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Original Research Paper

Yield, quality, antioxidants and elemental composition of peanut as affected by plant density and harvest time

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Abstract: With the perspective of reintroducing peanut cultivation in southern Italy about six decades after its dismissal, research was carried out with the aim to identify the best performing farming management in terms of yield and quality. In this respect, the effect of the factorial combination between four plant densities (6.1, 7.8, 10.3, and 12.1 plants m^{-2}) and two harvest times (100 and 110 days after planting) was assessed on pod and seed yield, as well as on seed quality, antioxidant activity, and elemental composition. The later harvest time determined a 26.9% dry weight increase, but a 14.3% decrease in the number of seeds per pod. Plant density significantly influenced all the yield and growth indices except for mean seed weight. Yield and growth of each plant were best affected by the lowest plant density, whereas the opposite trend was recorded for the same parameters referred to the surface area unit. The density of 12.1 plants m^{-2} resulted in a 32% reduction in pods per plant compared to 6.1 plants m^{-2}, but had the greatest effect on seed production per m^2. The leaf area index was the highest with the density of 12.1 plants m^{-2}. The total dry weight increased by 1.7-fold from 6.1 to 12.1 plants m^{-2}. Compared to the first harvest time, in the second one the protein content decreased by 6.8%, and total polyphenols and antioxidant activity decreased by 11.2% and 7.6%, respectively. The second harvest time led to a depletion of N, P, and Mg, by 6.8%, 6.2%, and 6.8%, respectively, and a 7.1% Ca increase. The reintroduction of peanut cultivation in southern Italy is a realistic goal, though further studies regarding the crop system management are needed.

Keywords: *Arachis hypogaea* L.; farming management; production; proteins; lipids; polyphenols

1. Introduction

Peanut or groundnut (*Arachis hypogaea* L.) belongs to the *Fabaceae* family, originated in South America (Higgins, 1951) and is cultivated mainly in Asia (China, India, Birmania), Africa (Nigeria, Sudan, Tanzania) and the USA, with a production of 45.9 million of tons worldwide (FaoStat, 2021). According to ISTAT (2021), in Italy the cropping area and total production are very limited: 48 hectares and 44.3 tonnes, respectively.

It is an economically important legume, whose roots establish a symbiotic relationship with bacteria fixing atmospheric nitrogen and is used both as a food and fodder crop in the semi-arid tropics.

Peanut is a source of easily digestible proteins and edible oil (Nwokolo, 1996; Venkatachalam et al., 2006), the latter being extracted from its seeds (44-56% content) and further used in confectionery (Gantait et al., 2019). Peanut is included among the richest healthy oil products, which are resistant to rancidity (Gantait et al., 2019). Its high nutritional value is also due to the significant presence of biologically active compounds (Gomez-Alonso et al., 2002; Tuberoso et al., 2007), whereas the oil content and composition represent a shelf-life index (Campos-Mondragòn et al., 2009). Magnesium, phosphorus, calcium and potassium are the major mineral elements in the seeds (Asibuo et al., 2008).

A wide range of groundnut varieties are nowadays available, thanks to the efforts done to improve the resistance of this crop to biotic and abiotic stresses, thus satisfying both the demand of producers and consumers (Gantait et al., 2019). The different varieties belong to the sub-species *fastigiata*, *vulgaris*, *aequatoriana* and *peruviana* (Bertioli et al., 2011), and in particular the agronomic type Valencia (*fastigiata*) is generally erect with 3 to 4 seeds per pods, widely spread in South America (Ferguson et al., 2004). Within the latter type, variety Lotos grows up to 35 cm height and 75 cm width, approximately, has cylindrical, yellowish fruits containing prevalently 2-3 seeds, and occasionally 4-5 seeds. The seed is oblong-oval shaped, with pale red threads, and 700-800 mg weight. The crop cycle lasts 110-120 days (Shsadovo, 2021).

The appropriate plant spacing, in addition to other factors (soil structure, seedbed uniformity, planting depth, weed control, irrigation), is crucial for the cultivation success (Gantait et al., 2019). Therefore, determining the optimum plant density is an essential agronomic objective in order to maximise yield, because the highest production amount can be achieved if the canopy intercepts as much sunlight as possible, mainly during the reproductive phases (Bhargavi et al., 2016). In this respect, Ma et al. (1992) recorded a positive correlation between LAI (leaf area index), leaf dry matter, and total plant biomass in eight peanut cultivars. El Naim et al. (2010) stated that an inappropriate spacing could cause the crop shading, which limits plant branching. In a study performed in North Carolina (U.S.A.) by Lanier et al. (2004), a significant increase in pod yield was induced by plant spacing ranging from 12 to 15 plants m^{-2}, as a consequence of the pod number increase by 8%. Bihter et al. (2016) reported a decrease in seed protein percentage from 24.0% to 22.7%, and an increase of oil from 45.5% to 47.5% associated to the plant spacing increase obtained by modifying the along-row distance from 5 to 25 cm.

Harvest time significantly affected quantitative and qualitative parameters of peanut, such as the number and weight of pods per plant (Arioglu et al., 2018), seed protein, and oil content and fatty acid composition (Savage and Keenan, 1994), also interacting with the variety (Bakal and Arioglu, 2019). Changes in seed oil content during seed ripening were reported by Bakal and Arioglu (2019), with a 3.2% oil increase from 130 to 170 days after seeding (DAS). Furthermore, Arioglu et al. (2018) reported that delaying harvest time results in benefits to seed weight and pod yield, but in seed protein decrease. A study on oleaginous plant seeds indicated that harvest time significantly affected the mineral element content (Loukou et al., 2011).

Considering the above developed topics, the aim of this research was to study the effect of plant spacing and harvest time on yield, quality, antioxidants and mineral composition of peanut seeds belonging to the Valencia type (subsp. *fastigiata*).

2. Materials and Methods

Research was carried out on peanut (*Arachis hypogaea* L., cultivar Lotos) at the experimental fields of the Department of Agricultural Sciences of University of Naples Federico II, in Portici (Naples), southern Italy, characterized by a typical Mediterranean climate, in 2020. The soil was sandy-loam (77% sand, 14.5% silt, 8.5% clay), with 365 µS cm^{-1} electrical conductivity, 1.7% organic matter, 1 g kg^{-1} N, 60.4 mg kg^{-1} P_2O_5, 1.7 g kg^{-1} K_2O. The values of monthly mean air temperature and total rainfall recorded at the research site, using a WatchDog 1000 Series Micro Station (Spectrum Technologies, Aurora, Illinois, United States) equipped with temperature and rainfall sensor devices, were the following: 14.4 °C and 27.7 °C, the minimum and maximum air temperature, respectively, and

66.2 mm rainfall, in June; 18.2 °C and 32.7 °C, the minimum and maximum air temperature, respectively, and 28.4 mm rainfall, in July; 18.8 °C and 33.0 °C, the minimum and maximum air temperature, and 15.4 mm rainfall, in August; 16.1 °C and 29.3 °C, the minimum and maximum air temperature, and 120.2 mm rainfall, in September.

The experimental protocol was based on the factorial combination between four plant densities (6.1, 7.8, 10.3 and 12.1 plants m^{-2}) and two harvest times (100 and 110 days after planting), using a split-plot design with three replicates. Plant density was assigned to the plots and harvest time to the sub-plots, the latter covering a 6 m^2 (3 × 2 m) surface area.

The plant densities were achieved through a 75 cm spacing between the single rows and a spacing between the plants along each row of 21.9, 17.1, 12.9 and 11.0 cm, corresponding to the densities of 6.1, 7.8, 10.3 and 12.1 plants m^{-2} respectively.

Peanut seeds were sown in multi-cell trays placed in an unheated greenhouse on 23 May and 4-leaf seedlings were transplanted in the field on 14 June, in a soil ploughed at 30 cm and hoed at 15 cm depth; ridging was done twice, one and two months after transplant, respectively. Fertilization was carried out with 90 kg ha^{-1} of N, 60 kg ha^{-1} of P_2O_5 and 120 kg ha^{-1} of K_2O. Phosphorus was supplied at planting, whereas nitrogen and potassium were given both prior to crop establishment (40%) and the remainder on dressing, one and two months after transplant, respectively. Drip irrigation started when soil available water capacity decreased to 80%, and each watering consisted of 50 m^3 ha^{-1}. Crop protection was performed just with one treatment against aphids.

Harvests were done on 23 September and 3 October for the experimental treatments corresponding to 100 and 110 days, respectively. At harvest, five plants per plot were randomly sampled to measure leaf area, by using a benchtop LI-COR leaf area meter, and calculate leaf area index (LAI). Total plant dry weight was determined upon drying at 70 °C in a ventilated oven until constant weight.

After harvesting, the plants were left in the field in windrows for a week and then under a PE covered tunnel for a further week to reach 6-7% seed humidity, after that the following determinations were done in each experimental plot: pod number and total weight; on a random 50-pod sample, mean pod weight as well as seed number and mean weight. For the qualitative analysis of peanut seeds, 50-pod samples randomly selected from the plants placed in the central rows of each experimental plot were collected and sent to the laboratory.

2.1. Extraction of total polyphenols

Ten grams of ground peanut seeds were placed in acetone with a 1:4 (p/v) ratio, to degrease the sample and concurrently extract polyphenols. The samples were left in acetone for 24 hours, the subsequent day were centrifuged at 1792 g-force for 5 minutes, the surnatant was taken and dried for analysing total polyphenols and antioxidant activity.

2.2. Determination of total polyphenols

Total polyphenols were measured by a colorimetric assay, using the capacity of polyphenols to react with some molecules and form chromophore compounds. Polyphenol concentration was obtained through a calibration line built using different concentrations of the standard, i.e. gallic acid; the result was reported as GAE (gallic acid equivalent). The assay described, named Folin-Ciocalteu assay, is based on a colorimetric oxidation-reduction reaction between a reagent (Folin-Ciocalteu) and the polyphenols present in the sample (Singleton et al., 1999). The Folin-Ciocalteu reagent is composed of an appropriate mixture of sodium tungstate, molibdate, phosphate and copper salts, which reacts with the polyphenol hydroxyl groups, at a 10-10.5 pH, giving rise to a coloration ranging from yellow to dark green, whose intensity is proportional to phenolic residues number, with the highest absorption at 760 nm.

2.3. Measurement of antioxidant activity

The 2,2-difenil-1-picrilidrazile (DPPH•) is a very stable nitrogen radical, characterized by an intense purple red colour, which bleaches when is reduced by an antioxidant molecule. The absorbance variation of DPPH solution, after reacting with an antioxidant compound, allows to quantify the reducing capacity of the examined substance, either if it transfers hydrogen or releases electrons. The result is usually expressed as IC50, i.e., the sample amount able to reduce the initial DPPH concentration by 50%.

2.4. Analysis of mineral elements

A gram of peanut seeds was treated with 5 mL of HNO_3 (65%) and 1 mL of H_2O in a microwave digestion system (MARS 6, CEM, Matthews, NC, USA), increasing the temperature up to 210 °C. The solutions were cooled down to room temperature, transferred to a calibrated flask and diluted to a final volume of 10 mL with deionized bi-distilled water. The identification and quantification of mineral elements was carried out by Plasma Spectroscopy Inductively Coupled (iCAP 6200 DUO, Thermo Scientific, Waltham, MA, USA).

2.5. Determination of total lipids

Total lipids were measured using a continuous flux extraction through a semi-automated extraction system (SER 148 Velp Scientifica).

2.6. Data statistical processing

Yield, growth, and quality data were statistically processed by two-way analysis of variance (ANOVA), and the mean separation was performed through the Duncan's multiple range test, referring to $P \leq 0.01$ and $P \leq 0.05$ probability levels.

3. Results and discussion

3.1. Plant growth and yield

For all the measured parameters, no significant effect of the interaction between the two experimental factors ('plant density' and 'harvest time') was detected, and therefore only their main effects are presented. Plant density significantly influenced yield and growth parameters (Tables 1-3), except mean seed weight (1.05 g on average). Yield and growth values per plant increased when plant density decreased, though pod yield and leaf area progressively increased when plant density decreased from 12.1 to 7.8 plants m^{-2}. Conversely, in most cases the same parameters related to the surface area unit increased when plant density increased from 6.1 to 10.3 plants m^{-2}. Particularly, pod yield per m^2 did not significantly differ between 10.3 and 12.1 plants m^{-2} (Table 1), which showed an average increase of 55.9% and 28.7% compared to 6.1 and 7.8 plants m^{-2}, respectively; the plant density 12.1 m^2 led to a reduction of the number of pods per plant by 32.3%, compared to the best performing plant density in this respect (6.1 plants m^{-2} density). As regards the seed yield per m^2 (Table 2), the plant densities of 10.3 and 12.1 plants m^{-2} gave the highest values, with the latter treatment also performing at the best in terms of number of seeds per m^2. Harvest time only affected the number of seeds per pod (Table 2) and their dry weight (Table 3); indeed, the harvesting at 110 DAS induced, on average, a 26.9% increase in seed dry weight, whereas it decreased the number of seeds per pod by 14.3%.

Table 1. Pod yield parameters of open field grown peanut in southern Italy, as affected by plant density and harvest time.

Experimental treatment	Pod yield (g per plant)	Pod yield (g m^{-2})	Mean pod weight (g per pod)	No. Pods per plant	No. Pods per m^2
Plant density - PD					
6.1 plants m^{-2}	61.9 a	374.4 c	3.36 b	18.6 a	112.5 b
7.8 plants m^{-2}	57.8 a	453.6 b	3.65 ab	16.0 b	125.2 b
10.3 plants m^{-2}	55.4 ab	567.0 a	3.83 a	14.7 b	150.9 a
12.1 plants m^{-2}	49.5 b	599.2 a	3.95 a	12.6 c	152.1 a
Harvest time (HT)					
100 DAT	54.3	482.0	3.86	14.4	125.0
110 DAT	58.0	515.3	3.53	16.5	145.4
	n.s.	n.s.	n.s.	n.s.	n.s.
Significance					
PD	*	*	*	*	*
HT	n.s.	n.s.	n.s.	n.s.	n.s.
PD × HT	n.s.	n.s.	n.s.	n.s.	n.s.

DAT: days after transplant; n.s. not statistically significant at $P<0.05$; within each column, the values followed by different letters are statistically different according to Duncan's multiple range test at $P\leq0.05$.

Table 2. Seed yield parameters of open field grown peanut in southern Italy, as affected by plant density and harvest time.

Experimental treatment	Seed yield (g per plant)	Seed yield (g m^{-2})	Mean seed weight (g per seed)	No. Seeds per plant	No. Seeds per m^2	No. Seeds per pod
Plant density (PD)						
6.1 plants m^{-2}	40.0 a	242.7 c	1.01	39.6 a	240.2 d	2.17 b
7.8 plants m^{-2}	39.6 ab	310.4 b	1.04	38.1 ab	298.4 c	2.40 ab
10.3 plants m^{-2}	37.5 ab	382.2 a	1.07	34.9 bc	357.9 b	2.42 a
12.1 plants m^{-2}	34.7 b	421.0 a	1.09	32.0 c	387.5 a	2.57 a
Harvest time (HT)						
100 DAT	37.3	333.4	1.04	35.9	317.4	2.55 a
110 DAT	38.6	345.8	1.06	36.4	324.6	2.23 b
Significance						
PD	*	*	n.s.	*	*	*
HT	n.s.	n.s.	n.s.	n.s.	n.s.	*
PD × HT	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

DAT: days after transplant; n.s. not statistically significant;
* significant at $P\leq0.05$; within each column, the values followed by different letters are statistically different according to Duncan's multiple range test at $P\leq0.05$.

As can be observed in Table 3, the leaf area per plant was the lowest under the highest plant density (-21.7%, compared to the average of the two lowest densities); however, the leaf area index was the highest (2.17 m^2 m^{-2}) when the density was 12.1 plants m^{-2}, though not statistically different from the density 10.3 plants m^{-2}. The plant dry matter per area unit significantly increased with plant density, and it was 1.7 times higher with 12.1 plants m^{-2} compared to 6.1 plants m^{-2}.

Table 3. Growth indices of open field grown peanut in southern Italy, as affected by plant density and harvest time.

Experimental treatment	Lear area (cm^2 per plant)	Leaf area index (m^2 m^{-2})	Plant dry matter (g per plant)	Plant dry matter (g m^{-2})
Plant density (PD)				
6.1 plants m^{-2}	2351.2 a	1.42 c	60.2 a	364.9 d
7.8 plants m^{-2}	2226.0 a	1.75 bc	57.6 ab	431.7 c
10.3 plants m^{-2}	2039.3 ab	2.06 ab	54.0 ab	553.4 b
12.1 plants m^{-2}	1792.6 b	2.17 a	52.0 b	629.8 a
Harvest time (HT)				
100 DAT	2034.4	1.77	49.3 b	439.3 b
110 DAT	2170.2	1.93	62.6 a	560.6 a
Significance				
PD	*	*	*	*
HT	n.s.	n.s.	*	*
PD × HT	n.s.	n.s.	n.s.	n.s.

DAT: days after transplant; n.s. not statistically significant; * significant at P≤0.05; within each column, the values followed by different letters are statistically different according to Duncan's multiple range test at P≤0.05.

In our research, the plant densities 10.3 and 12.1 plants m^{-2} resulted in higher pod and seed yield compared to those of 6.1 and 7.8 plants m^{-2}. These yield values were even higher than those recorded by other authors with the plant density of 8.3 plants m^{-2}, which was more effective compared to densities of 3.0, 5.3, and 14.8 plants m^{-2} (Raseck et al., 2010) or obtained from other cultivars grown in different regions (Arioglu et al., 2018). Consistently with our findings, in previous investigations plant density influenced peanut seed yield (Lanier et al., 2004), and its increase led to higher plant dry weight (Gardner and Auma, 1989). Alam et al. (2002) showed that groundnut pod yield increased with reduced plant density, due to better light interception and air circulation across plant canopies, resulting in enhanced photosynthetic activity and adequate carbon supply to sinks.

In our work, no differences were found between the two harvest times in terms of yield and growth parameters, probably because of the unfavourable climatic conditions occurred after the earlier harvest (100 DAT), which did not allow the growing pods to reach the harvest maturity 10 days later (110 DAT). Furthermore, the harvest delay combined with climatic conditions probably led to many overripe pods, which were not marketable. Contrary to our results, Arioglu et al. (2018) in a study on 11 cultivars ('Halisbey', 'Sultan', 'Arioglu-2003', 'Osmaniye-2005', 'NC-7', 'Batem-5025', 'Flower-22', 'Flower-32', 'Flower-36', 'Brantley' and 'Wilson') of Virginia type peanut harvested at four times (149, 156, 163, and 170 days after sowing), reported that peanut, being an indeterminate growth crop, produced flowers and pods over a long time span and, therefore, the pod yield increased when the harvest time was delayed.

Previous studies found that even 15-20 days harvesting delays can result in yield increase but in plant dry weight reductions (Canavar and Kaynak, 2013). Timmannavar et al. (2003) observed that an excessive harvesting delay led to a higher pod number, but also to an increase in the waste fraction, thus

resulting in a lower marketable yield, and suggesting that the appropriate plant density and harvest time, related to the specific farming system and peanut variety, need to be identified.

3.2. Quality and Antioxidant Activity

For all the quality and antioxidant variables of peanut seeds, no significant effect of the interaction between the two experimental factors ('plant density' and 'harvest time') was detected. As can be observed in Table 4, seed proteins, lipids and total polyphenols content, as well as antioxidant activity, were not influenced by plant density. Our results are in agreement with those of Bihter et al. (2016), who reported no significant variation between the different plant density treatments tested (i.e., 5, 10, 15, 20, and 25 cm along the rows, which were 70 or 75 cm apart). In particular, protein and oil contents ranged from 21.9 to 24.4% and from 45.4 to 48.5% respectively. Cemal et al. (2017) found that decreasing plant density from 21.05 to 10.53 plants m^{-2} enhanced protein content but the oil content decreased from 19.05 to 9.52 plants m^{-2}, due to the increased intra-row space.

Table 4. Quality features of open field grown peanut seeds in southern Italy, as affected by plant density and harvest time.

Experimental treatment	Proteins (g 100 g^{-1} f.w.)	Lipids (g 100 g^{-1} f.w.)	Total polyphenols (µg GAE g^{-1} f.w.)	Antioxidant activity (DPPH)
Plant density (PD)				
6.1 plants m^{-2}	21.06	45.30	640.7	15.57
7.8 plants m^{-2}	20.03	44.76	649.9	14.69
10.3 plants m^{-2}	20.46	46.02	628.5	15.58
12.1 plants m^{-2}	20.88	46.16	621.3	15.36
Harvest time (HT)				
100 DAT	21.33 a	42.75 b	672.8 a	15.91 a
110 DAT	19.88 b	48.39 a	597.4 b	14.70 b
Significance				
PD	n.s.	n.s.	n.s.	n.s.
HT	*	*	*	*
PD × HT	n.s.	n.s.	n.s.	n.s.

DAT: days after transplant; f.w., fresh weight; n.s. not statistically significant; * significant at $P \leq 0.05$; within each column, the values followed by different letters are statistically different according to Duncan's multiple range test at $P \leq 0.05$.

In our research, delaying harvest time caused the reduction of protein and total polyphenol contents as well as antioxidant activity in peanut seeds, by 6.8%, 11.2% and 7.6%, respectively. In contrast, lipids content was positively affected by the second harvest time (+13.2%). During fruit growth, biochemical compounds in oilseed crops can be subject to significant quantitative and qualitative changes and, indeed, establishing the optimal harvest time for a specific crop improves the quality of the seeds produced (Loukou et al., 2011). A study of Sanders (1980) on the biosynthesis and accumulation of lipids in the seeds of three peanut varieties showed a Gaussian pattern of lipid accumulation as the seeds ripened. The investigation of Loukou et al. (2011) on an oilseed crop showed that the content of amino acids and the saturated fatty acids (SFAs) decreased, whereas monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) increased, from 30 days after fruit set until full fruit ripeness. It is supposed that the lower accumulation of protein and higher accumulation of fatty acids is due to a priority for the formation of fatty acids, since both amino acid and fatty acid synthesis share carbon com-

pounds (Ghasemnezhad and Honermeier, 2008). The most abundant phenol components in peanut seeds are gallic acid, 3,4-dihydroxybenzoic acid, (+)-catechin, and 1,2-dihydroxybenzene (Salamatullah et al., 2021). Gutfinger et al. (1988) found that a relatively high level of polyphenols is linked to high resistance to oxidation of fats and oil. In accordance with the work of Salamatullah et al. (2021), the phenolic compound content and antioxidant activity of peanut seeds showed fluctuations, not closely related to ripening, depending on the harvest time; these variations may be attributed to genetic factors, variety, agricultural factors, growing conditions, and ecological and climatic factors (Salamatullah et al., 2021).

3.3. Mineral elements

Plant density did not have significant effects on the mineral element content of peanut seeds (Table 5).

Table 5. Mineral composition of open field grown peanut seeds in southern Italy, as affected by plant density and harvest time.

Experimental treatment	N	Na	K	Ca	P	Mg	Zn	Fe	Cu
	(g 100 g^{-1} d.w.)								
Plant density (PD)									
6.1 plants m^{-2}	3.34	7.4	540.7	48.5	190.5	120.5	2.63	4.1	0.92
7.8 plants m^{-2}	3.18	6.9	494.9	47.4	193.0	124.7	2.58	4.1	0.90
10.3 plants m^{-2}	3.25	6.7	533.4	49.8	185.9	127.4	2.68	4.2	0.89
12.1 plants m^{-2}	3.31	7.3	506.5	49.1	186.2	122.4	2.67	4.2	0.91
Harvest time (HT)									
100 DAT	3.39 a	7.3	525.8	47.0 b	195.0 a	128.9 a	2.65	4.2	0.92
110 DAT	3.16 b	6.9	512.0	50.4 a	182.9 b	118.6 b	2.63	4.1	0.90
Significance									
PD	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
HT	*	n.s.	n.s.	*	*	*	n.s.	n.s.	n.s.
PD × HT	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

DAT: days after transplant; d.w., dry weight; n.s. not statistically significant; * significant at $P \leq 0.05$.

The second harvest time caused a decrease in N, P, and Mg contents by 6.8 %, 6.2% and 8%, respectively, and an increase in Ca by 7.1%, whereas the other minerals analysed (i.e., Na, K, Zn, Fe, Cu) were not significantly affected by this experimental factor. Compared to the reports of Savage and Keenan (1994), in our research the contents of K, Mg, and Zn in peanut seeds were slightly lower, whereas Fe level was much higher (-31,2%, -30.8%, -44.4%, and +247.5%, respectively). Differences in mineral content in response to the harvest time were also recorded in other nut species, probably due to genetic factors and environmental conditions (Soler et al., 1988). In a previous study on *Leguminosae* crops, decreases in mineral components were found in response to delayed harvest time (Türk, 2020).

4. Conclusions

The results of this study suggest that plant density significantly affected most of production and growth parameters, but did not influence quality, antioxidant, and mineral composition of peanut seeds. Differently, yield was not affected by harvesting time, but the earlier harvest induced a higher protein and polyphenol content as well as antioxidant activity, whereas the later harvest resulted in increased lipid content. Peanut pod and seed yields of cultivar Lotos in the Mediterranean region could be competitive with cultivars stably cultivated in other countries. Therefore, it can be inferred that there are promising perspectives relevant to the chance of reintroducing peanut cultivation in Campania region.

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