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Comparison of Quality and Yield Components of Peanut Market Types Using PCA

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ABSTRACT
The aim of this study was to compare of agronomic and quality parameters of peanut varieties (*Arachis hypogea* L.) grown as main crop in Mediterranean Region of Türkiye. Principal component analysis (PCA) was used for evaluating the results of varieties. Field experiments were conducted over during the main crop seasons of the years 2018 and 2019. The experiment was designed as randomized complete block design (RCBD) with three replications. Runner (Georgia Green), Spanish (Florispan) and Virginia market types (Sultan, Brantley, BATEM-Cihangir, BATEM-5025, Arioglu-2003, Halisbey, NC-7, Flower-22, Wilson, NC-V-11, Com, Osmaniye-2005, Gazipasa) peanut varieties were used as plant materials. According to PCA two-year average, PC1, PC2 and PC3 explained about 80% in joined years. Georgia Green could be recommended to achieve high efficiency shelling percentage (73.96%) and pod yield (497.24 kg da^{-1}), and Arioglu-2003 could be the optimum selection on the first quality pod ratio (80.28%) and protein content (28.76%).

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Yerfıstığı Pazar Tiplerinin Kalite ve Verim Bileşenlerinin TBA Kullanılarak Karşılaştırılması

ÖZET
Bu çalışmada, Akdeniz Bölgesi'nde ana ürün olarak yetiştirilen yerfıstığı çeşitlerinin (*Arachis hypogea* L.) bazı agronomik ve kalite özelliklerinin karşılaştırılması amaçlanmıştır. Tesadüf blokları deneme desenine göre 3 tekerrürlü ve 2 yıl (2018 ve 2019) süreyle yürütülmüştür. Elde edilen sonuçların değerlendirilmesi için temel bileşen analizi (TBA) kullanılmıştır. Runner (Georgia Green), Spanish (Florispan) ve Virginia pazar tiplerine (Sultan, Brantley, BATEM-Cihangir, BATEM-5025, Arıoğlu-2003, Halisbey, NC-7, Flower-22, Wilson, NC-V-11, Com, Osmaniye-2005, Gazipaşa) ait yerfıstığı çeşitleri bitki materyali olarak kullanılmıştır. Yapılan TBA sonucunda, iki yıllık ortalamalara göre PC1, PC2 ve PC3 bileşenleri toplam varyasyonun yaklaşık %80'ini açıklamıştır. Sonuç olarak, Georgia Green çeşidi hem iç oranı (%73.96) hem de meyve verimiyle (497.24 kg da^{-1}) ön plana çıkarken, birinci kalite meyve sayısı oranı (%80.28) ve protein içeriği (%28.76) açısından ise Arıoğlu-2003 çeşidi ön plana çıkmıştır.

Tarla Bitkileri

Araştırma Makalesi

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Anahtar Kelimeler
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INTRODUCTION

Peanut (*Arachis hypogea* L.), from *Fabaceae*, is an important oil crop and used in both human and animal nutrition because of its protein, mineral and carbohydrate contents (Awal & Aktar, 2015; Arioglu et al., 2016; Yilmaz, 2022). Peanut seeds contain approximately 45-55% oil and 25-30% protein. Peanut oil is composed of 43% oleic acid (|C18:1|), 30% linoleic acid (|C18:2|), and 12% palmitic acid (|C16:0|) (Shin et al., 2010; Yasli et al., 2020). High oleic acid content provides an extended shelf life for peanut-derived

products in food applications (Yol & Uzun, 2018; Sahin et al., 2022). Because of crop pulp has the highest crude protein (45%) after the oil extraction, it is used for making mixed feed in developed countries (Arioglu et al., 2016). There are four market types of peanuts such as Spanish, Valencia, Runner, and Virginia. Each market type has own nutritional composition, flavor, and pod size (Arioglu, 2014; Zhao et al., 2017; Karabulut & Tuncturk, 2019).

Peanut absorbs the high amount of nitrogen from the soil when harvesting because of it is a legume plant and its seed contains high protein content. The researchers reported that peanut plant fixed about 45-150 kg ha^{-1} nitrogen during the growing period (Gohari & Niyaki, 2010; Yilmaz et al., 2022). Nitrogen, fixed by *Rhizobium*, is stored as nodules in plant roots and a large proportion of this nitrogen is used by the plants (Arioglu et al., 2016; Karabulut & Tuncturk, 2019; Yasli et al., 2020).

The World produced about 53.6 million tonnes of peanut on 31.5 million ha area in 2020. The top producers are China, India, Nigeria, the USA, and Sudan (FAO, 2022). In 2020, Republic of Türkiye produced about 216 thousand tonnes of peanut on 54.7 thousand ha area. Adana and Osmaniye, located in Mediterranean region, were the top producer provinces as about 90% (TUIK, 2022). Peanut can be valuable alternative crop for the irrigated areas of the Mediterranean basin which has suitable temperature regimes for both vegetative and reproductive growth of peanut (Caliskan et al., 2008; Yol & Uzun, 2018). In 2020, shelled peanut is one the most important market product in the World which has 3.6 billion USD import and 3.5 billion USD export values. The importers were Netherlands, Indonesia, UK, Mexico, and Germany while the top five exporters were India, China, USA, Argentina, and Netherlands (FAO, 2022).

The percentage of flowers turned to pegs and the percentage of pegs turned to pods were the most promising characteristics that could contribute to seed yield increase in peanut production (Caliskan et al., 2008). These researchers also reported that the highest pod yield was obtained from Osmaniye 2005 variety which had the lowest number of flowers per plant and the highest percentage of flowers turned to pods.

Arioglu et al. (2016) investigated the some important agronomical and quality properties of peanut varieties in main crop season. As a result of study, they indicated that pod yield varied between 366-879 kg da^{-1}, and average oil and protein contents were 49% and 26%, respectively.

Asik et al. (2018) reported that the number of pods per plant, 100 seed weight, internal rate and pod yield were varied between 15.53-43.31, 53.27-132.68 g, 62.40-76.57% and 234.46-655.41 kg da^{-1}, respectively. Halisbey, Osmaniye-2005, Sultan, NC-V-11, BATEM-5025 and Brantley were as alternative varieties for NC-7, mostly chosen by farmers, for getting highest pod yield.

The objectives of this study were to determine the agronomic and quality characteristics of peanut varieties grown as a main crop season in Mediterranean Region of Türkiye.

MATERIAL and METHOD

Material

Georgia Green, Sultan, Brantley, BATEM-Cihangir, BATEM-5025, Arioglu-2003, Halisbey, NC-7, Florispan, Flower-22, Wilson, NC-V-11, Com, Osmaniye-2005 and Gazipasa were used as a plant material in the study (Table 1). Experiments were carried out over the experimental fields of Osmaniye Oil Seed Research (37°03′41”N, 36°06′79”E; 50 m) in Türkiye during the main growing seasons of 2018 and 2019.

Table 1. Some characteristics of peanut varieties.
Çizelge 1. Yerfıstığı çeşitlerinin bazı özellikleri

Varieties	Growing Type	Market Type	Origin
Florispan	Erect	Spanish	USA
BATEM-Cihangir	Semi-erect	Virginia	Türkiye
Georgia Green	Spreading	Runner	USA
Sultan	Semi-spreading	Virginia	Türkiye
Brantley	Semi-spreading	Virginia	USA
BATEM-5025	Semi-spreading	Virginia	Türkiye
Arioglu-2003	Semi-spreading	Virginia	Türkiye
Halisbey	Semi-spreading	Virginia	Türkiye
NC-7	Semi-spreading	Virginia	USA
Flower-22	Semi-spreading	Virginia	China
Wilson	Semi-spreading	Virginia	USA
NC-V-11	Semi-spreading	Virginia	USA
Com	Semi-spreading	Virginia	Türkiye
Osmaniye-2005	Semi-spreading	Virginia	Türkiye
Gazipasa	Semi-spreading	Virginia	Türkiye

The pH of the clay-loam soil used in the study was slightly alkaline (pH ~8). Lime content of the soil was optimum (~10%) while the organic matter of soil was low (~1.20%). Climate parameters -total precipitation, average temperature and relative humidity- during 2018 and 2019 growing period and long year (LY) were shown in Figure 1. The total precipitation was 220.1 mm in 2018 and 193.8 mm in 2019. Although LY (260.2 mm) was similar with 2018 but a bit difference with 2019. The average temperature in studied years and LY were no significant differences. The average temperatures were 25.1°C and 24.6°C in 2018 and 2019, respectively.

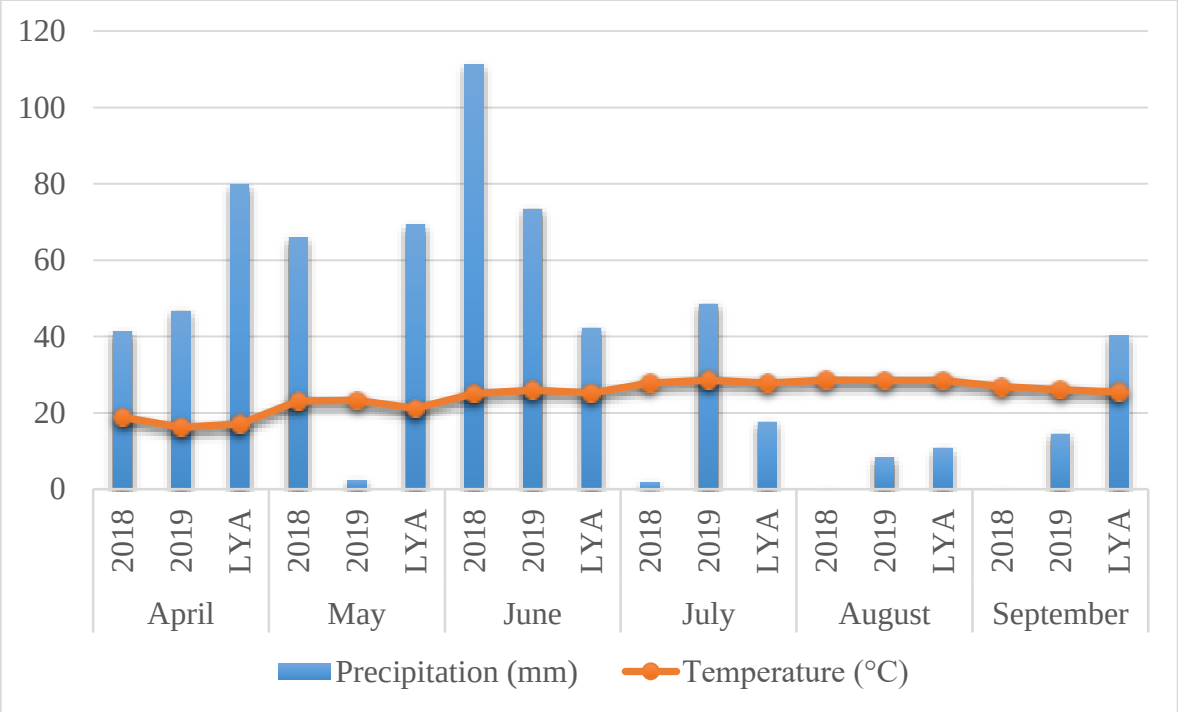


Figure 1. Climate parameters of the research field (2018, 2019, and long-year average)
Şekil 1. Araştırma alanının meteorolojik verileri (2018, 2019 ve uzun yıllar ortalaması)

Method

Experiments were conducted in randomized complete block design (RCBD) with three replications. Each plot had 5 m long four rows with 70 cm row and 15 cm plant spacing. Di-ammonium phosphate (DAP) fertilizer was used at the rates of 25 kg da^{-1} before sowing. Sowing was performed on April 6, 2018 in the first year and on April 30, 2019 in the second year. Hand weeding was performed with the emergence of the plants. Irrigations were performed to prevent drought effects with a drip irrigation system. Manuel harvests were performed on September 11, 2018 in the first year and on September 25, 2019 in the second year. Harvests were performed from two inner rows by taking into consideration side effects.

Number of pods per plant, pod weight per plant, 100-seed weight, 100-pod weight, shelling percentage, first quality pod ratio, protein content, and pod yield were measured over 20 plants randomly selected from each plot following the harvest. For 100-seed/pod weight, 4 × 100 seed/pod groups were taken from each plot and they were weighed, and averaged to get 100-seed/pod weight. Same groups (4 x 100 pods) were also used for calculating shelling percentage. Pod yield was determined through weighing the seeds of all plants of a plot except side effect rows. Seed nitrogen content was calculated by Kjeldahl method using Behr Distillation Unit S2. The conversion factor is 5.46 for peanut protein content. Each pod containing two seeds were counted and were determined for the first quality pod ratio.

Statistical Analysis

Experimental data were subjected to analysis of variance in accordance with RCBD separately for each year and joined years with the aid of R v4 software. Means were compared with the aid of Duncan's multiple range test. PCA was also performed with the aid of JMP 13 software.

RESULTS and DISCUSSION

The data was statistically analyzed using RCBD according to two-year values (each year separately and joined) and the probability level (p-value) for years, varieties, and years × varieties interaction were presented in Table 2. Pod weight per plant, 100-pod weight, first quality pod ratio, pod yield and protein content were found to be significant for years.

However, all investigated parameters were found to be significant ($p < 0.01$) for varieties in joined year analysis but no significant ($p > 0.05$) for years x varieties interaction.

Table 2. Results of the analysis of variance for characteristics studied in the experiment.
Çizelge 2. İncelenen özelliklere ait ANOVA sonuçları

SV	df	NP	PW	HPW	HSW	SP	FQP	PC	PY
Block	4	ns	ns	ns	ns	ns	ns	ns	ns
Year	1	ns	**	**	ns	ns	**	**	*
Varieties	14	**	**	**	**	**	**	**	**
Y × V	14	ns	ns	ns	ns	ns	ns	ns	ns

SV: Source of variation, df: Degree of freedom, * $p < 0.05$, ** $p < 0.01$, NP: Number of pods per plant, PW: Pod weight per plant, HPW: 100-pod weight, HSW: 100-seed weight, SP: Shelling percentage, FQP: First quality pod ratio, PC: Protein content, PY: Pod yield

The result for the number of pods per plant was significant ($p < 0.01$) for varieties but not for year and year × varieties interaction (Table 2). It was observed that the number of pods varied between 16.40±1.28-56.0±2.69 in two-year average. The highest value of pods number per plant was obtained from Georgia Green as 54.80±5.82 and 57.20±0.98 in 2018 and 2019, respectively with the average of 56.00±2.69. (Table 3). Georgia green almost doubled the rest of varieties that belong to Virginia type. Runner type peanut varieties produce more branches and pods number than Virginia type varieties (Gulluoglu et al., 2017). Asik et al. (2018) reported that the highest number of pods per plant is obtained from Runner type varieties because of growing spreading. Besides, number of pods increases to the pod yield, there is a positive correlation between them. These findings were similar with Arioglu et al. (2016), Gulluoglu et al. (2017) and Asik et al. (2018), lower than Caliskan et al. (2008) and Yol & Uzun (2018).

Upon analyzing the mean values of two years for pod weight per plant was significant ($p < 0.01$) for varieties and year but not for year × varieties interaction (Table 2). Pod weight per plant varied between 20.61±1.16-54.01±2.71 g in two-year average. The highest value of pod weight for 2018 (50.81±4.87 g), 2019 (57.20±1.67 g) and joined years (54.01±2.71 g) was obtained from Brantley, followed by NC-7 and Wilson as 51.31±2.57 g while lowest average was obtained from Florispan as 20.61±1.16 g (Table 3). Although Florispan had the second place for number of pods per plant, it got behind among all varieties for pod weight per plant. Thus, it also came last place for the pod yield. Pod weight per plant affected the pod yield directly in contrast to number of pods per plant. The pod size of the varieties that are mostly in the Virginia type are bigger than the other types (Asik et al., 2018). These findings were similar with Asik et al. (2018), lower than Arioglu et al. (2016), Gulluoglu et al. (2017) and Onat et al. (2017).

When the average values for 100-pod weight were examined, the highest mean was obtained from Osmaniye-2005 as 282.24±12.20 g, 295.17±4.07 g and 288.71±6.44 g in 2018, 2019 and average of studied years, respectively, while the lowest mean from Georgia Green as 113.08±2.22 g (Table 2 and 3). However, there is no statistical difference between them and Florispan variety. A hundred-pod weight was correlated with pod yield and 100-seed weight, positively, and number of pods per plant, negatively. Thus, it means 100-pod weight affect the pod yield directly. These findings were similar with Asik et al. (2018), lower than Arioglu et al. (2016).

A hundred-seed weight result was significant ($p < 0.01$) for varieties but not for year and year × varieties interaction (Table 2). It varied between 52.39±0.89-115.55±2.37 g in two-year average. The highest 100-seed weight was observed from Brantley as 118.30±4.49 g in 2018. BATEM-5025 (117.14±2.44 g) had the maximum 100-seed weight with Brantley (112.57±3.85 g) and NC-V-11 (115.58±4.89 g) cultivars in 2019. While the lowest value was obtained as 55.91±1.51 g from Georgia Green cultivar in the same group with Florispan cultivar (Table 4). Gulluoglu et al. (2017) reported that there is a positive correlation between seed size and 100-seed weight, and when the seed size increasing, affects the 100-seed weight positively. Similar to 100-pod weight, 100-seed weight was correlated with pod yield and pod weight per plant, positively, and number of pods per plant, negatively. These findings were similar with Caliskan et al. (2008), Arioglu et al. (2016), Gulluoglu et al. (2017), Asik et al. (2018), lower than Onat et al. (2017) but higher than Yol & Uzun (2018).

As can be observed in Table 2, the result of shelling percentage was significant ($p < 0.01$) for varieties but not for year and year × varieties interaction. It varied between 62.17±4.32-73.96±1.00% in two-year average. The highest value of shelling percentage was obtained from Georgia Green with the values of 75.97±0.82%, 71.95±0.54% and 73.96±1.00% in 2018, 2019 and joined years, respectively (Table 4). Asik et al. (2018) reported that Runner type peanut varieties had the highest ratio of shelling, about 75-80%, among all market types. Shelling percentage is changed according to the planting date, varieties, and environmental factors

Table 3. Average values of number of pods per plant, pod weight per plant and 100-pod weight.
Çizelge 3. Bitki başına meyve sayısı, bitki başına meyve ağırlığı ve 100 meyve ağırlığı ortalamaları

	Number of pods per plant			Pod weight per plant (g)			100-pod weight (g)		
Varieties	2018	2019	Average	2018	2019	Average	2018	2019	Average
Florispan	30.68±7.77 b	40.67±2.75 b	35.68±4.31 b	19.09±1.21 d	22.13±1.72 e	20.61±1.16 f	118.17±2.87 g	117.62±3.86 h	117.89±2.15 j
B-Cihangir	17.26±2.61 c	15.54±0.75 g	16.40±1.28 e	27.32±2.94 cd	29.81±0.86 e	28.56±1.48 e	203.13±4.69 fg	224.32±2.15 f	213.73±5.27 h
G. Green	54.80±5.82 a	57.20±0.98 a	56.00±2.69 a	47.62±3.32 ab	41.39±1.27 d	44.51±2.11 bc	113.72±3.64 g	112.43±3.30 h	113.08±2.22 j
Sultan	19.95±1.94 bc	30.05±1.73 cd	25.00±2.54 cd	42.13±5.42 ab	47.91±2.51 ad	45.02±2.97 bc	251.55±10.43 bc	264.04±7.86 cd	257.80±6.47 c
Brantley	27.43±1.58 bc	26.76±1.33 ce	27.10±0.94 cd	50.81±4.87 a	57.20±1.67 a	54.01±2.71 a	244.55±5.95 cd	236.45±2.87 ef	240.50±3.46 ef
B-5025	22.48±4.66 bc	23.63±3.36 ef	23.05±2.58 cd	43.65±9.55 ab	53.00±6.97 ab	48.32±5.68 ab	250.43±5.22 bc	251.60±6.10 de	251.02±3.60 de
A-2003	23.80±1.77 bc	19.24±1.43 fg	21.52±1.44 de	37.53±1.25 bc	42.99±1.34 cd	40.26±1.47 d	210.45±4.01 ef	222.02±1.96 f	216.24±3.27 gh
Halisbey	26.07±0.50 bc	22.57±1.93 ef	24.32±1.19 cd	47.29±1.28 ab	46.15±1.78 bd	46.72±1.01 bc	269.06±9.54 ab	281.02±2.60 ab	275.04±5.17 b
NC-7	27.12±0.90 bc	30.92±1.47 c	29.02±1.15 c	49.63±1.88 ab	53.00±4.49 ab	51.31±2.31 ab	244.11±15.71 cd	263.36±8.71 cd	253.73±9.11 cd
Flower-22	23.52±4.39 bc	24.48±0.40 ef	24.00±1.98 cd	37.42±1.50 bc	46.68±1.59 bd	42.05±2.29 cd	184.08±4.37 g	190.47±5.82 g	187.28±3.56 i
Wilson	29.11±0.96 b	25.10±1.41 de	27.10±1.18 cd	46.37±1.15 ab	56.26±2.69 a	51.31±2.57 ab	230.14±1.73 ce	249.84±1.60 de	240.00±4.53 ef
NC-V-11	23.02±3.41 bc	27.92±1.53 ce	25.47±2.00 cd	46.35±4.71 ab	50.66±4.49 ac	48.50±3.07 ab	275.85±4.77 a	269.56±5.00 bc	272.71±3.40 b
Com	22.22±0.84 bc	23.52±0.53 ef	22.87±0.53 cd	37.39±1.05 bc	41.01±0.71 d	39.20±0.99 d	209.30±5.39 ef	204.97±3.07 g	207.13±2.94 h
O-2005	27.77±1.57 bc	23.81±0.92 ef	25.79±1.20 cd	48.53±1.74 ab	48.80±0.15 ad	48.66±0.79 ab	282.24±12.20 a	295.17±4.07 a	288.71±6.44 a
Gazipasa	22.47±1.52 bc	26.79±0.68 ce	24.63±1.22 cd	45.59±2.75 ab	53.00±1.14 ab	49.29±2.12 ab	225.67±3.25 df	229.36±6.75 f	227.52±3.45 fg
Average	26.51±1.44	27.88±1.48	27.20±1.03	41.78±1.51 B	46.00±1.53 A	43.89±1.09	220.83±7.56 B	227.48±7.88 A	224.16±5.44
CV (%)	21.12	10.37	16.39	16.00	10.53	13.30	5.86	3.84	4.92

CV: Coefficient of variation. Letters show different groups in each column.

Table 4. Average values of 100-seed weight, shelling percentage and first quality pod ratio
Çizelge 4. 100 tohum ağırlığı, kabuk/İç oranı ve birinci kalite meyve sayısı oranı ortalamaları

	100-seed weight (g)			Shelling percentage (%)			1st quality pod ratio (%)		
Varieties	2018	2019	Average	2018	2019	Average	2018	2019	Average
Florispan	52.26±0.91 g	52.53±1.77 e	52.39±0.89 f	68.50±1.61 ac	70.38±1.59 ab	69.44±1.10 b	75.51±5.44 ad	75.37±3.28 bd	75.44±2.84 ab
B-Cihangir	90.15±1.71 ef	93.68±0.94 c	91.91±1.18 d	60.28±0.64 de	67.80±1.17 ad	64.04±2.12 ef	82.47±2.87 a	76.50±1.53 ac	79.49±1.97 ab
G. Green	57.99±1.98 g	53.84±1.79 e	55.91±1.51 f	75.97±0.82 a	71.95±0.54 a	73.96±1.00 a	71.75±3.60 bd	72.59±1.43 be	72.17±1.74 cd
Sultan	110.26±3.61 ac	103.28±1.37 b	106.77±2.33 b	66.05±0.29 bd	63.48±0.45 de	67.77±0.62 de	67.71±1.17 d	65.97±1.98 f	66.84±1.10 f
Brantley	118.30±4.49 a	112.57±3.85 a	115.44±2.94 a	69.27±0.54 ac	68.37±1.26 ab	68.82±0.64 bc	76.77±1.09 ad	77.08±1.29 ab	76.92±0.76 ab
B-5025	113.96±4.31 ac	117.14±2.44 a	115.55±2.37 a	68.96±0.03 ac	69.81±0.99 ab	69.39±0.48 b	76.04±1.07 ad	72.71±1.40 be	74.38±1.08 bc
A-2003	94.85±0.81 e	98.99±0.66 bc	96.92±1.04 cd	65.19±0.12 bd	62.32±1.08 e	63.75±0.80 ef	79.06±2.59 ab	81.51±1.82 a	80.28±1.52 a
Halisbey	107.74±4.18 bd	101.57±0.48 b	104.66±2.33 b	62.43±0.30 ce	63.58±1.16 ce	63.00±0.59 ef	77.56±2.04 ac	66.18±2.73 f	71.87±2.97 cd
NC-7	109.19±0.87 ad	104.11±1.88 b	106.65±1.47 b	71.33±0.36 ab	67.90±2.32 ac	69.61±1.30 b	72.65±4.31 bd	68.12±2.63 ef	70.38±2.47 de
Flower-22	99.35±3.46 de	104.63±3.15 b	101.99±2.40 bc	69.51±0.87 ac	66.23±1.87 be	67.87±1.18 cd	79.51±2.07 ab	70.85±0.92 cf	75.18±2.19 ab
Wilson	107.96±0.13 bd	105.04±0.66 b	106.50±0.72 b	64.52±1.58 bd	67.70±0.76 ad	66.11±1.06 cd	74.08±0.65 ad	77.15±1.29 ab	75.62±0.94 ab
NC-V-11	115.22±5.98 ab	115.58±4.89 a	115.40±3.46 a	67.92±0.96 bc	66.52±0.77 bd	67.22±0.63 cd	71.34±3.41 bd	69.33±1.06 ef	70.34±1.66 de
Com	81.83±1.86 f	76.75±2.17 d	79.29±1.71 e	64.96±0.96 bd	67.03±1.15 bd	65.99±0.81 cd	69.23±0.58 cd	67.20±0.71 ef	68.22±0.61 ef
O-2005	108.40±0.11 ad	102.96±1.64 b	105.68±1.42 b	57.18±8.15 e	67.16±1.51 bd	62.17±4.32 f	74.55±2.54 ad	70.46±0.54 df	72.51±1.48 cd
Gazipasa	104.54±2.47 cd	101.39±1.26 b	102.97±1.43 b	68.52±1.38 ac	66.69±0.96 bd	67.61±0.86 cd	68.22±2.25 d	66.52±2.05 f	67.37±1.41 ef
Average	98.13±2.99	96.27±2.93	97.20±2.08	66.70±0.84	67.13±0.46	66.92±0.48	74.43±0.86 B	71.84±0.80 A	73.13±0.60
CV (%)	5.41	3.90	4.73	5.98	3.35	4.84	6.38	4.43	5.53

CV: Coefficient of variation. Letters show different groups in each column.

(Arioglu et al., 2016; Gulluoglu et al., 2017). The pod filling period extended, and the pods fully matured when the harvesting time was delayed. As this reason, the shelling percentage was increased when the harvesting time delayed (Arioglu et al., 2016). Hence, it can be concluded that the shelling percentage is correlated with 100-pod weight and 100-seed weight, negatively. These findings were similar with Caliskan et al. (2008), Arioglu et al. (2016), Gulluoglu et al. (2017), Onat et al. (2017), Asik et al. (2018), and Yol & Uzun (2018).

The first quality pod ratio, also known fancy pod percentage, is an important quality parameter in peanut production and has positive correlation with peanut quality. The effect of varieties on the first quality pod ratio was found to be significant ($p < 0.01$) but not for year × varieties interaction (Table 2). The first quality pod ratio varied between 66.84±1.10-80.28±1.52% in two-year average. The highest ratio of the first quality pod was obtained from BATEM-Cihangir as 82.47% in 2018 and Arioglu-2003 as 80.28±1.52% in 2019. Arioglu-2003 had also the maximum first quality ratio in average of the studied years with 80.28% (Table 4). These findings were supported by Arioglu et al. (2016), Onat et al. (2017), and Asik et al. (2018).

The data belonging to protein content result was significant ($p < 0.01$) for varieties and year but not for year × varieties interaction (Table 2). It was observed that protein content varied between 26.35±0.88-29.18±1.03% in two-years average. The highest value of protein content was obtained from Florispan, Spanish type, as 31.45±0.42% and 29.18±1.03% in 2018 and joined years while BATEM-5025 (29.20±0.12%) and Wilson (29.07±0.21%) had the maximum protein content in 2019 (Table 5). Gulluoglu et al. (2017) indicated that the protein is the major nutrient components of different varieties of peanut. These findings were similar with Arioglu et al. (2016), Gulluoglu et al. (2017), Asik et al. (2018), higher than Onat et al. (2017).

As it can be seen in Table 2, the result for pod yield was significant ($p < 0.01$) for varieties but not for year and year × varieties interaction. It was found that pod yield varied between 237.84±9.12–510.22±21.46 kg da^{-1} in two-years average. The highest value of pod yield was obtained from Halisbey as 541.17±35.80 kg da^{-1} and Osmaniye-2005 as 494.88±8.42 kg da^{-1} in 2018 and 2019, respectively. For joined years, Halisbey and Georgia Green had the maximum pod yield with 510.22±21.46 kg da^{-1} and 497.24±16.86 kg da^{-1}, and the minimum from Florispan as 237.84±9.12 kg da^{-1} (Table 5). The variation in pod yield of varieties was probably attributable to genetic differences between varieties and how they responded to environmental changes (Onat et al., 2017). Gulluoglu et al. (2017) explained the variation in peanut yields with three physiological processes which are partitioning of assimilate between the reproductive and vegetative structures, the duration of pod filling and the rate of the pod formation. The findings of present study were similar with Caliskan et al. (2008), lower than Arioglu et al. (2016), Gulluoglu et al. (2017), Asik et al. (2018) but higher than Yol & Uzun (2018). The differences among the studies were due to varieties and environmental factors.

Table 5. Average values of protein content and pod yield
Çizelge 5. Protein oranı ve dekara meyve verimi ortalamaları

	Protein content (%)			Pod yield (kg da^{-1})		
Varieties	2018	2019	Average	2018	2019	Average
Florispan	31.45±0.42 a	26.90±0.09 ce	29.18±1.03 a	230.73±14.04 h	244.94±12.97 h	237.84±9.12 f
B-Cihangir	27.54±0.48 de	27.11±0.19 cd	27.32±0.25 ef	319.10±35.26 eh	310.54±11.53 f	314.82±16.70 de
G. Green	26.36±0.60 e	27.35±0.14 c	26.86±0.35 fg	508.77±28.02 ab	485.71±22.42 ab	497.24±16.86 a
Sultan	27.53±0.12 de	26.83±0.02 ce	27.18±0.17 ef	406.13±56.33 ce	416.65±25.99 d	411.39±27.84 c
Brantley	26.44±0.29 e	27.35±0.11 c	26.89±0.25 fg	365.73±23.50 df	472.90±10.45 ac	419.32±26.58 c
B-5025	28.97±0.50 bd	29.20±0.12 a	29.09±0.18 ab	354.35±33.60 df	450.29±0.85 bd	402.32±26.20 c
A-2003	30.59±0.48 ab	26.93±0.33 ce	28.76±0.86 ab	432.02±17.61 bd	442.83±6.26 cd	437.43±8.70 bc
Halisbey	27.44±0.25 de	26.64±0.21 de	27.04±0.23 fg	541.17±35.80 a	479.26±8.01 ac	510.22±21.46 a
NC-7	28.15±0.59 cd	28.47±0.23 b	28.31±0.29 bc	330.73±26.28 eg	371.49±5.19 e	351.11±15.05 d
Flower-22	29.40±1.17 bc	26.61±0.14 de	28.00±0.82 de	252.37±25.56 gh	302.77±3.93 fg	277.57±16.15 ef
Wilson	28.99±0.49 bd	29.07±0.21 a	29.03±0.24 ab	393.50±2.54 ce	412.17±14.40 d	402.84±7.77 c
NC-V-11	28.23±0.55 cd	24.47±0.14 f	26.35±0.88 g	439.57±24.71 bd	414.38±10.87 d	426.98±13.32 c
Com	27.41±0.24 de	26.43±0.25 e	26.92±0.27 fg	285.27±3.36 fh	268.77±15.76 gh	277.02±8.10 ef
O-2005	27.38±0.37 de	27.07±0.40 cd	27.22±0.25 ef	464.43±31.27 ac	494.88±8.42 a	479.66±16.00 ab
Gazipasa	28.97±0.37 bd	27.47±0.16 c	28.22±0.41 cd	317.37±18.72 eh	333.15±9.24 f	325.26±9.99 de
Average	28.32±0.24 A	27.19±0.17 B	27.76±0.16	376.08±14.51 B	393.38±12.38 A	384.73±9.53
CV (%)	3.13	1.23	2.42	13.27	5.75	10.07

CV: Coefficient of variation. Letters show different groups in each column.

Correlation

The correlation matrix is provided in Table 6. The highest positive correlation matrix was observed between 100-seed weight and 100-pod weight (r =

0.851). Also, pod weight per plant was correlated with 100-pod weight (r = 0.550) and 100-seed weight (r = 0.579), positively but was negatively correlated with the first quality pod ratio (r = -0.292). Pod yield was correlated with pod weight per plant (r = 0.471), 100-pod weight (r = 0.265) and 100-pod weight (r = 0.355), positively. On the other hand, number of pods per plant had negative correlations with 100-pod weight (r = -0.563) and 100-seed weight (r = -0.569) but positive correlation with shelling percentage (r = 0.356). Similar results were also observed in Gulluoglu et al. (2017) and Onat et al. (2017). It can be seen that the significant and positive correlations were among pod weight, 100-pod weight and 100-seed weight. These parameters affect the pod yield directly.

Table 6. Correlation analysis for the parameters according to 2-years average.
Çizelge 6. İki yıllık verilere göre incelenen özelliklerin korelasyon analiz sonucu

	NP	PW	HPW	HSW	SP	FQP	PC
NP	1						
PW	0.098	1					
HPW	**-0.563**	**0.550**	1				
HSW	**-0.569**	**0.579**	**0.851**	1			
SP	**0.356**	0.006	**-0.407**	**-0.264**	1		
FQP	-0.097	**-0.292**	-0.167	-0.055	-0.137	1	
PC	-0.102	-0.186	-0.147	-0.043	0.086	0.185	1
PY	0.164	**0.471**	**0.355**	**0.265**	-0.106	-0.006	-0.196

$p < 0.05$ in bold; NP: Number of pods per plant, PW: Pod weight per plant, HPW: 100-pod weight, HSW: 100-seed weight, SP: Shelling percentage, FQP: First quality pod ratio, PC: Protein content, PY: Pod yield

Principal component analysis (PCA)

Variance percentage and eigenvalues of PCA analysis are provided in Table 7 and factor loadings are provided in Table 8. PCA using the eight characteristics including quality parameters, yield and yield components indicated that more than 80.50% variability was accounted for the first three PCs with eigenvalues > 1. Variance explanation ratios over 70% were sufficient in PCA analysis (Yol et al., 2018; Beyzi et al., 2019; Sahin & Isler, 2021). Eigenvalues of higher than 1.0 are accepted as the descriptor of the variance in a data set according to Kaiser rules (Kaiser, 1960).

Table 7. Eigenvalues and percentage of variance for average year parameters of PCA analysis.
Çizelge 7. İncelenen özelliklerin eigenvalue değerleri ve varyasyon oranları

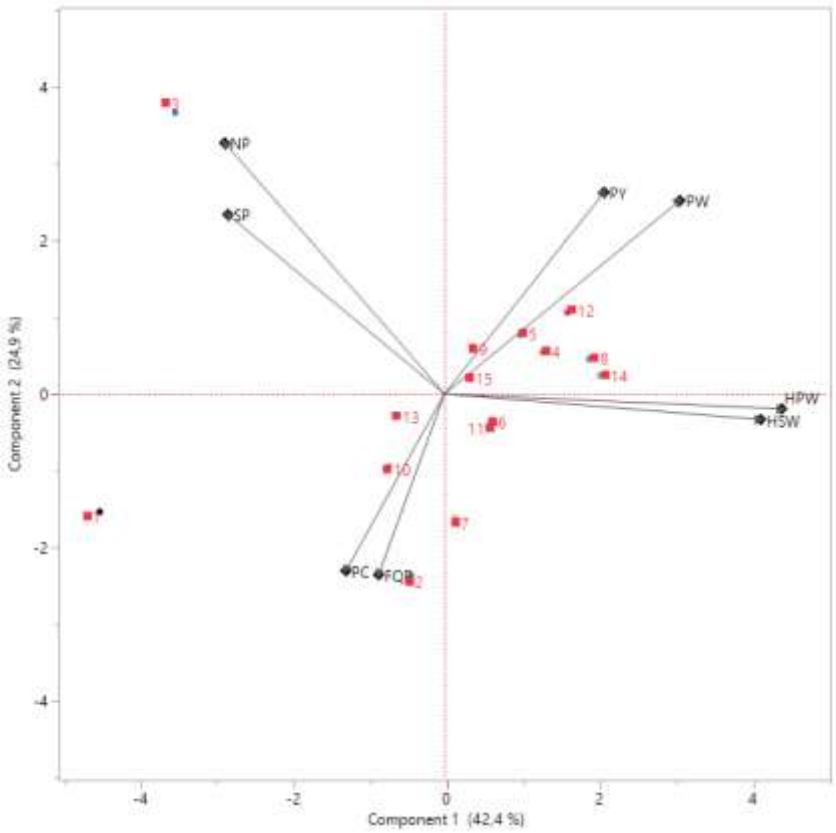
Principal Component	Eigenvalue	Variability (%)	Cumulative (%)
PC1	3.3935	42.418	42.418
PC2	1.9952	24.940	67.358
PC3	1.0511	13.138	80.496
PC4	0.9694	12.117	92.613
PC5	0.4392	5.491	98.104

Table 8. Factor loadings for parameters of PCA analysis (2-years average).
Çizelge 8. İncelenen özelliklerin factor loading değerleri (2 yıllık ortalama)

Parameters	PC1	PC2	PC3
NP	**-0.637**	**0.727**	0.161
PW	**0.683**	**0.560**	0.309
HPW	**0.978**	-0.043	-0.021
HSW	**0.916**	-0.074	0.210
SP	**-0.628**	**0.519**	0.258
FQP	-0.191	**-0.523**	**0.619**
PC	-0.286	**-0.512**	**0.562**
PY	**0.463**	**0.584**	0.346

NP: Number of pods per plant, PW: Pod weight per plant, HPW: 100-pod weight, HSW: 100-seed weight, SP: Shelling percentage, FQP: First quality pod ratio, PC: Protein content, PY: Pod yield

The first principal component (PC1) explained 42.42% of the total variation with eigenvalue of 3.39. PC1 was found to be related to all parameters except the first quality pod ratio and protein content. 100-pod weight and 100-seed weight had the highest positive factor loading values while number of pods per plant and shelling percentage had the highest negative factor loading values in PC1. The second principal component (PC2) had an eigenvalue of 2.00 and explained 24.94% of the total variation. PC2 was found to be related to all parameters except 100-pod weight and 100-seed weight. Number of pods per plant had the highest positive factor loading value in PC2. The third principal component (PC3) explained 13.14% of the total variation with eigenvalue of 1.05. PC3 was found to be mainly related to the first quality pod ratio and protein content, positively. PCA graph which consisted of PC1 and PC2, for investigated parameters on varieties was presented in Figure 2. Spanish market type (Florispan) was distributed on the left-down of the plot which was related to PC2. Similarly, Runner market type (Georgia Green) was distributed on the left-up of the plot that was related to PC1.



Şekil 2. İncelenen özelliklerin 2 yıllık ortalamalarına ait PCA şekilleri

Figure 2. PCA graphs of varieties for investigated parameters of the 2-year average.

1: Florispan, 2: BATEM-Cihangir, 3: Georgia Green, 4: Sultan, 5: Brantley, 6: BATEM-5025, 7: Arioglu-2003, 8: Halisbey, 9: NC-7, 10: Flower-22, 11: Wilson, 12: NC-V-11, 13: Com, 14: Osmaniye-2005, 15: Gazipasa, NP: Number of pods per plant, PW: Pod weight per plant, HPW: 100-pod weight, HSW: 100-seed weight, SP: Shelling percentage, FQP: First quality pod ratio, PC: Protein content, PY: Pod yield.

CONCLUSION

In conclusion, PC1, PC2 and PC3 explained about 80% in joined years according to PCA analysis. Pod yield was positively correlated with pod weight per plant and 100-pod weight in both years. As a result, Georgia Green could be recommended to get high shelling percentage (73.96%) and pod yield (497.24 kg da^{-1}), and Arioglu-2003 could be the optimum selection on the first quality pod ratio (80.28%) and protein content (28.76%).

Author's Contributions

Dr. Şahin carried out the laboratory experiments, performed the statistical analysis, and wrote this article. Dr. Yılmaz carried out the field experiments. Dr. İşler and Mr. Yıldız coordinated process of the field experiments. All authors read and approved the final manuscript.

Statement of Conflict of Interest

Authors have declared no conflict of interest.

REFERENCES

Arioglu, H. H. (2014). *The oil seed crops growing and breeding*. University of Cukurova Faculty of Agriculture Publishing. *(In Turkish)*

Arioglu, H. H., Bakal, H., Gulluoglu, L., Kurt, C. & Onat, B. (2016). The determination of some important agronomical and quality properties of peanut varieties in main crop conditions. *Journal of Field Crops Central Research Institute, 25*(Special Issue-2), 24-29. https://doi.org/10.21566/tarbitderg.281656 *(In Turkish)*

Asik, F. F., Yildiz, R. & Arioglu, H. H. (2018). The determination of new peanut varieties for Osmaniye Region and their important agronomic and quality characteristics. *KSU J. Agric Nat, 21*(6), 825-836. https://doi.org.10.18016/ksutarimdoga.vi.452842 *(In Turkish)*

Awal, M. A. & Aktar, L. (2015). Effect of row spacing on the growth and yield of peanut (*Arachis hypogaea* L.) stands. *International Journal of Agriculture, Forestry and Fisheries, 3*(1), 7-11.

Beyzi, E., Gunes, A., Arslan, M. & Satana, A. (2019). Effects of foliar boron treatments on yield and yield components of fenugreek (*Trigonella foenum graecum* L.): detection by PCA analysis. *Commun Soil Sci Plan, 50*(16), 2023-2032. https://doi.org/

10.1080/00103624.2019.1648661

Caliskan, S., Caliskan, M. E. & Arslan, M. (2008). Genotypic Differences for Reproductive Growth, Yield, and Yield Components in Groundnut (*Arachis hypogaea* L.). *Turk J Agric For, 32,* 415-424.

FAO, (2022). Food and agriculture data. http://www.fao.org/faostat/en/#data/QC (Access: 27.06.2022)

Gohari, A. A. & Niyaki, N. S. A. (2010). Effects of iron and nitrogen fertilizers on yield and yield components of peanut (*Arachis hypogaea* L.) in Astaneh Ashrafiyeh, Iran. *American-Eurasian J Agric and Environ Sci, 9*(3), 256-262.

Gulluoglu, L., Bakal, H., Onat, B., Kurt, C. & Arioglu, H. H. (2017). Comparison of agronomic and quality characteristics of some peanut (*Arachis hypogaea* L.) varieties grown as main and double crop in Mediterranean Region. *Turk J Field Crops, 22*(2), 166-177. https://doi.org/10.17557/tjfc.356208

Kaiser, H. F. (1960). The application of electronic-computers to factor-analysis. *Educational and Psychological Measurement, 20*(1), 141–51. https://doi.org/10.1177/001316446002000116

Karabulut, B. & Tuncturk, R. (2019). Investigation of agricultural and quality characteristics of peanut (*Arachis hypogaea* L.) cultivars growing as main crop in the Diyarbakir-Bismil ecological conditions. *Yüzüncü Yıl Üniversitesi Fen Bilimleri Enstitüsü Dergisi, 24*(2), 97-104. *(In Turkish)*

Onat, B., Bakal, H., Gulluoglu, L. & Arioglu, H. H. (2017). The effects of row spacing and plant density on yield and yield components of peanut grown as a double crop in Mediterranean environment in Turkey. *Turk J Field Crops, 22*(1), 71-80. https://doi.org/10.17557/TJFC.303885

Sahin, C. B. & Isler, N. (2021). Foliar applied zinc and iron effects on yield and yield components of soybean: Determination by PCA analysis. *Commun Soil Sci Plan, 52*(3), 212-221. https://doi.org/10.1080/00103624.2020.1854297

Sahin, C. B., Yilmaz, M. & Isler, N. (2022). Determination of Oil Quality and Fatty Acid Compositions of Some Peanut (*Arachis hypogaea* L.) Genotypes Grown in Mediterranean Region. *Turk J Field Crops, 27*(1), 142-148. https://doi.org/10.17557/tjfc.1095649

Shin, E. C., Pegg, R. B., Phillips, R. D. & Eitenmiller, R. R. (2010). Commercial Runner peanut cultivars in the USA: Fatty acid composition. *Eur J Lipid Sci Technol, 112*, 195–207. https://doi.org/10.1002/ejlt.200900141

TUIK, (2022). Crop production statistics. https://biruni.tuik.gov.tr/medas/ (Access: 27.06.2022)

Yasli, S., Isler, N. & Sahin, C. B. (2020). The effect of single and twin planting patterns on yield and important agricultural characteristics of main cropped peanut under Diyarbakir conditions. *KSU J. Agric Nat, 23*(1), 91-98. https://doi.org/10.18016/ksutarimdoga.vi.552168 *(In Turkish)*

Yilmaz, M. (2022). Determination of saturated and unsaturated fatty acids in late peanut cultivation in the eastern Mediterranean. *BSJ Agri, 5*(3), 189-194. https://doi.org/10.47115/bsagriculture.1071618

Yilmaz, M., Sahin, C. B., Yildiz, D., Demir, G. & Yildiz, R. (2022). General situation of peanut (*Arachis hypogaea*) production in the World and in Turkey, major problems and solution suggestions. *Mus Alparslan University Journal of Agriculture and Nature, 2*(1), 8-17. *(In Turkish)*

Yol, E. & Uzun, B. (2018). Influences of genotype and location interactions on oil, fatty acids and agronomical properties of groundnuts. *Grasas Y Aceites, 69*(4), e276. https://doi.org/10.3989/gya.0109181

Yol, E., Furat, S., Upadhyaya, H. D. & Uzun, B. (2018). Characterization of groundnut (*Arachis hypogaea* L.) collection using quantitative and qualitative traits in the Mediterranean Basin. *Journal of Integrative Agriculture, 17*(1), 63-75. https://doi.org/10.1016/S2095-3119(17)61675-7

Zhao, C., Shao, C., Yang, Z., Wang, Y., Zhang, X., Wang, M. & McGiffen, M. E. (2017). Effect of planting density on pod development and yield of peanut under the pattern of precision planted peanuts. *Legume Research, 40*(5), 901-905.