Journal of Agricultural Sciences
(Tarim Bilimleri Dergisi)

J Agr Sci-Tarim Bili
e-ISSN: 2148-9297
jas.ankara.edu.tr

Macro and Micro Element Composition of Some Peanut (*Arachis hypogaea* L.) Varieties in Turkey

Ferrin Ferda AŞIK[a*], Barış Bülent AŞIK[b]

[a]*Nature Conservation and National Parks, 2nd Regional Directorate, Bursa, TURKEY*

[b]*Bursa Uludag University Faculty of Agriculture, Department of Soil Science and Plant Nutrition, Bursa, TURKEY*

ARTICLE INFO
Research Article
Corresponding Author: Ferrin Ferda AŞIK, E-mail: ferrinferda.asik@tarimorman.gov.tr
Received: 08 July 2021 / Revised: 25 January 2022 / Accepted: 02 February 2022 / Online: 18 January 2023

Cite this article
AŞIK F F, AŞIK B B (2023). Macro and Micro Element Composition of Some Peanut (*Arachis hypogaea* L.) Varieties in Turkey. *Journal of Agricultural Sciences (Tarim Bilimleri Dergisi),* 29(1):38-46. DOI: 10.15832/ankutbd.962154

ABSTRACT
This study was conducted to determine the macro and micro element contents of fourteen peanuts in Turkey. Virginia (NC-7, Halisbey, Arıoğlu-2003, Sultan Flower-22, Osmaniye-2005, Brantley, Wilson, Batem-5025, Batem-Cihangir, NC V 11 and Polen) Runner (Georgia Green) and Spanish (Florispan) market types have been evaluated. The research was conducted for two years (2015 to 2016) under main crop conditions in the trial areas of belonging to the Oil Seed Research Institute. The highest nitrogen content is from the Florispan (4.56%) variety, the highest phosphorus and sodium content is from the Halisbey (0.10%) variety, the highest potassium content is from the Sultan (0.46%) variety, the highest calcium content is from the Flower-22 (0.07%) variety and the highest the magnesium content was taken from Arıoğlu-2003 (0.26%) variety. The highest iron content is in Batem-Cihangir (27.34 mg kg^{-1}) variety, the highest copper content is in Flower-22 (7.08 mg kg^{-1}), the highest zinc content is in Sultan (29.35 mg kg^{-1}), the highest manganese content NC-7 (20.61 mg kg^{-1}) variety, the highest boron content was found in Florispan (26.99 mg kg^{-1}) variety. According to the results of this study, varieties with different chemical compositions can be used in food and breeding studies.

Keywords: Macro Nutrients, Micro Nutrients, Market Type, Osmaniye, Peanut Pods

1. Introduction

Peanut is oil-seed legume that is used in many ways and its seeds are also important economically and medicinally (Akram et al. 2018). India, China, America, Senegal, Indonesia, Nigeria, Brazil and Argentina are important countries producing peanuts (FAO, 2020). Peanut has become one of the major global oil-seed crops cultivated on approximately 26 million ha in about 120 countries yielding about 35 to 40 million tons of peanut pods annually (Patel et al. 2016; Sarkar et al. 2016; FAO 2020). In Turkey, peanuts are grown mostly in Adana, Osmaniye, Hatay, Mersin and Gaziantep regions.

The major constituents of peanut seeds are carbohydrates (15% to 20%), oil (36% to 54%) and protein (16% to 36%) (Davis et al. 2016). They also contain other beneficial minerals such as phosphorus, potassium, iron, manganese, calcium, sodium, selenium, copper and zinc are also present in peanuts (Ayoola et al. 2012). Moreover, multivitamins including tocopherols, thiamine and folic acid are present in peanut seeds (Isanga & Zhang 2007). The presence of flavonoids, vitamin E, resveratrol and different hydroxycinnamic acids including chlorogenic, caffeic, ferulic acids and coumaric give peanut its high antioxidant capacity (Hasan et al. 2013; Jonnala et al. 2006; Sales & Resurreccion 2010; Zhang et al. 2017).

Peanuts are cultivated in almost all soil types around the world and require macro and micronutrients for growth and development compared to many other crops (Cox et al. 1970, 1982; Dwivedi 1988; Hartzog & Adams 1988; Singh 1999, 2004).

For an adequate fertilization management, the designation of nutrient uptake and congregation during the plant development are important. So that, it is possible to identify the times at which elements are needed want during crop development and the dispensation of the elements in different parts of the plant. In order to determine the nutritional needs of a plant, both the chemical composition and accumulation of nutrients in fruits and leaves should be considered. This information may facilitate the estimation of the amount of nutrients to supply during fertilization.

Its cultivation improves soil fertility through atmospheric nitrogen fixation (Lal 2008). There are numerous peanut varieties that are usually preferred on the basis of high-blanch abilities, high fat content, high yield and low-shelling (Deshpande et al.

2008, Mulando & Resurreccion 2006). Morover, the quality and composition of peanut oil varies among genotypes and developmental stages and in response to environmental factors (Andersen & Gorbet 2002; Krishna et al. 2015).

In the study, the nutrient content of fourteen different peanut varieties were compared. The results obtained will reveal which variety will need which nutrient element is more sensitive or more in peanut cultivation.

2. Material and Methods

2.1. Material

Polen, Halisbey, Sultan, Arıoğlu-2003, Flower-22, Osmaniye-2005, Brantley, Wilson, Georgiya Green, Florispan, Batem-5025, Batem-Cihangir, NC V 11 and NC-7 peanut varieties used as materials in the study were provided from Çukurova University Faculty of Agriculture Field Crops Department. After the harvest, the pods of peanut varieties were broken and the seeds were removed. And then plant nutrient analysis of the seeds was made. In the province of Osmaniye where the study was conducted, the average climate data for the long years of April-September for the trial years of 2015-2016 are given in Table 1.

Table 1- Monthly temperature, total precipitation, relative humidity in 2015-2016 growing seasons and long-term (1994-2016) averages in Osmaniye Province

Months	*Average Temperature (^0C)*			*Total Precipitation (mm)*			*Relative Humidity (%)*			*Soil Temperature at 10 cm (^0C)*	
	2015	*2016*	*Average (1994-2016)*	*2015*	*2016*	*Average (1994-2016)*	*2015*	*2016*	*Average (1994-2016)*	*2015*	2016
April	16.1	19.6	16.08	76.6	11.7	85.60	60.0	51.3	61.77	18.2	21.2
May	21.9	20.6	20.41	42.0	87.1	67.84	58.3	67.1	60.18	22.6	24.3
June	24.4	26.3	23.23	31.8	9.3	36.08	64.1	62.2	55.63	28.6	31.4
July	27.9	28.7	28.00	-	0.8	12.01	62.3	65.1	65.75	34.9	36.5
August	29.0	29.2	27.32	1.9	10.0	7.48	56.2	66.8	61.82	35.9	36.2
September	27.5	24.8	24.11	2.6	79.1	35.33	54.5	60.8	58.66	33.3	31.1

When the months of the experiment are examined, it is seen that the temperature values of 2016 are generally higher. The highest temperature in both years occurred in August. However, when the average of the long term is examined in terms of temperature, it is seen that the highest temperature value is in July. The province of Osmaniye has a typical Mediterranean climate with warm and rainy winters and dry and hot summers. When the total amount of precipitation for the years of the experiment is examined, it is seen that the most important difference occurred in April 2015. This difference in precipitation that occurred in April 2015 caused the planting to take place on April 9. According to the long-term average, the total precipitation values varied between 7.48 mm and 85.60 mm. It is seen that rainfall values vary according to years, months and years.

Soil samples were taken from 0-30 cm depth of the fields where peanuts are grown. Soil analyzes were carried out by Bursa Uludağ University Faculty of Agriculture Soil Science and Plant Nutrition Department in the first year and by Osmaniye Korkutata University Soil Laboratory in the second year (Kacar 1994). Soil analysis results are given in Table 2.

Table 2- Some physical and chemical characteristics of the soils of the experimental sites

Properties	*Year 2015 (Toprakkale)*	*Year 2016 (Alahanlı)*
pH	7.30	7.80
Lime, $CaCO_3$, (%)	6.93	0.82
Organic matter (%)	1.161	1.692
Total N (%)	0.061	0.071
NH_4-N, mg kg^{-1}	21.6	36.3
NO_3-N, mg kg^{-1}	4.4	8.4
$NaHCO_3$-P, mg kg^{-1}	11.3	4.1
Exc. K, mg kg^{-1}	55	72
Exc. Ca, mg kg^{-1}	2714	2602
DTPA-Cu, mg kg^{-1}	0.5	0.8
DTPA-Zn, mg kg^{-1}	1.0	0.3
DTPA-Mn, mg kg^{-1}	2.4	4.7
DTPA-Fe, mg kg^{-1}	5.8	4.0

As a result of the soil analysis, the pH value of Toprakkale (7.30) and Alahanlı (7.80) soils were evaluated as slightly alkaline and salt-free in both soils according to the EC values. In terms of lime content, Toprakkale soil (6.93%) is calcareous and Alahanlı soil (0.82%) is in the lime-free class. The organic matter content of both soils (1.161% - 1.692%) was evaluated as a low (Tüzüner 1990). According to the plant nutrient analysis results; It was determined that the nitrogen content of both soil samples (0.061% - 0.071%) was low (Silanpaa 1990). In terms of P (phosphorus), Toprakkale soil (11.3 mg kg^{-1}) was sufficient, while Alahanlı soil (4.1 mg kg^{-1}) was determined to be low (Silanpaa 1990). K (potassium) was found to be low in both soils (55-72 mg kg^{-1}), Fe (iron) was found to be very high in Toprakkale (5.8 mg kg^{-1}), and high in Alahanlı (4.0 mg kg^{-1}) (Lindsay & Norwell 1978). Toprakkale soil is evaluated as high in terms of Cu (copper), Zn (zinc) and low Mn (manganese) content. Alahanlı soil is evaluated as high in Cu and low in Mn and Zn content.

2.2. Method

In the research, field trials were carried out for 2 years (in 2015-2016) in the irrigable test areas of Oil Seed Research Institute in Osmaniye province in Toprakkale and Alahanlı during the main crop growing periods. The experiment was set up with 4 replications according to the randomized blocks trial pattern. The parcels are 5 m long and consist of 4 rows (5.0 m x 2.8 m = 14.0 m^2). The planting density is arranged as 70 x 15 cm. Before planting, the seeds were disinfected with Korconil 75W (Chlorothalonil) and Korban 25W (25% Chlorpyrifos-Ethyl) as 1.0 kg drug per 100 kg of seeds. Before planting, soil preparation operations were carried out. 200 kg 20-20-0 compound fertilizer per hectare was used according to the analysis results. A total of 40 kg da^{-1} of CAN 26% (calcium ammonium nitrate) fertilizer was applied, with the first top fertilizer being 20 kg da^{-1} at the beginning of flowering and the second top fertilizer being 20 kg da^{-1} at the beginning of pod formation. It has been used in fertilizers containing microelements during cultivation. Sowing was done manually on April 8 and April 9, in 2015 and 2016, on a date when soil and weather conditions were appropriate. Sprinkler irrigation system has been used for sufficient plant germination after planting. During the growing period, the necessary activities (hoeing, irrigation and spraying) were carried out on time in accordance with the technique. The harvest of varieties in the Virginia group is between 140-160 days, and Flower-22 from this group can be harvested in 125-130 days because it is early, Georgia Green in the Runner group in 135-140 days, and the Florispan variety in the Spanish group in 120-130 days (August in the middle of the second week of September). After the harvest, 20 plants were removed randomly from each plot and their fruits were ground, and their macro and micro element contents were determined.

2.3. Analysis methods of macro and micro elements of peanut pods

The seed samples of the plant were dried until they reached a constant weight in 65 ^oC air-dried oven. Total nitrogen in plant samples was determined with a Buchi K-437/K-350 Digestion/Distillation Unit according to the Kjeldahl method (Bremner 1960). Seed samples were digested at 180 degrees with 4 ml HNO_3 and 3 ml H_2O_2 (Berghof MWS 2 DAP 60 K microwave oven). Macro and micro nutrients were analyzed from extracts using the ICP OES (Perkin Elmer OPTIMA 2100 DV) (Kacar & İnal 2014).

The research data were analyzed through use of JUMP 5.0.1 statistics package program according to the randomized block trial design. The differences between the average values were compared to significance level by using LSD Multiple Comparison Test.

3. Results and Discussion

N, P, K, Fe, Cu, B, Ca, Zn, Mn, Mg elements are considered essential for plants (Gascho & Davis 1994). Nutrients must be in sufficient quantities in the soil in order to get enough yields. Year x varieties interactions were found to be significant ($P<0.05$) in N, K, Zn and B (Table 3 and 4). On the other hand, P, Ca, Mg, Na, Fe, Cu and Mn were found to be insignificant in the years x cultivars interaction of the average of years. The two-year averages of the peanut product were evaluated in the study.

Nutrient element determined as the highest nitrogen and the lowest copper in the plant as a 4.38 % and 3.08 mg kg^{-1}. In varieties, nitrogen content range from 3.67% to 4.38%, P content of the cultivars varied between 0.460% and 0.558%, K ranged from 0.367% to 0.458%, Ca content of the cultivars is between 0.052% and 0.072%, the Mg content of the varieties varied between 0.237 and 0.262%. Na element content of the varieties varied between 0.080 and 0.099%. The highest N content was obtained from the Florispan variety with 4.38%, while the lowest N content was obtained from the Georgia Green variety with 3.67% (Table 3). Of all of the necessary mineral nutrients, plants require N in the greatest amounts. Regulation of N uptake in plant is complex, with carefully controlled integration of NH_4^+ and NO_3 uptake, besides occurs at both genetic and physiological levels. In leguminous plants, where most of the required N is obtained from close associations with N2-fixing bacteria in root nodules, the regulatory system is even more complicated and is likely to involve proteins and signals specific for the transfer of $NH4^+$ across the peribacteroid membrane (Tyerman et al. 1995; Marini et al. 2000). Steer & Hocking (1984) reported that the N content of the seeds, besides the Napplied to the plant, the variety characteristics of the plants and the environmental conditions were effective.

The average P content of the cultivars varied between 0.460% and 0.558%. Jonnala et al. (2005) determined P content between 0.356 and 0.427% in different pistachio lines; Shokunbi et al. (2012) determined the P content between 0.372% and 0.403% in their study on Boro Light, Boro Red, Mokwa, Campala and Ela peanut cultivars. While the highest average P content was obtained from Halisbey (0.56%) cultivar, the lowest P content (0.46%) was obtained from Batem-5025 variety (Table 3). The results found by the researchers (0.25-0.66%) are consistent with the results we found. Although it is extracted in smaller quantities compared to other macronutrients, P is considered the main productivity factor of the peanut crop (Bolonhezı et al. 2005). The accumulation of more than 70% of the P taken by the peanut plant in the fruits shows how important this element is in the formation and development of the fruits (Feitosa et al. 1993). Regulation of the uptake of P appears to be via the internal nutrient status of the plant. Gene expression and kinetics studies both suggest that the high-affinity P transporters are more responsive to nutrient status than low-affinity transporters.

The average K content varied from 0.367% to 0.458%. The highest K content was observed in Sultan (0.458%) cultivars, while the lowest average K content was observed in Florispan (0.367%) (Table 3). Jonnala et al. (2005) found the K content between 0.564% and 0.615, Shokunbi et al. (2012) found the K content between 0.575% and 0.611%. The amount of K element can vary. K is very important to plants and is the second-most absorbed element, overcome only by N. K has the physiological function of an enzymatic activator and, once absorbed, can be transferred from the older parts of the aerial portions to the newer parts (Tasso et al. 2004). K plays an important role in the formation of fruits, acting in the transport of photoassimilates in the phloem (Taiz & Zeiger 2013). The deposition of biomass in fruit is necessarily accompanied by the accumulation of K. In addition, K is a required nutrient in the activation of several enzymes essential to the synthesis of organic compounds, among them starch (Laviola & Dias 2008).

Regulation of K uptake is still poorly understood. It has been shown that plants respond to low concentrations of K by increasing the capacity for high-affinity K transport (White 1997), which might be due either to an increase in the number of transporters or to a higher activity of existing transporters.

The average Ca content of the cultivars is between 0.052% and 0.072% (Table 3). The highest Ca content was obtained from Flower-22 variety, which is in the Virginia group, while the lowest average Ca content was obtained from Halisbey and Arıoğlu-2003 cultivars (Table 3). Cobb & Johnson (1973) found that the Ca content in the seed was in the range of 0.01-0.08%. The results are consistent with the results found by the researchers. Shokunbi et al. (2012) also found that the Ca content Boro Light, Boro Red, Mokwa, Campala and Ela in the peanut varieties was in the range of 0.044-0.063%. Shibli et al. (2019) reported that the Ca content BARD-9, BARD-479 and Local 334 in the peanut seed was in the range of 0.039-0.048%.

Ca has chemical attributes that give it a special role in controlling many aspects of plant growth and development. Ca is rather unusual among plant nutrients in that most Ca is localized outside of the cell where it has an important role in stabilizing cell walls by cross-linking acidic side groups on adjacent pectic polysaccharide molecules. In plants without pectin in cell walls, essentiality for Ca is difficult to demonstrate (O'Kelley 1968).

The highest Mg element content was obtained from Arıoğlu-2003 (0.262%) variety, while the lowest Mg content was obtained from Polen, Osmaniye-2005, Batem-5025, Florispan and Batem-Cihangir varieties with 0.237%. Gaines and Hammons (1981) found the Mg content between 0.20-0.25%. They conducted with Early Bunch, Florigiant, Florunner and Tifrun peanut varieties. Jonnala et al. (2005) found Okrun peanut and 188, 540, 654 in the peanut lines Mg content between 0.189 and 0.219%, Shokunbi et al. (2012) also found that the Mg content Boro Light, Boro Red, Mokwa, Campala and Ela in the peanut seed was in the range of 0.098-0.112%, Shibli et al. (2019) reported that Mg content between 0.068 and 0.083%. These results are consistent with our study. Mg is present in plant cells in high concentrations and has a range of important functions: it is a cofactor in reactions involving ATP, stabilizes DNA and RNA molecules and cellular membranes, and is a component of chlorophyll. Despite this, our understanding of Mg uptake is very poor, with almost nothing reported in the literature about the mechanism of Mg entry into plant cells. The Na element content of the varieties varied between 0.08-0.099%. The highest average Na content was obtained from Halisbey variety, the lowest average Na content was obtained from NC-7, Wilson, Batem-5025 and Georgia Green varieties.

Peanut plant also contains different amounts of micro nutrients. Micronutrients are essential elements that are used by plants in small quantities. In spite of this low requirement, critical plant functions are limited if micronutrients are unavailable, resulting in plant abnormalities, reduced growth and lower yield. In such cases, expensive, high requirement crop inputs such as nitrogen and water may be wasted. Because of higher yields, higher commodity prices and higher costs of crop inputs, growers are reviewing all potential barriers to crop production, including micronutrient deficiencies. Micro element analysis results are given in Table 4.

Table 3- Macro Element Content of Peanut Varieties

Macro Elements	*Years*	*Varieties*													
		Polen	*Halisbey*	*NC-7*	*Sultan*	*Flower-22*	*Osmaniye-2005*	*Brantley*	*Wilson*	*Batem-5025*	*Arıoğlu-2003*	*Georgia Green*	*Florispan*	*NC V 11*	*Batem-Cihangir*
N (%)	1. Years	3.72 bc	3.54 e-g	3.44 g	3.58 ef	3.50 fg	3.77 b	3.70 b-d	3.53 e-g	3.62 c-e	3.61 d-f	3.25 h	3.94 a	3.44 g	3.56 ef
	2. Years	4.35 b-e	4.25 c-e	4.33 b-e	4.46 b-d	4.20 c-e	4.15 d-e	4.41 b-e	4.34 b-e	4.53 a-c	4.42 b-e	4.09 e	4.83 a	4.61 ab	4.37 b-e
	Means	4.04 bc	3.89 b-d	3.88 cd	4.02 b-d	3.85 de	4.06 bc	4.05 bc	3.94 b-d	4.07 b	4.02 b-d	3.67 e	4.38 a	4.03 b-d	3.96 b-d
P (%)	1. Years	0.470 d-e	0.563 a	0.480 c-e	0.500 b-e	0.510 bc	0.503 b-d	0.520 b	0.480 c-e	0.465 e	0.493 b-e	0.505 b-d	0.505 b-d	0.480 c-e	0.510 bc
	2. Years	0.470 c-e	0.555 a	0.473 c-e	0.500 b-d	0.503 b-d	0.495 b-e	0.515 ab	0.463 de	0.455 e	0.478 b-e	0.475 b-e	0.495 b-e	0.480 b-e	0.510 bc
	Means	0.470 gh	0.558 a	0.476 e-h	0.500 b-e	0.506 b-d	0.498 b-f	0.517 b	0.471 f-h	0.460 h	0.485 c-h	0.490 b-g	0.500 b-e	0.480 d-h	0.510 bc
K (%)	1. Years	0.400 c-e	0.425 cd	0.395 de	0.465 a	0.380 e	0.430 bc	0.413 cd	0.395 de	0.375 e	0.415 cd	0.458 ab	0.405 c-e	0.420 cd	0.430 bc
	2. Years	0.370 c	0.428 ab	0.343 de	0.453 a	0.378 c	0.430 ab	0.358 cd	0.380 c	0.363 cd	0.418 b	0.438 ab	0.330 e	0.418 b	0.438 ab
	Means	0.385 de	0.426 c	0.368 de	0.458 a	0.378 de	0.430 bc	0.385 de	0.387 d	0.368 de	0.416 c	0.447 ab	0.367 e	0.418 c	0.433 bc
Ca (%)	1. Years	0.060 b-d	0.053 d	0.063 a-d	0.070 ab	0.073 a	0.060 b-d	0.070 ab	0.068 ab	0.065 a-c	0.053 d	0.060 b-d	0.065 a-c	0.055 cd	0.070 ab
	2. Years	0.050 c	0.053 bc	0.063 ab	0.060 bc	0.073 a	0.060 bc	0.058 bc	0.060 bc	0.058 bc	0.053 bc	0.058 bc	0.050 c	0.060 bc	0.053 bc
	Means	0.055 cd	0.052 d	0.062 bc	0.065 ab	0.072 a	0.060 b-d	0.064 b	0.064 b	0.061 bc	0.053 d	0.059 b-d	0.057 b-d	0.057 b-d	0.061 bc
Mg (%)	1. Years	0.238 bc	0.255 ab	0.243 a-c	0.245 a-c	0.245 a-c	0.243 a-c	0.245 a-c	0.248 a-c	0.243 a-c	0.258 a	0.245 a-c	0.238 bc	0.250 a-c	0.235 c
	2. Years	0.245 bc	0.250 bc	0.258 ab	0.255 ab	0.255 ab	0.243 bc	0.245 bc	0.250 bc	0.243 bc	0.268 a	0.255 ab	0.238 c	0.243 bc	0.250 bc
	Means	0.241 bc	0.252 ab	0.250 a-c	0.250 a-c	0.250 a-c	0.242 bc	0.245 bc	0.248 bc	0.242 bc	0.262 a	0.250 a-c	0.237 c	0.246 bc	0.242 bc
Na (%)	1. Years	0.093 bc	0.103 a	0.093 bc	0.095 a-c	0.090 b-d	0.095 a-c	0.093 bc	0.083 d	0.083 d	0.098 ab	0.088 cd	0.093 bc	0.098 ab	0.093 bc
	2. Years	0.080 c-e	0.095 a	0.075 e	0.085 b-d	0.080 c-e	0.085 b-d	0.080 c-e	0.078 de	0.080 c-e	0.090 ab	0.080 c-e	0.080 c-e	0.088 a-c	0.088 a-c
	Means	0.086 c-e	0.099 a	0.084 de	0.090 b-d	0.085 de	0.090 b-d	0.086 c-e	0.080 e	0.081 e	0.093 ab	0.084 de	0.086 c-e	0.084 a-c	0.090 b-d

CV (N) years x cultivars (P<0.05): 4.6, CV (P) years x cultivars (P<0.05): 5.6, CV (K) years x cultivars (P<0.05): 5.0, CV (Ca) years x cultivars (P<0.05): 13.16, CV (Mg) years x cultivars (P<0.05): 5.1, CV (Na) years x cultivars (P<0.05): 7.6

2015 Year: Toprakkale; 2016 Year: Alahanlı

Table 4- Micro Element Content of Peanut Varieties

Micro Elements	*Years*	*Varieties*													
		Polen	*Halisbey*	*NC-7*	*Sultan*	*Flower-22*	*Osmaniye-2005*	*Brantley*	*Wilson*	*Batem-5025*	*Arıoğlu-2003*	*Georgia Green*	*Florispan*	*NC V 11*	*Batem-Cihangir*
Fe (mg kg^{-1})	1. Years	17.09 g	24.99 a-d	22.29 e	23.85 c-e	19.55 f	23.88 b-e	24.29 b-e	19.84 f	18.06 fg	26.11 ab	25.97 a-c	22.92 de	24.21 b-e	26.76 a
	2. Years	16.96 f	24.74 b-d	21.44 e	26.89 ab	24.39 b-d	23.71 c-e	23.28 c-e	21.30 e	18.08 f	25.02 b-d	25.77 a-c	22.86 de	24.37 b-d	27.91 a
	Means	17.02 h	24.86 b-d	21.86 fg	25.37 b-d	21.97 fg	23.80 c-e	23.78 de	20.57 g	18.07 h	25.56 bc	25.87 ab	22.89 ef	24.29 b-e	27.34 a
Cu (mg kg^{-1})	1. Years	3.33 b	3.38 b	3.43 b	3.38 b	7.17 a	3.97 b	3.45 b	4.06 b	3.92 b	4.04 b	3.94 b	3.86 b	4.05 b	4.09 b
	2. Years	3.86 bc	2.78 c	2.64 c	3.52 bc	7.00 a	4.01 bc	3.27 bc	3.17 bc	3.30 bc	3.82 bc	3.96 bc	4.59 b	4.09 bc	4.16 bc
	Means	3.59 b-d	3.08 cd	3.04 d	3.45 b-d	7.08 a	3.99 b-d	3.36 b-d	3.61 b-d	3.61 b-d	3.93 b-d	3.95 b-d	4.23 b	4.07 b-d	4.13 bc
Zn (mg kg^{-1})	1. Years	22.55 gh	21.95 h	26.14 d-f	31.78 a	30.92 ab	29.76 a-c	28.41 cd	27.89 c-e	25.79 ef	26.29 d-f	29.39 bc	24.51 fg	25.92 ef	24.21 f-h
	2. Years	22.70 cd	22.21 c-e	17.59 hı	26.92 a	20.13 e-g	22.29 c-e	18.26 g-ı	18.78 g-ı	19.02 g-ı	24.33 bc	19.74 f-h	25.59 ab	17.27 ı	21.68 d-f
	Means	22.63 de	22.08 de	21.87 de	29.35 a	25.52 b	26.02 b	23.33 cd	23.33 cd	22.41 de	25.31 b	24.57 bc	25.05 b	21.60 e	22.94 de
Mn (mg kg^{-1})	1. Years	17.05 ef	18.97 a-e	20.66 a	17.10 e	19.76 a-c	17.77 c-e	17.58 de	17.86 c-e	18.37 b-e	14.98 f	19.29 a-d	18.91 a-e	19.39 a-d	19.97 ab
	2. Years	16.07 d-f	16.16 d-f	20.56 a	16.67 de	17.58 c-e	17.42 c-e	17.55 c-e	17.52 c-e	18.56 bc	14.53 f	15.84 ef	17.69 cd	18.87 a-c	19.99 ab
	Means	16.56 e	17.56 de	20.61 a	16.89 e	18.67 b-d	17.59 de	17.57 de	17.69 de	18.46 cd	14.76 f	17.57 de	18.30 cd	19.13 bc	19.98 ab
B (mg kg^{-1})	1. Years	18.22 e	24.83 bc	16.92 e	25.54 ab	18.01 e	22.17 d	17.02 e	17.82 e	17.10 e	16.84 e	22.36 d	26.65 a	23.34 cd	18.26 e
	2. Years	17.70 e	24.92 b	17.67 e	22.93 bc	24.72 b	21.00 d	17.21 e	16.83 e	15.85 e	23.93 b	21.35 cd	27.34 a	22.68 b-d	23.01 bc
	Means	17.96 g	24.87 b	17.29 gh	24.24 bc	21.36 ef	21.38 ef	17.12 gh	17.32 gh	16.48 h	20.38 f	21.86 de	26.99 a	23.01 cd	20.64 ef

CV (Fe) years x cultivars (P<0.05): 7.7, CV (Cu) years x cultivars (P<0.05): 27.8, CV (Zn) years x cultivars (P<0.05): 6.6, CV (Mn) years x cultivars (P<0.05): 7.8, CV (B) years x cultivars (P<0.05): 6.6

2015 Year: Toprakkale; 2016 Year: Alahanlı

Fe element, one of the micro elements, varied between the cultivars between 17.02 and 27.34 mg kg^{-1}. The highest average Fe content was 27.34 mg kg^{-1} from Batem-Cihangir variety, while the lowest average Fe content was obtained from Polen (17.02 mg kg^{-1}) (Table 4). In previous studies by researchers, it was determined that the Fe content of peanuts varied between 18 and 70 mg kg^{-1} (Hallock 1980; Cobb & Johnson 1973). In a study conducted by Gaines and Hammons in 1981, they found the rate of Fe element in peanut seed at the rate of 23-32 mg kg^{-1}. Shokunbi et al. (2012) found the content of Fe in the peanut seeds between 13.3-16.7 mg kg^{-1}. The Fe content that we found in our study is between 17.02-27.34 mg kg^{-1}, and it is consistent with the findings of the researchers.

The variety with the highest average Cu content among the varieties was Flower-22 (7.08 mg kg^{-1}). The variety with the lowest Cu content was NC-7 (3.04 mg kg^{-1}). It was determined that the Cu content of peanuts varied between 3 and 20 mg kg^{-1} by previous researchers (Hallock et al. 1971; Walker & Hymowitz 1972). James Yaw et al. (2008) were found the Cu content between 17 and 27 mg kg^{-1} with twenty peanut varieties in their study. The Zn content of 14 different peanut varieties grown under main crop conditions varied between 21.60-29.35 mg kg^{-1}. The highest Zn content was obtained from the Sultan variety with 29.35 mg kg^{-1} and the lowest Zn content was obtained from the NC V 11 variety with 21.60 mg kg^{-1} (Table 4). The Zn content was determined in previous studies to vary between 17 and 800 mg kg^{-1} (Hallock et al. 1971; Walker & Hymowitz 1972; Cobb & Johnson 1973). The Zn content was determined in previous studies to vary between 27 and 65 mg kg^{-1} (Jonnala et al. 2005; James Yaw et al. 2008; Shokunbi et al. 2012; Shibli et al. 2019). When the Mn content is evaluated; the highest Mn content is in the NC-7 (20.61 mg kg^{-1}) variety, the lowest Mn content is determined in the cultivar Arıoğlu-2003 (14.76 mg kg^{-1}) (Table 4). The Mn content was determined in previous studies to vary between 11.0 and 32.0 mg kg^{-1} (Hallock & Allison 1980; Hallock 1980). Boron (B) content of the varieties varied between 16.48-26.99 mg kg^{-1}. The highest B content was obtained from Florispan (26.99 mg kg^{-1}) and the lowest B content was obtained from Batem-5025 (16.48 mg kg^{-1}) (Table 4).

In our study, the peanut varieties were ranked as N>P>K>Mg>Ca>Na>Zn>Fe> B>Mn>Cu in terms of the amount of plant nutrients. Silva et al. (2016) reported macro and micro nutrient uptake in their study in descending order was: N > K > Ca > Mg > S > P and Fe > Zn > Mn > Cu > B, respectively. According to Malavolta et al. (1997) the majority of crops, in general, obey the N > K > Ca > Mg > P ≈ S order of macro- and Fe > Mn > Zn > Cu ≈ B order of micronutrients. However, in peanuts, an inversion of Mn with respect to Zn occurs.

There are several factors known to affect the plant nutrient composition of foods; genetic factors, climate, geography, geochemistry, agricultural practices such as fertilizer use, stage of maturity, and the growth period. There is a considerable variety of peanut varieties used for the study, and this variety provides the opportunity to select genotypes with desired characteristics for use in fertilizer programs. Further studies should be performed on these varieties to demonstrate the effects of agricultural operations on plant nutrient composition.

References

Akram N A, Shafiq F & Ashraf M (2018). Peanut (*Arachis hypogaea* L.): A prospective legume crop to offer multiple health benefits under changing climate. Institute of Food Technologists. *Comprehensive Reviews in Food Science and Food Safety* 17 (5): 1325-1338. https://doi:10.1111/1541-4337.12383

Andersen P C & Gorbet D W (2002). Influence of year and planting date on fatty acid chemistry of high oleic acid and normal peanut genotypes. *Journal of Agricultural and Food Chemistry* 50(5): 1298-1305. https://doi.org/10.1021/jf0113171

Ayoola P B, Adeyeye A & Onawumi O O (2012). Chemical evaluation of food value of groundnut (*Arachis hypogaea*) seeds. *American Journal of Food and Nutrition* 2(3): 55-57. https://doi.org/10.5251/ajfn.2012.2.3.55.57

Bolonhezı D, Santos R C & Godoy I J (2005). Manejo cultural do amendoim. In: Santos, R.C. (Ed.). O agronegocio do amendoim no Brasil. Campina Grande: Embrapa Algodao CNPA 2(6): 451-475.

Bremner J M (1960). Determination of nitrogen in soil by the Kjeldahl method, Journal of Agricultural Science 5 (1):11-33. https://doi.org/10.1017/S0021859600021572

Cobb W Y & Johnson B R (1973). Physicochemical properties of plants. In Peanuts Culture and Uses. Amer. Peanut Res. Educ. Assn., Inc., Stillwater, pp. 209-263.

Cox F R, Nicholaids K K, Reid P H, Hallock D L & Martins D C (1970). Nutrient concentration in Virginia, type peanuts during the growing season. North Carolina Agric. Exp. Stn. Tech. Bull, 204 p.

Cox F R, Adams J F & Tucker B B (1982). Liming, fertilization and mineral nutrition. In: H E Pette & C T Young (Eds.), Peanut Science and Technology. American Peanut Research and Education Society Inc. Yoakum, Texas, U.S.A, pp. 139-163.

Davis J P, Price K M, Dean L L, Sweigart D S, Cottonaro J M & Sanders T H (2016). Peanut oil stability and physical properties across arrange of industrially relevant oleic acid/ linoleic acid ratios. *Peanut Science* 43(1): 1-11.

Deshpande R P, Chinnan M S & Phillips R D (2008). Process development of a chocolate-flavoured peanut–soy beverage. *International Journal of Food Science and Technology* 43(5): 886-894. https://doi.org/10.1111/j.1365-2621.2007.01537.x

Dwivedi R S (1988). Mineral nutrition of groundnut. Metropolitan Book Co, New Delhi, India 135p.

FAO 2020. Statistical Database. Retrieved from http://faostat.fao.org/faostat/collections?Subset=agriculture

Feitosa C T, Nogueira S S S, Gerin M A N & Rodrigues Filho F S O (1993). Avaliaçao do crescimento e da utilizaçao de nutrientes pelo amendoim. *Scientia Agrícola, Piracicaba* 50(3): 427-437. https://doi.org/10.1590/s0103-90161993000300015

Gaines T P & Hammons R O (1981). Mineral Composition of Peanut Seed as Influenced by Cultivar and Location. *Peanut Science* 8:16-20. https://doi.org/10.3146/i0095-3679-8-1-5

Gascho G J & Davis G (1994). The Groundnut Crop: A scientific basis for improvement, pp 214-254. Edited by 1. Smartt. Published by Chapman & Hall, London

Hallock D L, Martens D C & Alexander M W (1971). Distribution of P, K, Ca, Mg, B, Cu, Mn, and Zn in peanut lines near maturity. *Agron. Journal* 63: 251-256. https://doi.org/10.2134/agronj1971.00021962006300020017x

Hallock D L & Allison A H (1980). Effect of three Ca sources applied on peanuts in Virginia. I. Productivity and seed quality. *Peanut Sci* 7: 19-25 https://doi.org/10.3146/i0095-3679-7-1-6

Hallock D L (1980). Soil or foliar applied nutrient effects on mineral concentrations and germinability of peanut seed. *Peanut Sci* 7: 50-54. https://doi.org/10.3146/i0095-3679-7-1-12

Hartzog D L & Adams J F (1988). Soil fertility experiments with peanuts in Albana, 1973-1986. Albana Agric. Exp. Stn. Bull. 594:1-39.

Hasan M M, Cha M, Bajpai V K & Baek K H (2013). Production of a major stilbene phytoalexin, resveratrol in peanut (*Arachis hypogaea*) and peanut products: A mini review. *Reviews in Environmental Science and Biotechnology* 12: 209-221. https://doi.org/10.1007/s11157-012-9294-7

Isanga J & Zhang G N (2007). Biologically active components and nutraceuticals in peanuts and related products. *Food Reviews International* 23(2): 123-140. https://doi.org/10.1080/87559120701224956

James Yaw A, Richard A, Osei S K, Adu-Dapaah, Hans Kofi A D, Seth O D & Adelaide A (2008). Chemical composition of groundnut, *Arachis hypogaea* (L) landraces, *African Journal of Biotechnology* 7(13): 2203-2208.

Jonnala R S, Dunford N T & Chenault K (2005). Nutritional composition of genetically modified peanut varieties. *Journal of Food Science* 70: 254-256. https://doi.org/10.1111/j.1365-2621.2005.tb07198.x

Jonnala R S, Dunford N T & Chenault K (2006). Tocopherol, phytosterol and phospholipid compositions of genetically modified peanut varieties. *Journal of the Science of Food and Agriculture* 86: 473-476. https://doi.org/10.1002/jsfa.2372

Kacar B & İnal A (2014). Plant Analysis, Nobel Publishing Distribution, Ankara

Kacar B (1994). Chemical analysis of plants and soil III. Soil analysis. Ankara Unv. Faculty of Agriculture Education Research and Development Foundation Publications, No:3, 705s, Ankara (In Turkish) https://doi.org/10.5152/kd.2018.37

Krishna G, Singh B K, Kim E K, Morya V K & Ramteke P W (2015). Progress in genetic engineering of peanut (*Arachis hypogaea* L.): A review. *Plant Biotechnology Journal* 13(2): 147-162. https://doi.org/10.1111/pbi.12339

Lal R (2008). Soils and sustainable agriculture: A review. *Agronomy for Sustainable Development*, 28: 57-64. https://doi.org/10.1051/agro:2007025

Laviola B G & Dias L A S (2008). Teor e acumulo de nutrientes em folhas e frutos de pinhao-manso. *Revista Brasileira de Ciencia do Solo, Viçosa* 32(1): 1969-1975. https://doi.org/10.1590/s0100-06832008000500018

Lindsay W L & Norwell W A (1978). Development of a DTPA micronutrient soil test for Zinc, Iron, Manganese, and Copper, *Soil Science Society of America Journal* 42 (3): 421-428. doi:10.2136/sssaj1978.03615995004200030009x

Malavolta E, Vitti G C & Oliveira S A (1997). Avaliacao do estado nutricional das plantas: principios e aplicacoes. 2.ed. Piracicaba: Associacao Brasileira para Pesquisa da Potassa e do Fosfato. 319 p

Marini A, Springael J, Frommer W & Andre B (2000). Cross-talk between ammonium transporters in yeast and interference by the soybean SATI protein. *Mol. Microbiol* 35: 378-385. https://doi.org/10.1046/j.1365-2958.2000.01704.x.

Mulando T M M & Resurreccion A V A (2006). Peanut extract and emulsifier concentration affect sensory and physical properties of liquid whitener. *Journal of Food Science* 59(2): 344-349. https://doi.org/10.1111/j.1365-2621.1994.tb06963.x

O'Kelley J (1968). Mineral nutrition of algae. Annu. Rev. *Plant Phsiol* 19: 89-112. https://doi.org/10.1146/annurev.pp.19.060168.000513

Patel K G, Mandaliya V B, Mishra G P, Dobaria J R & Thankappan R (2016). Transgenic peanut overexpressing mtlD gene confers enhanced salinity stress tolerance via mannitol accumulation and differential antioxidative responses. Acta Physiologiae Plantarum 38: 181. https://doi.org/10.1007/s11738-016-2200-0

Sales J M & Resurreccion A V A (2010). Phenolic profile, antioxidants, and sensory acceptance of bioactive-enhanced peanuts using ultrasound and UV. *Food Chemistry* 122(3): 795-803. https://doi.org/10.1016/j.foodchem.2010.03.058

Sarkar T, Thankappan R, Kumar A, Mishra G P & Dobaria J R (2016). Stress inducible expression of AtDREB1A transcription factor in transgenic peanut (*Arachis hypogaea* L.) conferred tolerance to soil-moisture deficit stress. *Frontiers in Plant Science* 7: 935. https://doi.org/10.3389/fpls.2016.00935

Sillanpaa M (1990). Micronutrient assessment at the country level: An International Study. *FAO Soils Bulletin No. 63,* Rome. Food and Agriculture Organization; 10.1186/s12889-016-2765-y

Silva E D B, Ferreira E A, Pereira G A M, Silva D V & Oliveira A J M (2016). Peanut plant nutrient absorption and growth. *Universidade Federal Rural do Semi-Arid.* 30: 653-661. http://dx.doi.org/10.1590/1983-21252017v30n313rc

Singh A L (1999). Mineral nutrition of groundnut. In: A Hemantranjan (Ed.), Advances in Plant Physiology Vol II, Scientific Publishers (India), Jodhpur, pp. 161-200.

Singh A L (2004). Mineral nutrient requirement, their disorders and remedies in Groundnut. In: M S Basu & N B (Eds) Groundnut Research in India National Research center for groundnut (ICAR),Junagadh, India, pp. 137-159.

Shibli S, Siddique F, Raza S, Ahsan Z & Raza I (2019). Chemical composition and sensory analysis of peanut butter from indigenous peanut cultivars of Pakistan. *Pakistan Journal of Agricultural Research* 32(1): 159-169. https://doi.org/10.17582/journal.pjar/2019/32.1.159.169

Shokunbi O S, Fayomi E T, Sonuga O S & Tayo G O (2012). Nutrient composition of five varieties of commonly consumed Nigerian groundnut (*Arachis hypogaea* L.). *Grasas y Aceites. International Journal of Fats and Oils* 63(1): 14-18. https://doi.org/10.3989/gya.056611

Steer B T & Hocking P J (1984). Nitrogen nutrition of sunflower (*Helianthus annuus* L.) acquisition and partitioning of dry matter and nitrogen by vegetative organs and their relationship on seed yield. *Field Crops Research* 9: 237-251. https://doi.org/10.1016/0378-4290(84)90029-7

Tasso J L C, Marques M O & Nogueira G A A (2004). Cultura do Amendoim. 1. ed. Jaboticabal, SP: UNESP, p. 220

Taiz L & Zeiger E (2013). Plant physiology. California: The Benjamin/Cummigs Publishing, p. 559

Tüzüner A (1990). Soil and water analysis laboratories handbook. T.R. Ministry of Agriculture and Rural Affairs, General Directorate of Rural Services, pp. 61-73, Ankara (In Turkish) https://doi.org/10.5152/kd.2020.61

Tyerman S, Whitehead L & Day D (1995). A channel–like transporter for NH_4^+ on the symbistic interface of N_2 fixing plants. *Nature* 378: 629-632. https://doi.org/10.1038/378629a0

Walker W M & Hymowitz T (1972). Simple correlations between certain mineral and organic components of common beans, peanuts and cowpea. Commun. *Soil Sci. Plant Analysis* 3:505-511. https://doi.org/10.1080/00103627209366407

White P J (1997). The repulation of K^+ influx into roots of rye (*Secale cereale* L.) seedlings by negative feedback via the K^+ flux from shoot to root in the phloem. *Journal of Experimental Botany* 48: 2063-2073. https://doi.org/10.1093/jxb/48.12.2063

Zhang B, Sun L, Wu Y, Xu H & Tu K (2017). Adsorption kinetics of flavonoids from peanut hull by macroporous resin. China Oils and Fats 42(3): 122-126.