DETERMINATION OF NITROGEN UTILISATION AND NITROGEN UPTAKE EFFICIENCY OF SOME WHEAT GENOTYPES UNDER LIMITED NITROGEN CONDITIONS

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Abstract

Wheat is one of the most important human foods in Turkey and the most important nutrient of wheat plant is nitrogen. Since the green revolution in wheat variety breeding, high nitrogen high yielding varieties have been bred. Nitrogen resources of our world are limited, the use of excess nitrogen fertilisers for years has caused environmental pollution. It is also one of the important costs in wheat farming. There is a need to breed new wheat varieties that will reduce the use of nitrogen fertiliser. In order to reduce the damage to the environment and economic damage to the producer, it is important to breed high yielding varieties that require less nitrogen fertiliser. Otherwise, the cost of nitrogen fertiliser and the depletion of its reserve will negatively affect wheat production. A total of 7 genotypes including 4 local bread wheat genotypes, 2 durum wheat varieties (svevo, fırat93), 1 local siyez wheat collected from the villages of the Southeastern Anatolia region which is the homeland of wheat plant were used. The experiment was established according to split-plot design with 4 nitrogen doses and four replications. Nitrogen uptake efficiency and nitrogen utilisation efficiency were inversely proportional to nitrogen dose and nitrogen uptake efficiency increased as nitrogen dose decreased. Increasing nitrogen doses had an inverse effect on nitrogen uptake efficiency and the nitrogen dose with the highest nitrogen uptake efficiency was in the lowest nitrogen dose application. The genotype with the highest value among the local genotypes was GYE4.

Keywords: Nitrogen Uptake, Nitroge Utilization, Wheat

INTRODUCTION

Wheat plant is one of the most important food crops which is widely produced in the world, can be grown almost everywhere and meets the energy needs of people (Kızılaslan, 2004). Village varieties are promising materials for transferring their qualitative characteristics to new varieties by breeding methods. Therefore, village varieties with genetic diversity should be collected and protected from the existing regions and used in breeding programmes. However, with the development of too many varieties and the breeding pressure, local varieties face the risk of extinction (Akçura et al. 2014; Kendal and Enver, 2020; Tekdal et al. 2018). Historical remains have been found to support that the Southeastern Anatolia Region within the Fertile Crescent is the homeland of wheat. The fact that Turkey was the first place where wheat was cultivated has both economic, social, cultural, and historical importance (Kan et al. 2017). Village populations carry hope in the development of quality new varieties by using quality, disease-resistant, desired commercial characteristics in breeding studies (Kendal & Enver, 2020; Yıldız et al. 2019). Recently, the increase in interest in organic products has also led to an increase in studies on local varieties. In a study consisting of local populations and varieties developed by breeding studies, the protein value of local lines was found to be higher than the varieties (sevim et al. 2020).

Nitrogen is the most needed and most deficient nutrient element in plants. It has been determined that giving more than it should be given to the plant reduces nitrogen intake instead of increasing yield, even damages the environment by mixing into groundwater and causes economic losses due to unnecessary use. Therefore, it is recommended to know the amount of nutrients in the soil before fertilisation and to fertilise accordingly. It has also been determined that nitrogen uptake is high at high temperature and humidity (Kara şahin and Muhammet, 2014). In recent years, it has become obligatory to use nitrogen in a controlled manner due to the environmental damage and economic losses caused by the excessive use of active nitrogen and at the same time, nitrogen fertiliser resources are limited (Çullu et al. 1999). Since different varieties ripen at different times, it has been reported that nitrogen is taken at different levels (Bruetsch et al. 1976). Since the root and morphological characteristics of plants are different, nitrogen uptake differs even if the varieties belong to the same species (Maizlish et al. 1980). Nitrogen uptake has also been found to have an effect on grain yield, and when high nitrogen doses were applied, yield decreased (Bozkurt et al. 2001). Fertiliser use efficiency seriously affects fertiliser economy. In order to reduce the use of chemical fertilisers, it has been found useful to use varieties that do not require less fertiliser, pesticide use and do not require excessive irrigation and are adapted to local conditions (Karaman et al. 2012). Global changes and nitrate pollution, which have recently been on the agenda in the world, carry serious risks on environmental pollution and human health. Therefore, the use of organic fertilisers increases its importance in terms of both environmental pollution and human health (Aksu and Tuğçe, 2017). Nitrogen utilisation efficiency should be at optimum value both to prevent environmental pollution and to obtain economically high yields (Bozkurt et al. 2001). With the effect of increasing population, studies to increase food production have intensified.

MATERIALS AND METHODS

In the growing period of 2021-2022, 4 genotypes of hexaploid (bread) wheat, 2 genotypes of tetraploid (durum) wheat, 1 genotype of diploid (siyez) wheat were used as plant material and four different nitrogen fertiliser doses (3, 6, 9, 12 kg N da-1) were used. Ammonium nitrate (15-15-15% NPK) was applied as nitrogen fertiliser. In the experiment, nitrogen doses were divided into two and half of them were applied with sowing and the other half was applied before emergence (Yürür, 1998).

The experiment was established according to split-plot experimental design with four replications. Varieties were placed in the main plots and nitrogen fertiliser doses were placed in the sub-plots. Plot length was 2 m and width was 0.6 m and plot area was 1.2 m2. The variance analysis of the data obtained from the experiment was carried out according to the "Split Plots" experimental design. The statistical significance of the differences between the means were calculated with the help of JMP statistical package programmes. In significance tests, 1% and 5% probability levels were used and 5% probability level was used in determining different groups.

(soil analysis results and climate data to be added)

Table 1. Wheat genotypes used in the study

Southeast Local Bread two	Origin 12-13	Farmer's Name	Province
GYE-1	3	Mehmet ORAK	Diyarbakir/ Eğil/ Baysu
GYE-2	68	Abdurrahman DÜZEN	Adiyaman/ Gerger/ Basdaglica
GYE-3	12/1	Mehmet TÜYSÜZ	Sanliurfa/ Siverek/ Sublime
GYE-4	26/1	Osman TEYMUR	Mardin/ Midyat/ Shenkoy
Proprietary durum			
Svevo			
Firat 93			
Siyez wheat			
GYS			

Features:

-Grain nitrogen content (% kg/ha)

Nitrogen will be determined by Micro Kjeldahl method from grains taken from 5 randomly selected plants from each replicate (Anderson. et. al.1984).

Amount of N removed by the above-ground parts at harvest (kg/ha):

At harvest, 5 plants randomly selected from each replicate were dried in an oven, ground and N content was determined using the Micro Kjeldahl method.

-Nitrogen utilisation efficiency

Grain yield of each replicate will be divided by the amount of N applied to that plot (kg/area).

-Nitrogen utilisation efficiency

It will be obtained by dividing the grain yield of each replicate by the amount of N removed by the above-ground parts (kg/area).

- Nitrogen uptake efficiency

The amount of N removed by the above-ground parts of each replicate at harvest (kg/area) divided by the applied N dose.

RESULTS AND DISCUSSIONS

Analysis of variance results of yield components obtained from the study are given in Table 2.

Table 2. Analysis of variance results for yield and yield components of seven wheat genotypes and four different nitrogen doses.(continued)

Sources of variation	SD	Amount of above-ground N removed at harvest	N utilisation efficiency	Nitrogen Content	N utilisation efficiency	Nitrogen uptake efficiency
Repetition	3	2,60	9,14	0,78	10,64	0,16
Genotype	6	17,82**	966,20**	27,30**	737,76**	0,44**
Nitrogen Dose	3	2055**	1017,38**	9,21**	11,55	5,86**
Dose*Genotype	18	2,26	63,61**	1,03*	25,95	0,07
Error	81	1,62	16,70	0,55	20,20	0,07
Total	111	3,14	102,48	2,31	59,43	0,26

*: 0,05: statistically significant at probability levels.

**: Statistically significant at 0,01 probability level

As can be seen from the analysis of variance results, the effects of wheat genotypes on above-ground N content, grain N content, plant height, number of grains per spike, thousand grain weight, grain yield, N uptake efficiency and N utilisation efficiency were found to be statistically significant at 1% probability level. However, the effect of N utilisation efficiency was not statistically significant (Table 2.).

When nitrogen doses were analysed, the effects of nitrogen doses on the number of grains per spike, thousand grain weight, grain yield, amount of nitrogen removed from the above-ground parts, grain nitrogen content and N uptake efficiency were found to be statistically significant at 1% probability level. Unlike genotypes, nitrogen doses had no statistically significant effect on plant height, N utilisation efficiency and N utilisation efficiency (Table 2.).

When the genotype x nitrogen dose interactions were analysed, it was found that the effects of the interactions on thousand grain weight and grain nitrogen content were statistically significant at 1% probability level, while the interactions had no statistically significant effect on the other traits examined (Table 2).

Grain Nitrogen content

The results of the analysis of variance for the grain nitrogen content values of four different nitrogen dose applications in seven wheat genotypes are given in Table 2 and mean values are given in Table 3.

In terms of grain nitrogen content values, it was statistically determined that it was significant between genotypes and nitrogen doses at 1% probability level. Nitrogen dose*genotype interaction was statistically significant at 5% probability level (Table 3).

When Table 3 is analysed, it is seen that the average nitrogen content values of the varieties varied between 0.11-5.39. The genotype with the highest nitrogen content was FIRAT93 with 12kg/da nitrogen dose.

Nitrogen content increased in parallel with the increase in nitrogen dose.

Table 3. mean grain nitrogen content values and significance groups for seven wheat genotypes and four nitrogen doses

Genotype/Dose	3		6		9		12		Average	
FIRAT93	2,45	F-J	3,19	E-G	4,25	B-D	5,39	A	3,82	A
GY1	1,09	L-N	2,32	F-K	2,33	F-K	2,13	H-K	1,97	C
GY2	1,36	K-M	2,16	G-K	2,14	H-K	1,7	I-L	1,84	C
GY3	1,48	J-L	2,3	F-K	2,68	E-I	3,54	C-E	2,5	B
GY4	1,68	I-L	2,65	E-I	3,03	E-H	2,85	E-H	2,55	B
SIYEZ	0,15	N	0,13	N	0,11	N	0,36	M-N	0,19	D
SVEVO	3,28	D-F	3,64	C-E	5,03	A-B	4,35	A-C	4,07	A
Average	1,64	C	2,34	B	2,79	A	2,9	A	2,42	

*: 0,05: statistically significant at probability levels. **: Statistically significant at 0,01 probability levels

N uptake efficiency

The results of the analysis of variance for the grain nitrogen uptake efficiency values of four different nitrogen dose applications in seven wheat genotypes are given in Table 2 and the mean values are given in Table 4.

In terms of nitrogen uptake efficiency, the differences between the values of different nitrogen doses and between

genotypes were found to be statistically significant at 1% probability level (Table 4).
When Table 4. is analysed, the mean values of the genotypes varied between 0.5 and 1.89 and the genotype with the highest nitrogen uptake efficiency value was obtained in svevo bread wheat variety.
The increase in nitrogen doses had an inverse effect on nitrogen uptake efficiency and the nitrogen dose with the highest nitrogen uptake efficiency was 3kg/ha.(Table 4.)

Table 4. mean nitrogen uptake efficiency values and significance groups for seven wheat genotypes and four nitrogen doses.

Genotype/Dose	3	6	9	12	Average	
FIRAT93	1,73	0,85	0,83	0,66	1,02	A
GY1	1,65	0,96	0,75	0,5	0,97	A
GY2	1,69	1,07	0,51	0,48	0,94	A
GY3	1,75	1,08	0,77	0,6	1,05	A
GY4	1,53	1,07	0,74	0,59	0,98	A
SIYEZ	0,94	0,66	0,46	0,36	0,6	B
SVEVO	1,89	0,94	0,94	0,72	1,12	A
Average	1,6 a	0,95 b	0,71 c	0,56 d	0,96	

*: 0,05: statistically significant at probability levels.**: Statistically significant at 0,01 probability level.

Nitrogen Utilisation Efficiency

The results of the analysis of variance for the grain nitrogen utilisation efficiency values of four different nitrogen dose applications in seven wheat genotypes are given in Table 2 and the mean values are given in Table 5.
The differences between the values of the genotypes in terms of nitrogen utilisation were found to be statistically significant at 1% probability level.(Table 5)
When Table 5. is analysed, the mean values of the genotypes varied between 1,39 and 26,61 and the genotype with the highest nitrogen utilisation efficiency value was obtained in svevo bread wheat variety at 6kg/da nitrogen dose.
Increasing nitrogen dose affected nitrogen utilisation. The nitrogen dose with the highest average nitrogen utilisation efficiency was determined as 6kg/ha.(Table 5)

Table 5. mean nitrogen utilisation efficiency values and significance groups for seven wheat genotypes and four nitrogen doses.

Genotype/Dose	3	6	9	12	Average	
FIRAT93	21,68	23,49	21,88	24,26	22,82	A
GY1	16,78	15,47	13,88	12,94	14,77	B
GY2	12,9	13,63	20,74	10,85	14,53	B
GY3	11,94	15,99	14,44	17,59	14,99	B
GY4	14,33	15,48	16,57	17,25	15,91	B
SIYEZ	2,62	1,54	1,39	3,01	2,14	C
SVEVO	21,98	26,61	20,62	18,98	22,05	A
Average	14,6	16,03	15,65	14,98	15,32	

Amount of Nitrogen Removed by the Above Ground Part at Harvest

The results of the analysis of variance for the nitrogen uptake by the aboveground parts at harvest of four different nitrogen dose applications in seven wheat genotypes are given in Table 2 and the mean values are given in Table 6.

It was statistically determined that nitrogen doses and genotypes were statistically significant at 1% probability level in terms of the amount of nitrogen removed by the aboveground parts at harvest. (Table 6.) When the values of the genotypes were examined, the values of the genotypes varied between 2.82 and 8.63 and the genotype with the highest number of grains was obtained in SVEVO genotype.

As nitrogen dose averages, the highest value was 12kg/da nitrogen dose. Among the genetypes, the highest value was svevo with 7,61 (Table 6.).

Table 6. mean values and significance groups of nitrogen content of above-ground parts at harvest for seven wheat genotypes and four nitrogen doses.

Genotype/Dose kg/d	3	6	9	12	Average	
FIRAT93	5,18	5,12	7,44	7,91	6,41	AB
GY1	4,96	5,78	6,74	6,04	5,88	BC
GY2	5,07	6,44	4,63	5,77	5,48	C
GY3	5,26	6,49	6,91	7,15	6,45	AB
GY4	4,59	6,4	6,67	7,13	6,2	BC
SIYEZ	2,82	3,95	4,12	4,34	3,81	D
SVEVO	5,67	5,65	8,48	8,63	7,11	A
Average	4,79 c	5,69 b	6,43 a	6,71 a	5,9	

*: 0,05: statistically significant at probability levels. **: Statistically significant at 0,01 probability levels.

Nitrogen Utilisation Efficiency

The results of the analysis of variance for the nitrogen use efficiency values of four different nitrogen dose applications in seven wheat genotypes are given in Table 2 and the mean values are given in Table 7.

In terms of nitrogen dose values, statistical differences were determined at 1% probability level in genotypes, nitrogen doses and nitrogen dose*genotype interaction (Table 7.).

When Table 7 is analysed, it is seen that the genotype values varied between 0.6 and 42.09. When analysed in terms of nitrogen doses, it was observed that the nitrogen utilisation efficiency decreased in inverse proportion with the increase in nitrogen doses. The genotype with the highest nitrogen utilisation efficiency was the svevo variety with a nitrogen dose of 3kg/da.(Table 7.)

Table 7. mean nitrogen use efficiency values and significance groups for seven wheat genotypes and four nitrogen doses.

Genotype/Dose	3		6		9		12		Average	
FIRAT93	35,74	B	19,75	C-E	18,03	D-F	16,37	DH	22,47	A
GY1	17,3	DEFG	15,11	E-I	10,44	IK	6,49	JL	12,34	B
GY2	21,08	CD	14,3	E-I	9,76	IK	5,23	KM	12,59	B
GY3	21,13	CD	17,56	D-G	11,1	HJ	10,45	IK	15,06	B
GY4	21,22	CD	16,49	D-H	12,17	GJ	10,09	IK	14,99	B
SIYEZ	1,84	LM	0,98	LM	0,6	M	1,13	LM	1,14	C
SVEVO	42,09	A	24,81	C	19,72	CE	13,71	FI	25,08	A
Average	22,91	A	15,57	B	11,69	C	9,07	D	14,81	

*: 0,05: statistically significant at probability levels. **: Statistically significant at 0,01 probability levels.

Amount of Nitrogen Removed by the Above Ground Part at Harvest

The results of the analysis of variance of four different nitrogen dose applications on the amount of nitrogen removed by the aboveground parts at harvest in seven wheat genotypes are given in Table 2 and the mean values are given in Table 11.

It was statistically determined that nitrogen doses and genotypes were statistically significant at 1% probability level in terms of the amount of nitrogen removed by the aboveground parts at harvest. (Table 11.) When the values of the genotypes were examined, the values of the genotypes varied between 2.82 and 8.63 and the genotype with the highest number of grains was obtained in SVEVO genotype.

As nitrogen dose averages, the highest value was 12kg/da nitrogen dose. Among the genetypes, the highest value was svevo with 7,61 (Table 11.).

Table 11. mean values and significance groups of nitrogen content of above-ground parts at harvest for seven wheat genotypes and four nitrogen doses.

Genotype/Dose kg/d	3	6	9	12	Average	
FIRAT93	5,18	5,12	7,44	7,91	6,41	AB
GY1	4,96	5,78	6,74	6,04	5,88	BC
GY2	5,07	6,44	4,63	5,77	5,48	C
GY3	5,26	6,49	6,91	7,15	6,45	AB
GY4	4,59	6,4	6,67	7,13	6,2	BC
SIYEZ	2,82	3,95	4,12	4,34	3,81	D
SVEVO	5,67	5,65	8,48	8,63	7,11	A
Average	4,79c	5,69 b	6,43 a	6,71 a	5,9	

*: 0,05: statistically significant at probability levels. **: Statistically significant at 0,01 probability level.

DISCUSSION AND CONCLUSION:

In this research, it is aimed to determine the genotypes with high nitrogen use efficiency, high yield and high nitrogen use efficiency of the genotypes consisting of 4 local bread wheat village varieties collected from different locations of the Southeastern Anatolia region of Turkey, which is produced as the world's staple food, two registered durum varieties and one siyez wheat, which are the most widely cultivated in Southeastern Anatolia, and to determine the appropriate parents for the relevant breeding programmes.

The results obtained from our research: The effects of wheat genotypes on plant height, number of grains per spike, thousand grain weight, grain yield, N utilisation efficiency, N uptake efficiency and N utilisation efficiency were found to be statistically significant. However, the effect of above-ground N removal and grain N content were not statistically significant.

Svevo bread wheat variety had the highest values in terms of most yield components followed by fırat93 durum wheat variety. Among Siyez and local wheats, GYE4 was the genotype with the highest values in nitrogen uptake efficiency and grain yield, followed by GYE3.

Nitrogen uptake efficiency and nitrogen utilisation efficiency were inversely proportional to nitrogen dose and nitrogen uptake efficiency increased as nitrogen dose decreased. With 3kg/da nitrogen dose, svevo had the highest average nitrogen uptake efficiency and GYE4 had the highest value among the local genotypes. The reason for the low grain yield in general is thought to be due to the small amount of sowing per unit area. Among the genotypes, svevo and fırat93 had the highest values in terms of most traits. The genotype that we can recommend to the farmer for sowing is fırat93 if durum will be sown and svevo if bread wheat will be sown. Among the local genotypes, GYE4 and GYE3 can be recommended for breeding studies.

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