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

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**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 benefical 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% CaCO3, 217.4 mmol $kg^{-1}$ $P_2O_5$, 294.24mmol $kg^{-1}$ $K_2O$, 6.21 pH, 2.04% organic matter and 2.28 dS $m^{-1}$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 Paremeters | Years | October | November | December | January | February | March | April | May | June | July | Total/Av. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Max.Temp.** | **2014-15** | 29.2 | 21.6 | 17.5 | 18.0 | 20.9 | 22.2 | 23.0 | 30.3 | 32.0 | 37.9 | 25.3 |
| | **Long-Term** | 18.4 | 1.5 | 15.7 | 13.6 | 18.5 | 20.6 | 26.1 | 30.2 | 36.7 | 37.5 | 23.8 |
| **Min.Temp.** | **2014-15** | -0.5 | -7.0 | -8.0 | -14.5 | -17.0 | -7.9 | -3.8 | 0.2 | 8.7 | 10.5 | -3.9 |
| | **Long-Term** | -7.2 | -10.5 | -7.2 | -18.2 | -11.3 | -8.3 | -5.3 | -4.9 | 4.5 | 6.7 | -6.1 |
| **Av..Temp.** | **2014-15** | 14.5 | 6.0 | 4.6 | 1.5 | 4.9 | 5.9 | 9.2 | 15.2 | 18.1 | 21.9 | 10.2 |
| | **Long-Term** | 11.4 | 7.3 | 4.6 | -3.6 | -5.6 | 6.3 | 7.7 | 15.4 | 22.7 | 23.3 | 8.9 |
| **Tot.Rainfall** | **2014-15** | 9.0 | 29.5 | 65.1 | 36.0 | 42.8 | 32.6 | 23.9 | 20.7 | 79.0 | 7.4 | 346.0 |
| | **Long-Term** | 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 $ha^{-1}$ (half at sowing stage and half at tillering stage) and 60 kg $ha^{-1}$ $P_2O_5$ (once at sowing). Seeds were planted at the second week of September with 500 seed/ $m^2$ rate. Experimental design was randomized complete block design with three replications. Plot size was 6 m/1.2 m (7.2 $m^2$). 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 contents 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 |
|---|---|---|---|---|---|---|---|
| **SeedYield** | 4.74±0.62 | 3.43 | 5.62 | **Mg** | 944.8±337.1 | 465.7 | 1623.9 |
| **SeedWe./Spike** | 2.16±0.44 | 1.21 | 2.54 | **S** | 340.4±75.7 | 215.5 | 537.0 |
| **SPAD** | 53.87±10.92 | 31.00 | 68.00 | **Fe** | 68.17±26.43 | 31.85 | 107.04 |
| **N** | 3.59±0.97 | 2.03 | 5.01 | **Mn** | 52.00±17.03 | 27.61 | 78.32 |
| **P** | 1815±540 | 757 | 2499 | **Zn** | 60.15±14.94 | 39.99 | 91.23 |
| **K** | 16649±5209 | 8965 | 23675 | **Cu** | 59.85±23.20 | 34.65 | 110.66 |
| **Ca** | 4396±979 | 2915 | 6205 | **Mean** | 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 | $F_{value}$ |
|---|---|---|---|---|
| **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.** $R^2$= 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.*** $R^2$*= 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.

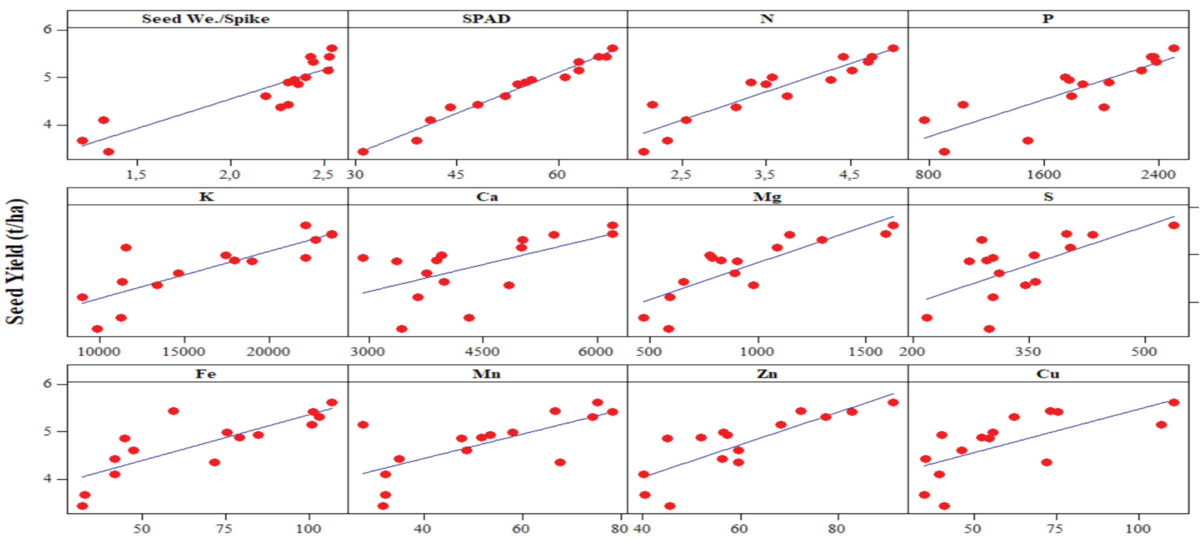



**Figure 1.** The relationship between seed yield and plant characters.

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$_1$ | Factor$_2$ | Factor$_3$ | Factor$_4$ | Factor$_5$ | Factor$_6$ | Factor$_7$ |
|---|---|---|---|---|---|---|---|
| **Eigenvalue** | 9.7238 | 1.2178 | 0.6797 | 0.4237 | 0.3594 | 0.2269 | 0.1414 |
| **%Total Variance** | 74.798 | 9.368 | 5.228 | 3.259 | 2.765 | 1.745 | 1.088 |
| **Cumulative %** | 74.798 | 84.167 | 89.395 | 92.655 | 95.420 | 97.166 | 98.254 |
| | **Factor$_8$** | **Factor$_9$** | **Factor$_{10}$** | **Factor$_{11}$** | **Factor$_{12}$** | | **Factor$_{13}$** |
| **Eigenvalue** | 0.099 | 0.060 | 0.045 | 0.009 | 0.008 | | 0.003 |
| **%Total Variance** | 0.765 | 0.463 | 0.352 | 0.070 | 0.064 | | 0.029 |
| **Cumulative %** | 99.019 | 99.482 | 99.835 | 99.905 | 99.970 | | 100.000 |
| | **Factor$_1$** | **Factor$_2$** | **Factor$_3$** | **Factor$_4$** | **Factor$_5$** | **Factor$_6$** | **Factor$_7$** |
| **SeedYield** | -0,945 | -0,194 | -0,162 | 0,111 | 0,092 | 0,080 | -0,053 |
| **SeedWe./Spike** | -0,834 | -0,231 | -0,294 | 0,229 | 0,130 | -0,296 | -0,026 |
| **SPAD** | -0,932 | -0,166 | -0,178 | 0,081 | 0,138 | 0,139 | -0,126 |
| **N** | -0,936 | -0,147 | -0,110 | -0,154 | -0,020 | 0,188 | 0,101 |
| **P** | -0,914 | -0,115 | 0,013 | -0,306 | 0,130 | -0,143 | 0,016 |
| **K** | -0,804 | -0,496 | 0,236 | 0,069 | 0,006 | 0,132 | 0,075 |
| **Ca** | -0,763 | 0,473 | 0,342 | -0,083 | 0,165 | 0,006 | -0,199 |
| **Mg** | -0,926 | 0,137 | 0,191 | 0,017 | 0,193 | 0,027 | 0,129 |
| **S** | -0,754 | 0,498 | -0,068 | 0,365 | -0,156 | 0,044 | 0,079 |
| **Fe** | -0,857 | -0,043 | -0,246 | -0,222 | -0,364 | -0,010 | -0,098 |
| **Mn** | -0,794 | -0,258 | 0,449 | 0,055 | -0,222 | -0,177 | 0,039 |
| **Zn** | -0,934 | 0,172 | 0,097 | 0,067 | -0,162 | 0,037 | -0,086 |
| **Cu** | -0,813 | 0,479 | -0,192 | -0,181 | 0,029 | -0,067 | 0,156 |
| | **Factor$_8$** | **Factor$_9$** | **Factor$_{10}$** | **Factor$_{11}$** | **Factor$_{12}$** | | **Factor$_{13}$** |
| **SeedYield** | 0.056 | 0.082 | -0.018 | -0.008 | 0.030 | | -0.042 |
| **SeedWe./Spike** | -0.072 | -0.007 | 0.019 | 0.014 | -0.031 | | 0.001 |
| **SPAD** | 0.080 | 0.004 | -0.049 | -0.028 | 0.002 | | 0.038 |
| **N** | -0.078 | -0.010 | -0.101 | 0.037 | -0.035 | | -0.004 |
| **P** | 0.039 | -0.123 | -0.017 | 0.016 | 0.045 | | 0.001 |
| **K** | 0.058 | -0.075 | 0.121 | -0.009 | -0.022 | | -0.004 |
| **Ca** | 0.040 | 0.007 | 0.017 | 0.023 | -0.030 | | -0.008 |
| **Mg** | -0.120 | 0.116 | 0.054 | 0.011 | 0.028 | | 0.018 |
| **S** | 0.084 | -0.065 | -0-004 | 0.032 | 0.017 | | 0.004 |
| **Fe** | 0.009 | 0.066 | 0.081 | 0.019 | 0.004 | | 0.008 |
| **Mn** | 0.069 | 0.062 | -0.086 | -0.011 | -0.003 | | 0.004 |
| **Zn** | -0.199 | -0.079 | -0.011 | -0.042 | 0.009 | | -0.007 |
| **Cu** | 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$_1$ and Factor$_2$ 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$_1$; Ca (0.473) and S (0.498) in Factor$_2$ had the highest contributions. Seed weight per spike, SPAD, N, P, K, Mg, Fe and Zn in Factor1; Cu and Ca in Factor 2 were found as the best contributors. Rotated loadings of data in bread wheat were given in Figure 2.

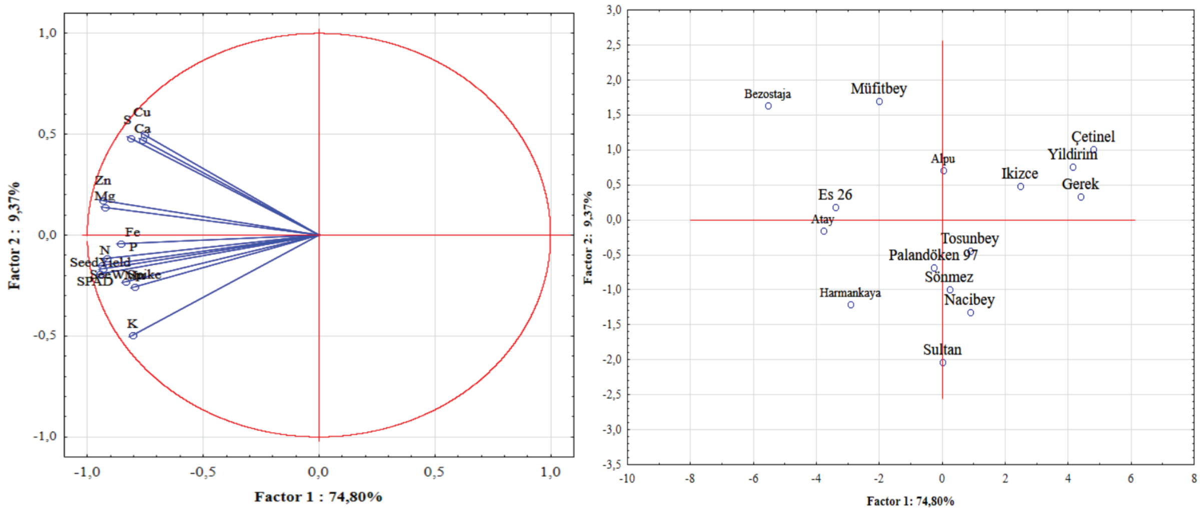
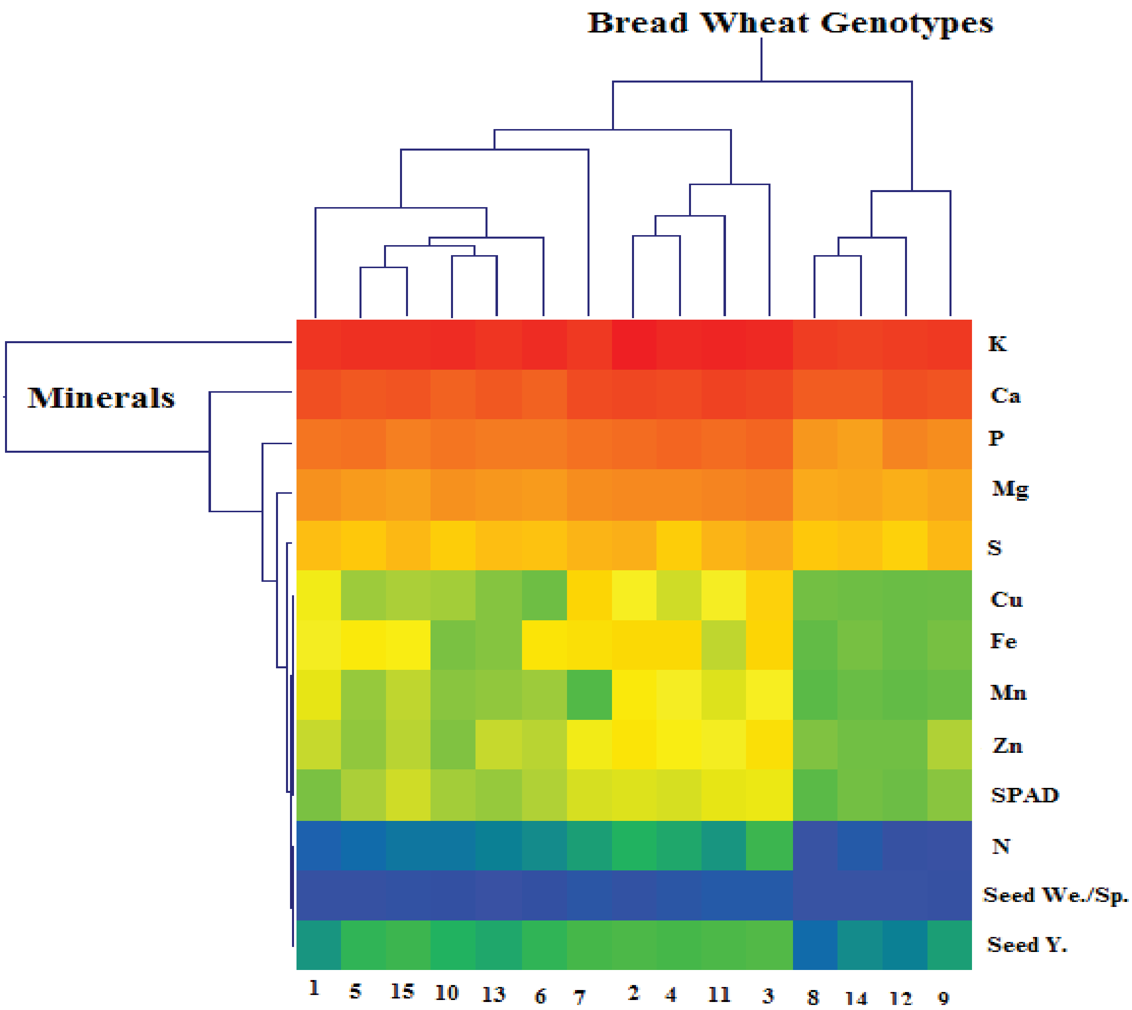



**Figure 2.** Rotated loadings in data of bread wheat.

Seed weight per spike, SPAD, N, P, Fe, Mn, Mg and Zn had the best contribution and the formed the smallest angle with $Factor_1$ and S had also best contribution with smallest angle with $Factor_2$ (Table 5 and Figure 2). The total variability of $Factor_1$ was primarily influenced by Bezostaja (-5.540), Çetinel (4.795), Es 26 (-3.396), Gerek (4.385) and Yıldırım (4.144). $Factor_2$ was influenced by Sultan (-2.031), Müfitbey (1.702) and Harmankaya (1.640). Bezostaja and Çetinel commonly explained $Factor_1$ (content of seed weight per spike, SPAD, N, P, Fe, Mn, Mg and Zn), and Sultan mostly explained $Factor_2$ (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 dendogram 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 dendogram 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, Harmankaya, Es 26 and Bezostaja took part in one group. Last group covered Çetinel, Yıldırım, Gerek and Ikizce.




1- Alpu, 2-Atay, 3-Bezostaja, 4-Harmankaya, 5-Sönmez, 6-Sultan, 7-Müfitbey- 8-Çetinel, 9-İkizce, 10-Nacibey, 11-Es 26, 12-Gerek, 13-Tosunbey, 14-Yıldırım, 15-Palandöken 97

**Figure 3.** Double dendogram 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.

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