

## Determination of Relationship Between Minerals and Yield Components by Different Statistical Methods in Bread Wheat (*Triticum aestivum* L.) under Irrigated Conditions

Murat OLGUN<sup>1</sup>, Okan SEZER<sup>3</sup>, Metin TURAN<sup>2</sup>, Zekiye BUDAK BAŞÇİFTÇİ<sup>1</sup>, N. Gözde AYTER<sup>1</sup>, Doğan AYDIN<sup>1</sup>, Murat ARDIÇ<sup>3\*</sup>, Onur KOYUNCU<sup>3</sup>

<sup>1</sup>Eskişehir Osmangazi University, Faculty of Agriculture, 26160, Eskişehir/TURKEY

<sup>2</sup>Yeditepe University, Faculty of Engineering and Architecture, Department of Genetics and Bioengineering, 34755, İstanbul/TURKEY

<sup>3</sup>Eskişehir Osmangazi University, Faculty of Arts and Science, Department of Biology, 26160, Eskişehir/TURKEY

\*Corresponding Author:  
E-mail:mardic@ogu.edu.tr

Received: February 15, 2017  
Accepted: July 10, 2017

### Abstract

The purpose of this study was to reveal the effect of minerals (Mg, S, Fe, N, Ca, Mn, Zn, P, Cu and K) and some yield component (seed weight per spike and SPAD) on seed yield, to show similarities/dissimilarities in behavior of genotypes and minerals by some statistical methods. Multiple regression (Minitab Software 16), conditional formatting (Excel 2016), principal component and classification (Statistica 10) and cluster (NCSS) analyses were used in evaluation of data. Though some minerals are highly effective on some processes, their behavior in genotypes are almost similar and effect of them is integrative. Effectiveness of minerals are under genotype x environment interaction and mainly under genetic control. Seed weight per spike, SPAD, N, P, are closely related to seed yield; Fe, Mn, Zn and Cu are also related to photosynthesis. Besides, Atay, Bezostaja, Harmankaya and Es 26 were determined as better genotypes in yield components and mineral content.

**Keywords:** Bread wheat genotypes, mineral, yield components, statistical analyses, irrigated conditions

### INTRODUCTION

Being a most produced crop in the world, demands to bread wheat (*Triticum aestivum* L.) production should be met by increasing production that will be responded to increasing population. Water, which is the most important factor that affects plant development and limits crop production to a large part of the world's agricultural areas, significantly affects agricultural production in wheat. If wheat farming in the world is thought to be made on considerably dry conditions, it is obvious how much will increase with irrigation. In particular, the elimination of the need for water at the time of flowering and grain filling of the plant is the insurance of the increase in production. Irrigation in arid and semi-arid areas is an unavoidable necessity. It is expected that the expansion of irrigated areas and the effective use of water will cause a significant increase in the will of the world because of the growing population, because of the stated condition, which will cause more food production in the future. In the case of water deficiency, the water potential of the plant decreases and at the further stages, the turgor pressure falls, the stomata is closed, the leaf growth decreases and the photosynthetic and metabolic activities declines and therefore yield decreases [4; 16]. If climate and geographic factors are left aside, increase in yield strongly depends upon water and minerals [1; 25]. Plants need minerals to metabolic activities including physiological and biochemical processes, and increase in metabolic processes requires mineral uptake and use, so they tend to increase mineral uptake and use in irrigated conditions [6; 7]. Minerals play vital role in plant activities and revealing their levels in plants will be beneficial to develop promising genotypes in breeding programs [15; 17; 29].

It is possible to feed the growing population with increase in irrigated areas and relatively increase in yield per ha in the world. Seed yield is main target and criterion, examining and revealing relationship between yield and yield components such as SPAD and seed weight per spike may create opportunity to make great advances in development of novel genotypes [10; 30]. Main aim of this study was to determine the effect of minerals (N, P, K, Ca, Mg, S, Fe, Mn, Zn and Cu) and some yield component (seed weight per spike and SPAD) on seed yield, to show similarities/dissimilarities in behavior of genotypes and minerals by some statistical methods.

### MATERIALS and METHODS

This study was conducted in Eskişehir Osmangazi University, Faculty of Agriculture, in 2014-15 crop growing seasons. Soil in the experimental area was loamy texture (37.5% sand, 38.1% silt, and 24.4% clay); 0.34% CaCO<sub>3</sub>, 217.4 mmol kg<sup>-1</sup> P<sub>2</sub>O<sub>5</sub>, 294.24mmol kg<sup>-1</sup> K<sub>2</sub>O, 6.21 pH, 2.04% organic matter and 2.28 dS m<sup>-1</sup> electrical conductivity. Average, minimum and maximum temperatures, precipitations in 2014-15 and long term years in Eskişehir were given in Table 1. Maximum, minimum and average temperatures in 2014-15 and long term years were 25.3 and 23.8, -3.9 and -6.1, 10.2 and 8.9, respectively. Precipitations in 2014-15 and long term years were 346.0 mm and 326.6 mm, respectively. Bread wheat genotypes; İkizce, Nacibey, Es 26, Gerek, Tosunbey, Alpu, Atay, Bezostaja, Harmankaya, Sönmez, Yıldırım, Palandöken 97, Sultan, Müfitbey and Çetinel were used. Average, minimum and maximum temperatures, precipitations in 2014-15 and long term years was given in Table 1.

**Table 1.** Average, minimum and maximum temperatures, precipitations in 2014-15 and long term years in Eskişehir.

Climatic Parameters	Years	October	November	December	January	February	March	April	May	June	July	Total/Av.
<b>Max.Temp.</b>	<b>2014-15</b>	29.2	21.6	17.5	18.0	20.9	22.2	23.0	30.3	32.0	37.9	25.3
	<b>Long-Term</b>	18.4	1.5	15.7	13.6	18.5	20.6	26.1	30.2	36.7	37.5	23.8
<b>Min.Temp.</b>	<b>2014-15</b>	-0.5	-7.0	-8.0	-14.5	-17.0	-7.9	-3.8	0.2	8.7	10.5	-3.9
	<b>Long-Term</b>	-7.2	-10.5	-7.2	-18.2	-11.3	-8.3	-5.3	-4.9	4.5	6.7	-6.1
<b>Av..Temp.</b>	<b>2014-15</b>	14.5	6.0	4.6	1.5	4.9	5.9	9.2	15.2	18.1	21.9	10.2
	<b>Long-Term</b>	11.4	7.3	4.6	-3.6	-5.6	6.3	7.7	15.4	22.7	23.3	8.9
<b>Tot.Rainfall</b>	<b>2014-15</b>	9.0	29.5	65.1	36.0	42.8	32.6	23.9	20.7	79.0	7.4	346.0
	<b>Long-Term</b>	25.5	29.8	38.2	38.2	32.5	33.0	35.4	43.1	29.3	13.9	326.6

\*Data of regional meteorology station and long-term years (1970-2013) in Eskişehir.

Fertilizers given were 60 kg N ha<sup>-1</sup> (half at sowing stage and half at tillering stage) and 60 kg ha<sup>-1</sup> P<sub>2</sub>O<sub>5</sub> (once at sowing). Seeds were planted at the second week of September with 500 seed/ m<sup>2</sup> rate. Experimental design was randomized complete block design with three replications. Plot size was 6 m/1.2 m (7.2 m<sup>2</sup>). Grain yield, seed weight per spike, SPAD [10; 30], minerals as N, P, K, Ca, Mg, S, Fe, Mn, Zn and Cu [27] were evaluated. SPAD were measured at flowering period. Seed weight per plant and seed yield were measured in maturity period and after harvest. Minerals were determined in bread wheat seeds. The Kjeldahl method and a Vapodest 10 Rapid Kjeldahl Distillation Unit (Gerhardt, Konigs winter, Germany) were used to determine the total N content [12, 31]. The Ca, Mg, K, P, Fe, Cu, Mn, Zn con-

tents in genotypes were determined by using an Inductively Coupled Plasma spectrometer (Perkin-Elmer, Optima 2100 DV, ICP/OES, Shelton, CT 06484-4794, USA [27]. Multiple regression (Minitab Software 16), conditional formatting (Excel 2016), principal component and classification (Statistica 10) and cluster (NCSS) analyses were used in evaluation of data.

## RESULTS and CONCLUSION

In the study, minimum, maximum, mean values of plant characters and minerals in bread wheat genotypes was given in Table 2.

**Table 2.** Minimum, maximum, mean values of plant characters and minerals in bread wheat genotypes.

Variable	Mean	Minimum	Maximum	Variable	Mean	Minimum	Maximum
<b>SeedYield</b>	4.74±0.62	3.43	5.62	<b>Mg</b>	944.8±337.1	465.7	1623.9
<b>SeedWe./Spike</b>	2.16±0.44	1.21	2.54	<b>S</b>	340.4±75.7	215.5	537.0
<b>SPAD</b>	53.87±10.92	31.00	68.00	<b>Fe</b>	68.17±26.43	31.85	107.04
<b>N</b>	3.59±0.97	2.03	5.01	<b>Mn</b>	52.00±17.03	27.61	78.32
<b>P</b>	1815±540	757	2499	<b>Zn</b>	60.15±14.94	39.99	91.23
<b>K</b>	16649±5209	8965	23675	<b>Cu</b>	59.85±23.20	34.65	110.66
<b>Ca</b>	4396±979	2915	6205	<b>Mean</b>	1881±504	1111	2658

It has been revealed that some yield elements such as seed weight per spike and SPAD have a significant effect on yield. Once seed weight per spike assign seed yield performance of crop, SPAD is well indicator of plant chlorophyll content [30]. Nitrogen is a main component of metabolic activities such as enzymes, organic and amino acids, nucleic acids, chlorophyll in plant [3]. Calcium is also another mineral; it is known as vital mineral in ion uptake, in the formation of calmodulin that is Ca-linked protein in stress conditions, [9]. Osmotic events, metabolite and mineral movements, metabolic activities such as protein synthesis and cell division are regulated by potassium [26]. Besides, phosphorus is necessary in dry matter production and photosynthesis, in energy transfer, generative and storage events

[23]. Stress-stimulating mineral Ca is involved in many metabolic events such as cell division, ion transport. Magnesium, sulfur, iron, manganese, zinc and copper take part in photosynthesis enzyme, dry matter production, plant development and protein synthesis. Zinc plays a role in the carbohydrate synthesis and in membrane stability [11]. One of the important methods used to determine the degree and shape of the independent variables on the dependent variable is regression analysis that is useful tool to search relationship between a dependent variable and predictors [13; 14]. This analysis is used safely in both bread breeding, agronomic, and quality studies in bread wheat [2; 28]. Multiple regression analysis showing the effects of characteristics on seed yield was given in Table 3.

**Table 3.** Multiple regression analysis on the effects of characteristics on seed yield.

Source	Deg. of Fr.	SS	MS	F <sub>value</sub>
Regression	12	5.86839	0.48903	34.36**
Residual Error	3	0.04270	0.01423	
Total	15	5.91109		

Predictor	Coefficient	T	P
Constant	1.9452	4.94	0.016
Seed We./Spike	0.1698	0.60	0.588
SPAD	0.04239	2.64	0.078
N	0.0232	0.11	0.917
P	-0.0001061	-0.31	0.777
K	-0.00000200	-0.08	0.944
Ca	-0.0000407	-0.25	0.818
Mg	0.0005202	1.03	0.379
S	0.000507	0.27	0.802
Fe	0.003917	0.97	0.402
Mn	0.002733	0.52	0.640
Zn	-0.00798	-0.73	0.517
Cu	-0.001995	-0.23	0.832

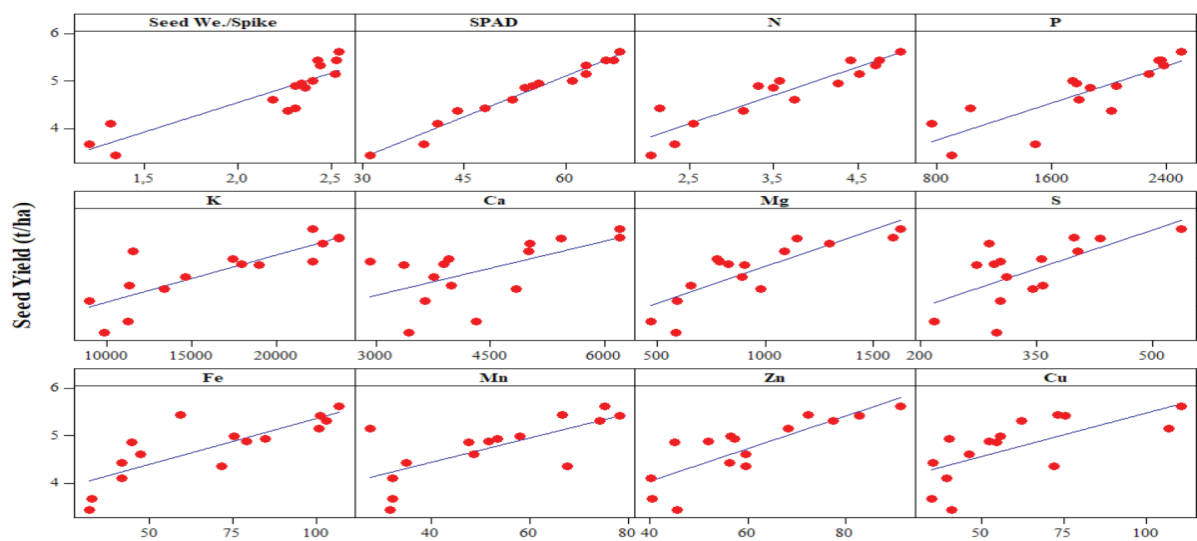
**Seed Yield = 1.95 + 0.170 x Seed We./Spike + 0.0424 x SPAD + 0.023 x N - 0.000106 x P - 0.000002 x K - 0.000041 x Ca + 0.000520 x Mg + 0.00051 x S + 0.00392 x Fe + 0.00273 x Mn - 0.0080 x Zn - 0.00199 x Cu. R<sup>2</sup>= 96.4 %**

Even though effects of each characters were determined as insignificant, cumulative effects of characters on seed yield was found to be significant at 1%. Seed yield could be forecasted as

**Seed Yield = 1.95 + 0.170 x Seed We./Spike + 0.0424 x SPAD + 0.023 x N - 0.000106 x P - 0.000002 x K - 0.000041 x Ca + 0.000520 x Mg + 0.00051 x S + 0.00392 x Fe + 0.00273 x Mn - 0.0080 x Zn - 0.00199 x Cu. R<sup>2</sup>= 96.4 %**

As already explained above, although there are specific

metabolic events in which minerals are effective, they show similar effects in many metabolic events. They therefore have a holistic effect in metabolic events. This analysis confirms this situation. Besides, the relationship between seed yield and plant characters was seen Figure 1. Almost linear relationship occurred between plant characters and seed yield. This linear effects were more specific in SPAD, M, P, K, Mg, Mn and Zn.

**Figure 1.** The relationship between seed yield and plant characters.

Conditional formatting is an Excel feature that can be used to format inspected characters according to their contents. Conditional formatting groups the attributes of the table based on their similarity and differences quickly and emphasize colors [5]. Conditional formatting table in genotypes and plant characters was given in Table 4.

**Table 4.** Conditional formatting table in genotypes and plant characters.

	Se.Y.	Se.W/S.	SPAD	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	Mean
Alpu	4.36	2.27	44	3.14	2011.26	13380.67	4843.21	976.97	344.65	71.76	67.69	59.45	71.74	1683.17
Atay	5.43	2.43	66	4.75	2357.22	23675.22	5427.12	1143.76	432.13	101.32	78.32	82.67	75.33	2573.21
Bezostaja	5.62	2.54	68	5.01	2499.32	22164.30	6197.50	1623.87	537.04	107.04	75.28	91.23	110.66	2575.95
Harmankaya	5.32	2.44	63	4.71	2381.36	22717.01	5021.54	1295.23	287.35	103.34	74.23	77.34	62.11	2468.84
Sönmez	4.89	2.31	55	3.30	2048.58	17943.23	3891.34	824.55	293.66	79.32	51.78	51.76	52.12	1946.30
Sultan	4.94	2.34	56	4.26	1763.34	22133.30	2915.44	786.45	301.76	84.84	53.38	57.11	39.92	2169.47
Müfitbey	5.15	2.52	63	4.52	2270.00	11546.52	5005.17	1082.65	402.78	101.04	27.61	68.23	106.73	1591.22
Çetinel	3.43	1.35	31	2.03	896.34	9842.34	3426.12	582.35	296.44	31.85	31.72	45.47	40.57	1171.62
İkizce	4.43	2.31	48	2.13	1024.22	11346.31	3983.12	653.54	357.76	41.45	34.84	56.12	35.21	1353.03
Nacibey	4.86	2.36	54	3.49	1864.76	18976.45	3365.65	900.43	271.76	44.56	47.66	44.74	54.28	1971.92
Es 26	5.44	2.53	67	4.41	2345.65	23670.87	6205.42	1587.61	397.43	59.33	66.65	72.18	73.19	2658.29
Gerek	3.67	1.21	39	2.31	1478.23	11256.23	4315.34	465.65	215.54	32.45	32.11	40.22	34.65	1378.20
Tosunbey	4.61	2.19	52	3.75	1788.34	14657.12	3748.26	886.9	310.42	47.33	48.56	59.43	46.13	1665.77
Yıldırım	4.1	1.32	41	2.54	756.98	8964.76	3634.26	587.34	301.43	41.54	32.15	39.99	39.32	1111.29
Palandöken 97	4.99	2.4	61	3.56	1745.76	17458.76	3954.76	774.34	355.32	75.34	57.99	56.28	55.73	1892.79
Mean	4.75	2.17	53.87	3.59	1815.42	16648.87	4395.62	944.78	340.36	68.17	52.00	60.15	59.85	1880.74

In plant characters, Atay, Bezostaja, Harmankaya and Es 26 participated one group; Müfitbey, Gerek and Tosunbey joined same group. Sönmez, Palandöken 97 and Nacibey created another group. Yıldırım and İkizce had one group. Moreover, Seed yield, SPAD, N, P, created same group. Ca, Mg, Fe, Mn and Zn formed same group.

The principal component and classification analysis is used to solve relationship between characters examined.

This method analyze two types of analyses depending upon type of data standardized or centered. This method makes diagonal analysis of the symmetric matrix: correlation or covariance. This method has also the graphic analysis providing case for the classification of characters [8; 20; 22]. Eigen values and total variances in principal component and classification analysis on plant characteristics were given in Table 5.

**Table 5.** Eigen values and total variances in principal component and classification analysis.

	Factor <sub>1</sub>	Factor <sub>2</sub>	Factor <sub>3</sub>	Factor <sub>4</sub>	Factor <sub>5</sub>	Factor <sub>6</sub>	Factor <sub>7</sub>
<b>Eigenvalue</b>	9.7238	1.2178	0.6797	0.4237	0.3594	0.2269	0.1414
<b>%Total Variance</b>	74.798	9.368	5.228	3.259	2.765	1.745	1.088
<b>Cumulative %</b>	74.798	84.167	89.395	92.655	95.420	97.166	98.254
	Factor <sub>8</sub>	Factor <sub>9</sub>	Factor <sub>10</sub>	Factor <sub>11</sub>	Factor <sub>12</sub>	Factor <sub>13</sub>	
<b>Eigenvalue</b>	0.099	0.060	0.045	0.009	0.008	0.003	
<b>%Total Variance</b>	0.765	0.463	0.352	0.070	0.064	0.029	
<b>Cumulative %</b>	99.019	99.482	99.835	99.905	99.970	100.000	
	Factor <sub>1</sub>	Factor <sub>2</sub>	Factor <sub>3</sub>	Factor <sub>4</sub>	Factor <sub>5</sub>	Factor <sub>6</sub>	Factor <sub>7</sub>
<b>SeedYield</b>	-0,945	-0,194	-0,162	0,111	0,092	0,080	-0,053
<b>SeedWe./Spike</b>	-0,834	-0,231	-0,294	0,229	0,130	-0,296	-0,026
<b>SPAD</b>	-0,932	-0,166	-0,178	0,081	0,138	0,139	-0,126
<b>N</b>	-0,936	-0,147	-0,110	-0,154	-0,020	0,188	0,101
<b>P</b>	-0,914	-0,115	0,013	-0,306	0,130	-0,143	0,016
<b>K</b>	-0,804	-0,496	0,236	0,069	0,006	0,132	0,075
<b>Ca</b>	-0,763	0,473	0,342	-0,083	0,165	0,006	-0,199
<b>Mg</b>	-0,926	0,137	0,191	0,017	0,193	0,027	0,129
<b>S</b>	-0,754	0,498	-0,068	0,365	-0,156	0,044	0,079
<b>Fe</b>	-0,857	-0,043	-0,246	-0,222	-0,364	-0,010	-0,098
<b>Mn</b>	-0,794	-0,258	0,449	0,055	-0,222	-0,177	0,039
<b>Zn</b>	-0,934	0,172	0,097	0,067	-0,162	0,037	-0,086
<b>Cu</b>	-0,813	0,479	-0,192	-0,181	0,029	-0,067	0,156
	Factor <sub>8</sub>	Factor <sub>9</sub>	Factor <sub>10</sub>	Factor <sub>11</sub>	Factor <sub>12</sub>	Factor <sub>13</sub>	
<b>SeedYield</b>	0.056	0.082	-0.018	-0.008	0.030	-0.042	
<b>SeedWe./Spike</b>	-0.072	-0.007	0.019	0.014	-0.031	0.001	
<b>SPAD</b>	0.080	0.004	-0.049	-0.028	0.002	0.038	
<b>N</b>	-0.078	-0.010	-0.101	0.037	-0.035	-0.004	
<b>P</b>	0.039	-0.123	-0.017	0.016	0.045	0.001	
<b>K</b>	0.058	-0.075	0.121	-0.009	-0.022	-0.004	
<b>Ca</b>	0.040	0.007	0.017	0.023	-0.030	-0.008	
<b>Mg</b>	-0.120	0.116	0.054	0.011	0.028	0.018	
<b>S</b>	0.084	-0.065	-0.004	0.032	0.017	0.004	
<b>Fe</b>	0.009	0.066	0.081	0.019	0.004	0.008	
<b>Mn</b>	0.069	0.062	-0.086	-0.011	-0.003	0.004	
<b>Zn</b>	-0.199	-0.079	-0.011	-0.042	0.009	-0.007	
<b>Cu</b>	0.077	0.015	0.011	-0.049	-0.026	-0.005	

First factor shows the highest largest eigenvalue (9.7238) covers almost 74.798% of the total variance. The second factor assign the eigenvalue of 1.2178 has 9.368% of the total variance. With 84.167% of cumulative variance, Factor<sub>1</sub> and Factor<sub>2</sub> explain most of total variance in the study. Table 5 gives that seed weight per spike (-0.945), SPAD (-0.932), N (-0.936), P (-0.914), K (-0.804), Mg (-0.926), Fe (-0.857),

Mn (-0.794), Zn (-0.934) and Cu (-0.813) in Factor<sub>1</sub>; Ca (0.473) and S (0.498) in Factor<sub>2</sub> had the highest contributions. Seed weight per spike, SPAD, N, P, K, Mg, Fe and Zn in Factor<sub>1</sub>; Cu and Ca in Factor<sub>2</sub> were found as the best contributors. Rotated loadings of data in bread wheat were given in Figure 2.

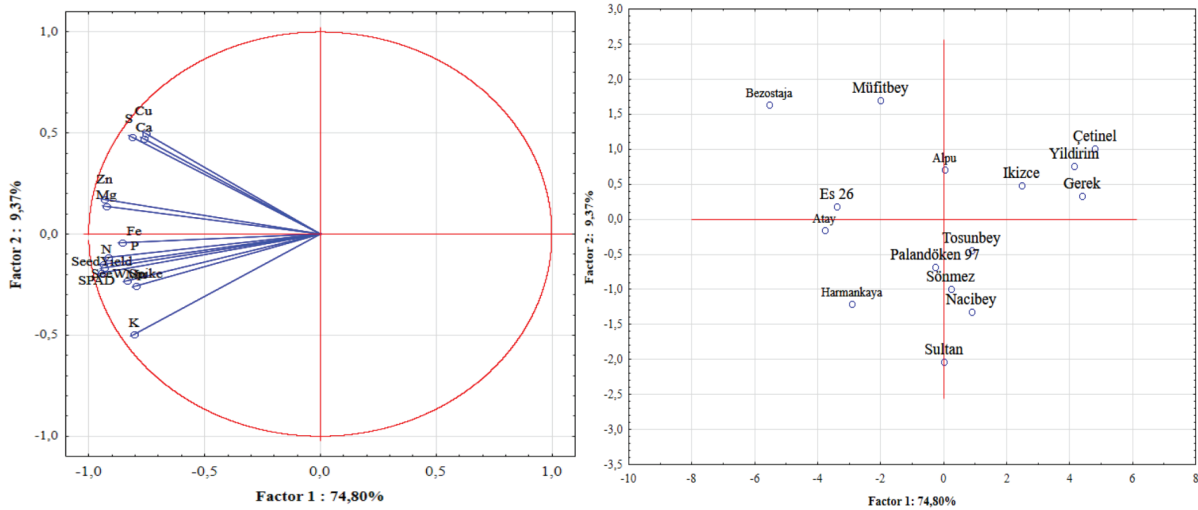
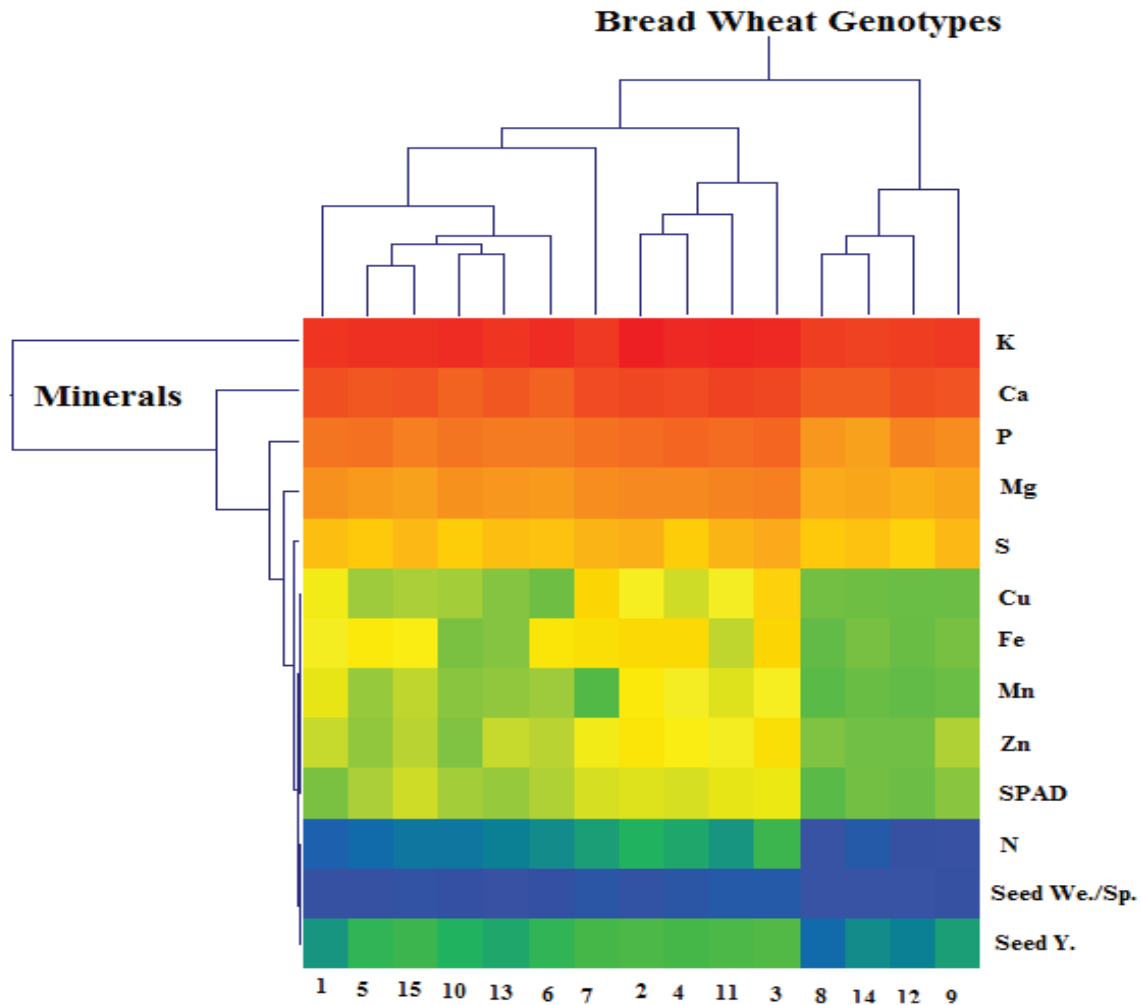


Figure 2. Rotated loadings in data of bread wheat.

Seed weight per spike, SPAD, N, P, Fe, Mn, Mg and Zn had the best contribution and the formed the smallest angle with Factor<sub>1</sub> and S had also best contribution with smallest angle with Factor<sub>2</sub> (Table 5 and Figure 2). The total variability of Factor<sub>1</sub> was primarily influenced by Bezostaja (-5.540), Çetinel (4.795), Es 26 (-3.396), Gerek (4.385) and Yıldıırım (4.144). Factor<sub>2</sub> was influenced by Sultan (-2.031), Müfitbey (1.702) and Harmanakaya (1.640). Bezostaja and Çetinel commonly explained Factor<sub>1</sub> (content of seed weight per spike, SPAD, N, P, Fe, Mn, Mg and Zn), and Sultan mostly explained Factor<sub>2</sub> (content of S) (Figure 2). Principal component and classification analysis gave opportunity to make a group genotypes and plant characters.

Cluster analysis is a multivariate statistical analysis technique used to divide individuals or objects into clusters or groups according to their similarities. The clustering analysis results in the clusters in which the units in the same cluster are compared to each other more closely than the units in the other clusters do. In other words, cluster analysis is a

group of multivariate techniques in which the main objective individual groups are grouped based on their characteristic features. The clustering analysis is a set of objects that are very similar within the cluster and will be different between the clusters [19; 21; 24]. The double dendrogram is also a unit of the clustering analysis. Two-way clustering is possible in this analysis. In this analysis, two different categories of characters are related to each other [18]. Double dendrogram analysis of bread wheat genotypes for plant characteristics was given in Figure 3. Seed weight per spike, seed yield and N formed same group; SPAD, Zn, Mn, Fe and Cu joined another group. S, Mg, P, Ca and K occupied one group. Besides, bread wheat genotypes showed different groups in yield components and minerals. Genotypes forms three distinct groups. Alpu, Sönmez, Palandöken 97, Nacibey, Tosunbey, Sultan and Müfitbey created same group. Atay, Harmanakaya, Es 26 and Bezostaja took part in one group. Last group covered Çetinel, Yıldıırım, Gerek and İkizce.



1- Alpu, 2-Atay, 3-Bezostaja, 4-Harmankaya, 5-Sörmez, 6-Sultan, 7-Müftbey- 8-Çetinel, 9-İkizce, 10-Nacibey, 11-E s 26, 12-G erek, 13-Tosurbey, 14-Yıldırım, 15-Palandöken 97

Figure 3. Double dendrogram analysis of bread wheat genotypes for plant characteristics.

Successful and strong seed development and breeding could be successful when they use effective and powerful plant characters and statistical programs. In this case, superior genotypes could be developed. Multiple regression, conditional formatting, principal component and classification and cluster analyses revealed that though some minerals are highly effective on some processes, their behavior in genotypes are almost similar and effect of them is integrative. Effectiveness of minerals are under genotype x environment interaction and mainly under genetic control. Seed weight per spike, SPAD, N, P, are closely related to seed yield; Fe, Mn, Zn and Cu are also related to photosynthesis. Besides, Atay, Bezostaja, Harmankaya and Es 26 were determined as better genotypes in yield components and mineral content. Determining levels and changes on minerals in bread wheat could strongly make increases in success of breeding programs.

## REFERENCES

- [1] Acevedo E, Conesa AP, Monneveux P, Srivastava JP (1989) Physiology-Breeding of Winter Ceceals for Stressed Mediterranean Environments. INRA Editions, Versailles Cedex, France.
- [2] Andales AA, Gren TR, Ahuja LR, Erksine RH, Peterson GA (2007) Temporally stable patterns in grain yield and soil water on a dry land catena. *Agricultural Systems*. 94:119–127.
- [3] Andriolo JI, Erpen L, Cardoso FI, Cocco C, Casagrande GS, Janisch DI (2011) Nitrogen Levels in the Cultivation of Strawberries in Soilless Culture. *Horticultura Brasileira*, 29: 516-519.
- [4] Anonymous (2013) Research on Bread Waste in Turkey, T.M.O. 2nd Press, Ankara.
- [5] Anonymous (2016) <https://www.actx.edu/web/files/filecabinet/folder7/Excel>
- [6] Ashraf M, Harris PJC (2004) Potential biochemical indicators of salinity tolerance in plants. *Plant Science* 166, 3-16.
- [7] Bonfil DJ, Kafkafi U (2000) Wild wheat adaptation in different soil ecosystems as expressed in the mineral concentration of the seeds. *Euphytica* 114, 123-134.
- [8] Borgognone MG, Bussi J, Hough G (2001) Principal Component Analysis: Covariance or Correlation Matrix. *Food Quality and Preference*, 12: 323-326
- [9] Bothwell JHF, Ng CKY (2005) The evolution of  $Ca^{2+}$  signalling in photosynthetic eukaryotes. *New Phytol.* 166: 21-38.
- [10] Ceylan A (1994) Field Crop Production. İzmir: Ae-

gean University Press. 520 p.

[11] Cakmak I (2008) Enrichment of cereal grains with zinc: agronomic or genetic biofortification. *Plant and Soil* 302: 1-17.

[12] Doğan, R., 2002: Determination of Grain Yield and Some Agronomic Characters of Bread Wheat (*Triticum aestivum* L.) Lines. *Journal of Agricultural Faculty of Uludağ University* 16 (2): 149-158.

[13] Frank IE, Kowalski BR (1984) Prediction of Wine Quality and Geographic Origin from Chemical Measurements by Partial Least-Squares Regression Modeling, *Analytica Chimica Acta*, 162: 241-251.

[14] Frank IE, Friedman JH (1993) A Statistical View of Some Chemometrics Regression Tool, *Technometrics*, 35: 109-135

[15] Garcia del Moral LF, Rharrabti Y, Villegas D, Royo C (2003) Evaluation of grain yield and its components in durum wheat under Mediterranean conditions: An ontogenic approach. *Agron. J.* 95(2): 266-274.

[16] Genç İ (1977) Physiological and Morphological Basis in Cereals. Çukurova Üniv. Agric. Fac. Press.

[17] Kouakou, B., Alexis KSS, Adjehi D, Marcelin DK, Dago G (2008) Biochemical changes occurring during germination and fermentation of millet and effect of technological processes on starch hydrolysis by the crude enzymatic extract of millet. *Journal of Applied Science Research* 4: 1502-1510.

[18] Handl S, Dowd SE, Garcia-Mazcorro JF, Steiner JM, Suchodolski JS (2011) Massive parallel 16S rRNA gene pyrosequencing reveals highly diverse fecal bacterial and fungal communities in healthy dogs and cats. *FEMS Microbiol. Ecol.*, 76: 301–310.

[19] Johnson AR, Wichern DW (1992) Applied multivariate statistical analysis. International Editions, New Jersey: Prentice Hall.

[20] Jolliffe IT (2002) Principal Component Analysis. 2nd. Ed. Springer, ISBN 0-387-95442-2, New York, USA

[21] Kaufman L, Rousseeuw PJ (1990) Finding groups in data: An introduction to cluster analysis, New York: John Wiley and Sons.

[22] Krzanowski WJ (2000) Principal of Multivariate Analysis, A User's Perspective. Oxford, ISBN 0-19-850708-9, New York, USA.

[23] Lambers H, Cramer MD, Shane MW, Wouterlood M, Poot P, Veneklass EJ (2003) Structure and Functioning of Cluster Roots and Plant responses to Phosphate Deficiency. *Plant and Soil*, 248: 9-19.

[24] Marriot FHC (1971) Practical problems in a method of cluster analysis. *Biometrics*, 27: 501-514.

[25] McIntosh GH, Noakes M, Royle PJ, Foster PR (2003) Whole-grain rye and wheat foods and markers of bowel health in overweight middle-aged men. *American J. Clinical Nutrition*, 77/4: 967-974

[26] Marschner H (1995) Mineral Nutrition of Higher Plants. Academic Press, 657-680.

[27] Mertens D (2005) AOAC official method 975.03. in: W. Horwitz, G. W. Latimer (eds) *Metal in Plants and Pet Foods. Official Methods of Analysis*, 18th edn. Maryland, USA, pp 3-4.

[28] Özdamar K (1999) Statistical Data Analysis with Computer Programs, 2nd Edn. Vol: I-II, Eskisehir, Turkey.

[29] Roberts TL (2010) Nutrient best management practices: Western perspectives on global nutrient stewardship. *Proceedings of the 19th World Congress of Soil Science: Soil solutions for a changing world*, 172-175.

[30] Singhl BK, Shaner DL (1995) Biosynthesis of branched chain amino acids: From test tube to field, *The Plant Cell*, 7: 935-944.

[31] Varga B, Svecnjak Z, Pospisi A (2002) Grain yield and yield components of winter wheat grown in two management systems. *Die Bodenkultur* 51(3): 145-150.