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Determination of Macro and Microelement Content of Some Virginia Market Type Peanut Varieties

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ABSTRACT

This study was designed to investigate the macro and micronutrient contents of 10 different Virginia market peanut cultivars under Kahramanmaras conditions for 2 years. Arıoğlu 2003, Halisbey, Osmaniye 2005, and Sultan varieties registered by Çukurova University, Batem 5025, Batem Cihangir, Brantley, NC-7, and Wilson varieties registered by Western Mediterranean Agricultural Research Institute, Brantley, NC-7, and Wilson varieties originating from the USA, and lastly Flower-22 variety originating from China were used as material. The research was conducted for two years (2018-2019) under main crop conditions in the experimental fields of Kahramanmaraş Sütçü İmam University, Faculty of Agriculture, Department of Field Crops, Application and Research Centre. It was observed that the cultivars were considerably different in terms of macro and micronutrient contents, and the variety-year interactions were significant. The two-year average results showed that the highest N, P, Fe, Ni, and Cu contents were obtained from the Flower-22 variety, the highest K and Ca contents were obtained from the Batem Cihangir variety, and the highest Zn contents were obtained from Sultan and Osmaniye-2005 varieties. Principal component biplot analyses (PCA) accounted for 52.7% of the relationships between the studied traits. As a consequence of the study, it was observed that P value had positive and important relationships with Fe, Zn, Mo and Cu contents, Ca content had positive and important relationships with Fe, Mn, Ni, and Cu, and K values had negative and important relationships with Fe, Mn and Ni.

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Bazı Virginia Pazar Tipi Yer Fıstığı Çeşitlerinin Makro ve Mikro Element İçeriklerinin Belirlenmesi

ÖZET

Bu çalışmada, Kahramanmaraş koşullarında 10 farklı Virginia Pazar tipi yerfıstığı çeşitlerinin makro ve mikro besin element içerikleri 2 yıl süreyle araştırılmıştır. Çukurova Üniversitesi tarafından tescil edilen Arıoğlu 2003, Halisbey, Osmaniye 2005 ve Sultan çeşitleri, Batı Akdeniz Tarımsal Araştırma Enstitüsü tarafından tescil edilen Batem 5025, Batem Cihangir, Brantley, NC-7 ve Wilson çeşitleri, ABD orijinli Brantley, NC-7 ve Wilson çeşitleri ve son olarak Çin orijinli Flower-22 çeşidi materyal olarak kullanılmıştır. Araştırma, Kahramanmaraş Sütçü İmam Üniversitesi Ziraat Fakültesi Tarla Bitkileri Bölümü Uygulama ve Araştırma Merkezinde ana ürün koşullarında iki yıl (2018-2019) süreyle yürütülmüştür. Çeşitlerin makro ve mikro besin element içerikleri bakımından önemli derecede farklı olduğu ve çeşit-yıl interaksiyonlarının önemli olduğu görülmüştür. İki yıllık ortalama sonuçlar, en yüksek N, P, Fe, Ni ve Cu içeriklerinin Flower-22 çeşidinden, en yüksek K ve Ca içeriklerinin Batem Cihangir çeşidinden, en yüksek Zn içeriklerinin ise Sultan ve Osmaniye-2005 çeşitlerinden elde edildiğini göstermiştir. Çalışılan özellikler arasındaki ilişkilerin %52,7'si temel bileşen biplot analizi

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(PCA) ile açıklanmıştır. Çalışma sonucunda, P değerinin Fe, Zn, Mo ve Cu içerikleriyle, Ca içeriğinin Fe, Mn, Ni ve Cu içerikleriyle, K değerlerinin ise Fe, Mn ve Ni ile negatif ve önemli ilişkilere sahip olduğu görülmüştür.

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INTRODUCTION

Peanut (*Arachis hypogaea* L.) is a one-year oilseed plant from the legume family, originating from South America, grown as a main and second crop. Peanut, which is widely used in human and animal nutrition, is an important oil plant that enriches the soil where it is grown with nitrogen (Arıoğlu, 2014). It is a legume plant grown in tropical and temperate climates (Ayoola & Adeyeye, 2012), emphasized due to its high protein content (27%-29%) and consumed worldwide due to its nutritive properties (Guo et al., 2020; Mattil et al., 1964; Zhang et al., 2020).

Peanut oil is superior to many vegetable oils in terms of flavor and durability. For this reason, it is consumed very much. Peanut varieties, which are grouped due to differences such as flavour, oil content, size, shape, and tolerance to diseases, are preferred for specific and special uses. Different varieties can be used for many uses, but the most preferred varieties are Spanish, Runner, Virginia, and Valencia (Woodroof, 1983). In spite of the fact that peanut is a legume plant, it is usually classified among oilseeds because of its very high oil content, rich in protein, fat, as well as fibre (Suchoszek-Lukaniuk et al., 2011). Nutritionally, peanut seeds are rich in oil, protein, niacin, fibre, magnesium, vitamins, manganese, and phosphorus (Davis & Dean, 2016; Fletcher & Shi, 2016). Peanut seeds are a rich source of minerals (phosphorus, calcium, magnesium, and potassium) and vitamins (E, K, and group B) (Arya et al., 2016; Grosso & Guzman, 1995; Kholief, 1987; Singh & Singh, 1991). Peanut is an important source of mineral elements for the nutritional requirements of humans and animals (Asibuo et al., 2008). In addition, studies conducted in Turkey have shown that different peanut genotypes exhibit significant differences in terms of yield and quality characteristics under various environmental conditions (Uçak et al., 2017).

Peanuts are an affordable and rich source of essential nutrients, including proteins, carbohydrates, fats, vitamins, minerals, and fiber. Often called the "poor man's protein," peanuts provide vital nutrients that support growth, energy, and disease prevention when consumed in sufficient amounts. They contain essential vitamins, metal ions for enzyme activity, and fatty acids that boost heart-healthy HDL cholesterol. Additionally, peanuts supply essential amino acids and carbohydrates, crucial for protein synthesis and energy production. Including peanuts in the diet can help prevent illness and promote overall health (Settaluri et al., 2012).

The chemical composition of peanut seeds, especially the macro (K, Ca, Mg, P) and micro (Fe, Zn, Cu, Mn) elements it contains, directly affects both the nutritional value when consumed as food and the germination ability, seedling development and seed quality when used as seed material (Fageria, 2009; Welch & Graham, 2004). In a study by Bakal & Arıoğlu (2021), agronomic and quality characteristics of different groundnut varieties were examined, and the effects of mineral composition on seed quality were emphasized. While nutrient deficiencies may lead to micronutrient deficiencies in terms of human health, the toxic accumulation of some elements may pose a health risk (White & Broadley, 2009). At the same time, adequate levels of minerals in the seed increase the vigor of the seed and make the young plant more resistant to stress conditions (Farooq et al., 2012). In this context, the determination of macro and micro elements in peanut seeds is of great importance for both nutritional security and quality seed production. The main objective of this research was to evaluate the macro and micro element values of different Virginia market peanut varieties for two years under Kahramanmaras conditions. For this purpose, ten different peanut cultivars were grown in the main crop production conditions for two years, and the mineral performances of the cultivars used in the study were determined by PCA and correlation analyses.

MATERIAL and METHOD

The experiment was established in Kahramanmaraş conditions within the main crop peanut growing season for two years (2018 and 2019). Kahramanmaraş is located in the Mediterranean Region on the coordinates of north latitude 37°35'40.77‘ and east longitude 36°48'51.43’.

Soil samples taken from the experimental area at 0-30 cm depth before planting were analyzed in the laboratories of Kahramanmaraş Sütçü Imam University, University-Industry-Public Cooperation Development Application and Research Center, and the results of these analyses are given in Table 1.

The soils of the test area have a clay loamy texture and are flat and nearly flat sloping. There is no salinity problem in the test area with high lime content. The phosphorus and potassium content is low, and the organic matter content is at a medium level. In addition, the pH value of the soil is 7.50, and the soil is basic (Table 1).

Table 1. Soil analysis (0-30 cm depth) results of the research area (*)
Tablo 1. Araştırma alanının toprak analiz (0-30 cm derinlik) sonuçları (*)

Location	Texture (% Sat.)	Salinity (%)	Organic Matter %	Lime CaCO3 (kg/da)	Phosphorus mg/kg	Potassium (mg/kg)	pH	Total Nitrogen (%)
Kahramanmaras	59.40	0.13	2.65	2.19	5.78	112.10	7.50	0.08

* Soil analyses were carried out in the laboratory of Kahramanmaraş Sütçü İmam University, University-Industry-Public Cooperation Development Application and Research Centre.

The trials were conducted in 2018 and 2019 at Kahramanmaraş Faculty of Agriculture, Department of Field Crops Research and Application Centre. Kahramanmaraş, with its geographical location and other factors, shows a climate characteristic closer to the Mediterranean climate among the three different climate types.

Table 2. Mean temperature, precipitation, and relative humidity data for the experimental years and long years (April-October average during the main crop growing season).
Tablo 2. Deneme yılları ve uzun yıllar için ortalama sıcaklık, yağış ve bağıl nem verileri (ana ürün yetiştirme sezonu boyunca Nisan-Ekim ortalaması).

Climate values	Years	April	May	June	July	August	September	October	Total	Average
Average temperature (°C)	2018	20.10	24.40	26.40	29.10	29.60	27.90	22.90	180.40	25.77
	2019	17.00	24.10	27.10	28.40	29.60	27.30	24.20	177.70	25.39
	Long Years	18.50	21.75	26.28	29.23	29.50	26.73	22.43	174.42	24.92
Average precipitation (mm)	2018	33.00	29.20	23.40	0.00	0.00	1.20	64.00	150.80	21.54
	2019	59.40	2.60	13.80	28.00	0.00	0.00	22.80	126.60	18,09
	Long Years	50.27	52.38	25.09	5.71	6.26	25.73	29.52	194.96	27.85
Average relative humidity (%)	2018	61.20	62.80	70.20	69.80	68.80	63.60	58.60	455.00	65.00
	2019	67.00	57.60	68.70	68.80	68.00	62.10	61.60	453.80	64.83
	Long Years	63.46	67.94	67.60	68.85	69.58	64.58	58.17	460.18	65.74

Monthly precipitation, temperature, and relative humidity data for the 2018-2019 production year and for many years are given in Table 2. In the 2018-2019 growing season, the average temperature values reached 25.77 °C in 2018, which was higher than the long-term average. When the average precipitation is analyzed, it is seen that there is lower precipitation compared to long years. In addition, it was determined that there were no significant differences between the relative humidity values during the growing period and long-year averages (Table 2).

A total of ten genotypes registered by Çukurova University and Western Mediterranean Agricultural Research Institute were used. These genotypes are given in Table 3.

Table 3. Variety names, market type, origin, and growth forms of the varieties
Tablo 3. Çeşit isimleri, pazar tipi, orijin ve çeşitlerin büyüme formları

Variety names	Market type	Origin	Growth forms
Arıoğlu- 2003	Virginia	Türkiye	Semi-spreading
Batem 5025	Virginia	Türkiye	Semi-spreading
Batem Cihangir	Virginia	Türkiye	Semi Upright
Brantley	Virginia	ABD	Semi-spreading
Flower-22	Virginia	Çin	Semi-spreading
Halisbey	Virginia	Türkiye	Semi-spreading
NC-7	Virginia	ABD	Semi-spreading
Osmaniye-2005	Virginia	Türkiye	Semi-spreading
Sultan	Virginia	Türkiye	Semi-spreading
Wilson	Virginia	ABD	Semi-spreading

The research was designed as a randomized block design with three replications. Sowing was arranged in 4 rows with 70 cm between rows and 15 cm above rows, and 9500 seeds per decare.

The plot size was applied as 5 m long-2.8 m wide (5 m x 2.8 m) and 14 m². Before sowing, 30 kg/da 18-46-0 (N-P-K) DAP (Diammonium phosphate) fertilizer was applied by hand sprinkling, and 15 kg/da urea (46% N) fertilizer was applied approximately 60 days after emergence. Other maintenance operations (irrigation, weed and pest control) were carried out considering plant and soil moisture.

Data collection

The peanut plants in the experimental area were mechanically harvested after reaching physiological ripeness (in October), the peanut plants were inverted and left to dry, and finally, peanut fruits were harvested by hand after three days of drying. Seed samples were separated and dried in an air dryer at 65 °C until reaching constant weight. Seeds were digested at 180° with 4 ml HNO_3 and 3 ml H_2O_2 (Berghof MWS 2 DAP 60 K microwave oven). Macro and micronutrients were analyzed from the extracts using ICP OES device (Kacar & Inal, 2014).

Data Evaluation

The data were analyzed by analysis of variance for two years using LSD test to compare the means. Correlation coefficients and principal component analyses were calculated and evaluated on average data (JMP 17 SAS Institute Inc, 2020).

RESULTS and DISCUSSION

Average values and analysis of variance findings of N, P, K and Ca among macro elements and Fe, Mn, Zn, Ni, Mo and Cu among micro elements of the peanut varieties used in the study for two years are reported in Table 4.

Macro elements

Nitrogen is a necessary element for vegetative growth, nutrient absorption, photosynthesis, and capsule improving (Sing, 1999). N, P, K, Ca, Fe, Mn, Zn, Ni, Mo, and Cu are obligatory for plants (Gascho & Davis, 1994), and these nutrients should be present in sufficient amounts in the soil to obtain high yields (Aşık & Aşık, 2023). Peanuts are a good food source of macro minerals, which are needed in quantities of more than 100 mg/day (Derise et al., 1974; Settaluri et al., 2012). In this study, the varieties produced different results in terms of N content, and all varieties had higher N content in the second year (Figure 1). When the two-year cultivar averages (Table 4 and Figure 1) were analyzed, it was observed that N content varied between 3.51-3.98%. Flower-22 variety had the highest N content, followed by Sultan (3.84%), NC-7 (3.80%), and Brantley (3.76%) varieties. Wilson (3.51%) and Arıoğlu-2003 (3.53%) varieties had the lowest nitrogen content. In their study, Aşık & Aşık (2023), determined the nitrogen content between 3.67 and 4.38%. Nitrogen content in the seed is affected by plant applications, variety characteristics, and environmental conditions (Steer & Hocking, 1984).

The phosphorus value of plants varies from 0.1-0.8 percent of the dry matter. Phosphorus is present in low quantities in peanut plants; however, plants can absorb phosphorus even in soils very poor in phosphorus (Aşik, 2023a). Phosphorus is also involved in energy utilization, storage as well and transport in plants (Tasso et al., 2004). Feitosa et al. (1993) concluded that over 70% of the phosphorus uptake by peanut plants from pellets accumulates in the fruit and that the element has a significant effect on fruit formation. In this study, the varieties produced different results in terms of phosphorus (P) contents (Table 1). All varieties except Batem-5025 and Sultan varieties had lower P content in the second year (Figure 1). When the two-year variety averages (Table 4 and Figure 1) are analyzed, it is seen that P content varied between 0.397-0.548%. Brantley (0.548%) and Flower-22 (0.547%) varieties had the highest P content, followed by Halisbey (0.540%) and Osmaniye-2005 (0.531%) varieties. The lowest phosphorus content was found in Batem-5025 (0.397%). In the study conducted by Abd EL-Kader (2013), it was determined that the phosphorus content in peanut seeds was between 0.40-0.50%.

Potassium is another element that is important for plants and is absorbed in significant amounts. It plays a significant role in capsule formation and grain weight increase (Taiz & Zeiger, 2013). Potassium values of the varieties ranged between 0.052 and 0.074 % (Table 4). All varieties except Sultan had similar or higher K content in the second year (Figure 1). According to the two-year variety averages (Table 1 and Figure 1), the highest potassium value was obtained from Batem Cihangir variety (0.522%), and the lowest potassium value was obtained from Wilson variety (0.320%). Oerise et al. (1974) reported an average of 0.63% potassium element in seeds of 3 Virginia-type peanut varieties; Aşik (2023b) reported that seed potassium content varied between 0.37% and 0.43%.

Table 4. Mean squares and values of macro and microelement contents for peanut varieties from two years (2018 and 2019) average.
Tablo 4. Yer fıstığı çeşitlerinin makro ve mikro element içeriklerinin iki yıllık (2018 ve 2019) ortalama değerler ve kareler ortalaması

Varieties	N (%)	P (%)	K (%)	Ca (%)	Fe(mg kg^{-1})	Mn(mg kg^{-1})	Zn(mg kg^{-1})	Ni(mg kg^{-1})	Mo(mg kg^{-1})	Cu(mg kg^{-1})
Arıoğlu-2003	3.53±0.22	0,450±0.02	0.517±0.01	0.054±0.00	17.86±0.81	13.94±0.42	25.14±0.54	2.37±0.13	1.13±0.02	4.42±0.04
Batem 5025	3.69±0.37	0.397±0.06	0.464±0.02	0.059±0.00	13.23±0.36	16.82±0.41	21.72±0.32	5.33±0.09	1.08±0.00	3.55±0.06
Batem Cihangir	3.59±0.21	0.523±0.04	0.522±0.02	0.072±0.00	23.34±1.10	17.64±0.59	23.61±0.33	8.05±0.15	0.65±0.02	4.49±0.05
Brantley	3.76±0.14	0.548±0.03	0.463±0.01	0.056±0.00	22.58±0.68	16.76±0.22	25.98±0.77	5.30±0.04	2.22±0.10	3.50±0.16
Flower-22	3.98±0.19	0.547±0.02	0.363±0.01	0.074±0.00	24.68±0.55	19.76±0.32	25.14±0.87	8.35±0.10	0.63±0.01	7.08±0.02
Halisbey	3.75±0.25	0.540±0.01	0.415±0.01	0.052±0.00	17.52±0.65	18.04±0.34	20.90±0.28	5.19±0.01	2.14±0.01	3.52±0.08
NC-7	3.80±0.19	0.459±0.01	0.349±0.01	0.065±0.00	23.15±0.52	21.13±0.21	24.46±1.02	8.28±0.04	0.31±0.00	3.17±0.05
Osmaniye 2005	3.61±0.25	0.531±0.02	0.453±0.02	0.067±0.00	21.89±0.33	17.12±0.34	28.48±0.11	5.20±0.03	1.09±0.02	3.65±0.11
Sultan	3.84±0.34	0.526±0.01	0.405±0.01	0.060±0.00	24.38±0.31	17.14±0.26	28.90±0.78	7.25±0.08	2.19±0.06	3.11±0.00
Wilson	3.51±0.25	0.450±0.00	0.320±0.01	0.064±0.00	21.37±0.46	18.18±0.44	20.35±0.61	6.29±0.06	0.35±0.02	3.39±0.14
LSD (P=0.05)	2.47	6.07	8.25	7.81	6.77	5.59	6.58	3.08	7.35	4.84
Analysis of variance for macro and microelement contents combined over years										
Makro ve mikro element içerikleri için yıllara göre birleştirilmiş varyans analizi										
Cultivars (C)	1.18**	0.15**	0.25**	0.002**	716.06**	196.56**	461.89**	190.51**	30.55**	75.48**
Years (Y)	17.03**	0.002	0.06**	1.66	9.87	2.35	10.38*	0.01	0.02	0.10**
C x Y	1.40**	0.009	0.10**	0.0004*	26.38	1.91	12.07	0.86*	0.11	0.81*

*, **: Significant at the 0.05 and 0.01 level of probability

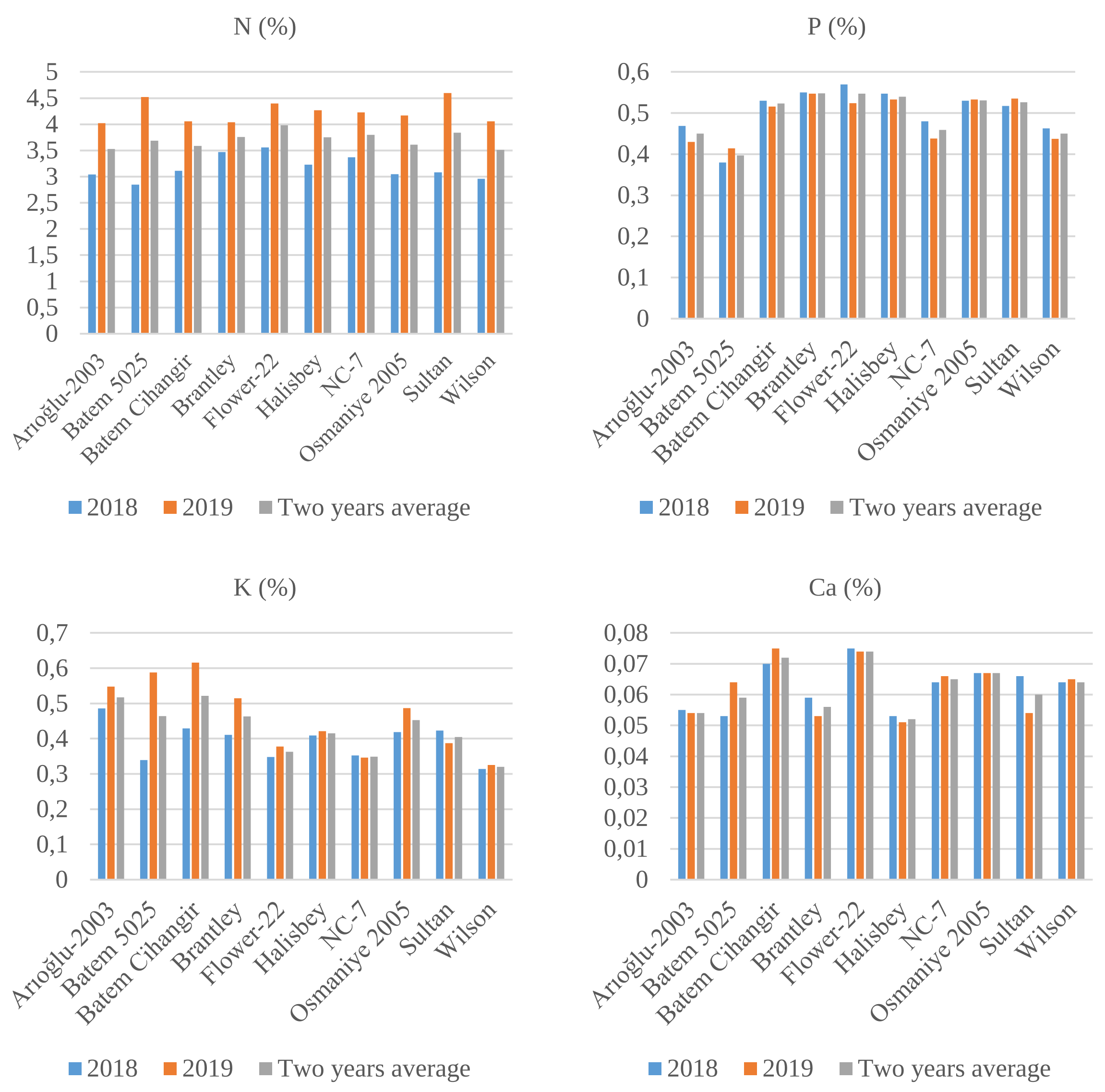

Figure 1. Macroelement contents of peanut varieties
Şekil 1. Yer fıstığı çeşitlerinin makroelement içerikleri

Calcium is one of the crucial elements in peanut generation, and its deficiency causes yield and quality losses (Cox et al., 1982). It is a necessary and important element for the formation of gynophores and filling of capsules in the plant (Aşık, 2023a). Calcium values of the cultivars ranged between 0.052 and 0.074% (Table 1). According to the two-year cultivar averages (Table 4 and Figure 1), the highest calcium value was obtained from Flower-22 (0.074%) and Batem Cihangir (0.072%), and the lowest was obtained from Halisbey (0.052%) and Arıoğlu-2003 (0.054%). Although peanuts do not remove much calcium from the soil, it has a special role in regulating many aspects of plant growth and development (Arıoğlu, 2014). Branch and Gaines (1983) reported that seed calcium contents varied between 0.04% and 0.08% in a study with 26 different peanut germplasms.

Micro elements

Variances of cultivar, year, and year-cultivar interactions were found to be significant in terms of micronutrients (Table 1). Peanut cultivars showed significant differences in the micronutrients (Fe, Mn, Zn, Ni, Mo, and Cu) analyzed (Table 4 and Figure 2). When the two-year averages were analyzed, it was determined that the Flower-22 variety had high values in terms of iron (24.68 mg kg^{-1}), nickel (8.35 mg kg^{-1}), and copper (7.08 mg kg^{-1}) contents. In addition, NC-7 variety had high values in terms of Mn (21.13 mg kg^{-1}) and Ni (8.28 mg kg^{-1}) value, Sultan variety had high values in terms of Zn (28.90 mg kg^{-1}) and Mo (2.19 mg kg^{-1}) value, Osmaniye-2005 variety had high values in terms of Zn (28.48 mg kg^{-1}) content, Brantley (2.22 mg kg^{-1}) and Halisbey (2.14 mg kg^{-1}) varieties had high values in terms of Mo content.

Figure 2. Microelement contents of peanut varieties

Şekil 2. Yer fıstığı çeşitlerinin mikroelement içerikleri

Batem-5025 (13.23 mg kg^{-1}) had the lowest Fe content, Arıoğlu-2003 had the lowest Mn (13.94 mg kg^{-1}) and Ni (2.37 mg kg^{-1}) contents, Wilson (20.35 mg kg^{-1}) and Halisbey (20.90 mg kg^{-1}) varieties had the lowest Zn content.

In addition, NC-7 (0.37 mg kg-1) and Wilson (0.35 mg kg-1) varieties had the lowest Mo content, and Sultan (3.11 mg kg-1) and NC-7 (3.17 mg kg-1) varieties had the lowest Cu content (Table 4 and Figure 2). Iron, an important micro mineral in human and animal nutrition, is implicated in many biological functions like the transport, storage, and utilization of oxygen by red blood cells and redox potentials (İnce & Çağındı, 2020). Fe composition is important in peanuts, and its absence leads to chlorosis of the leaves (Aşık, 2023a). In this study, Flower-22 variety attracted attention with its high Fe content. Zinc, which has important physiological effects in living organisms and performs a role in many biological functions, is an important micronutrient in human nutrition and is associated with many enzyme systems in the human body (Kınık et al., 2001). Zinc is the second-highest trace element in the human body after iron and is essential for the function of over 300 enzymes in the body (Akdeniz et al., 2016). Zinc deficiency is an important problem worldwide (Hambidge, 2000). In this study, Sultan and Osmaniye-2005 varieties stood out with high Zn content. This findings regarding Fe and Zn values are consistent with the results of Chen et al. (2022). The values of Mn, Ni, Mo and Cu obtained in this study are in agreement with the findings of many researchers (Hallock et al., 1971; Gaines & Hammons, 1981; Chen et al., 2022).

Principal Component Analysis

PCA (Principal component analysis), a dimensionality minimization method, was applied utilizing the dataset of the examined agricultural traits. Total variation was obtained from 10 principal component axes, and the Eigenvalues, Variability (%), and Cumulative values (%) are shown in Table 5. The first principal component (PC1) accounts for 33.101% of the overall variation. The secondary principal component (PC2) accounts for 19.599% of the overall variation. The third principal component explains 13.532 of the overall variation (PC3). The cumulative proportion of the three main components in the overall variation is 66.7233%. Remaining principal components (PC4=11.266%, PC5=7.672%, PC6=5.503%, PC7=3.091%, PC8=2.634%, PC9=2.478% and PC10=1.124%) have 33.22% of the overall variation. As a consequence of PCA analysis, 10 principal component axes were identified, and these axes showed the total variation. All 10 principal components revealed 100% of the overall variation.

Table 5. Eigenvalues, Variability and Cumulative Values
Tablo 5. Ekovalans, varyabilite ve kümülatif değerler

	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
Eigenvalue	3,31009	1,959925	1,353241	1,1266	0,76719	0,550319	0,30908	0,263369	0,247809	0,112378
Variability (%)	33,101	19,599	13,532	11,266	7,672	5,503	3,091	2,634	2,478	1,124
Cumulative (%)	33,101	52,7	66,233	77,499	85,17	90,674	93,764	96,398	98,876	100

The Scree Plot (graphical representation of eigenvalues) is presented in Figure 3. Eigenvalues obtained for PC1 are 3.310. Other eigenvalues were 1.959 (PC2), 1.353 (PC3), 1.126 (PC4), 0.767 (PC5), 0.550 (PC6), 0.309 (PC7), 0.263 (PC8), 0.247 (PC9), and 0.112 (PC10), respectively. Eigenvalues above 1 indicate that the considered principal component weight values are found to be reliable (Mohammadi & Prasanna, 2003). Moreover, Iezzoni and Pritts (1991) reported that PCs with eigenvalues greater than 1 (PCs with eigenvalues >1.0) are more informative than the original variable.

Principal component analysis is used to see the variation among the varieties used in the research and the relationships between the examined traits of these varieties visually more clearly and enough to be understood (Chakravorty et al., 2013; Tekdal et al., 2018). According to PCA (Principal Component Analysis) analysis, it is possible to see the relationships between the varieties and the traits examined visually together. According to the PCA biplot analysis performed at the 2-year average results of the features examined in terms of nutrients in this research, principal component 1 (PC1) was found to be 33.1%, principal component 2 (PC2) 19.6%, and 52.7% in total. It was observed that there was a positive relationship between Molybdenum and Potassium contents, Zn, N, P, Fe, and Cu contents, while there was a negative relationship with other properties (Ca, Mn, and Ni) (Figure 4).

Correlation Coefficient Analysis

Correlation coefficient values between variables are given in Table 6. It is seen that nitrogen content is positively correlated with potassium, and potassium is negatively and significantly correlated with Fe, Mn, and Ni. Phosphorus content was positively correlated with Fe, Zn, Mo, and Cu element contents. It was found that among the macronutrients analyzed, Ca content had a positive and prominent correlation with Fe, Mn, Ni, and Cu content and a negative and significant correlation with Mo content. Among micronutrients, Fe has a positive and important correlation with Mn, Zn, and Ni. A positive and important correlation was found between Mn content and Ni content, and a negative and important correlation was found among Mo content. In comparison, a negative and significantly correlation was found among Mo content and Cu and Ni content (Table 6).

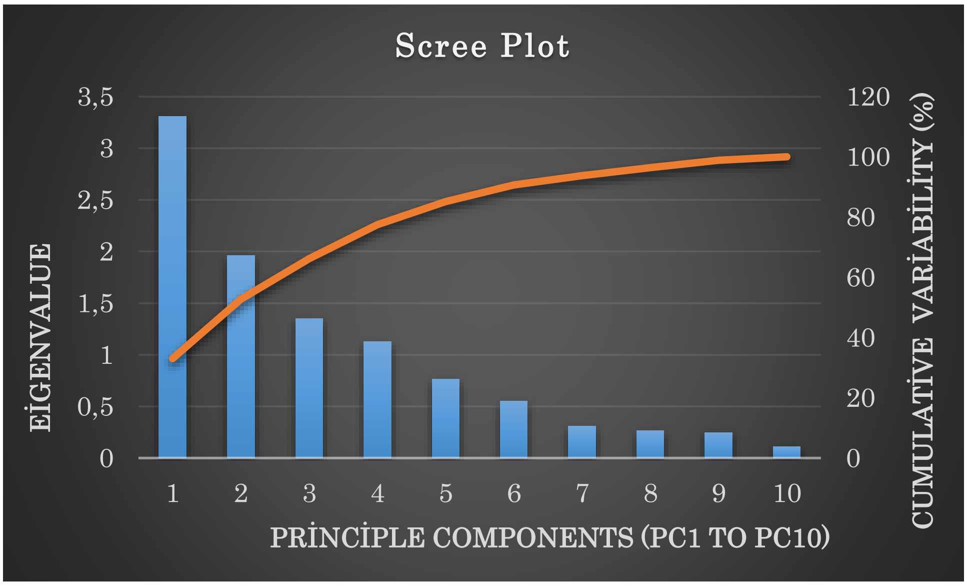

Figure 3. Graphical representation of Eigenvalues
Şekil 3. Ekovalans değerlerinin grafiksel gösterimi

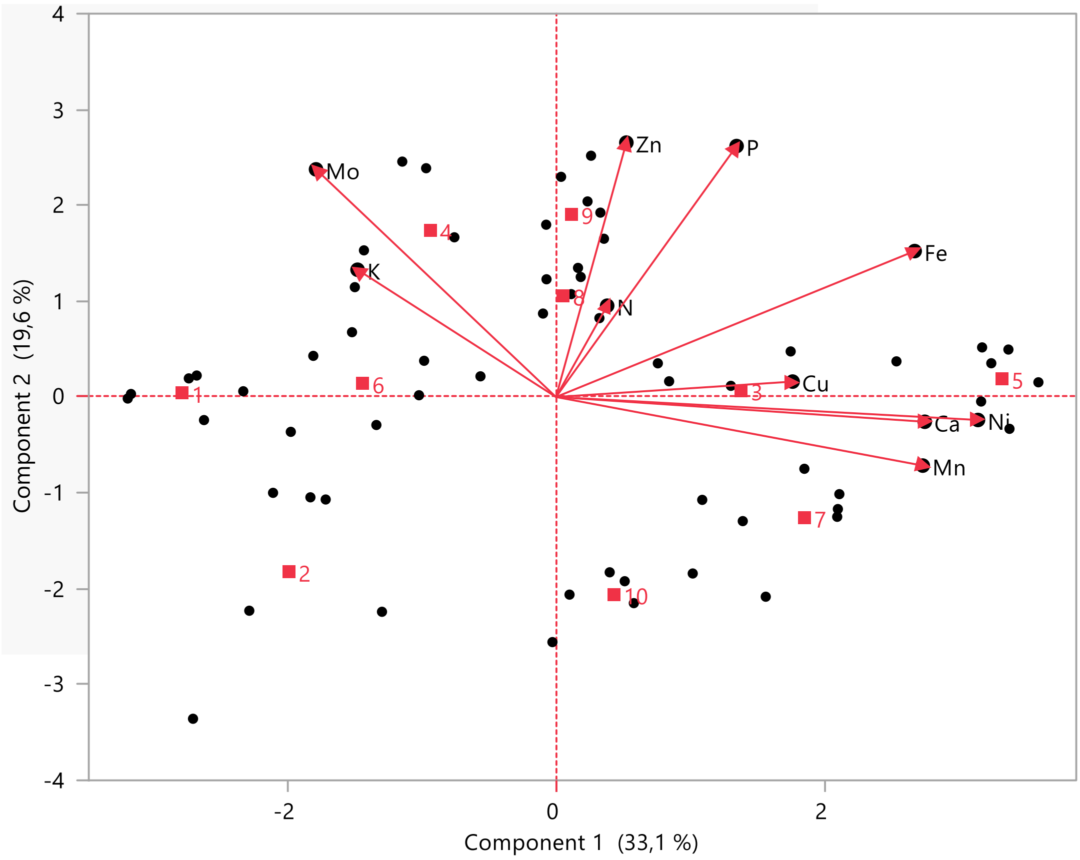

Figure 4. Relationships between genotypes and traits analyzed according to principal component analysis
Şekil 4. Temel bileşenler analizine göre genotipler ve incelenen özellikler arasındaki ilişkiler

CONCLUSION

In this study, macro and micronutrient contents of 10 peanut cultivars were determined for 2 years, and PCA analysis and correlation coefficients were estimated for the traits. It was determined that the varieties were significantly different for each macro- and micronutrient element investigated. Flower-22 cultivar had high values in terms of N, P, Fe, Ni, and Cu contents, and Sultan and Osmaniye-2005 cultivars had high values in terms of Zn contents. When the two-year averages were analyzed in terms of macro and micronutrient contents, it was determined that the Flower-22 variety showed a superior performance compared to other varieties.

Table 6. Relationships and correlation coefficients between the analysed traits of peanut varieties.
Tablo 6. Yerfıstığı çeşitlerinin incelenen özellikleri arasındaki ilişkiler ve korelasyon katsayıları.

	N (%)	K (%)	P (%)	Ca (%)	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})	Ni (mg kg^{-1})	Mo (mg kg^{-1})	Cu (mg kg^{-1})
N	1									
K	0.3156*	1								
P	0.0382	0.0048	1							
Ca	0.0285	-0.0523	0.2001	1						
Fe	0.02	-0.2759*	0.5448**	0.4459**	1					
Mn	0.2111	-0.4388**	0.1556	0.3823**	0.3981**	1				
Zn	0.1734	0.1743	0.3382**	0.0884	0.4287**	-0.0626	1			
Ni	0.1429	-0.3637**	0.2304	0.5996**	0.5942**	0.7539**	0.0373	1		
Mo	0.0367	0.2134	0.3872**	-0.5484**	-0.1062	-0.3771**	0.2504	-0.3511**	1	
Cu	0.0639	-0.0161	0.261*	0.4771**	0.2433	0.1404	0.0343	0.2373	-0.3155*	1

According to biplot analysis, principal component 1 (PC1) was found to be 33.1%, principal component 2 (PC2) 19.6%, and 52.7% in total. As a consequence of the correlation analysis, it was determined that N value had a positive and meaningful relationship with K content, P value had a positive and meaningful relationship with Fe, Zn, Mo and Cu content, Ca value had a positive and meaningful relationship with Fe, Mn, Ni and Cu, and K content had a negative and meaningful relationship with Fe, Mn and Ni.

There are numerous factors known to influence the nutrient composition of plants in foods, including hereditary factors, climate, topography, soil chemistry, agricultural practices such as fertilizer application, the stage of ripeness, and the growing season. A significant variety of peanut cultivars are used in the study, and this diversity provides the opportunity to select genetic types with desirable traits for use in fertilizer programs. Further research should be carried out in more than one location and on these cultivars to show the effects of agricultural practices on the nutrient composition of seeds.

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Contribution Rate Statement Summary of Researchers

The authors declare that they have contributed equally to the article.

Conflict of Interest

The authors declare that he/she has no conflict of interest.

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