.64 in 400 seed m^{-2} and 15 kg da^{-1} pure nitrogen application of einkorn wheat, followed by 19.90 grains per spike obtained in 500 seed m^{-2} and 10 kg da^{-1} pure nitrogen application of einkorn wheat. The highest number of grains per spike was 63.89 in 400 seeds m^{-2} and 15 kg da^{-1} pure nitrogen application, followed by 58.76 450 seed m^{-2} and 57.97 in 400 seeds m^{-2} and 20 kg da^{-1} and 10 kg da^{-1} pure nitrogen application. The lowest

number of grains in the spike was 35.76 in 550 seed m^{-2} application with 15 kg da^{-1} pure nitrogen in mirabile wheat.

In einkorn wheat genotype, the highest number of grains per spike was 24.75 in 450 seed m^{-2} and 15 kg da^{-1} pure nitrogen application, followed by the value obtained in 550 seed m^{-2} and 15 kg da^{-1} pure nitrogen application with 22.52. The lowest number of grains in the spike was 18.64 grains in the spike obtained from 400 seeds m^{-2} and 15 kg da^{-1} pure nitrogen. In NKU Zirve bread wheat genotype, the highest number of grains per spike was 58.38 at 500 seeds m^{-2} and 10 kg da^{-1} pure nitrogen application, followed by 56.83 and 55.70 at 500 and 450 seeds m^{-2} and 15 and 20 kg da^{-1} pure nitrogen application. The lowest number of grains in the spike was 44.08 with 400 seeds m^{-2} and 15 kg da^{-1} pure nitrogen application.

Table 5. Genotype x seed rate, genotype x nitrogen dose, seed rate x dose and genotype x seed rate x nitrogen dose interaction averages and significance

Genotype	Seed rate	Nitrogen Dose			Genotype x seed rate int.
		10	15	20	
Einkorn	400	20.32 ı	18.64 ı	22.43 ı	20.46 d
	450	22.15 ı	24.75 ı	22.32 ı	23.07 d
	500	19.90 ı	22.16 ı	20.57 ı	20.87 d
	550	20.04 ı	22.52 ı	20.34 ı	20.97 d
Genotype x Dose int.		20.60 c	22.02 c	21.41 c	
Mirabile Wheat	400	57.97 ab	63.89 a	53.23 bcd	58.36 a
	450	55.66 bc	56.40 bc	58.76 ab	54.73 ab
	500	37.35 gh	46.35 def	52.13 b-e	44.44 c
	550	43.34 fg	35.76 h	49.62 c-f	45.95 bc
Genotype x Dose int.		53.44 a	50.60 ab	48.58 b	
NKU Zirve	400	46.54 def	44.08 f	45.34 ef	45.32 bc
	450	50.52 c-f	50.38 c-f	55.70 bc	52.20 abc
	500	58.38 ab	56.83 bc	47.33 def	54.18 abc
	550	46.21 def	50.21 c-f	45.33 ef	47.25 bc
Genotype x Dose int.		48.42 b	50.38 ab	50.41 ab	

Genotype x Seed Rate X Nitrogen Dose Int.	Nitrogen Dose		
Seed rate	10	15	20
400	41.61 abc	42.20 abc	40.33 a-d
450	42.77 ab	43.84 a	43.38 a
500	38.54 cde	41.78 abc	39.17 b-e
550	36.53 de	36.16 e	41.48 abc

3.3. Grain Weight in the Spike

Grain weight in spike, which is the result of many yield components that occur in early developmental stages of wheat, is one of the main yield factors affecting yield. Grain weight per spike plays an important role in yield formation as it directly affects the harvest index. Grain weight per plant is a direct indicator of the efficient utilisation of nutrients and their transport to the storage parts of the plant (Borojevic, 1983). Since grain yield is a combined quantitative trait under the influence of many traits and environmental conditions, grain weight per spike should be increased in order to achieve high grain yield (Syme, 1972). Variance analysis was carried out with the values related to grain weight in spike of wheat genotypes and when the results of variance analysis were analysed, the difference between year, genotypes, genotype x seed rate x nitrogen dose interactions and genotype x seed rate interactions were found statistically significant at 0.01% level. The difference between seed rates was statistically significant at 0,05% level. Genotype, seed rate, nitrogen dose averages for grain weight in spike trait are given in Table 6.

The highest spike grain weight was measured in NKU Zirve genotype with 2.08 g, followed by mirabile wheat with 1.64 g and einkorn wheat with 0.53 g. The highest spike grain weight was measured in 400 seed m^{-2} with 1.48 g, followed by 450 and 500 seed m^{-2} sowing seed rate with 1.46 g and 1.45 g, respectively. The highest average grain weight in the spike was 1.43 g at 15 and 20 kg da^{-1} pure nitrogen dose treatments. The lowest nitrogen dose average was 1.39 g in 10 kg da^{-1} pure nitrogen dose application. Genotype x seed rate, genotype x nitrogen dose, seed rate x nitrogen dose and seed rate x dose interaction averages and significance for

grain weight in spike are given in Table 7.

Table 6. Genotype, seed rate, nitrogen dose averages and significance for grain weight in the spike

Genotype	Average	Seed rate	Average	Nitrogen Dose	Average
Einkorn	0.53 b	400	1.48 a	10	1.39
Mirabile Wheat	1.64 a	450	1.46 a	15	1.43
NKU Zirve	2.08 a	500	1.45 a	20	1.43
		550	1.28 b		

Table 7. Seed rate x nitrogen dose and genotype x seed rate x nitrogen dose interaction averages and significance

Genotype	Seed rate	Nitrogen Dose			Genotype x Seed rate
		10	15	20	
Einkorn	400	0.58 ı	0.43 ı	0.61 ı	0.54 f
	450	0.59 ı	0.64 ı	0.58 ı	0.61 f
	500	0.43 ı	0.54 ı	0.49 ı	0.49 f
	550	0.51 ı	0.56 ı	0.42 ı	0.49 f
Genotype x Dose int.		0.53	0.54	0.53	
Mirabile Wheat	400	2.12 bcd	2.17 a-d	1.84 c-f	2.05 ab
	450	1.62 efg	1.91 c-f	1.51 fg	1.68 cd
	500	1.28 gh	1.57 efg	1.65 efg	1.50 de
	550	1.33 gh	1.07 h	1.59 efg	1.33 e
Genotype x Dose int.		1.59	1.68	1.65	
NKU Zirve	400	1.83 c-f	1.75 def	1.97 cde	1.85 bc
	450	1.93 cde	1.95 cde	2.40 ab	2.09 ab
	500	2.53 ab	2.38 ab	2.19 abc	2.37 a
	550	1.93 cde	2.13 a-d	1.94 cde	2.00 bc
Genotype x Dose int.		2.05	2.05	2.12	

Genotype x Seed Rate x Nitrogen Dose Int.	Nitrogen Dose		
Seed rate	10	15	20
400	1.51	1.45	1.48
450	1.38	1.50	1.50
500	1.41	1.49	1.45
550	1.26	1.26	1.31

In NKU Zirve bread wheat genotype, the highest spike grain weight was measured at 500 seed m^{-2} seed rate with 2.37 g, followed by 450 seed m^{-2} with 2.09 and 550 seed m^{-2} seed rate with 2.00. In mirabile wheat genotype, the highest spike grain weight was measured at 400 seed m^{-2} seed rate with 2.05 g, followed by 450 seed m^{-2} seed rate with 1.68 g and 500 seed m^{-2} seed rate with 1.50 g. In einkorn wheat genotype, the highest spike grain weight was measured at 450 seed m^{-2} seed rate with 0.61 g, followed by 400 seed m^{-2} with 0.54 g, 550 and 500 seed m^{-2} seed rate with 0.49 g. In NKU Zirve bread wheat genotype, the highest spike grain weight was measured at 20 kg da^{-1} pure nitrogen dose with 2.12 g, followed by 10 and 15 kg da^{-1} pure nitrogen dose treatments with 2.05 g. The highest spike grain weight was measured at 15 kg da^{-1} pure nitrogen dose with 1.68 g in mirabile wheat genotype and the highest spike grain weight was measured at 15 kg da^{-1} pure nitrogen dose with 0.54 g in einkorn wheat. When these results obtained in the experiment were analysed, the highest grain weight in spike was obtained in NKU Zirve bread wheat genotype when 500 seeds m^{-2} and 20 kg da^{-1} pure nitrogen was applied. Decreases in nitrogen dose caused a decrease in grain weight in spike in NKU Zirve wheat genotype. It was determined that the grain weight in the spike decreased due to the long plant height of mirabile wheat at 500 seeds m^{-2} and above, and the grain weight in the spike did not increase when a fertiliser application above 15 kg pure nitrogen was applied per decare. It is seen that 400 seed m^{-2} density and 15 kg da^{-1} pure nitrogen

application is sufficient for mirabile wheat genotype. In einkorn wheat genotype, the highest spike grain weight was obtained at 450 seed m^{-2} and 15 kg da^{-1} pure nitrogen application. When the genotype x seed rate x nitrogen dose interaction was analysed, the highest grain weight in the spike with 2.53 g and 2.40 g was obtained in NKU Zirve genotype with 500 and 450 seeds m^{-2}, 10 and 20 kg da^{-1} pure nitrogen applications. These were followed by 500 seeds m^{-2} and 15 kg da^{-1} pure nitrogen applications of NKU Zirve genotype with 2.38 g in the same statistical group. The lowest spike grain weight of NKU Zirve genotype was 1.75 g in 400 seed m^{-2} and 15 kg da^{-1} pure nitrogen application. This was followed by the grain weight of NKU Zirve genotype with 1.83 g obtained in 400 seed m^{-2} and 10 kg da^{-1} pure nitrogen application. The highest grain weight of mirabile wheat genotype was 2.17 g in 400 seeds m^{-2} and 15 kg da^{-1} pure nitrogen application, followed by 2.12 g and 1.91 g in 400 and 450 seeds m^{-2} and 10 kg da^{-1} and 15 kg da^{-1} pure nitrogen application. The lowest spike grain weight was obtained from 550 seeds m^{-2} with 1.07 g in 15 kg da^{-1} pure nitrogen application. In einkorn wheat genotype, the highest spike grain weight was 0.64 g in 450 seed m^{-2} and 15 kg da^{-1} pure nitrogen application, followed by the values obtained in 400 seed m^{-2} and 20 kg da^{-1} pure nitrogen application with 0.61 g. The lowest spike grain weight was obtained from 550 seeds m^{-2} and 20 kg da^{-1} pure nitrogen application with 0.42 g.

4. Discussion

Spike length is one of the important morphological traits affecting the yield potential of wheat. Long spike length is generally associated with higher grain number and thus higher yield potential, while short spike length is generally associated with lower grain number and yield. The long spike length of NKU Zirve genotype makes this genotype advantageous in terms of grain number and therefore yield potential. The short spike length of einkorn wheat shows that this genotype has a limited structure in terms of grain number and yield potential. Short spike length is generally associated with low grain number and therefore low yield. Grain number is an important parameter that directly affects the yield potential of wheat. High grain number is generally associated with higher yield, while low grain number indicates that yield potential is limited. In addition to the high number of grains per spike in mirabile wheat, the effect of grain number on yield also depends on other factors such as grain weight and fullness. If the grains are not small and plump, high grain number may not always mean high yield. Mirabile wheat genotype can be included in breeding studies due to its high grain number. The low number of grains per spike of einkorn wheat shows that this genotype has a limited structure in terms of yield potential. Grain weight in the spike is an important parameter that directly affects the yield potential and quality characteristics of wheat. High grain weight is generally associated with plump and high-quality grains, while low grain weight causes a limited potential in terms of yield and quality. The high grain weight per spike of NKU Zirve genotype indicates that this genotype produces plump and heavy grains. Although the number of grains per spike is high in spelt wheat, the grain weight is not at the desired level, which is due to the insufficient development of the grains. The low grain weight of einkorn wheat shows that this genotype should be preferred for more quality-oriented production and can be evaluated in terms of its adaptation to traditional and low-input agricultural systems. In a study conducted on 4 bread wheat cultivars in Bangladesh during the 2004-2005 growing period, it was shown that nitrogen applications made by division had a significant effect on spike length and number of grains per spike (Ferdous et al., 2005). In a study aiming to determine some morphological and biological traits in einkorn wheat depending on nitrogen fertilisation level, it was found that nitrogen fertilisation had significant effects on spike length, number of grains in spike and spike grain weight in einkorn wheat. In addition, it is understood that there is a positive relationship between different nitrogen levels and plant growth (Kirchev and Semkova, 2016). In a study conducted in Pakistan in 2015-2016 growing period, the effects of applying nitrogen doses at different times on spike length and spike weight were found statistically significant (Shahzad and Akmal, 2017).

5. Conclusion

The highest spike length was measured in the NKU Zirve genotype with 9.22 cm, and the einkorn wheat genotype with 5.75 cm was the genotype with the lowest spike length among the wheat genotypes tested. The fact that the spike length of the NKU Zirve bread wheat genotype is higher than that of the einkorn and mirabile wheat genotypes shows that it has a high potential in terms of grain number and yield potential in the spike, while the einkorn wheat genotype with a short spike length has a limited structure in terms of grain number and yield potential. It was determined that the number of grains per spike of the mirabile wheat was higher than that of the NKU Zirve bread wheat genotype. It was determined that the number of grains per spike decreased when the mirabile wheat genotype reached 400 seeds m-2 and above due to its long plant height. The highest grain number was counted in the mirabile wheat with 50.87 grains, and the lowest grain number per spike was obtained from the einkorn wheat genotype with 21.34. It has been determined that genotypes with high grain counts may provide an advantage in terms of yield potential, but other factors such as grain fullness and weight should also be taken into consideration, as in mirabile wheat. It has been determined that the grain weight measured in the spike in the NKU Zirve wheat genotype is 4 times higher than the einkorn genotype.

Decreases in nitrogen dose caused a decrease in the grain weight in the spike in the NKU Zirve wheat genotype. It has been determined that the grain weight in the spike decreases when the mirabile wheat genotype reaches 500 seeds m-2 and above due to its long plant height. It is observed that genotypes with high grain weight provide an advantage in terms of yield potential, but other factors should also be taken into consideration.

Author Contributions

The percentages of the author' contributions are presented below. All author reviewed and approved the final version of the manuscript.

	M.A.	İ.B.
C	50	50
D	50	50
S	50	50
DCP	50	50
DAI	50	50
L	50	50
W	50	50
CR	50	50
SR	50	50
PM	50	50
FA	50	50

C= concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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