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Determination of the Effects of Mineral on Seed Yield by Different Statistic Methods in Bread Wheat (*Triticum aestivum* L.) under Drought Conditions

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ABSTRACT

The purpose of this study is to determine the effect of minerals (N, P, K, Ca, Mg, S, Fe, Mn, Zn and Cu) on yield components by different statistical methods and this will help to understand efficiency of them in breeding programs. This study was carried out in the location of Eskişehir Osmangazi University, Faculty of Agriculture, in 2014-15 arid cropping seasons. Success mainly depends on power of effectiveness parameters used and statistical methods could be safely used to reveal effectiveness of parameters in the breeding programs. Results of correlation, cluster, principal component and conditional formatting analyses revealed that with in the efficiency limits (between the lowest dose and toxicity level) integrative effects of minerals were determined. This means that behavior of minerals among genotypes are mainly similar. some minerals called **MEPG** (N, P, K, Ca, S and Zn) are mostly effective in growth, others called **MECA** (Mg, Fe, Mn and Cu) are mostly effective in photosynthesis, and 0,767 unit increase **MEGA** and 0,481 unit in **MECA** increases result in 1 unit increase in the grain yield. Harmankaya, Sultan, Müfitbey and Tosunbey were found as higher performance and stabile bread wheat genotypes. To determine the changes of the minerals in the genotypes, are important for definig their effect on yield as well as the yield components. Obtained data will make contributions to the success of breeding programs that will be done in the future.

Keywords: Bread wheat, genotypes, mineral, yield components, statistical analyze methods

1. INTRODUCTION

Bread wheat (*Triticum aestivum* L.) is one of the most produced crop and plays vital role in human nutrition, trade and industry in the world. Human population has been increasing more and more but increase in acreage and production of bread wheat haven't been meeting this. With these characteristics, wheat also appears to be far from meeting the growing need of humans for nutrition in the near future. Extensive adaptation capability in different environments, resistance to pests and diseases make bread wheat popular in the world. Moreover, bread wheat is processed as source of starch, protein, minerals, vitamins etc. [11], [17], [45]. Meeting almost the need of 50% of carbohydrates, proteins and minerals in daily human nutrition, bread wheat occupy more than 50% of total food cereal production in the world [5], [44]. Like the other living organism, plants need certain minerals in enough level to act basic and important roles in physiological and biochemical processes. Studies reported that

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effectiveness and necessity of minerals for plants closely depend upon availability of minerals in plants and soil plant growth stage, health of biochemical processes, effect of genotype x environment interaction, effect of stress environment [10], [22], [29], [30], [37], [41].

Plant growth effects the grain yield which is one of the important characters and so subject to many factors. Knowledge on genetic association between yield and yield components might develop the effectiviness of breeding programs with determining and using key criteria for selecting wheat genotypes. Basic purpose of wheat breeding programs is improve novel cultivars which have high winter resistance, high yielding ability and finally resistance to drought and diseases. These novel cultivars have high importance for breeding of the world. Some essential plant characteristics such as grain yield and seed weight per spike are known as important ingredients in bread wheat breeding programs [1], [16], [34], [40], [48]. As well as knowing the minerals that are effective in the plant and their mode of action in plants will be of benefit to the development of highly efficient genotypes [10], [29], [30], [41]. Determining the effect of plant characteristics on yield helps to create opportunity developing novel genotypes. Different statistical methods including correlation, principal component, cluster, factor and conditional formatting analyses could be used to assess plant characteristics in breeding programs [4], [35], [38], [46]. The purpose of this study is to determine the effect of minerals (N, P, K, Ca, Mg, S, Fe, Mn, Zn and Cu) on yield components by different statistical methods and this will help to understand efficiency of them in breeding programs.

2. MATERIALS AND METHODS

This study was carried out in the location of Eskişehir Osmangazi University, Faculty of Agriculture, in 2014-15 arid cropping seasons. Soil in the experimental area was loamy texture (39,4% sand, 40,2% silt and 20,4% clay); 0.38% $CaCO_3$, 228,5mmol kg^{-1} P_2O_5, 307,44mmol kg^{-1} K_2O, 6,18 pH, 2,13% organic matter and 2,13dS m^{-1}electrical conductivity. Average, minimum and maximum temperatures, precipitations in 2014-15 and long term years in Eskişehir were given in Table 1. Precipitations in 2014-15 and long term years were 346,0 mm and 326,6 mm, respectively. 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. Fifteen bread wheat genotypes (Alpu, Atay, Bezostaja, Harmankaya, Sönmez, Sultan, Müfitbey, Çetinel, İkizce, Nacibey, Es 26, Gerek, Tosunbey, Yıldırım and Palandöken 97) were used.

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

Climatic Param.	Years	October	November	December	January	February	March	April	May	June	July	Tot./Av.
Max.Temp.	2014-15	29,2	21,6	17,5	18	20,9	22,2	23,0	30,3	32,0	37,9	25,3
	Long	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	-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	11,4	7,3	4,6	-3,6	-5,6	6,3	7,7	15,4	22,7	23,3	8,9
Tot. Rainf.	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	25,5	29,8	45,9	38,2	32,5	33	35,4	43,1	29,3	13,9	326,6

*Data of regional meteorology station, Eskişehir. Long term years (1970-2015)

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 (Ceylan 1994; Singhl et al. 2002), minerals as N, P, K, Ca, Mg, S, Fe, Mn, Zn and Cu [36] were evaluated. Samples for determining minerals were taken at tillering period, flowering period, maturity period and seed. The Kjeldahl method and a Vapodest 10 Rapid Kjeldahl Distillation Unit (Gerhardt, Konigs winter, Germany) were used to determine the total N content [13], [49]. 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 [36]. Correlation principal components clusters, factor and conditional formatting analysis were used to determine the effect of minerals on wheat yield. Minitab 16, SPSS 16 and Excel 2016 software programs were used.

3. RESULTS

In the study, minimum, maximum, mean values of plant characters and minerals in bread wheat genotypes were given in Table 2. Correlation analysis is the way of evaluation of relationship between two variables. It is commonly used in breeding programs to assess relationships between plant characters. Once coefficient reaches to zero, it means that two plant characters seem to be independent from each other.

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

Variable	Mean	Minimum	Maximum	Variable	Mean	Minimum	Maximum
SeedYield	3,16±0,39	2,39	3,81	Mg	896,5±231,3	569,8	1311,6
SeedWe./Spike	1,77±0,14	1,57	2,060	S	846,8±229,5	517,8	1148,9
N	3,00±0,45	2,13	3,73	Fe	80,93±6,94	70,45	91,22
P	1855,3±290,8	1464,4	2345,7	Mn	37,62±5,43	26,77	46,54
K	14793±4254	10855	25513	Zn	40,43±11,69	25,02	60,29
Ca	1116,6±180,2	859,6	1472,4	Cu	50,17±6,37	39,47	59,00

If coefficient closes to 1/-1, it means that two characters are negatively/positively related to each other [38], [20]. Correlation analysis on plant characteristics in bread wheat was given in Table 3.

Table 3. Correlation analysis on plant characteristics in bread wheat

	Seed Yield	Seed We./Spike	N	P
Seed We./Spike	0,855**			
N	0,767**	0,718**		
P	0,831**	0,677**	0,749**	
K	0,846**	0,787**	0,799**	0,826**
Ca	0,588*	0,565*	0,635*	0,670**
Mg	0,864**	0,753**	0,801**	0,877**
S	0,825**	0,633*	0,829**	0,916**
Fe	0,835**	0,795**	0,577*	0,621*
Mn	0,482ns	0,408ns	0,289ns	0,309ns
Zn	0,826**	0,804**	0,825**	0,848**
Cu	0,511*	0,364ns	0,158ns	0,446ns
	K	**Ca**	**Mg**	**S**
Ca	0,763**			
Mg	0,877**	0,798**		
S	0,863**	0,727**	0,943**	
Fe	0,734**	0,420ns	0,724**	0,699**
Mn	0,127ns	0,173ns	0,593*	0,367ns
Zn	0,897**	0,580*	0,847**	0,877**
Cu	0,400ns	0,138ns	0,471ns	0,443ns
	Fe	**Mn**	**Zn**	
Mn	0,582*			
Zn	0,786**	0,240ns		
Cu	0,561*	0,588*	0,479ns	

Once relationship between Mn and seed yield was insignificant, significant relationship (p<0,05) between Cu and seed yield was found. Cluster analysis is a hierarchical method, and the procedure forms its own set of closely related variables. In other words, the variables form groups according to the degree of closeness. In this method, the variables closest to each other are combined. The variables then join the same or different clusters according to their closeness [15], [27]. Cluster analysis in plant characteristics and bread wheat was given in Figure 1. Minerals have important roles in plants such as structural, enzymatic and osmotic processes [32]. Depending upon roles and efficiencies, concentrations of minerals expose changes, they increase and draw polynomial range during the developmental stage in plants [9]. Higher grain and biomass productions are direcly related to amount and availability of minerals in soil [7].

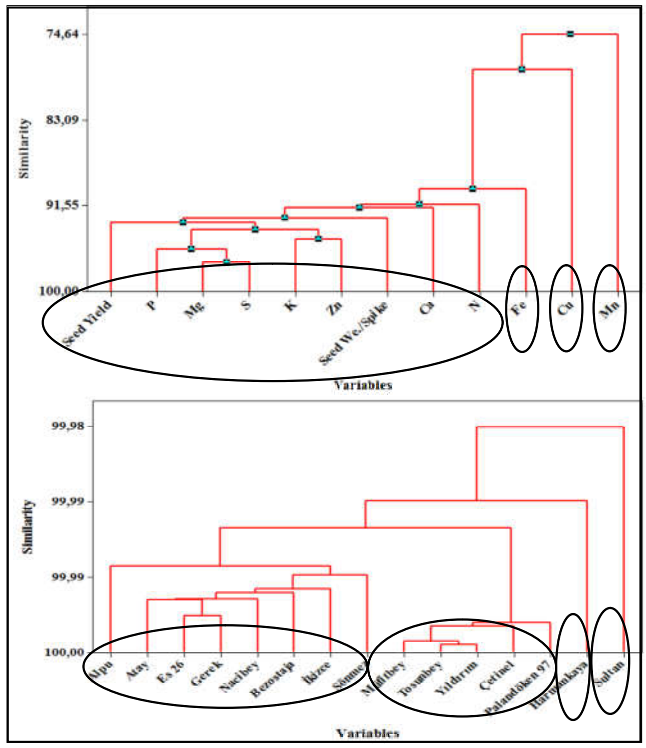


Figure 1. Cluster analysis in plant characteristics and bread wheat

Plant characteristics covered four groups; one big, three alone clusters. Fe, Cu and Mn occupied their separate groups; seed yield, P, Mg, S, K, Zn seed weight per spike, Ca and N joined big group. Besides, bread wheat genotypes were also divided into four clusters. Harmankaya and Sultan genotypes occupied separate groups. Alpu, Atay, Es 26, Gerek, Nacibey, Bezostaja, İkizce and Sönmez joined same group; Müfitbey, Tosunbey, Yıldırım, Çetinel and Palandöken 97 genotypes got into another group (Figure 1).

Nitrogen is the basic building block of the tissues in plants, and it is found in the structure of enzymes, organic and amino acids, nucleic acids, chlorophyll [3]. Phosphorus plays a role in the formation and storage of dry matter in generative development, such as flower, fruit and seed formation, in photosynthetic and metabolic events where energy transfer and storage events are required. phosphorus is found in the transfer and storage of energy in photosynthetic and metabolic events, flower, fruit and seed formation and development are found in the structure of various organic and amino acids [31]. Potassium plays a role in osmoregulation of the plant, in water intake, transport of metabolites and minerals, protein synthesis, regulation of stoma, cell division [33]. Calcium plant growth cell division is involved in many metabolic events such as ion uptake, and is involved in the formation of calmodulin, a Ca-linked protein in stress conditions, including drought, and serves as a signal for stress proteins in stress conditions [8].

Principal component analysis (PCA) is a mathematical model to give information for multivariate data with lower variables. Besides, principal component analysis assist to reveal covariance properties of variables. It makes variables into smaller numbers in this form [2], [12], [24]. Principal component analysis on plant characteristics in bread wheat, and bi plot analysis of plant characteristics and bread wheat genotypes was given in Table 4 and Figure 2. The first and the second principal components (PC1 and PC2) explained 80,9% of total variability with variance 8,3368 (PC1-69,5%, variance 1,3697 and PC2-11,4%, variance 0,6903). PC1 having similar sign, represented seed yield, seed weight pers pike, N, P, K, Mg, S and Zn. Moreover, PC2 had Mn and Cu (Table 4). In biplot analysis (Figure 2), PC1 shows performance abilities of parameters, while PC2 denotes variations/stabilities of parameters. In this instance, inside of triangle assign better performance and stability in parameters.

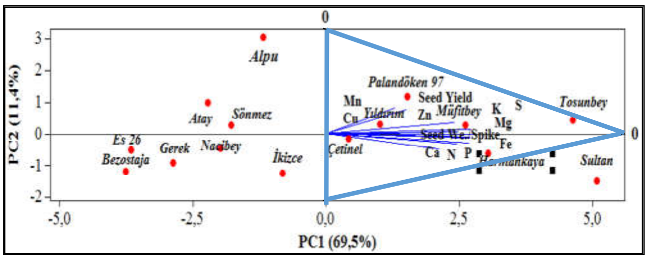


Figure 2. Biplot analysis of plant characteristics and bread wheat genotypes

Palandöken 97, Müfitbey, Yıldırım, Çetinel, Tosunbey and Harmankaya genotypes seemed to be high performance and stabile genotypes. Furthermore, all minerals (N, P, K, Ca, Mg, S, Na, Fe, Mn, Zn and Cu), seed yield and seed weight per spike in all bread wheat genotypes were showed well performance and stability.

Table 4. Principal component analysis on plant characteristics in bread wheat

Eigenvalues of The Correlations						
	PC_1	**PC_2**	**PC_3**	**PC_4**	**PC_5**	**PC_6**
Eigenvalue	**8,3368**	**1,3697**	0,6903	0,6127	0,3932	0,2039
Proportion	**0,695**	**0,114**	0,058	0,051	0,033	0,017
Cumulative	**0,695**	**0,809**	0,866	0,917	0,950	0,967
	PC_7	**PC_8**	**PC_9**	**PC_{10}**	**PC_{11}**	**PC_{12}**
Eigenvalue	0,1812	0,1179	0,0498	0,0248	0,0125	0,0072
Proportion	0,015	0,010	0,004	0,002	0,001	0,001
Cumulative	0,982	0,992	0,996	0,998	0,999	1,000
Variable	**PC_1**	**PC_2**	**PC_3**	**PC_4**	**PC_5**	**PC_6**
SeedYield	**0,325**	0,101	-0,025	-0,176	-0,001	0,173
SeedWe./Spike	**0,295**	0,045	-0,042	-0,531	-0,299	0,492
N	**0,293**	-0,237	0,189	-0,224	0,467	0,050
P	**0,312**	-0,093	-0,024	0,278	0,275	0,333
K	**0,321**	-0,212	-0,233	0,021	-0,190	-0,036
Ca	0,253	-0,342	0,351	0,301	-0,625	-0,032
Mg	**0,333**	-0,022	0,203	0,187	-0,053	-0,081
S	**0,324**	-0,093	0,067	0,285	0,277	-0,341
Fe	0,259	0,297	-0,228	-0,338	-0,194	-0,662
Mn	0,154	**0,600**	0,660	-0,060	0,081	-0,009
Zn	**0,322**	-0,071	-0,292	-0,074	0,235	-0,037
Cu	0,179	**0,565**	-0,407	0,478	-0,108	0,222
Variable	**PC_7**	**PC_8**	**PC_9**	**PC_{10}**	**PC_{11}**	**PC_{12}**
SeedYield	0,370	0,656	0,007	-0,481	-0,152	-0,023
SeedWe./Spike	-0,039	-0,289	0,037	0,034	0,356	0,284
N	-0,522	0,280	-0,319	0,174	0,154	-0,213
P	0,583	-0,241	-0,260	0,350	-0,045	-0,199
K	-0,120	0,259	0,394	0,551	-0,416	0,217
Ca	-0,125	-0,044	-0,393	-0,162	-0,120	-0,036
Mg	-0,022	-0,081	0,638	-0,099	0,366	-0,495
S	0,085	-0,026	0,023	-0,139	0,332	0,686
Fe	0,187	-0,062	-0,278	0,177	0,110	-0,222
Mn	-0,048	-0,104	0,056	0,139	-0,344	0,127
Zn	-0,220	-0,494	0,050	-0,453	-0,490	-0,063
Cu	-0,356	0,123	-0,168	0,011	0,149	-0,02

Palandöken 97, Müfitbey, Yıldırım, Çetinel, Tosunbey and Harmankaya genotypes seemed to be high performance and stabile genotypes. Furthermore, all minerals (N, P, K, Ca, Mg, S, Na, Fe, Mn, Zn and Cu), seed yield and seed weight per spike in all bread wheat genotypes were showed well performance and stability.

Magnesium is involved in metabolic events such as storage of photosynthetic energy, protein synthesis, nucleotide formation, and hydrolysis of many organic compounds [25], [33]. Sulfur influences product quality and product quality changes due to its various functions within the plant. It helps proteins, enzymes and vitamins function in plants. In plants, root hydraulic permeability, stoma openings and photosynthesis decrease in sulfur deficiency. Protein synthesis is reduced in sulfur deficiency. Chloroplast and chlorophyll synthesis decrease in sulfur deficiency [47]. Iron is the essential element of chlorophyll, which has vital importance in plant dry matter production, and functions in photosynthesis and associated enzymatic reactions in chlorophyll. Therefore, the development of young parts of the plant is closely related to the amount of Mg in dry matter production [28], [33]. Manganese is important for plant growth at a certain concentration. Trace element Mn plays a role in photosynthesis, respiration, enzyme activation and antioxydative metabolism [18], [39]. Zinc plays a role in the synthesis of carbohydrates, in structure of enzymes, in protein synthesis in membrane stability, photosynthesis and respiratory events, taking place in different metabolic events in plants [14], [42]. Copper is quite useful at a certain concentration in plant development. Copper plays a role in protein synthesis by entering into the structure of certain enzymes. Cu, acting as a signal for certain hormones, plays a role in mitochondrial respiration in photosynthesis [50].

Analysis of conditional formatting in Excel is a way of revealing better variants. When two or more conditional formatting rules are applied to a cell range, these rules are evaluated according to the order of priority listed (from top to bottom) in the dialog box [4]. Conditional formatting of plant characteristics and bread wheat genotypes were given in Table 5. Clear information in plant characteristics and bread wheat genotypes could be observed.

Table 5. Conditional formatting of plant characteristics and bread wheat genotypes

	Seed Yield	Seed We./Spike	N	P	K	Ca	Mg	S	Fe	Mn	Zn	Cu	Mean
Alpu	3,2	1,8	2,4	1663,2	11556,4	859,6	805,6	650,9	84,3	46,5	33,6	59,0	1313,9
Atay	3,2	1,8	2,9	1510,2	10975,0	872,4	600,4	517,8	79,7	38,3	28,9	49,5	1223,3
Bezostaja	2,8	1,7	2,1	1503,1	12159,2	1111,3	569,8	527,3	76,7	26,8	25,0	42,7	1337,4
Harmankaya	3,7	1,9	3,6	2224,1	19942,2	1004,0	1005,4	1128,2	91,2	33,9	60,3	49,8	2129,0
Sönmez	2,9	1,6	2,6	1961,0	12527,8	984,6	758,6	833,2	71,3	32,5	36,3	58,9	1439,3
Sultan	3,8	2,0	3,7	2223,5	25513,4	1472,4	1311,6	1148,9	87,4	34,4	59,7	54,4	2659,6
Müfitbey	3,4	1,8	3,3	2145,4	18456,2	1352,8	1155,3	1116,6	85,7	43,5	42,1	54,6	2038,4
Çetinel	3,2	1,7	3,4	1712,3	14654,9	1198,3	946,0	975,7	81,5	40,6	41,5	48,7	1642,3
İkizce	3,1	1,7	3,1	2004,3	12547,7	1146,9	899,9	841,4	74,6	37,7	33,9	39,5	1469,5
Nacibey	3,0	1,7	2,8	1687,6	11546,5	1104,9	821,5	746,9	73,2	38,8	27,6	42,5	1341,4
Es 26	2,4	1,6	2,6	1464,4	10854,7	992,4	582,4	574,4	75,9	31,9	31,7	45,5	1221,6
Gerek	2,7	1,7	2,9	1592,4	11346,3	1005,7	712,7	625,6	70,5	33,6	34,8	43,8	1289,4
Tosunbey	3,8	2,1	3,5	2345,7	18976,5	1398,3	1197,4	1108,4	89,5	44,6	58,4	56,2	2107,0
Yıldırım	3,2	1,9	3,1	1879,6	15642,3	1097,4	999,0	905,6	83,6	39,9	46,8	50,6	1729,4
Palandöken 97	3,3	1,8	3,0	1913,5	15196,5	1148,7	1082,7	1000,5	89,0	41,5	45,7	56,9	1715,3
Mean	3,2	1,8	3,0	1855,3	14793,0	1116,6	896,5	846,8	80,9	37,6	40,4	50,2	1643,8

Harmankaya, Sultan and Tosunbey in seed yield; Sultan and Tosunbey in seed weight per spike; Harmankaya, Sultan and Tosunbey in N and P; Sultan in K; Sultan and Tosunbey in Ca; Sultan, Müfitbey and Tosunbey in Mg; Harmankaya, Sultan, Müfitbey and Tosunbey in in S and Fe; Alpu, Müfitbey and Tosunbey in Mn, Harmankaya, Sultan and Tosunbey in Zn, Alpu, Sönmez, Tosunbey and Palandöken 97 in Cu had the best performances. As a means of plant characteristics, Harmankaya, Sultan, Müfitbey and Tosunbey were similar and had the best performance. In means of genotypes, bread wheat genotypes in seed yield, N, Ca, Mg, S, Fe, Mn and Cu gave similarities (Table 5).

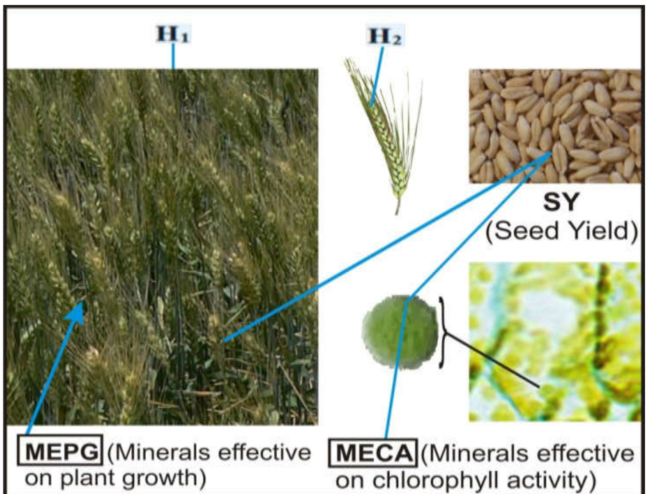
Factor analysis is a multivariate analysis technique that conceptually reduces to a smaller number of dimensions to facilitate the determination of relationships between variables known to be correlated. In other words, factor analysis facilitates the interpretation of the relationships between the concepts of the variables by revealing the factors belonging to the various variables related to each other. In other words, main aim in this technique is to allow summarize of covariance structure on fewer dimensions in data collected [6], [19], [26]. Mineral concentrations in plant are formed by genotype x environment interactions. Mineral uptake and level are significantly related to plant health. Increase in mineral uptake by plants causes to increase dry matter and mineral content in plant and relatively more yield occurs [41], [43]. Minerals are generally known to be effective in plants such as biochemical events, photosynthesis, and growth, resistance to stress conditions, osmotic regulation; Minerals such as Mg, Cu, Fe, Mn play an important role mainly in photosynthetic events [33]. Inspired by this, the minerals were examined in two groups; MEPG: Minerals effective on plant growth (N, P, K, Ca, S and Zn) and MECA: Minerals effective on chlorophyll activity (Mg, Fe, Mn and Cu) in the present study. Descriptive factor analysis of plan characteristics and minerals were given in Table 6.

Table 6. Descriptive factor analysis of plan characteristics and minerals in bread wheat

Characters	Loadings	% of Variance explained	Suggested Factor Name
FACTOR I	**5,860**	**56,396**	**MEPG:** Minerals effective on plant growth
K	0,938		
S	0,897		
N	0,881		
Zn	0,875		
P	0,860		
Ca	0,825		
FACTOR II	**1,353**	**24,067**	**MECA:** Minerals effective on chlorophyll activity
Cu	0,845		
Mn	0,820		
Fe	0,620		
Mg	0,760		
Cumulative variance			80,163
***KMO Measure of Sampling Adequacy**			0,70
FACTOR III	**1,829**	**91,430**	**Seed Weight per Spike**
Seed We./Spike	0,956		
Seed Yield	0,956		
Cumulative variance			91,430
***KMO Measure of Sampling Adequacy**			0,50

***KMO:** Kaiser Meyer Olkin Measure

Table 6 shows that two main factors are determined in parameters for 80,163% of total variability in the study. The first and the second factors accounted for 56,396% and 24,087%, respectively. The third factor covered 91,430% of total variability. The first factor gave 56,396% of total variability. The loading coefficients of the parameters are very close to each other, meaning that all parameters considered in **FACTOR I**, have almost equal effect on the total variance. So, all of them created **MEPG** and they (N, P, K, Ca, S and Zn) are all recommended. In the same way, all parameters (Mg, Fe, Mn and Cu) occupied for **MECA** with 24,067% of total variability in **FACTOR II** and all were suggested. Seed yield and seed weight per spike in **FACTOR III** had same loading coefficient covering 91,430% of total variability. Suggested character was seed weight per spike (Table 6). Kaiser Meyer Olkin (**KMO**) test measures the fitness of the working volume for factor analysis. The value of **KMO** is set at 0.70, which is usually greater than 0.50 in scientific research, indicating that the working volume is sufficient. In addition, in **FACTOR III**, the loading coefficients of the seed yield and seed weight per spike were the same. Seed yield (**SY**) as dependent variable, **MEPG** and **MECA** as independent variables were taken, when preparing the hypothesis, **H_1** and **H_2**, given below, and the regression analysis was constructed on this (Figure 3).



H_1: The effect of **MEPG** an **SY** is significant.
H_2: The effect of **MECA** an **SY** is significant.

Figure 3. Hypothesis preparing diagram

Multiple regression analysis should cover some assumptions such as; linear Relationship between the dependent variable and the independent variables; normal distribution in variables; no high correlations among independent variables; similar variance of error terms in independent variables [21], [23]. Multiple regression analysis in plant characteristics was given in Table 7. In the analysis, **MEPG** and **MECA** as independent variables seed yield (**SY**) as dependent variable were taken into consideration. Table 7 assigns that the effect of variables in total was significant at 1%. Moreover, the individual effects of **MEPG** and **MECA** on seed yield (**SY**) were also found to be significant (p <0,01). Formula explains that in 0,767 unit in increase **MEGA** and 0,481 unit in **MECA** increases result in 1 unit increase in the grain yield.

Table 7. Multiple regression analysis in plant characteristics in bread wheat genotypes

Independent Variables	Standardized Regression Coefficients	*t*	*P*
MEPG	0,767	6,243	<0,0001
MECA	0,481	3,916	0,002
R^2: 0,905, F: 27,156** (df: 2,12)			
SY (SeedYield): 0,767 x MEPG (Minerals effective on plant growth) + 0,481 x MECA (Minerals effective on chlorophyll activity)			

DISCUSSION

Success mainly depends on the power of effectiveness parameters used and the statistical methods could be safely used to reveal effectiveness of parameters in the breeding programs. Results of correlation, cluster, principal component and conditional formatting analyses revealed that with in the efficiency limits (between the lowest dose and toxicity level) integrative effects of minerals were determined. This means that behavior of minerals among genotypes are mainly similar. As known, levels and trenchancies of minerals are generally under the influence of the genotype x environment interaction, but considerably under genotypic influence [1], [16], [40]. Minerals as nutrients and/or effective ingredients on enzymatic processes play vital role on biochemical processes of plant growth and development of seed, therefore on yield. Some minerals have mainly important in growth, resistance to stress conditions, osmotic regulation; some have mainly photosynthesis [22], [33]. Factor analysis revealed that while some minerals called MEPG (N, P, K, Ca, S and Zn) are mostly effective for growth, others called MECA (Mg, Fe, Mn and Cu) are mostly effective on photosynthesis, and 0,767 unit in increase MEGA and 0,481 unit in MECA increases result in 1 unit increase in the grain yield. Harmankaya, Sultan, Müfitbey and Tosunbey were found as higher performance and stabile bread wheat genotypes. Correlation principal components clusters, factor and conditional formatting analysis revealed that N, P, K, S, Mg, Zn and Fe are closely related to plant yield. Factor analysis revealed the effect of minerals on yield with a different approach by divides minerals into MEGA and MEPG. Factor analysis determined the real effect shapes of mineral on yield. To determine the changes of the minerals in the genotypes their effect on yield as well as the yield components will increase the success of breeding programs. Evaluating plants for minerals, distribution and effect of minerals on seed yield could make breeding objectives more successful.

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