Determination of Optimum Nitrogen Requirements of Some Bread Wheat Varieties in Adana Conditions

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ABSTRACT
This research was conducted to determine the optimum nitrogen fertilizer requirements of bread wheat varieties registered by Eastern Mediterranean Agricultural Research Institute. The experiments were carried out in a randomized block split-plot experimental design with three replicates, with varieties in the main plots and nitrogen doses in the sub-plots. Four bread wheat varieties (Gökkan, Yakamoz, Altınöz and Candaş) were used as seed material. Five different nitrogen levels (0, 70, 140, 210 and 280 kg N/ha) were applied for bread wheat varieties. At sowing, 80 kg P_2O_5/ha was applied to all plots. As a result of the research, the optimum nitrogen doses required for wheat varieties were determined by regression analysis. It was determined that there was a quadratic relationship ($Y= a+bx+cx^2$) between yield and nitrogen dose in all varieties. As a result of the analysis, the optimum nitrogen dose for the Gökkan variety is 213.84 kg/ha, for the Yakamoz variety 186.28 kg/ha, for the Altınöz variety 176.03 kg/ha and for the Candaş variety 192.81 kg/ha. The highest yield was obtained from Gökkan variety and the lowest yield was obtained from Yakamoz variety. It was determined that increasing nitrogen doses increased plant height and the number of spike per square meter increased with increasing nitrogen doses, but caused a decrease in the high nitrogen dose (280 kg N/ha). It was determined that high nitrogen doses caused a decrease in 1000 grain weight. In this study, nitrogen fertilization and variety selection were found to be important on yield in Adana conditions.

Key words: Bread wheat, variety, optimum nitrogen dose, yield

INTRODUCTION

In order to increase the yield and quality per unit area, research is carried out on both breeding and cultivation techniques suitable for the conditions. It is very important to determine all necessary agricultural practices to obtain optimum yield. One of these agricultural practices is nitrogen (N) fertilization, which is determined according to crop needs at different developmental stages of the plant (Martinez et al., 2022). By understanding the relationship between grain yield and N uptake (Xiao et al., 2022), farmers can better manage N inputs according to the specific requirements of the variety (Saudy et al., 2018). Variety selection and determination of N fertilization in cropping systems are important decisions to increase yields (Yang et al., 2022). With the increasing global demand for wheat, it is vital to develop varieties that improve yield and resource utilization. Yield is a genetically controlled trait (Guo et al., 2023). However, agronomic practices and environmental factors cause changes in yield (Tudor et al., 2023; Lopez et al., 2023).

Wheat yield is highly influenced by various agronomic factors and most importantly by nitrogen management. Nitrogen is the most abundant nitrogen in the atmosphere and is an important component of proteins and nucleotides essential for life (Khan et al., 2017a). Proper fertilization is necessary to grow wheat and provide the desired yield (Rawal et al., 2022). Nutrient management, especially nitrogen, is difficult in agricultural production. Its production and application require large amounts of energy, and excessive nitrogen applications produce nitrous oxide, which is harmful to the environment (Khan et al., 2017b). Nitrogen pollution is a problem worldwide (Kanter et al., 2020). In addition, nitrogen affects soil fertility and crop growth and development (Wang et al., 2019). Especially in regions with environmental problems and resource deficits, proper nitrogen applications can increase yield and biomass by optimizing the nutritional status of plants (Maher et al., 2023). Of course, the response of plants to nitrogen fertilizer applications is influenced by factors such as yield potential of varieties, soil nitrogen content, other nutrients and soil water content (Joshi et al., 1986).

In agricultural production, nitrogen fertilizers are generally important for plant growth and development (Kostic et al., 2021). Wheat is one of the most nitrogen-consuming crops among cereals (Ladha et al., 2005). Therefore, the rate and application time of nitrogen fertilizers affect vegetative growth, biomass production, yield and nitrogen use efficiency in wheat (Haile et al., 2012). Studies have emphasized the importance of genetype selection for breeders and the difficulties in improving yield due to the inverse relationship between yield and grain protein content (Michel et al., 2019). This negative correlation between yield and protein suggests a complex balance in selection strategies (Liu et al., 2019). Proper use of nutrients in agricultural production can increase root development, root enzyme activities, biomass, nutrient absorption, transport, utilization and thus yield (Chen et al., 2020). In recent years, with the advancement of science and technology, the yield potential of breeding varieties is quite high. Consequently, the nutrients that these varieties will need will also increase. In order to obtain optimum yield from newly developed varieties, optimum fertilizer doses should be determined. In order to obtain maximum grain yield from high-yielding wheat varieties, it is necessary to provide sufficient nutrients (Adnan et al., 2020).

The effects of nitrogen fertilization and genotype selection on wheat productivity are important. In this study, it was aimed to determine the optimum nitrogen fertilizer requirements of bread wheat varieties with high yield potential developed by Eastern Mediterranean Agricultural Research Institute and to reveal the effects of nitrogen applications on yield and some yield parameters.

MATERIAL AND METHOD

Field trials were conducted at Doğankent location of Eastern Mediterranean Agricultural Research Institute for 2 years (2020-2021) during wheat planting seasons. Soil samples were taken from the trial areas before planting and analyzed. Some physical and chemical properties of the soils where field trials were conducted are given in Table 1.

Table 1. Some Physical and Chemical Properties of Soils of the Experimental Areas.

Year	Satution (%)	Texture	pH (1:2.5)	EC (mmhos/cm)	Lime (%)	Org.M. (%)	P_2O_5 (kg/da)	K_2O	NO_3	Zn (mg/kg)	Fe	Cu	Mn
1	52.80	Clay Loam	7.40	0.46	28.00	2.40	2.96	84.10	10.63	0.17	5.70	1.12	4.90
2	61.50	Clay Loam	7.69	0.83	18.12	1.58	1.72	130.55	8.63	0.73	6.72	1.58	11.80

Climate Data

When the climate data are evaluated in general, it clearly reveals the effect of rainfall in spring (April-May) on wheat yield under dry agricultural conditions. However, the distribution of precipitation to critical periods in the plant development period is as important as the amount of precipitation. Climatic differences between years in Adana location were reflected in the general average yield values (Table 2). Yield values were higher in the second year. Because both the distribution of precipitation by months and the relative humidity and temperature values were more ideal for wheat cultivation compared to the first year. In the region, wheat is sown in November and harvested in late May and June.

Table 2. Climatic Values of Wheat Growing Seasons

	Temperature (^{0}C)		Rainfall (mm)		Relative Humidity (%)	
	2019-2020	2020-2021	2019-2020	2020-2021	2019-2020	2020-2021
November	16.0	15.06	26.7	71.10	63.2	62.17
December	11.1	11.50	506.4	18.30	90.1	64.03
January	9.1	10.27	203.5	160.70	78.7	63.20
February	10.7	11.59	111.2	23.50	78.3	62.60
March	14.2	12.71	47.6	42.10	83.8	62.47
April	17.1	18.34	48.6	44.00	85.5	68.65
May	22.3	23.91	81.1	4.10	73.7	64.87
June	24.1	25.89	2.3	0.40	81.7	67.25
Total			**1027.4**	**364.2**		

In this study, 4 bread wheat varieties (Gökkan, Yakamoz, Altınöz and Candaş) registered by Eastern Mediterranean Agricultural Research Institute in recent years were used. The yield potential of the varieties is quite high compared to the old varieties.

Method

The experiments were conducted in a randomized block split plots experimental design with 3 replications. Varieties were placed in the main plots and nitrogen doses were placed in the sub-plots. Five different nitrogen levels (0, 70, 140, 210 and 280 kg N/ha) were applied for bread wheat varieties. The plots subjected to the experiments were adjusted to be 1.40cmx5m=7 m^2 in size and sowing was done with an 8-row plot seeder (140 cm width). Sowing density was taken as 450 grains/m^2. All plots were fertilized with 80 kg P_2O_5 per hectare. Some of the nitrogen doses were applied with sowing (30 kg N/ha) and the remaining amounts were applied during the tillering period (top dressing) according to the doses. In the experiment, triple super phosphate (TSP) (42% P) was used as phosphorus source and all of it was applied with sowing. Ammonium sulphate (21% N) was used as nitrogen source in base fertilization and urea (46% N) fertilizer was used in tillering stage. In both work packages, a 2.0 m wide isolation distance was left between the experimental plots and between the blocks to prevent fertilizer passage. Cultural precautions regarding weeds and diseases were applied for the healthy conduct of the trials.

Observations and Measurements

The effects of nitrogen doses on plant height (cm), number of spike per square meter (pcs/m^2), thousand grain weight (g) and grain yield (kg/ha) of wheat varieties were determined.

Statistical analysis

All data were analyzed using the JMP statistical software package developed by SAS (SAS Institute, Cary, North Carolina, USA). Analysis of variance (ANOVA) was conducted to examine the differences between the treatments. Following the ANOVA, post-hoc comparisons were conducted to identify statistically significant differences among the means. The Tukey Honesty Significant Difference (HSD) test was employed to perform these multiple comparisons, ensuring a rigorous evaluation of the differences between treatment groups. Statistical significance was assessed at two levels: a threshold of $P<0.05$ (*) indicating moderate significance, and a more stringent threshold of $P<0.01$ (**) indicating strong significance. Regression analysis was performed. Since the results showed that the effects of different amounts of nitrogen applications on yield can be expressed by the equation $Y= a+bx+cx^2$, the parameters a, b and c of the equation were calculated and the relationships between nitrogen doses and wheat yield were determined (Yurtsever, 1984). Regression analysis was performed for each variety and optimum nitrogen requirements of the varieties were determined.

The equation $X_{max} = -b/2.c$ was used to determine the optimum fertilizer doses (Yurtsever, 1984).

RESEARCH RESULTS AND DISCUSSION

As a result of the research, optimum nitrogen fertilizer requirements of bread wheat varieties developed by Eastern Mediterranean Agricultural Research Institute in recent years were determined for Adana region.

Yield (kg/ha) and Optimum Nitrogen Dose of Varieties

When the effects of nitrogen doses on yield results were examined, it was determined that year, nitrogen, and subjects were statistically significant at the 1% level, while variety, varietyxnitrogen, yearxnitrogen, and yearxvarietyxnitrogen interactions were significant at the 5% level (Table 3). When the yield values were analyzed, the average yield was 5760 kg in the first year and 6580 kg in the second year. The effect of nitrogen doses on varieties was found to be statistically significant. When the variety averages were analyzed, the lowest yield was obtained from Yakamoz variety with 5820 kg/ha and the highest yield was obtained from Gökkan variety with 6490 kg/ha. This was followed by Altınöz and Candaş varieties with 6250 and 6120 kg/ha. Altınöz, Gökkan and Candaş varieties were statistically in the same group. When the average values of nitrogen doses were analyzed; the lowest yield values were obtained from 0 kg N/da dose with 4070 kg and the highest yield values were obtained from 210 kg N/ha dose with 7690 kg. Higher nitrogen dose (280 kg N/ha) caused a decrease in yield (Table 3).

Table 3. Effect of nitrogen rates on yield ((kg/ha) values of bread wheat varieties

		Nitrogen dosages (kg/ha)						
Year	**Variety**	**0**	**70**	**140**	**210**	**280**	**Average**	**Year Av.**
	Gökkan	3340	5430	6950	7830	7320	6180	
1	**Yakamoz**	3150	5400	6450	6720	6010	5550	5760 b
	Altınöz	3740	5390	6670	7580	5590	5790	
	Candaş	3400	5220	6110	7330	5490	5510	
	Average	3410^{g}	5360^{e}	6540^{cd}	7370^{b}	6100^{cd}		
	Gökkan	5350	5790	7520	8530	6870	6810	
2	**Yakamoz**	4120	5890	7020	7290	6190	6100	6580 a
	Altınöz	4590	6310	7610	8620	6360	6700	
	Candaş	4880	5890	7900	7630	7300	6720	
	Average	4730^{f}	5970^{d}	7510^{ab}	8020^{a}	6680^{c}		
	Gökkan	4350^{h}	5610^{g}	7230^{a-d}	8180^{a}	7100^{cd}	**6490 A**	
VxN İnt.	**Yakamoz**	3640^{h}	5640^{g}	6730^{c-f}	7010^{cde}	6100^{efg}	**5820 B**	
	Altınöz	4170^{h}	5850^{fg}	7140^{bcd}	8100^{ab}	5970^{fg}	**6250 AB**	
	Candaş	4140^{h}	5560^{g}	7010^{cde}	7480^{abc}	4000^{d-g}	**6120 AB**	
Nitrogen Average		**4070 E**	**5670 D**	**7030 B**	**7690 A**	**6390 C**		
****: 0.01 *: 0.05**	**Y**, V*, YxV: ns, N**, VxN*, YxN*, YxVxN***							
CV: 7.33								

Means of same row and column followed by different levels are significantly at the 5% and 1% levels of probability using the Tukey test. *: P<0.05 , **: P<0.01, ns: stands for non-significant data at the 5% and 1% levels of probability. Y: year, V: variety, N: nitrogen.

The yield values of the varieties in nitrogen dose applications are also shown in Figure 1.

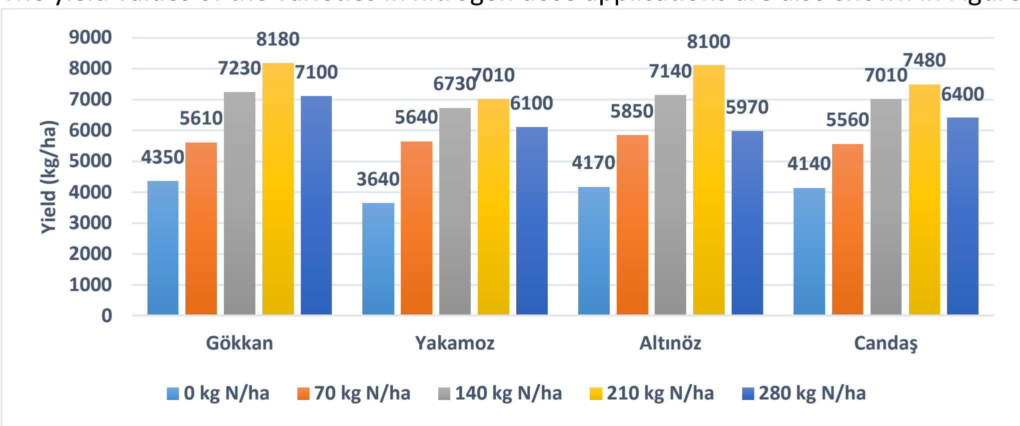
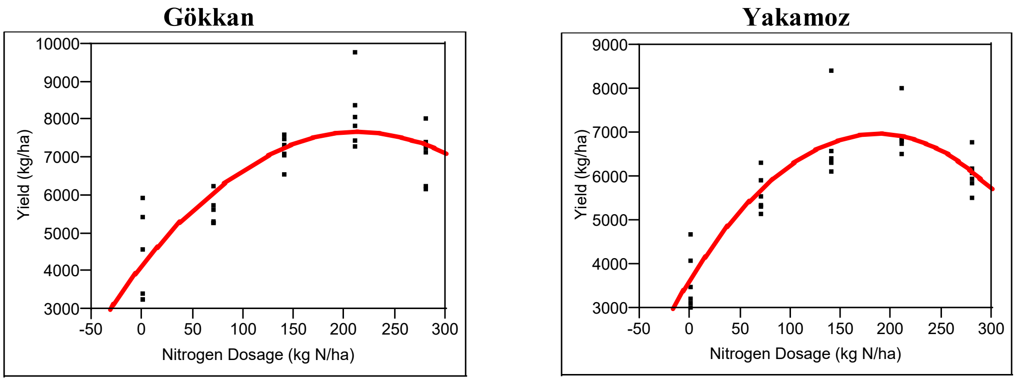


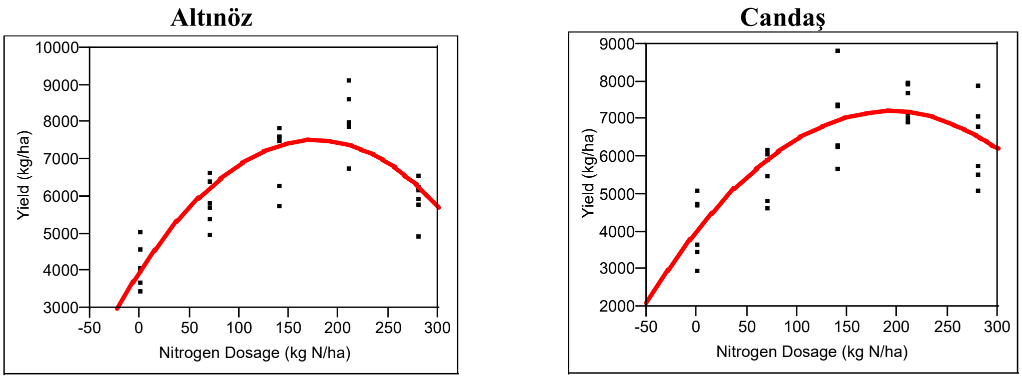
Figure 1. VxN interactions at Adana location, V: variety, N: nitrogen

The effect of nitrogen doses for each variety is shown separately below. According to the regression analysis, the relationship between nitrogen doses and wheat yield for Gökkan variety is equal to Y= 4119.17+33.36X-0.078X^2 and the optimum amount of nitrogen (N) that can be applied according to this equation is 213.84 kg N/ha. For Yakamoz variety, Y= 3613.96+36.14X-0.097X^2 and the optimum amount of nitrogen was determined as 186.28 kg N/ha, for Altınöz variety, Y= 3935.67+ 40.84X-0.116X^2 and the optimum amount of nitrogen was determined as 176.03 kg N/ha and for Candaş variety, Y= 3978.68+35.55X-0.087X^2 and the optimum amount of nitrogen was determined as 192.81 kg N/ha. The following figures show the effect of nitrogen doses for each variety at Adana location separately (Figures 2, 3).



$Y = 4119.17 + 33.36X – 0.078X^2$ $Y = 3613.96 + 36.14X – 0.097X^2$

Figure 2. Quadratic relationship between nitrogen rates and yield for Gökkan and Yakamoz varieties



$Y = 3935.67 + 40.84X – 0.116X^2$ $Y = 3978.67 + 33.55X – 0.087X^2$

Figure 3. Quadratic relationship between nitrogen rates and yield for Altınöz and Candaş varieties

Plant height (cm)

In the trials conducted for two years at Adana location, the analysis of variance showed that nitrogen and yearxnitrogen subjects were statistically significant at 1% level and year, variety, yearxnitrogen, varietyxnitrogen and yearxvarietyxnitrogen subjects were not statistically significant on plant height values (Table 4). When the general average of the years was analyzed; plant height was 103.73 cm in the first year and 101.43 cm in the second year. When the general average of the varieties in terms of plant height was analyzed; the lowest plant height was obtained from Yakamoz variety with 96 cm, while the highest plant height was obtained from Candaş variety with 109 cm. Gökkan and Altınöz varieties were statistically in the same group and their plant heights were 104 and 102 cm, respectively. When the general effect of nitrogen doses on plant height was analyzed, plant height values increased with the increase in nitrogen dose. The lowest plant height was obtained from 0 kg N/ha dose with 93.39 cm and the highest plant height was obtained from 210 kg N/ha dose with 107.25 cm (Table 4).

Table 4. Effect of nitrogen rates on plant height (cm) values of bread wheat varieties

		Nitrogen dosages (kg/ha)						
Year	**Variety**	**0**	**70**	**140**	**210**	**280**	**Average**	**Year Av.**
	Gökkan	88.67	99.33	108.67	117.33	113.00	105.40	
1	**Yakamoz**	87.67	96.67	100.33	103.00	100.00	97.53	103.73 a
	Altınöz	84.33	95.00	106.67	112.67	111.33	102.00	
	Candaş	96.67	108.67	114.67	115.33	114.67	110.00	
	Average	89.33[e]	99.92[cd]	107.58[ab]	112.08[a]	109.75[a]		
	Gökkan	96.17	101.33	104.50	102.83	104.83	101.93	
2	**Yakamoz**	87.66	95.33	94.67	96.33	93.50	93.50	101.43 b
	Altınöz	100.50	101.83	102.50	104.83	104.67	102.86	
	Candaş	105.50	108.00	108.33	105.67	109.50	107.40	
	Average	97.46[d]	101.62[cd]	102.50[bcd]	102.42[bcd]	103.13[bc]		
	Gökkan	92.42	100.33	106.58	110.08	108.92	**104 B**	
VxN İnt.	**Yakamoz**	87.66	96.00	97.50	99.66	96.75	**96 C**	
	Altınöz	92.42	98.42	104.58	108.75	108.00	**102 B**	
	Candaş	101.08	108.33	111.50	110.50	112.08	**109 A**	
Nitrogen Average		**93.39 C**	**100.77 B**	**105.04 A**	**107.25 A**	**106.43 A**		
****: 0.01 *: 0.05**	**Y*, V**, YxV: ns, N**, VxN: ns, YxN**, YxVxN: ns**							
CV: 3.98								

Means of same row and column followed by different levels are significantly at the 5% and 1% levels of probability using the Tukey test.
*: P<0.05 , **: P<0.01, ns: stands for non-significant data at the 5% and 1% levels of probability. Y: year, V: variety, N: nitrogen.

Number of Spike Per Square Meter (pcs/m^2)

The effects of nitrogen doses on the number of spike per square meter were examined. In the analysis of variance, it was determined that year 5%, nitrogen and yearxnitrogen subjects 1%, variety, yearxvariety, varietyxnitrogen and yearxvarietyxnitrogen subjects were not statistically significant on the number of spike per square meter (Table 5). When the general average of the years was examined, the number of spike per square meter was determined as 602 in the first year and 659 in the second year. There was no statistical difference between the varieties in terms of the number of spike. When the general average of the varieties was analyzed; the average number of spike of Gökkan, Yakamoz, Altınöz and Candaş varieties were determined as 631, 630, 643 and 704, respectively. When the general averages of nitrogen doses on the number of spike per square meter were examined; the increase in nitrogen dose increased the number of spike. The lowest number of spike was obtained from 0 kg N/ha dose with 470 pieces, while the highest number of spike was obtained from 210 kg N/ha dose with 723 pieces. Higher nitrogen dose (280 kg N/ha) caused a decrease in the number of spike (658 pieces) (Table 5).

Table 5. Effect of nitrogen rates on spike number (pcs/m^2) values of bread wheat varieties

		Nitrogen Dosages (kg/ha)						
Year	**Variety**	**0**	**70**	**140**	**210**	**280**	**Average**	**Year Av.**
	Gökkan	393	644	627	791	744	640	
1	**Yakamoz**	337	637	639	713	634	592	602 b
	Altınöz	347	616	633	750	691	607	
	Candaş	381	576	600	623	679	572	
	Average	365[e]	618[cd]	624[bcd]	719[a]	687[abc]		
	Gökkan	556	600	628	716	609	622	
2	**Yakamoz**	548	692	744	733	624	668	659 a
	Altınöz	543	652	692	668	661	643	
	Candaş	653	703	755	785	625	704	
	Average	575[d]	662[abc]	705[ab]	726[a]	630[bcd]		
	Gökkan	475	622	628	754	677	**631**	
VxN İnt.	**Yakamoz**	443	665	691	723	629	**630**	
	Altınöz	445	634	663	709	676	**625**	
	Candaş	517	639	677	704	652	**638**	
Nitrogen Average		**470 C**	**640 B**	**665 B**	**723 A**	**658 B**		
****: 0.01 *: 0.05**	**Y*, V: ns, YxV: ns, N**, VxN: ns, YxN**, YxVxN: ns**							
CV: 10.02								

Means of same row and column followed by different levels are significantly at the 5% and 1% levels of probability using the Tukey test.
*: P<0.05 , **: P<0.01, ns: stands for non-significant data at the 5% and 1% levels of probability. Y: year, V: variety, N: nitrogen.

1000 Grain Weight (g)

In the conducted research, in the data obtained, in the variance analysis; year and nitrogen issues were found to be significant at 1% and year x variety at 5% on 1000 grain weight. It was observed that variety, variety x nitrogen, year x nitrogen and year x variety x nitrogen issues were not statistically significant (Table 6). When the general average of the years on 1000 grain weight was examined; 1000 grain weight was determined as 46.07 g in the first year and 43.17 g in the second year. No statistical difference was observed between the varieties in terms of 1000 grain weight. When the general average of the varieties was examined; the average 1000 grain weights of Gökkan, Yakamoz, Altınöz and Candaş varieties were determined as 45.52, 44.92, 44.05 and 43.99 g, respectively. When the general averages of nitrogen doses on 1000 grain weight were examined, high nitrogen doses (210 and 280 kg N/ha) decreased the 1000 grain weight. This is related to the increased growth of the plants, tillering and the decrease in their living space (Table 6).

Table 6. Effect of nitrogen rates on 1000 grain weight (g) values of bread wheat varieties

		Nitrogen Dosages (kg/ha)						
Year	**Variety**	**0**	**70**	**140**	**210**	**280**	**Average**	**Year Av.**
	Gökkan	48.00	51.67	50.00	46.67	47.33	48.73^{a}	
1	**Yakamoz**	45.00	45.33	42.33	43.67	43.33	43.93^{ab}	46.07 a
	Altınöz	46.67	45.33	46.67	46.00	46.00	46.13^{ab}	
	Candaş	46.67	45.00	45.67	45.00	45.00	45.47^{ab}	
	Average	46.58	46.83	46.17	45.33	45.42		
	Gökkan	45.45	40.37	44.10	40.78	40.78	42.30^{b}	
2	**Yakamoz**	49.17	48.43	43.52	44.17	44.22	45.90^{ab}	43.17 b
	Altınöz	44.38	42.15	41.10	40.48	41.72	41.97^{b}	
	Candaş	44.53	44.46	39.83	41.38	42.38	42.52^{b}	
	Average	45.88	43.85	42.14	41.7	42.28		
	Gökkan	46.73	46.02	47.05	43.73	44.06	**45.52**	
VxN İnt.	**Yakamoz**	47.08	46.88	42.93	43.92	43.78	**44.92**	
	Altınöz	45.53	43.74	43.88	43.24	43.86	**44.05**	
	Candaş	45.60	44.73	42.75	43.19	43.69	**43.99**	
Nitrogen Average		**46.23 A**	**45.34 AB**	**44.15 A**	**43.52 B**	**43.85 B**		
: 0.01 *: 0.05		**Y**, V: ns, YxV*, N**, VxN: ns, YxN: ns, YxVxN: ns**						
CV: 5.14								

Means of same row and column followed by different levels are significantly at the 5% and 1% levels of probability using the Tukey test.
*: P<0.05 , **: P<0.01, ns: stands for non-significant data at the 5% and 1% levels of probability. Y: year, V: variety, N: nitrogen.

DISCUSSION

Plants need adequate nutrient supply to maintain normal plant growth, and nutrient absorption can vary in amount and rate during different growth periods (Zhang et al., 2016). Nitrogen is one of the most important macronutrients and its deficiency can negatively affect all developmental processes of plants (Due et al., 2021). In order to obtain maximum grain yield from high-yielding wheat varieties, it is necessary to provide adequate nutrient supply (Adnan et al., 2020). Vegetative growth organs (such as stems and leaves) are affected by nitrogen ratios (Jiang et al., 2017) and nitrogen deficiency retards growth and reduces grain yield and quality (Canfield et al., 2010). Profitable production based on high yields is not possible without mineral and organic fertilizer applications (Stevanovic et al., 2023).

Yield and Optimum Nitrogen Dose of Varieties

The optimum nitrogen dose was determined for the varieties developed in this research. It was observed that the varieties showed different rates of nitrogen requirement but close to each other. It was determined that there was a quadratic relationship between yield and nitrogen dose in all varieties. The optimum nitrogen dose for Gökkan variety was determined as 21.38 kg/da, for Yakamoz variety as 18.62 kg/da, for Altınöz variety as 17.60 kg/da and for Candaş variety as 19.28 kg/da. Under Adana conditions, the highest yield was obtained from Gökkan variety and the lowest yield was obtained from Yakamoz variety. This study showed that the effect of genotype selection and nitrogen application rates on wheat productivity was significant. Some studies reported that there was no significant interaction between nitrogen and cultivar and that the response to nitrogen fertilization was consistent among different genotypes (Hnizil et al., 2024). Nitrogen fertilization practices and specific agronomic techniques have been reported to be broadly applicable to different cultivars. It has been emphasized that the response to N fertilization may be generally the same, but may vary considerably in different genotypes, depending on their genetic characteristics, according to stress management (Shahin et al., 2023). Factors such as yield potential of plants, soil N content, other essential nutrients in the soil and soil water affect plant response to nitrogen (Khan et al., 2014). In this study, it was determined that nitrogen doses increased yield, but the highest nitrogen dose (280 kg/ha) caused a decrease in yield in all varieties. In other studies, it was reported that nitrogen doses increased grain yield, increased yield up to a certain dose, but decreased yield after a certain dose (Haile et al., 2012; Akgün and Ulupınar, 2019). It is in agreement with previous studies that nitrogen application significantly affects yield, biomass and wheat productivity increases with optimum nitrogen fertilization (Wang et al., 2022). It has been reported that agricultural practices and environmental factors cause variability in yield. Nitrogen use efficiency varies significantly among genotypes (Gülmezoğlu and Kutlu, 2017), grain yield depends on climatic conditions, variety, nitrogen dose and application time and soil structure (Nakano et al., 2008), and agricultural practices and environmental factors cause variability in yield (Tudor ve ark., 2023; Lopez ve ark., 2023). In this study, yield differences between the years are due to climatic conditions. The yield ranking of the varieties was similar in both years and Yakamoz variety showed the lowest yield potential. In previous studies, it has been stated that the differences in grain yield between crop years are closely related to the total amount of precipitation and its distribution during the vegetation period (Mahler et al., 1994) and the temperature between spike development and physiological maturity (Spiertz and Vos, 1985).

Plant height (cm)

In this study, it was observed that nitrogen doses increased the plant height and the plant heights of the varieties were different. Yakamoz variety had the lowest plant height while Candaş had the highest plant height. Candaş showed lodging tendency at high nitrogen doses. It has been reported that as nitrogen application increases and the size of the plant cell increases, the protein content of the cells increases, which causes the plant to be taller as a result of increased leaf area and photosynthesis rate (Wysocki et al., 2007). Plant height varies according to the amount of nitrogen dose applied (Ali et al., 2011; Ullah et al., 2018) and varieties (Hussain et al., 2006). Some researchers reported that plant height values increased up to a certain dose and decreased after this dose (Ciftci and Dogan, 2013), while some researchers reported that nitrogen fertilizer applications had no effect on plant height (Eid et al., 1986) and high dose applications caused lodging in the plant (Li et al., 2022).

Number of Spike Per Square Meter (pcs/m^2)

In this study, when the general averages of nitrogen doses on the number of spike per square meter were examined, the number of spike increased with increasing nitrogen dose and decreased at high nitrogen dose (280 kg/ha). The combination of plant density and optimum N amount can promote wheat growth and tiller number (Yang et al., 2019). Similar results were obtained in other studies. Some of the researchers found that the number of ears per square meter increased with increasing nitrogen doses (Hussain et al., 2006; Naseri et al., 2010). Some researchers reported that nitrogen fertilization increased the number of spike per m^2 up to a certain dose and higher doses decreased the number of spike per m^2 (Ciftci and Dogan, 2013; Ullah et al., 2018). In previous studies, it was reported that the number of spike per square meter in wheat is affected by the climate and soil characteristics of the growing area, the amount of nitrogen fertilizer applied, sowing frequency and genetic structure of the varieties (Naneli et al., 2015).

1000 Grain Weight (g)

Thousand grain weight is among the important quality criteria in wheat and it has been reported that thousand grain weight helps to predict wheat flour yield (Mut et al., 2007). In this study, 1000 grain weight increased up to 140 kg/ha nitrogen application and decreased at higher nitrogen doses

(210 and 280 kg/ha). It was determined that nitrogen applications increased 1000 grain weight (Ali et al., 2011), had no effect (Lloveras et al., 2001), were irregular (Dogan et al., 2008), but thousand grain weight decreased at high nitrogen doses (Liu et al., 2021). Climate is effective on grain weight. It has been reported that dry and hot post-flowering period in wheat causes a decrease in grain weight and an increase in crude protein content (Bulut, 2009).

Studies have shown that yield can be increased by nitrogen accumulation, transport and selection of quality wheat (Huang et al., 2020), genotype and correct nitrogen dose are important in yield optimization (Hnizil et al., 2024), environmental conditions, soil fertility potential and agricultural practices may also have an important effect (Ghafoor et al., 2021). Fertilization also has an important role on grain yield and quality. Therefore, the selection, application dose, timing and management of nitrogen fertilizer are important to increase crop yield and minimize nitrogen losses from the soil (Rhezali and Lahlali, 2017). Studies have reported that high nitrogen application increases wheat yield and promotes nitrogen absorption compared to low rates (Li et al., 2023). Breeding studies are always carried out to develop more efficient and high quality varieties. And developing varieties with high nitrogen utilization efficiency is among the goals of breeders. Varieties with high nitrogen use efficiency are beneficial for the ecology while saving fertilizer (Xu et al., 2020). The results of this study showed that nitrogen fertilization dose and variety selection on a regional basis are important for high yield and quality production. As a result of this research conducted at Adana location, it was observed that high nitrogen fertilizer rates did not increase grain yield.

CONCLUSION

In agricultural production systems, variety selection and determination of nitrogen application rates are important measures to be taken on yield. As a result of this research conducted for two years, it was observed that variety and nitrogen fertilizer rates had a significant effect on wheat yield. It was determined that high doses of nitrogen fertilizer did not increase grain yield. This indicates that excessive N application may adversely affect plant performance. The optimum nitrogen requirements of the varieties also differed. Nitrogen rates and variety selection were found to be important on yield and yield parameters. N optimization in the developed wheat varieties should be investigated under soil and climatic conditions in different locations. Optimum N requirements of newly developed wheat varieties should be determined. Breeding programs should aim to develop varieties with high nitrogen use efficiency. As in all plants, proper nutrient management in cereals is very important for plant growth and development. As long as breeding studies continue, the nitrogen issue will always remain topical.

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