

## The effect of top dressing fertilizer forms applied at different periods on yield and some yield components in durum wheat varieties

Makarnalık buğday çeşitlerinde farklı dönemlerde uygulanan üst gübre formlarının verim ve bazı verim öğelerine etkisi

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ARTICLE INFO	ABSTRACT
<p><b>Article history:</b> Recieved / Geliş: 09.09.2024 Accepted / Kabul: 24.10.2024</p> <p><b>Keywords:</b> Durum wheat Fertilizer Nitrogen application time Yield</p> <p><b>Anahtar Kelimeler:</b> Durum buğday Gübre Azot uygulama zamanı Verim</p> <p>✉Corresponding author/Sorumlu yazar: Uğur BİLGE udrbilge@gmail.com</p> <p>Makale Uluslararası Creative Commons Attribution-Non Commercial 4.0 Lisansı kapsamında yayınlanmaktadır. Bu, orijinal makaleye uygun şekilde atıf yapılması şartıyla, eserin herhangi bir ortam veya formatta kopyalanmasını ve dağıtılmasını sağlar. Ancak, eserler ticari amaçlar için kullanılamaz. © Copyright 2022 by Mustafa Kemal University. Available on-line at <a href="https://dergipark.org.tr/tr/pub/mkutbd">https://dergipark.org.tr/tr/pub/mkutbd</a></p> <p>This work is licensed under a Creative Commons Attribution-Non Commercial 4.0 International License.</p> <p> </p>	<p>This research was conducted to determine the effects of nitrogen fertilizer forms and application times used in the top dressing of some durum wheat varieties on yield and some yield parameters in GAP International Agricultural Research and Training Center Directorate (GAPUATEM) test fields between 2019-2021. In the study, the effect of six different application times using three nitrogen fertilizer forms (Urea (U 46% N), ammonium sulfate (AS 21% N) and calcium ammonium nitrate (CAN 26% N)) in Burgos, Eyyubi and Hasanbey durum wheat cultivars were treated according to the split-split plots in randomized complete block design. As a result of the study; the effect of wheat varieties on grain yield was found to be important in the first year of the experiment and insignificant in the second year. Although the effect of fertilizer varieties on the characteristics examined in both production seasons is insignificant, it has been observed that the effect of urea fertilizer is better than other fertilizer forms in terms of grain yield. As a result, when considering the climate conditions, in cases where precipitation is sufficient between January and March at the fourth application period, it can be recommended to use slow-release fertilizers (Urea 46%). If the amount of precipitation is insufficient in the same periods, it can be recommended to prefer fast-acting fertilizers (ammonium nitrate) at the third application time.</p> <p><b>ÖZET</b></p> <p>Bu araştırma, 2019-2021 yılları arasında GAP Uluslararası Tarımsal Araştırma ve Eğitim Merkezi Müdürlüğü (GAPUATEM) deneme alanlarında bazı makarnalık buğday çeşitlerinin üst gübrenmesinde kullanılan azotlu gübre formları ile uygulama zamanlarının verim ve bazı verim parametreleri üzerine etkisinin belirlenmesi amacı ile yürütülmüştür. Çalışma, Burgos, Eyyubi ve Hasanbey makarnalık buğday çeşitlerinde üç azotlu gübre formu (üre (%46 N), amonyum sülfat (%21 N) ve kalsiyum amonyum nitrat (%26 N)) kullanılarak altı farklı uygulama zamanının etkisi tesadüf bloklarında bölünen bölünmüş parseller deneme desenine göre üç tekrarlamalı olarak yürütülmüştür. Çalışma sonucunda; buğday çeşitlerinin tane verimine etkisi denemenin birinci yılında önemli, ikinci yılında ise önemsiz bulunmuştur. Gübre çeşitlerinin her iki üretim sezonunda incelenen özelliklere etkisi önemsiz olmasına rağmen tane verimi açısından üre gübresinin diğer gübre formlarına göre etkisinin daha iyi olduğu belirlenmiştir. Sonuç olarak, tane verimi açısından iklimsel şartlar dikkate alındığında Ocak-Mart ayları arasında yağışın yeterli olduğu durumlarda dördüncü uygulama zamanında yavaş salımlı gübreler (Üre %46) kullanılması, aynı dönemler için yağış miktarının yetersiz olduğu durumlarda ise üçüncü uygulama zamanında hızlı etkili gübrelerin (amonyum nitrat) tercih edilmesi önerilebilir.</p>
<p><b>Cite/Atıf</b></p>	<p>Bilge, U., &amp; Çimrin, K.M. (2025). The effect of top dressing fertilizer forms applied at different periods on yield and some yield components in durum wheat varieties. <i>Mustafa Kemal Üniversitesi Tarım Bilimleri Dergisi</i>, 30 (1), 13-34. <a href="https://doi.org/10.37908/mkutbd.1546080">https://doi.org/10.37908/mkutbd.1546080</a></p>

## INTRODUCTION

The origin of the wheat plant is accepted as Mesopotamia (Karacadag region), which covers the southern borders of Anatolia. Excavations made especially in recent years, in Göbeklitepe show that wheat was cultivated about twelve thousand years ago (Kaya, 2018). In addition to its used human nutrition since the dates of its cultivation, wheat has become more important compared to other agricultural products in terms of being the raw material of basic foods (bakery products, bread, bulgur, pasta, etc.). Cereals are the most produced product group in the world and in Türkiye in plant production. Wheat ranks first among cereals in terms of both cultivation area and production amount (TEPGE, 2022).

In the 2020-2021 production season, wheat production in the world increased by 1.4% to 774 million tons and the average yield was 3.45 tons/ha. In parallel with the increase in the population, wheat consumption increased by 20 million tons compared to the previous year and reached 766 million tons. Durum wheat production increased by 1.5% compared to the previous year and reached 33.9 million tons (TMO, 2023). As of 2020, the wheat cultivation areas of Türkiye constitute 3.2% of the world's wheat cultivation areas. The wheat cultivation area of our country ranks first among cereals areas with 69.2 million decares. Due to the increase in cultivation areas in Türkiye, in the 2020 production season an increase of 6.6% in yield was achieved and wheat production was 20.5 million tons. In the 2021 production season, there was a significant decrease in yield compared to the previous year due to unfavorable conditions such as drought, and wheat production decreased by 3.9% to 17.7 million tons (TAGEM, 2023a). Although wheat is grown in every region of Türkiye, it is widely produced in Central Anatolia and Southeastern Anatolia Region. Southeastern Anatolia Region ranks 3rd with a share of 18%. The Southeastern Anatolia Region ranks first in durum wheat production with a share of 43% (TurkStat, 2023). The Southeastern Anatolia Region takes an important place in Türkiye in terms of cool climate cereals. The importance of the region has increased even more with the GAP project and other dams and irrigation canals that are under construction in recent years. Durum wheat takes an important place in the region. For this reason, it is described as the most important durum group of Türkiye (Alagöz, 1991).

When we look at the amount of fertilizer consumption used in agriculture in Türkiye in recent years, it is estimated that 6.0 million tons of fertilizer was consumed in 2019 and approximately 7.1 million tons in 2020 (TAGEM, 2023b). There is an average of 95 kg fertilizer use per hectare in Turkey, while this rate is 116 kg per hectare in the world and over 200 kg in the European Union and other developed countries (ZMO, 2021). In order to increase yield and quality in agriculture, it is aimed to use appropriate cultivation techniques together with breeding studies. In Türkiye, 57% of the chemical fertilizers consumed for agricultural production are used in the production of cereals and 66% of this amount is used for wheat cultivation (Kacar & Katkat, 1999). Apart from the climatic conditions that restrict the yield in wheat, the most important issue is the sufficient and appropriate use of fertilizers at the right time. The previous, studies on the wheat-nitrogen relationship reports that nitrogen (N) deficiency can have a significant decrease in yield and can cause serious damage in excess (Atar, 2017). In addition to dividing and applying N fertilizers for high yields in wheat, the form and application time of such fertilizers are also important in terms of yield (Halaç & Yürür, 1999).

One of the biggest problems of Türkiye's agriculture is the inappropriate use of fertilizers. The habits of the producer and the lack of geographical knowledge especially at the point of fertilizer selection and consumption, have a great effect in improper fertilization. Although Türkiye's annual fertilizer consumption has approached developed countries in recent years, the lack of a planned and conscious fertilization causes it to lag behind these countries in terms of yield (Şahin, 2016). In addition to the losses of nitrogen fertilizers in the form of ammonia (NH<sub>3</sub>) gas in the soil, due to their high fertilizer solubility, their mobility increases especially in conditions of high precipitation, causing washing from the soil (Karaçal et al., 1988). In periods when the soil pH is greater than 7.3 and the temperature is high, the losses occurred in urea and ammonium nitrate fertilizers are higher (Atar, 2017). In studies

conducted with nitrogen fertilizer forms, it has been stated that there will be no significant differences in terms of yield as long as losses such as surface runoff and leaching do not occur in the soil due to reasons such as precipitation and temperature (Kaiser et al., 2013).

The Southeastern Anatolia Region has a semi-arid agricultural area. The fact that the soils of the region are generally poor in terms of organic matter increases the importance of nitrogen fertilization. Producers in the region tend to use the same amount of fertilizer every year and the type of fertilizer they can find. As a result, in some years is given a small amount of nutrient elements (fertilizer) in terms of effective substance, while in some years is used more N than necessary (Alagöz, 1991). In recent years, with the introduction of the use of new varieties with high yield power in the region, there has been an increase in the amount of N fertilizer consumed. In particular, it is seen that there are large differences between the N top dressing form used and the application times. Producers in the region generally apply nitrogen fertilization twice, half of which is applied in planting and the other half as top dressing in the spring. Urea (46% N), ammonium sulfate (21% N) and CAN (26% N) fertilizers are mostly used in top dressing and the application times vary. One of the most important factors limiting the yield of wheat cultivation in the Southeastern Anatolia Region is irregular and insufficient precipitation in recent years.

The aim of this study is to determine the effect of nitrogen fertilizer types (urea, ammonium sulfate and calcium ammonium nitrate) used in spring top dressing in durum wheat cultivation made in Diyarbakır conditions and the effect of application times on wheat yield and some yield elements.

## MATERIALS and METHODS

The study was carried out under precipitation-based conditions for two years (two yield years) in the 2019-2020 and 2020-2021 growing seasons on the land of the Gap International Agricultural Research and Training Center Directorate (GAPUATEM) in Diyarbakır province of Türkiye.

Growing seasons and long-term climate data obtained from Diyarbakır Regional Directorate of Meteorology are given in Table 1. There were significant differences in the total amount of precipitation received in both experiment seasons compared to the averages of many years. In the first cultivation year (2019-2020), the amount of precipitation (741.7mm) was higher than the average of twenty years (1991-2021) (473.2mm) and the distribution of precipitation by months was quite irregular. In the second cultivation year (2020-2021), the total annual precipitation was 212.9 mm, which was well below the average precipitation for twenty years (Table 1).

Table 1. Monthly average temperature and total precipitation data for the experiment year and the average of many years (Regional Directorate of Meteorology, 2022)

*Çizelge 1. Deneme yılı ve uzun yıllar ortalamasına ait aylık ortalama sıcaklık ve toplam yağış verileri (Meteoroloji Bölge Müdürlüğü, 2022)*

Months	2019-2020 Average		2020-2021 Average		Average of Many Years (1991-2021)	
	Total Monthly Precipitation (mm)	Monthly Average Temperature (°C)	Total Monthly Precipitation (mm)	Monthly Average Temperature (°C)	Total Monthly Precipitation (mm)	Monthly Average Temperature (°C)
September	8.70	25.2	0.0	27.7	4.1	25.1
October	52.0	19.1	0.0	20.0	32.5	17.9
November	9.00	9.70	54.0	10.6	54.1	9.30
December	185.4	6.80	27.6	4.70	70.7	3.80
January	89.4	3.60	39.1	4.10	63.2	2.20
February	58.6	3.70	40.2	7.00	71.7	3.90

Table 1 (continued). Monthly average temperature and total precipitation data for the experiment year and the average of many years (Regional Directorate of Meteorology, 2022)

Çizelge 1 (devamı). Deneme yılı ve uzun yıllar ortalamasına ait aylık ortalama sıcaklık ve toplam yağış verileri (Meteoroloji Bölge Müdürlüğü, 2022)

	March	April	May	June	Total	
Temperature (°C)	164.8	110.0	63.2	0.60	741.7	-
Precipitation (mm)	10.6	13.5	19.3	26.2	-	473.2
Average (°C)	43.6	5.60	2.80	0.00	212.9	-
Average (mm)	8.40	15.9	23.8	27.9	-	473.2

The routine soil properties of the experiment area for both years are given in Table 2, and macro and micro nutrient contents of these soils are given in Table 3. When the data of the experiment area soils for both years were examined, it was determined that they were clayey, slightly alkaline reaction, salt-free, moderately calcareous and poor in organic matter (Table 2.). It was determined that the total nitrogen (N) amounts were low, the amount of useful phosphorus (P) was very low, the amount of potassium (K) was sufficient and excessive, calcium (Ca) and magnesium (Mg) were high, copper (Cu) was sufficient, iron (Fe), zinc (Zn) and manganese (Mn) were low (Table 3.).

Table 2. Some physical and chemical analysis results of the soil of the experiment area in the 1st and 2nd years (1st year: 2019-2020; 2nd year: 2020-2021)

Çizelge 2. Deneme alanı topraklarının 1. ve 2. yıl bazı fiziksel ve kimyasal analiz sonuçları (1.yıl:2019-2020; 2.yıl: 2020-2021)

Years	Clay %	Silt %	Sand %	Texture class	pH Sat.	Salt %	Lime CaCO <sub>3</sub>	O.M %
1 <sup>st</sup> year	54.08	16.20	29.72	C	8.18	0.040	6.21	0.82
2 <sup>nd</sup> year	56.5	17.66	25.84	C	8.15	0.023	7.31	0.96

Table 3. Some macro and micro nutrient contents of the soils of the experiment area in the 1st and 2nd years (1st year: 2019-2020; 2nd year: 2020-2021)

Çizelge 3. Deneme alanı topraklarının 1. ve 2. yıl bazı bazı makro ve mikro besin elementi içerikleri (1.yıl:2019-2020; 2.yıl: 2020-2021)

Years	N %	P mg kg <sup>-1</sup>	K mg kg <sup>-1</sup>	Ca mg kg <sup>-1</sup>	Mg mg kg <sup>-1</sup>	Cu mg kg <sup>-1</sup>	Fe mg kg <sup>-1</sup>	Zn mg kg <sup>-1</sup>	Mn mg kg <sup>-1</sup>
1 <sup>st</sup> year	0.05	1.3	366.9	6293	768.2	0.559	1.933	0.075	4.483
2 <sup>nd</sup> year	0.06	5.1	390.7	6351	710.8	0.654	2.538	0.079	4.043

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Years	N %	P mg kg <sup>-1</sup>	K mg kg <sup>-1</sup>	Ca mg kg <sup>-1</sup>	Mg mg kg <sup>-1</sup>	Cu mg kg <sup>-1</sup>	Fe mg kg <sup>-1</sup>	Zn mg kg <sup>-1</sup>	Mn mg kg <sup>-1</sup>
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The research was conducted in 3 repetitions in accordance with the Split Parcels Experiment plan divided into Random Blocks. The experiment consisted of 162 parcels (parcel size; 7 m x 1.3 m = 9.1 m<sup>2</sup>) (3 wheat varieties x 3 fertilizers x 6 application times x 3 repetitions = 162). Varieties were included in the main parcels, top dressing forms in the sub-parcels, and application time in the sub-sub-parcels. The experiment was carried out with 500 seeds per m<sup>2</sup> and planting was done in November. In order to prevent the passage of fertilizer between the experiment main parcels, a 2.0 m wide isolation distance was left between the parcels. In this study we used durum Hasanbey and Eyyubi varieties developed by the GAPUATEM and Burgos durum wheat variety registered by RTS Seed. In the experiment, 20.20.0 compound fertilizer was used as nitrogen form in planting, and urea (46% N), ammonium sulfate (21% N) and CAN (26%) fertilizers were used as nitrogen sources in spring top fertilization. 30 kg da<sup>-1</sup> 20.20.0 compound fertilizer was used as base fertilizer, all of the phosphorus was applied with 6 kg P<sub>2</sub>O<sub>5</sub>/da<sup>-1</sup> and 6 kg da<sup>-1</sup> of the total 12 kg da<sup>-1</sup> nitrogen was applied at planting, and the remaining 6 kg da<sup>-1</sup> nitrogen amount was applied using different top fertilizer forms Urea (46%), Ammonium Sulphate (21%) and CAN (26%) at once, as mostly applied by farmers in the region. Under normal conditions, starting 15 days after the completion of emergence, different top fertilizer forms were applied at 6 different times (15-30-45-60-75 and 90 days) at 15-day intervals for each period, and the development periods of the plant were determined according to Zadok's scale at the time of application (Table 4.). In the experiment, weed control was carried out during the tillering period.

Table 4. Nitrogen fertilizer application times according to the Zadok's scale

Çizelge 4. Zadoks skalasına göre azotlu gübre uygulama zamanları

Topdressing Timing	Growth Stages of Wheat (Zadok's Scale)
1 <sup>st</sup> Application Time	Seedling growth (Zadok's 10-12)
2 <sup>nd</sup> Application Time	Tillering (Zadok's 20)
3 <sup>rd</sup> Application Time	Main stem and 4-5 tillers (Zadok's 24-25)
4 <sup>th</sup> Application Time	Pseudostem (youngest leaf sheath erection) (Zadok's 30)
5 <sup>th</sup> Application Time	Second node detectable (Zadok's 32)
6 <sup>th</sup> Application Time	Booting stages (Zadok's 39-40)

### Laboratory analyses

In soil samples, pH was determined according to Jackson (1958) in saturation sludge, lime was determined calcimally according to Hızalan and Ünal (1966) in Scheibler calcimeter, total salt was determined according to Richards, (1954), structure (Bouyoucos, 1951) and organic matter according to Walkley-Black (1947) method. In the soil samples taken, useful P was determined by sodium bicarbonate (pH=8.5) method (Olsen et al., 1954) and by ICP-AES device according to removable potassium (Jackson, 1958). Useful Zn, Fe, Mn and Cu were determined with DTPA in the ICP-OES device according to Lindsay and Norvell (1978).

### Statistical analysis

The data obtained from the study was subjected to analysis of variance using the JUMP statistical package program, and significant effects on the average present application are grouped according to least significant difference (LSD) multiple range test.

## RESULTS and DISCUSSIONS

The mean squares of error of wheat variety, fertilizer type and application times, which are among the sources of variation, were tested according to the Fmax test, and the data of both years were not found to be homogeneous. For this reason, each character was subjected to variance analyses carried out separately for each year. The variance analysis results of both years regarding the effect of three different wheat varieties, three fertilizer sources and six different nitrogen fertilizer application times on the yield and yield parameters are given in Table 5.

Table 5. Results of variance analysis related to yield characteristics

### Çizelge 5. İncelenen verim özellikleri ile ilgili varyans analizi sonuçları

Source of Variation	DF	Grain Yield		Thousand Grain Yield		Number of Grains per Spike		Grain Weight per Spike		Number of Spike		Plant Height	
		2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Block	2												
Wheat Variety (W)	2	234.01*	0,08	53.58**	1,58	21.35**	2,83	0,94	0,88	0,8	1,93	109.23*	18.04*
Error1	4												
Type of N (N)	2	0,300	0,040	0,100	0,020	1,330	0,160	0,650	0,110	0,070	0,050	2,890	0,390
W*N	4	0,010	0,620	0,030	0,180	0,380	0,530	0,140	0,690	0,450	1,680	0,210	0,320
Error2	12												
Times (T)	5	1,860	0,630	0,230	0,900	0,300	1,340	0,910	1,790	0,410	2,030	0,890	0,500
W*T	10	0,600	1,260	1,330	0,760	0,400	1,910	0,710	1,220	0,830	1,140	0,740	0,810
N*T	10	1,670	1,790	0,360	1,600	0,750	1,090	1,110	1,740	1,210	1,930	0,790	1,270
W*N*T	20	0,840	1,060	1,340	0,560	1,030	1,670	0,660	0,980	0,990	1,190	0,680	1,000
G. Error	90	731077,5	554945,7	303,18	456,9	1531,08	2117,28	3,57	2,62	443247	335556	2013,89	2187,65
G. total	161	2024194,8	1467141,3	1238,82	1100,71	5373,98	6035,19	12,05	5,76	1032455	815013	10621,61	6734,65
CV(%)		9,2	17,5	4,24	8,16	9,93	12,75	11	14,9	12,4	14,7	4,34	6,5

F-values, denoted by \*, \*\*, are significant at the level of 5% and 1%, respectively.

### Grain yield (kg da<sup>-1</sup>)

While the effect of wheat varieties on grain yield was found to be significant at the level of 1% in the first year, the effect of wheat varieties was insignificant for the second year. In the experiment, the interaction of fertilizer type, wheat variety x fertilizer type, application time, wheat variety x application time, fertilizer type x application time

and wheat variety x fertilizer type x application time for both years was found to be statistically insignificant (Table 5).

The effect of three different wheat varieties, three fertilizer sources and six different nitrogen fertilizer application times on grain yield and the average grain yields for both years are given in Table 6. The average grain yields of Burgos, Eyyubi and Hasanbey wheat varieties in the first year were 923, 988 and 1036 kg da<sup>-1</sup>, respectively, and the average grain yields of Burgos, Eyyubi and Hasanbey wheat varieties in the second year were 455, 449 and 442 kg da<sup>-1</sup>, respectively (Table 6).

In the first year of the experiment, as can be seen from the average grain yield values of the varieties and least significant difference (LSD) grouping, the highest grain yield average was obtained from the Hasanbey variety, which constitutes a different group with 1036 kg da<sup>-1</sup>. While the Eyyubi variety constituted the second group with 988 kg da<sup>-1</sup>, the Burgos variety constituted another group with 923 kg da<sup>-1</sup> and the lowest grain yield was obtained. This differences among wheat varieties in the first year of the experiment is thought to be related to their genetic structure. Grain yield emerges as a result of the combined effects of environmental factors and genetic potential (Öngören, 2013). The findings are in harmony with previous studies (Halaç & Yürür, 1999; Öngören, 2013; Irmak, 2019) which state that there are significant differences among wheat varieties in terms of grain yield. When the varieties considered in the second year of the study are examined, there is no statistically difference in terms of yield (Table 6). Especially in the second year, it is thought that the lack of sufficient precipitation between January and March and the fact that the varieties are affected by drought eliminate the differences that may occur between wheat varieties in terms of grain yield. In some of the previous studies, it was found that the differences among varieties in terms of grain yield were insignificant (Avcı, 2007; Ruby, 2011).

Table 6. Differences between the average grain yield and averages of wheat and nitrogen fertilizer types and application times for the years 2019-2021 (kg da<sup>-1</sup>)

Çizelge 6. Buğday ve azotlu gübre çeşidi ile uygulama zamanlarının 2019-2021 yıllarına ait ortalama tane verimi ve ortalamalar arasındaki farklar (kg da<sup>-1</sup>)

Wheat Variety	Type of N	Year	Application Times						W*N
			1	2	3	4	5	6	
Burgos	A. Sulfate	2019	942	860	920	938	993	917	928
		2020	437	475	483	447	395	423	443
	CAN	2019	908	892	960	940	905	795	900
		2020	486	371	469	524	449	422	454
	Urea	2019	892	951	944	963	927	963	940
		2020	510	449	548	404	458	443	469
Eyyubi	A. Sulfate	2019	991	1074	983	1037	893	973	992
		2020	439	505	442	524	412	372	449
	CAN	2019	944	996	1063	992	968	890	975
		2020	406	430	487	404	431	429	431
Eyyubi	Urea	2019	1036	988	983	1023	955	989	996
		2020	392	560	442	489	432	494	468
Hasanbey	A. Sulfate	2019	1017	1051	1036	1069	957	1082	1035
		2020	412	415	488	518	444	382	443
	CAN	2019	1118	980	1087	1000	1066	872	1020
		2020	543	398	426	404	559	519	475
	Urea	2019	1072	1075	995	1105	1076	983	1051
		2020	413	432	418	396	377	415	408
Avg. Application Time		2019	991	985	997	1007	971	940	Ave.
		2020	449	448	467	457	440	433	

Table 6 (continued). Differences between the average grain yield and averages of wheat and nitrogen fertilizer types and application times for the years 2019-2021 (kg da<sup>-1</sup>)Çizelge 6 (devamı). Buğday ve azotlu gübre çeşidi ile uygulama zamanlarının 2019-2021 yıllarına ait ortalama tane verimi ve ortalamalar arasındaki farklar (kg da<sup>-1</sup>)

Wheat Variety	Burgos	2019	914	901	942	947	942	892	<b>923c</b>
		2020	478	431	500	458	434	430	455
	Eyyubi	2019	990	1020	1010	1017	939	951	<b>988b</b>
		2020	412	498	457	472	425	432	449
	Hasanbey	2019	1069	1035	1039	1058	1033	979	<b>1036a</b>
		2020	456	415	444	439	460	438	442
Type of N	A.S	2019	984	995	980	1015	948	990	985
		2020	429	465	471	496	417	392	445
	CAN	2019	990	956	1037	977	980	852	965
		2020	479	400	461	444	480	456	453
	Urea	2019	1000	1005	974	1030	986	978	996
		2020	439	480	469	429	422	451	448

Due to the more favorable climatic conditions in the first year of the experiment and especially the drought that occurred in the second year, the grain yield of the first production season was higher compared to the second year. Kılıç et al. (2020) reported that the grain yield of bread wheat genotypes decreased under high temperature conditions in their study conducted under precipitation-based conditions.

The effect of nitrogen fertilizer forms on grain yield was found to be statistically insignificant in both experiment years. In terms of fertilizer types, the average grain yields of ammonium sulfate (AS; 21% N), calcium ammonium nitrate (CAN; 26% N) and urea (U; 46% N) fertilizers were 985 kg da<sup>-1</sup>, 965 kg da<sup>-1</sup> and 996 kg da<sup>-1</sup> respectively in the first year, and the average grain yields were 445 kg da<sup>-1</sup>, 453 kg da<sup>-1</sup> and 448 kg da<sup>-1</sup> in the second year, respectively (Table 7). It is stated that the losses in the form of ammonia (NH<sub>3</sub>) in the urea form fertilizer given to the soil surface in wheat cultivation are higher compared to the ammonium nitrate fertilizer. In addition, among the types of fertilizers, ammonium nitrate fertilizers are more effective in terms of soil dissolution rate compared to urea fertilizer and ammonium sulfate fertilizer; however, it is stated that urea fertilizer is used more effectively by plants due to its slow release (Fowler & Brydon, 1989; Başar et al., 1998; Adjetey et al., 2001; Halitligil et al., 2001; Howard et al., 2002; Melaj et al., 2003).

The fact that the climatic (precipitation and temperature) conditions in the first year of the study were more favorable than in the second year increased the grain yield compared to other fertilizer forms by enabling the use of urea (U; 46% N) fertilizer more effectively by the plant due to its slow-release feature. In the second year of the study, due to the drought experienced, it can be said that the losses in the form of NH<sub>3</sub> in calcium ammonium nitrate (CAN; 26% N) fertilizer are less than other fertilizer forms and the higher dissolution rate makes it easier to be taken by the plant and increases the grain yield. Similar studies have reported that the effect of fertilizer forms on grain yield is generally statistically insignificant (Jhan & Khan, 2000; Savaşlı, 2005; Avci, 2007; Öngören, 2013; Schulz et al., 2015; Akgün et al., 2021; Carpenter, 2021). Başar et al. (1998) in their study conducted in Bursa province of Türkiye, stated that there was no significant difference between fertilizer forms (ammonium sulfate, ammonium nitrate and urea fertilizers) in terms of grain yield in wheat.

The effect of nitrogen fertilizer application times on grain yield was insignificant in both experiment seasons, and the average grain yield was 991, 985, 997, 1007, 971 and 940 kg da<sup>-1</sup> in the first year, respectively; in the second year, it was determined as 449, 448, 467, 457, 440 and 433 kg da<sup>-1</sup> (Table 6). Due to the adverse climatic conditions (lack of precipitation and drought) experienced in the second year of the experiment, it is seen that the grain yield for the application times is higher in the first year. In similar studies, it has been reported that the effect of nitrogen

application times on grain yield is insignificant (Ağrı, 1993; Mooleki & Foster, 1993; Ayoub et al., 1994; Ünsal et al., 1995; Başar et al., 1998; Ooro et al., 1999; Adjetey et al., 2001; Biçer, 2001; Tümsavaş, 2001; Topal et al., 2003; Lestache et al., 2005; Savaşlı, 2005; Avcı, 2007; Yakut, 2011; Souza, 2014; Blandino et al., 2016; Dhillon et al., 2020; Mutlu, 2021). Evlice et al. (2008) reported that the effect of nitrogen application time on grain yield was significant in the first year of the study, but the effect of nitrogen application time on grain yield was insignificant in the second year of the study.

### **Thousand grain yield (g)**

While the effect of wheat varieties on the weight of one thousand grains was found to be significant at the level of 1% in the first year, the effect of wheat varieties was insignificant for the second year. In the experiment, the interactions between fertilizer type, wheat variety x fertilizer type, application time, wheat variety x application time, fertilizer type x application time and wheat variety x fertilizer type x application time in both years were found to be statistically insignificant (Table 5).

The two-year average values for the effect of three wheat varieties, three fertilizer sources and six different nitrogen fertilizer application times on a thousand grain weight are given in Table 7. As can be seen from the average thousand grain weights of the wheat varieties considered in the first year, the average thousand grain weights of the varieties were 44.9, 44.1 and 40.8 grams, respectively, and the average thousand grain weight values of the varieties and least significant difference (LSD) grouping, the highest average thousand grain weight Burgos (44.9 g) and Eyyubi (44.1 g) varieties were in the same group, while the Hasanbey variety (40.8 g) constituted a different group (Table 7). In his study, Yakut (2011) stated that the effect of durum wheat varieties on the weight of one thousand grains was significant in the first year, but insignificant in the second year. In some previous studies, it has been reported that the effect of wheat varieties on thousand grain weight is significant (Gökmen, 1993; Avcı, 2007; Tepecik et al., 2014; Irmak, 2019; Çobanoğlu, 2021).

It is seen that the average thousand grain weights of wheat varieties in the second year vary (28.6), (27.2) and (27.0) g, respectively. Although there is no statistically significant difference, the highest weight of one thousand grains was obtained from the Burgos variety and the lowest from the Hasanbey variety. In similar studies, the effect of wheat varieties on the weight of one thousand grains was insignificant (Yakut, 2011). The weight of one thousand grains may vary depending on the climatic characteristics of the place where the wheat is grown and the genotypic effect of the wheat variety used. Depending on climatic conditions, with the shortening of the grain filling time of wheat and the occurrence of ripening in a shorter time, there are decreases in the weight of a thousand grains (Avcı, 2007; Irmak, 2019).

Table 7. Differences between the average thousand grain yield of wheat and nitrogen fertilizer types and application times for the years 2019-2021 and the averages (g)

*Çizelge 7. Buğday ve azotlu gübre çeşidi ile uygulama zamanlarının 2019-2021 yıllarına ait ortalama bin tane ağırlığı ve ortalamalar arasındaki farklar (g)*

Wheat Variety	Type of N	Year	Application Times						W*N
			1	2	3	4	5	6	
Burgos	A. Sulfate	2019	44.4	45.7	44.5	45.3	46.0	44.0	45.0
		2020	28.1	28.3	29.5	29.7	28.0	27.8	28.6
	CAN	2019	43.9	44.7	45.9	44.2	44.5	46.7	45.0
		2020	29.9	27.2	28.1	29.8	29.0	27.5	28.6
	Urea	2019	45.7	43.8	44.4	45.7	44.0	44.3	44.7
		2020	29.9	27.7	31.3	27.7	27.1	29.0	28.8
Eyyubi	A. Sulfate	2019	42.8	44.0	45.3	43.9	44.1	42.9	43.8
		2020	26.0	27.8	27.4	30.2	25.3	25.0	26.9

Table 7 (continued). Differences between the average thousand grain yield of wheat and nitrogen fertilizer types and application times for the years 2019-2021 and the averages (g)

Çizelge (devamı). Buğday ve azotlu gübre çeşidi ile uygulama zamanlarının 2019-2021 yıllarına ait ortalama bin tane ağırlığı ve ortalamalar arasındaki farklar (g)

	CAN	2019	45.6	45.1	43.1	45.1	45.1	43.3	44.5
		2020	27.7	26.9	28.3	27.4	26.6	27.3	27.4
	Urea	2019	43.5	43.3	45.1	42.7	45.5	43.6	43.9
		2020	26.3	28.9	27.8	26.9	26.4	27.9	27.4
Hasanbey	A. Sulfate	2019	42.6	40.3	38.3	41.5	40.5	41.5	40.8
		2020	26.4	26.7	29.1	28.3	28.3	25.9	27.4
	CAN	2019	40.9	39.5	40.6	42.4	40.6	41.6	40.9
		2020	28.7	26.3	26.2	25.4	27.4	27.9	27.0
Urea	2019	41.3	41.1	40.5	40.3	38.9	42.0	40.7	
	2020	25.6	27.4	26.3	26.3	25.9	27.3	26.4	
Avg. Application Time		2019	43.4	43.1	43.1	43.5	43.3	43.3	Ave.
		2020	27.6	27.5	28.2	28.0	27.1	27.3	
Wheat Variety	Burgos	2019	44.7	44.7	44.9	45.1	44.8	45.0	<b>44.9a</b>
		2020	29.3	27.7	29.6	29.1	28.0	28.1	28.6
	Eyyubi	2019	44.0	44.1	44.5	43.9	44.9	43.2	<b>44.1a</b>
		2020	26.6	27.9	27.8	28.2	26.1	26.7	27.2
	Hasanbey	2019	41.6	40.3	39.8	41.4	40.0	41.7	<b>40.8b</b>
		2020	26.9	26.8	27.2	26.6	27.2	27.0	27.0
Type of N	A. Sulfate	2019	43.3	43.3	42.7	43.6	43.6	42.8	43.2
		2020	26.8	27.6	28.7	29.4	27.2	26.3	27.6
	CAN	2019	43.4	43.1	43.2	43.9	43.4	43.8	43.5
		2020	28.8	26.8	27.5	27.6	27.7	27.6	27.6
	Urea	2019	43.5	42.8	43.3	42.9	42.8	43.3	43.1
		2020	27.3	28.0	28.4	26.9	26.5	28.1	27.5

When the data obtained are examined, it is seen that the weight of a thousand grains is higher due to the fact that climatic conditions (precipitation and temperature) are more favorable in the first year of the study and the effects of the drought experienced in the second year. In their study conducted in Mardin under precipitation-based conditions, Akan et al. (2021) stated that the thousand grain weights of local and commercial durum wheat varieties under dry conditions was significantly affected by ecological conditions and therefore had significant effects on the yield and quality of wheat. Kılıç et al. (2020) reported that in their research conducted under precipitation-based conditions, significant decreases occurred in the weight of one thousand grains of wheat at high temperatures. In summary, it is thought that the change in climatic conditions according to the years and the difference in the spike times of the varieties used cause changes between the weights of one thousand grains.

The effect of nitrogen fertilizer types on a thousand grain weight was insignificant in both production seasons. The average thousand grain weights of AS, CAN and urea fertilizers were 43.2 g, 43.5 g and 43.1 g for the first year of the experiment, and 27.6 g, 27.6 g and 27.5 g for the second year, respectively (Table 7). Although the effect of fertilizer types was not statistically significant, the highest thousand grain weight was obtained from CAN fertilizer with 43.5 g in the first year, while ammonium sulfate and CAN fertilizers were obtained from 27.6 g in the second year. In similar studies, it has been stated that the effect of fertilizer forms on the weight of a thousand grains is insignificant (Gökmen, 1993; Savaşlı, 2005; Mahgoub & Ibrahim, 2012; Akgün et al., 2021).

In the study, the effect of fertilizer application times on thousand grain weight was found to be insignificant in both experiment seasons (Table 5). The mean thousand grain weights of nitrogen fertilizer application times were 43.4

g, 43.1 g, 43.1 g, 43.5 g, 43.3 g and 43.3 g in the first year, respectively, and 27.6 g, 27.5 g, 28.2 g, 28.0 g, 27.1 g and 27.3 g in the second year, respectively (Table 7). Although the effect of nitrogen application times on thousand grain weight was not statistically significant, the highest thousand grain weight was obtained at the 4th application time with 43.5 g for the first year, and at the 3rd application time with 28.2 g in the second year. When the findings obtained in the study are examined, there is a parallelism between grain yield and average thousand grain weights between application times. In his research, Çobanoğlu (2019) stated that the weight of a thousand grains is affected by environmental conditions, but it has a positive effect on yield in cases where the number of spikes in m<sup>2</sup> and environmental conditions are similar. Similarly, in many studies on the subject, it has been stated that the effect of application times on the weight of a thousand is statistically insignificant (Mooleki & Foster, 1993; Tumwar, 2001; Savaşlı, 2005; Hunter, 2007; Filho et al., 2011).

### **Number of grains per spike (pieces)**

While the effect of wheat varieties on the number of grains per spike was found to be significant at the level of 1% in the first year, the effect of wheat varieties was insignificant for the second year. In the experiment, the interaction of fertilizer type, wheat variety x fertilizer type, application time, wheat variety x application time, fertilizer type x application time and wheat variety x fertilizer type x application time for both years was found to be statistically insignificant (Table 5).

In the first year of the study, the number of grains of Burgos, Eyyubi and Hasanbey wheat varieties was 36.4, 43.4 and 44.9, respectively (Table 8). As can be seen from the average grain count values and least significant difference (LSD) grouping of the varieties, the average grain count in the highest spike was Hasanbey (44.9 units) and Eyyubi (43.4 units) varieties in the same group, while Burgos (36.4 units) was in a different group. In similar studies, it has been stated that the effect of wheat varieties on the number of grains per spike is significant (Hunter, 2007; Evlice et al., 2008; Cobanoğlu, 2013; Irmak, 2019). In the second year of the experiment, the effect of wheat varieties on the number of grains per spike was statistically insignificant. Although some studies have reported that the effect of wheat varieties on the number of grains is insignificant Öngören (2013), this is thought to be related to the drought that occurred in the second year of the study and the decrease in the amount of precipitation. As it is known, the number of grains per spike has an important place among the factors affecting the grain yield. He stated that there is generally a positive interaction between the number of grains and grain yield per spike (Mutlu, 2021).

Table 8. Differences between the number of grains per spike and the averages of the wheat and nitrogen fertilizer type and the application times for the years 2019-2021 (number/spike)

Çizelge 8. Buğday ve azotlu gübre çeşidi ile uygulama zamanlarının 2019-2021 yıllarına ait başakta tane sayısı ve ortalamalar arasındaki farklar (adet)

Wheat Variety	Type of N	Year	Application Times						W*N
			1	2	3	4	5	6	
Burgos	A. Sulfate	2019	38.6	38.1	31.8	37.1	38.4	37.0	36.8
		2020	30.4	33.4	36.4	38.0	33.8	37.6	34.9
	CAN	2019	35.1	37.4	35.8	37.2	34.8	34.7	35.8
		2020	38.1	35.5	38.8	38.9	32.7	35.3	36.5
	Urea	2019	34.9	35.5	36.8	36.4	36.2	39.3	36.5
		2020	32.1	34.8	35.3	39.1	36.5	34.0	35.3
Eyyubi	A. Sulfate	2019	39.9	47.5	46.2	44.0	46.0	42.6	44.4
		2020	36.7	42.9	38.5	39.7	35.8	37.5	38.5
	CAN	2019	43.4	40.8	44.6	43.6	38.0	42.3	42.1
		2020	38.5	42.5	39.4	37.4	35.7	37.9	38.6

Table 8 (continued). Differences between the number of grains per spike and the averages of the wheat and nitrogen fertilizer type and the application times for the years 2019-2021 (number/spike)

Çizelge 8 (devamı). Buğday ve azotlu gübre çeşidi ile uygulama zamanlarının 2019-2021 yıllarına ait başakta tane sayısı ve ortalamalar arasındaki farklar (adet)

Urea	2019	45.2	41.9	43.5	44.5	46.0	40.9	43.7	
	2020	38.4	43.5	39.0	42.0	37.9	38.4	39.8	
A. Sulfate	2019	46.5	46.0	44.7	46.6	43.0	45.7	45.4	
	2020	35.9	44.3	42.2	41.2	50.5	31.6	40.9	
Hasanbey	CAN	2019	45.3	42.7	46.4	46.7	45.5	42.8	44.9
		2020	38.6	40.6	31.9	41.0	41.5	47.2	40.2
Urea	2019	40.4	45.8	43.0	44.8	45.5	46.5	44.3	
	2020	38.0	36.0	37.6	34.6	38.0	41.2	37.6	
Avg. Application Time	2019	41.0	41.8	41.4	42.3	41.5	41.3	Ave.	
	2020	36.3	39.3	37.7	39.1	38.0	37.9		
Wheat Variety	Burgos	2019	36.2	37.0	34.8	36.9	36.5	37.0	<b>36.4b</b>
		2020	33.5	34.6	36.8	38.6	34.3	35.6	35.6
	Eyyubi	2019	42.8	43.4	44.8	44.0	43.3	41.9	<b>43.4a</b>
		2020	37.9	43.0	39.0	39.7	36.5	37.9	39.0
	Hasanbey	2019	44.0	44.9	44.7	46.0	44.7	45.0	<b>44.9a</b>
		2020	37.5	40.3	37.2	39.0	43.3	40.0	39.6
Type of N	A. Sulfate	2019	41.7	43.9	40.9	42.5	42.5	41.8	42.2
		2020	34.3	40.2	39.0	39.6	40.0	35.6	38.1
	CAN	2019	41.2	40.3	42.3	42.5	39.4	39.9	40.9
		2020	38.4	39.5	36.7	39.1	36.6	40.2	38.4
	Urea	2019	40.2	41.1	41.1	41.9	42.6	42.2	41.5
		2020	36.2	38.1	37.3	38.6	37.4	37.9	37.6

In both years of the experiment, it is seen that as the number of grains per spike increases, the weight of a thousand grains decreases. The highest number of grains per spike and also the lowest thousand grain weights in both experiment seasons were obtained from Hasanbey variety. Avcı (2007) stated that the Sarajevo variety, which has the lowest number of grains per spike among the wheat varieties, also has the highest thousand grain weight. He reported that there is a negative relationship between the number of grains per spike and the weight of a thousand grains, and that when the number of grains decreases per spike, the grain becomes larger, and on the contrary, the grain shrinks. Similar studies (Yılmaz & Şimşek, 2012; Çobanoğlu, 2013) show parallelism with the experiment results.

The effect of nitrogen fertilizer types on the number of grains per spike was insignificant in both production seasons. The mean spike grain numbers of ammonium sulfate (21% N), CAN (26% N) and urea (46% N) fertilizers were 42.2, 40.9 and 41.5 for the first year of the experiment, and 38.1, 38.4 and 37.6 for the second year respectively (Table 8). Many research results (Savaşlı, 2005; Avcı, 2007; Öngören, 2013) reporting that the effect of different nitrogen fertilizers on the number of grains per spike is not statistically significant support the findings from the experiment. In the study, the effect of fertilizer application times on the number of grains per spike was found to be insignificant in both production seasons (Table 8). The average number of grains per spike of nitrogen fertilizer application times was 41.0, 41.8, 41.4, 42.3, 41.5 and 41.3 in the first year, respectively, and 36.3, 39.3, 37.7, 39.3, 38.0 and 37.9 in the second year, respectively. When the findings of the experiment are examined, it is seen that the average number of grains per spike of the first year is higher. Especially in the first year, the high amount of precipitation during the stemming and spike periods and the lower temperature compared to the second year increased the number of grain-binding flowers. Shahzad & Akmal (2017) reported that nitrogen application times have a

significant effect on the number of grains per spike by affecting the number of flowering days and ripening times of wheat. In studies on the subject, it has been stated that the effect of application times on the number of grains per spike is statistically insignificant (Mooleki & Foster, 1993; Tümsavaş, 2001; Savaşlı, 2005; Filho et al., 2011; Mutlu, 2021).

### **Grain weight per spike (g)**

The effect of wheat varieties on grain weight per spike was insignificant for both years. In the experiment, the interaction of wheat variety, fertilizer type, wheat variety x fertilizer type, application time, wheat variety x application time, fertilizer type x application time and wheat variety x fertilizer type x application time was found to be statistically insignificant for both years (Table 5). The two-year average values related to the effect of three wheat varieties, three fertilizer sources and six different nitrogen fertilizer application times on the number of grains per spike are given in Table 9 below.

In the first year of the study, the average grain weight of Burgos, Eyyubi and Hasanbey wheat varieties was between 1.72, 1.86 and 1.83 g, respectively. In the second year of the experiment, it was seen that the average grain weights of wheat varieties ranged between 1.07, 1.16 and 1.17 g, respectively (Table 9). In the first year of the study, the highest grain weight per spike was obtained in the Eyyubi variety, while in the second year, it was obtained from the Hasanbey variety. The lowest spike grain weight for both years was obtained from the Burgos variety. Grain weight per spike is closely related to environmental conditions and the characteristics of the genotypes used (Çobanoğlu, 2013; Mutlu, 2021). In the study, although there was no statistically significant effect of the experiment subjects on the grain weight per spike for both years, it was seen that the grain weights per spike of the second year were lower than in the first year. The fact that the drought that occurred especially in the second year caused a decrease in grain yield, limited the grain weight per spike. Similarly, previous studies have reported that the effect of wheat varieties on grain weight is insignificant (Avcı, 2007; Irmak, 2019).

Table 9. Differences between grain weight per spike and averages in wheat and nitrogen fertilizer types and application times for the years 2019-2021 (g/spike)

Çizelge 9. Buğday ve azotlu gübre çeşidi ile uygulama zamanlarının 2019-2021 yıllarına ait başakta tane ağırlığı ve ortalamalar arasındaki farklar (g)

Wheat Variety	Type of N	Year	Application Times						W*N
			1	2	3	4	5	6	
Burgos	A. Sulfate	2019	1.80	1.80	1.58	1.67	1.75	1.80	1,73
		2020	0.94	1.04	1.07	1.19	1.03	1.12	1,06
	CAN	2019	1.58	1.77	1.71	1.86	1.67	1.60	1,70
		2020	1.22	1.04	1.16	1.28	1.06	1.06	1,14
	Urea	2019	1.65	1.68	1.65	1.76	1.78	1.87	1,73
		2020	1.05	1.05	1.11	1.17	1.17	1.04	1,10
Eyyubi	A. Sulfate	2019	1.70	1.95	2.01	1.95	1.86	1.76	1.87
		2020	0.99	1.30	1.18	1.33	1.10	1.03	1.16
	CAN	2019	1.86	1.76	2.00	1.97	1.58	1.72	1.81
		2020	1.18	1.23	1.06	1.12	1.12	1.14	1.14
	Urea	2019	1.92	1.83	1.91	1.93	1.94	1.85	1.90
		2020	1.13	1.25	1.13	1.32	1.14	1.16	1.19
Hasanbey	A. Sulfate	2019	1.79	1.88	1.80	1.96	1.92	1.82	1.86
		2020	0.95	1.39	1.25	1.28	1.34	1.00	1.20
	CAN	2019	1.77	1.73	1.92	1.93	1.85	1.65	1.81
		2020	1.18	1.26	0.92	1.14	1.24	1.34	1.18

Table 9 (continued). Differences between grain weight per spike and averages in wheat and nitrogen fertilizer types and application times for the years 2019-2021 (g/spike)

Çizelge 9 (devamı). Buğday ve azotlu gübre çeşidi ile uygulama zamanlarının 2019-2021 yıllarına ait başakta tane ağırlığı ve ortalamalar arasındaki farklar (g)

Urea	2019	1.81	1.88	1.86	1.73	1.71	1.93	1.82	
	2020	1.11	1.11	1.15	0.99	1.04	1.27	1.11	
Avg. Application Time	2019	1.76	1.81	1.83	1.86	1.79	1.78	Ave.	
	2020	1.08	1.19	1.12	1.20	1.14	1.13		
Wheat Variety	Burgos	2019	1.68	1.75	1.64	1.76	1.73	1.76	1.72
		2020	1.07	1.04	1.12	1.21	1.09	1.07	1.10
	Eyyubi	2019	1.83	1.85	1.97	1.95	1.79	1.78	1.86
		2020	1.10	1.26	1.12	1.26	1.12	1.11	1.16
	Hasanbey	2019	1.79	1.83	1.86	1.87	1.83	1.80	1.83
		2020	1.08	1.25	1.11	1.13	1.21	1.21	1.17
Type of N	A. Sulfate	2019	1.76	1.88	1.80	1.86	1.85	1.79	1.82
		2020	0.96	1.24	1.17	1.26	1.16	1.05	1.14
	CAN	2019	1.73	1.75	1.88	1.92	1.70	1.66	1.77
		2020	1.19	1.18	1.05	1.18	1.14	1.18	1.15
	Urea	2019	1.80	1.80	1.81	1.81	1.81	1.88	1.82
		2020	1.10	1.14	1.13	1.16	1.12	1.16	1.13

The effect of nitrogen fertilizer types on grain weight per spike was insignificant in both production seasons. The average grain weights of ammonium sulfate (21% N), CAN (26% N) and urea (46% N) fertilizers were 1.82, 1.77 and 1.82 g for the first year of the experiment, respectively, and 1.14, 1.15 and 1.13 g for the second year (Table 9). Although the effect of fertilizer types was insignificant, the grain weight per highest spike was obtained from ammonium sulfate and urea fertilizer with 1.82 g in the first year, and from CAN fertilizers with 1.15 g in the second year. In similar studies, it has been stated that the effect of fertilizer forms on grain weight per spike is insignificant (Başar et al., 1998; Gökmen et al., 2001; Savaşlı, 2005; Avcı, 2007; Evlice et al., 2008; Altuntaş & Akgün, 2016). In the study, the effect of application times on grain weight per spike was found to be insignificant in both experiment years (Table 5). The average grain weight of nitrogen fertilizer application times was 1.76, 1.81, 1.83, 1.86, 1.79 and 1.78 g in the first year, respectively, and 1.08, 1.19, 1.12, 1.20, 1.14 and 1.13 g in the second year, respectively. Similar results have been reported in many studies on the subject (Gökmen et al., 2001; Tümsavaş, 2001; Savaşlı, 2005; Avcı, 2007; Evlice et al., 2008; Mutlu, 2021). In both years of the study, the highest spike grain weight was obtained at the fourth application time, while the lowest spike grain weight was obtained at the first application time. When the data obtained are examined, it is seen that the average grain weight per spike of the first year is higher than the values in the second year. This was due to the difference in the amount of precipitation between the experiment years and the drought experienced in the second year.

### **Number of spike per m<sup>2</sup>**

The effect of wheat varieties on the number of spikes per square meter was insignificant for both years. In the experiment, the interaction of wheat variety, fertilizer type, wheat variety x fertilizer type, application time, wheat variety x application time, fertilizer type x application time and wheat variety x fertilizer type x application time was found to be statistically insignificant for both years (Table 5).

Table 10. Differences between the number of spikes per square meter and the averages of wheat and nitrogen fertilizer types and application times for the years 2019-2021 (piece)

Çizelge 10. Buğday ve azotlu gübre çeşidi ile uygulama zamanlarının 2019-2021 yıllarına ait metrekarede başak sayısı ve ortalamalar arasındaki farklar (adet)

Wheat Variety	Type of N	Year	Application Times						W*N
			1	2	3	4	5	6	
Burgos	A. Sulfate	2019	528	510	628	587	603	587	574
		2020	467	453	445	375	378	373	415
	CAN	2019	608	520	585	528	587	518	558
		2020	388	357	397	413	427	397	396
	Urea	2019	578	597	602	575	560	553	578
		2020	485	433	485	342	390	428	427
Eyyubi	A. Sulfate	2019	603	572	502	583	492	567	553
		2020	432	385	370	395	383	362	388
	CAN	2019	527	608	563	532	635	543	568
		2020	343	350	452	360	383	375	377
	Urea	2019	550	562	527	543	513	562	543
		2020	347	453	393	373	368	415	392
Hasanbey	A. Sulfate	2019	582	568	590	562	498	600	567
		2020	422	300	382	400	312	370	364
	CAN	2019	643	577	582	532	585	538	576
		2020	448	310	458	358	453	385	402
	Urea	2019	610	585	555	650	642	520	594
		2020	365	377	353	400	352	317	361
Avg. Application Time		2019	581	566	570	566	568	554	Ave.
		2020	411	380	415	380	383	380	
Wheat Variety	Burgos	2019	572	542	605	563	583	553	570
		2020	447	414	442	377	398	399	413
	Eyyubi	2019	560	581	531	553	547	557	555
		2020	374	396	405	376	378	384	386
	Hasanbey	2019	612	577	576	581	575	553	579
		2020	412	329	398	386	372	357	376
Type of N	A. Sulfate	2019	571	550	573	577	531	584	565
		2020	440	379	399	390	358	368	389
	CAN	2019	593	568	577	531	602	533	567
		2020	393	339	436	377	421	386	392
	Urea	2019	579	581	561	589	572	545	571
		2020	399	421	411	372	370	387	393

The average number of spikes per square meter of the varieties of Burgos, Eyyubi and Hasanbey wheat varieties considered in the first year was 570, 555 and 579, respectively, and the average number of spikes per square meter in the second year was determined as 436, 409 and 399, respectively (Table 10). In the first production year of the study, the highest number of spikes per square meter was obtained from the Hasanbey variety with 579 units, while in the second production season, the highest number was obtained from the Burgos variety with 436 units. In some previous studies, it has been stated that the effect of wheat varieties on the number of spikes per square meter is insignificant (Öngören, 2013). The findings contradict the researchers who report that the effect of wheat varieties on the number of spikes per square meter is significant (Avcı, 2007; Evlice et al., 2008; Çobanoğlu, 2013; Irmak, 2019).

The effect of nitrogen fertilizer types on the number of spikes per square meter was insignificant in both production seasons. The number of spikes per square meter of ammonium sulfate (21% N), CAN (26% N) and urea (46% N) fertilizers was 565, 567 and 571 for the first year of the experiment, and 412, 415 and 416 in the second year, respectively (Table 10). Although it was not statistically significant in both years of the study, the highest number of spikes per square meter was obtained from the parcels where urea fertilizer was applied. Similarly, some studies have stated that the effect of fertilizer forms on the number of spikes per square meter is insignificant (Mooleki & Foster, 1993; Ayoub et al., 1994; Savaşlı, 2005; Öngören, 2013).

In the study, the effect of fertilizer application times on the number of spikes per square meter was found to be insignificant in both production seasons (Table 5). The average number of spikes per square meter of nitrogen fertilizer application times was 581, 566, 570, 566, 568 and 554 in the first year, respectively, and the averages of 434, 402, 438, 402, 406 and 403 in the second year, respectively (Table 10). In some studies on the subject, it is stated that the effect of application times on the number of spikes per square meter is similarly statistically insignificant (Bellido et al., 2005; Savaşlı, 2005; Avcı, 2007; Evlice et al., 2008), and in some other studies, the effect of application times on the number of spikes per square meter is significant (Çoşkun & Öktem, 2003; Abedi et al., 2011; Çobanoğlu, 2013; Irmak, 2019).

### **Plant height**

While the effect of wheat varieties on plant height was found to be significant at the level of 1% in the first year, the effect of wheat varieties was significant at the level of 5% for the second year. In the experiment, the interaction of fertilizer type, wheat variety x fertilizer type, application time, wheat variety x application time, fertilizer type x application time and wheat variety x fertilizer type x application time in both years was found to be statistically insignificant (Table 5). The two-year average values related to the effect of three wheat varieties, three fertilizer sources and six different nitrogen fertilizer application times on plant height are given in Table 12 below.

The average plant height of the Burgos, Eyyubi and Hasanbey wheat varieties, which were discussed in the first year, was determined as 105, 118 and 103 cm, respectively, and the average plant height in the second year was determined as 73, 81 and 73 cm, respectively (Table 12). In the first and second years of the experiment, the highest average plant height of the varieties was obtained from the Eyyubi variety with 118 and 81 cm and constituted a different group from the others, while Burgos and Hasanbey were in the same group in both years. In similar studies conducted before, it has been stated that the effect of plant height on wheat varieties is important (Gökmen, 1993; Avcı, 2007; Çobanoğlu, 2013; Irmak, 2019).

Although plant height is a genotypic feature in wheat, it is significantly affected by cultivation technique and climatic conditions (Avcı, 2007; Irmak, 2019; Akan et al., 2021). The most important factor affecting plant height during the production season is known as the amount of precipitation and the distribution of this precipitation. When the years in which the experiment was conducted are examined, it is seen that the plant height of the first year is higher. It is thought that this result is due to the effect of the amount of precipitation received in the first production season, especially during the initial periods of tillering and uprising. In their study conducted under precipitation-based conditions in Mardin, Akan et al. (2021) stated that the plant height of local and commercial durum wheat varieties under dry conditions was significantly affected by ecological conditions and cultivation technique.

The effect of nitrogen fertilizer forms on plant height was found to be statistically insignificant in both experiment years. In terms of fertilizer types, the average plant heights of ammonium sulfate (AS; 21% N), calcium ammonium nitrate (CAN; 26% N) and urea (U; 46% N) fertilizers were 109, 110 cm and 108 cm in the first year, respectively, and the average plant heights were 75, 76 cm and 76 cm in the second year, respectively (Table 11).

Table 11. Differences between plant height and averages of wheat and nitrogen fertilizer type and application times for the years 2019-2021 (cm)

Çizelge 11. Buğday ve azotlu gübre çeşidi ile uygulama zamanlarının 2019-2021 yıllarına ait bitki boyu ve ortalamalar arasındaki farklar (cm)

Wheat Variety	Type of N	Year	Application Times						W*N
			1	2	3	4	5	6	
Burgos	A. Sulfate	2019	107	102	103	108	110	107	106
		2020	74	73	74	72	69	71	72
	CAN	2019	107	108	108	105	107	105	107
		2020	76	70	73	76	75	68	73
	Urea	2019	102	105	107	102	102	103	103
		2020	74	77	77	68	74	77	74
Eyyubi	A. Sulfate	2019	120	115	122	118	115	118	118
		2020	77	84	81	84	77	78	80
	CAN	2019	122	118	120	120	118	117	119
		2020	78	79	84	80	81	82	81
	Urea	2019	120	118	122	117	112	117	118
		2020	79	84	79	83	81	86	82
Hasanbey	A. Sulfate	2019	102	103	105	105	102	103	103
		2020	68	71	77	76	76	74	74
	CAN	2019	105	100	105	107	105	105	104
		2020	77	70	72	72	72	76	73
	Urea	2019	102	105	102	100	103	100	102
		2020	73	74	74	72	71	72	73
Avg. Application Time		2019	109	108	110	109	108	108	Ave.
		2020	75	76	77	76	75	76	
Wheat Variety	Burgos	2019	105	105	106	105	106	105	<b>105b</b>
		2020	74	73	75	72	73	72	<b>73b</b>
	Eyyubi	2019	121	117	121	118	115	117	<b>118a</b>
		2020	78	83	81	82	79	82	<b>81a</b>
	Hasanbey	2019	103	103	104	104	103	103	<b>103b</b>
		2020	73	71	75	74	73	74	<b>73b</b>
Type of N	A. Sulfate	2019	109	107	110	111	109	109	109
		2020	73	76	78	78	74	74	75
	CAN	2019	111	109	111	111	110	109	110
		2020	77	73	76	76	76	75	76
	Urea	2019	108	109	110	106	106	107	108
		2020	76	78	77	74	75	78	76

The findings are in line with the researchers who reported that the effect of fertilizer forms on plant height is statistically insignificant (Gökmen, 1993; Başar et al., 1998; Savaşlı, 2005; Tepecik et al., 2014; Khursheed et al., 2015). In some studies, the effect of fertilizer sources on plant height has been found to be significant (Nakano et al., 2008; Yılmaz et al., 2019).

The effect of nitrogen fertilizer application times on plant height was found to be statistically insignificant in both experiment years. The average plant height of nitrogen fertilizer application times was 109, 108, 110, 109, 108 and 108 cm in the first year, respectively; and 75, 76, 77, 76, 75 and 76 cm in the second year, (Table 12). In similar studies, it has been reported that the effect of nitrogen application times on plant height is insignificant (Ağrı, 1993; Tümsavaş, 2001; Ferdous et al., 2005; Savaşlı, 2005; Avcı, 2007; Akman & Topal, 2010; Filho et al., 2011; Yakut,

2011; Mutlu, 2021). In the first year of the experiment, it is seen that the plant heights of nitrogen application times were higher. Especially the fact that the amount of precipitation falling in the first year is above the average of many years has increased the plant height. In the second year of the experiment, it was thought that lower plant heights were obtained in plants affected by drought due to precipitation below the average precipitation for many years.

When the results of the research are examined, it is revealed that the effect of nitrogen fertilizer form and nitrogen application time on grain yield in both experiment years is statistically insignificant. In the first year of the study, the effect of wheat varieties on grain yield was significant, while in the second year it was insignificant.

Although the effect of the applied fertilizer forms on grain yield was not statistically significant in both experiment years, the highest grain yield among the fertilizer types was obtained in the first year of the study. In previous studies on fertilizer forms; It is stated that nitrogen losses in the form of  $\text{NH}_3$  in the fertilizer in the form of urea given to the soil surface in precipitation-based wheat cultivation are higher compared to ammonium nitrate fertilizer. In addition, among the types of fertilizers, ammonium nitrate fertilizers are more effective than urea fertilizers in terms of the rate of dissolution in the soil; However, they stated that urea fertilizer is used more effectively by plants due to its slow release. Depending on the climatic conditions, it can be said that the precipitation and temperature conditions in the first year of the study are more favorable compared to the second year and urea (U; 46% N) fertilizer is used more effectively by the plant due to its slow-release feature, increasing the grain yield compared to other fertilizer forms. In the second year of the study, it is thought that nitrogen losses in the form of  $\text{NH}_3$  in calcium ammonium nitrate (CAN; 26% N) fertilizer are less than other fertilizer forms and the dissolution rate is higher due to the increase in grain yield due to the amount of precipitation and drought. Depending on the amount of precipitation in Diyarbakır conditions, it may be recommended to use urea (U; 46% N) and calcium ammonium nitrate (CAN; 26% N) fertilizers compared to ammonium sulfate (AS; 21% N) fertilizers. Although the effect of nitrogen fertilizer application times on grain yield was statistically insignificant in both experiment years, the highest grain yield was obtained at the fourth application time with  $1007 \text{ kg da}^{-1}$  in the first year of the study, and the highest grain yield was obtained at the third application time with  $467 \text{ kg da}^{-1}$  in the second year. In both years of the study, as the nitrogen fertilizer application time is delayed, decreases in grain yield occurred and it is thought that it would be beneficial to fertilize between tillering and stem elongation periods in order to reduce yield losses. Considering the climatic conditions between the years in which the study was carried out, it may be recommended to use slow-release fertilizers (urea form) at the fourth application time of top fertilization (end of tillering-beginning of stem elongation) in the production seasons when the amount of precipitation between January and March is sufficient, and in cases where the amount of precipitation is insufficient, it may be recommended to prefer fast-acting (ammonium nitrate) fertilizers at the third application time of top fertilization (middle of tillering).

## ACKNOWLEDGEMENTS

This study was conducted under the supervision of Prof. Dr. Kerim Mesut ÇİMRİN and presents some findings from the doctoral thesis on "The Effect of Top Dressing Fertilizer Forms Applied at Different Periods on Yield and Quality Components in Durum Wheat Varieties." It was carried out by the General Directorate of Agricultural Research and Policies of the Ministry of Agriculture and Forestry of the Republic of Turkey, as part of project number TAGEM/BBAD/14/A08/P10/1. We would like to express our gratitude to the Ministry of Agriculture and Forestry of the Republic of Turkey for their contributions.

## STATEMENT OF CONFLICT OF INTEREST

The authors of the manuscript state that there are no conflicts of interest in terms of private or commercial interests within the scope of this study.

## AUTHOR'S CONTRIBUTIONS

The authors of the manuscript declare that they have contributed equally to the study.

## STATEMENT OF ETHICS CONSENT

Ethical approval is not applicable, because this article does not contain any studies with human or animal subjects.

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