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THE IMPACT OF THE SOWING TIME ON PEANUTS YIELD`S COMPONENTS IN MARGINAL SANDY SOILS IN SOUTHERN OLTENIA, ROMANIA

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ABSTRACT

Marginal sandy soils are frequently characterized by low fertility, low organic matter, moderate to high acidity and low cationic exchange capacity, limiting the options of smallholding farmers for various crops. To investigate the impact of the sowing time on grain yield, yield components, protein and oil content of peanuts cultivated in marginal sandy soils in Southern Oltenia, Romania, a bifactorial experiment in a randomized complete block design with three replications was conducted during 2015-2017 at the Research Development Station for Plant Culture on Sands Dăbuleni. The first factor was sowing time (the 25th April as early sowing and the 5th May as late sowing) and the second factor was peanut cultivar (Dăbuleni, Viorica, Viviana). According to the results of the experiment the sowing time had significant impact on the pods number per plant, the production of pods and the grain oil content.

Analyzing the interaction between the sowing time and the cultivar there were significant differences only in the pod number per plant in 2015 and the production of pods in 2016. In all peanut's genotypes studied, early sowing led to higher yields of pods compared to late sowing, probably due to the shortening of the vegetation period of the crop by late sowing on the 5th May, which led also to less dry matter and lower oil content accumulated in peanut grains. Therefore, the results suggested that early sowing time is the most recommended for peanuts growth and quality yield in sandy marginal areas.

Keywords: peanuts, sandy soils, production.

INTRODUCTION

Peanuts (*Arachis hypogaea* L.) are considered one of the most important oil crops in dry areas occupying a world area of 25.2 million hectares with an annual world production of peanuts of 35.9 million tons (FAO, 2005; dos Santos et al., 2017). Peanut seeds are an important source of protein, fat and fatty acids, carbohydrates, minerals, vitamins, dietary fibers, phytosterols, flavonoids, and phenolic acids for the food industry (Bishi et al., 2015). They have an oil content of 47-50% (Sanders, 2002). The growth and yield of a crop depend of various factors. However, climate plays the most important role. Among the climatic factors, solar radiation, temperature, humidity and precipitation are very important. Oilseeds, especially peanuts, are very sensitive to climatic factors such as temperature and solar radiation (Banik et al., 2009).

Studies on the thermal factor have shown that temperature plays an essential role in all phases of plant growth and development. The relationships of plants with the thermal factor are manifested starting with the germination phase and continuing throughout the vegetation period. For this, three biological temperature thresholds are taken into account: minimum, optimal and maximum temperature. Regarding the minimum level of germination temperature, on which depends the choice of the optimal time to sow, it is estimated that peanuts can germinate at a minimum temperature of 12°C (Kumar et al., 2017). Low temperature during early or late peanuts development may led to immature pods, while high temperatures (>45°C) affect crop growth rate and increase

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moisture stress (Chakraborty et al., 2018; Zhang et al., 2019; Dash and Chimmad, 2021).

Depending on the level of temperatures registered in the first phases of growth and development of peanut plants, the precocity and the level of production are influenced. In the semi-arid tropical regions, research has been more oriented towards studying the effect of the optimal temperature, depending on the main phases of vegetation of the plants as well as the effect of the maximum temperature that may have undesirable consequences (Meena and Yadav, 2014; Ijaz et al., 2021).

The optimum temperature during the flowering period is in a range of values between 20°C (according to Alae-Carew, 2020) and 30°C (according to Gulluoglu et al., 2018). For plant development, the optimum temperature was set between 20-25°C to 32-33°C (Alae-Carew, 2020).

The increase or decrease in the pods number per plant, according to Desmae et al. (2022), occurs at average daily temperatures between 23.2°C and 17.9°C, with the specification that high yields can be obtained when during the fruiting period average temperature of 20.4°C. Research made by Dash and Chimmad (2021) shows that the optimum temperature required during the period of growth and development is in a range of values between 25-30°C, and the optimal temperature for the period of reproductive growth can be similar to that of the period of increase or slightly lower, from 20°C to 25°C.

The research conducted by Hurdle et al. (2020), states that after germination and emergence, peanut plants can withstand low temperatures of up to 1.5°C. Plants suffer greatly when high-temperature amplitudes occur within 24 hours. The vegetation period of the variety, as well as the sowing season, can influence the elements of productivity, the production of pods and their quality. Research by Naab et al. (2004) indicated that early sowing led to 20 to 50% higher pod production than late sowing. Some previous studies have shown that the impact of the sowing time on the production of pods has been remarkable for all varieties of peanuts (Meena and Yadav, 2015). Late sowing peanuts yielded much lower yields than those sown earlier (in May or April) (Laurence, 1983; Mozingo et al., 1991; Ntare and Williams, 1998, Ijaz et al., 2021). The elements of productivity, as well as the number of flowers and gynophores, were significantly affected by the sowing time (Kasai et al., 1999). Frimpong (2004) reported that plant height, biomass and pod production were significantly influenced by sowing time and environmental factors. In the conditions of the sandy soils from the south of Oltenia, the sowing time is determined by the achievement in the soil at the sowing depth of a minimum seed germination temperature of 12-13°C and with a tendency of progressive heating of the weather (Pop et al., 1983).

Given these aspects related to the requirements of peanuts to the heat factor, Pop et al. (1983), establish that in Romania only early varieties of peanuts can be grown and only in the south of the country, in sandy and sandy-loam soils (due to pegging ability) where the average annual temperature is over 10°C and where an average daily temperature of over 12°C is achieved for 140-163 days, and the sum of the temperature degrees exceeds 2800°C.

Early varieties are indicated, with a short vegetation period for the maturity of as many pods as possible. The maturation of the pods depends on the genotype, the environmental conditions and the genotype x environment interaction (Prasad et al., 2000). Ijaz et al. (2021) suggested that in the spring the minimum temperatures that appeared later delay the sowing or even the development and maturation of the pods. Some research by Golombek et al. (2001) showed that temperature influences the concentration of oil and protein in the seeds of several species depending on the interaction of genotype and temperature. Considering the thermal requirements of the plant and the diversification of the assortment of varieties, it was necessary to know the optimal time to sow to obtain large and stable yields.

The research aim was to study the influence of two sowing times on the yield, productivity elements, oil and protein content of three cultivars of peanuts grown under irrigation with the purpose of optimizing planting time for peanuts in the sandy soils of southern Oltenia, Romania.

MATERIAL AND METHODS

The research was carried out in the period 2015-2017 at the Research-Development Station for Plant Culture on Sands Dăbuleni located in the south of Oltenia (Romania). The experimental plot was located at 43°80’ 60’’N and 24°05’97’’E on a sandy soil poor in nitrogen (0.02-0.06%), medium to well supplied with phosphorus 24-107 ppm) and low supplied with exchangeable potassium (15-38 ppm). The organic carbon content was low (0.07-0.49%), characteristic of sandy soils, and the soil reaction was moderately acidic to neutral (pH_{H2O} = 6.36-7.10).

The experiment was bifactorial and placed in the field in randomized complete block design in three replications.

Factor A - sowing time with the following graduations: early sowing (the 25th April), late sowing (the 5th May).

Factor B - cultivar with the following graduations: Dăbuleni, Viorica, Viviana. The size of each plot was 6.3 m^2 (2.1 x 3.0 m). The distance between rows was 0.7 m and the distance between plants in a row was 0.18 m, providing a sowing density of 7.9 plants/m^2.

Fertilization was done with 500 kg/ha complex fertilizers (15% N, 15% P, 15% K) before sowing and in vegetation at the beginning of flowering with 200 kg/ha ammonium nitrate. Weed control was done with Pendimetalin 4 l/ha applied pre-emergent (immediately after sowing), in vegetation through two mechanical ploughs and post-emergent herbicide with Fluazifop-p-butil 1.5 l/ha + Bentazon 0.25 l/ha. To supplement the water deficit in the soil during the vegetation period, the crop was irrigated by sprinkling. Harvesting was done manually by uprooting the bushes and then drying in the sun (up to 10% moisture contents), followed by a manual detachment of the pods. At harvest, biometric determinations were performed on some productivity elements (pod number per plant, 1000 grains mass, shelling percentage) and the production of pods at a humidity of 9% was determined. The manually shelled grains were dried in the sun and then the oil content and protein content were determined. The seed samples were ground and the oil was extracted with diethyl ether using a Soxhlet apparatus. The protein content was determined with the Perten apparatus.

The monthly air temperature, precipitation and humidity for 2015-2017 were recorded at the weather station from Research Development Station for Plant Culture on Sands Dăbuleni.

The experimental data were statistically processed by the variance analysis method (ANOVA) and Tukey's HSD test. $P < 0.05$ was taken to indicate statistical significance differences.

RESULTS AND DISCUSSION

Climatical factors have significant impact on production of any crop in a specific agro-ecological area.

Figure 1 presents the climatic data for the peanut vegetation period (April-October) period 2015-2017.

The meteorological conditions recorded during April, in the period 2015-2017 were: 11.7°C-average air temperature; 13.9°C - average ground temperature; 64.8 mm of precipitation. These allowed the achievement of optimal conditions for the preparation of the germination bed for sowing.

Atmospheric precipitation is one of the decisive factors in plant life. They are important for their annual quantity, but especially for the amount recorded during the vegetation period of the plants and how they are distributed in months.

The analysis of the data from Figure 1 highlights a nonuniformity of the precipitations registered monthly, with the accentuation of the nonuniformity during the summer.

In the experimental period (2015-2017) the average amount of precipitation in the vegetation period was 446.7 mm.

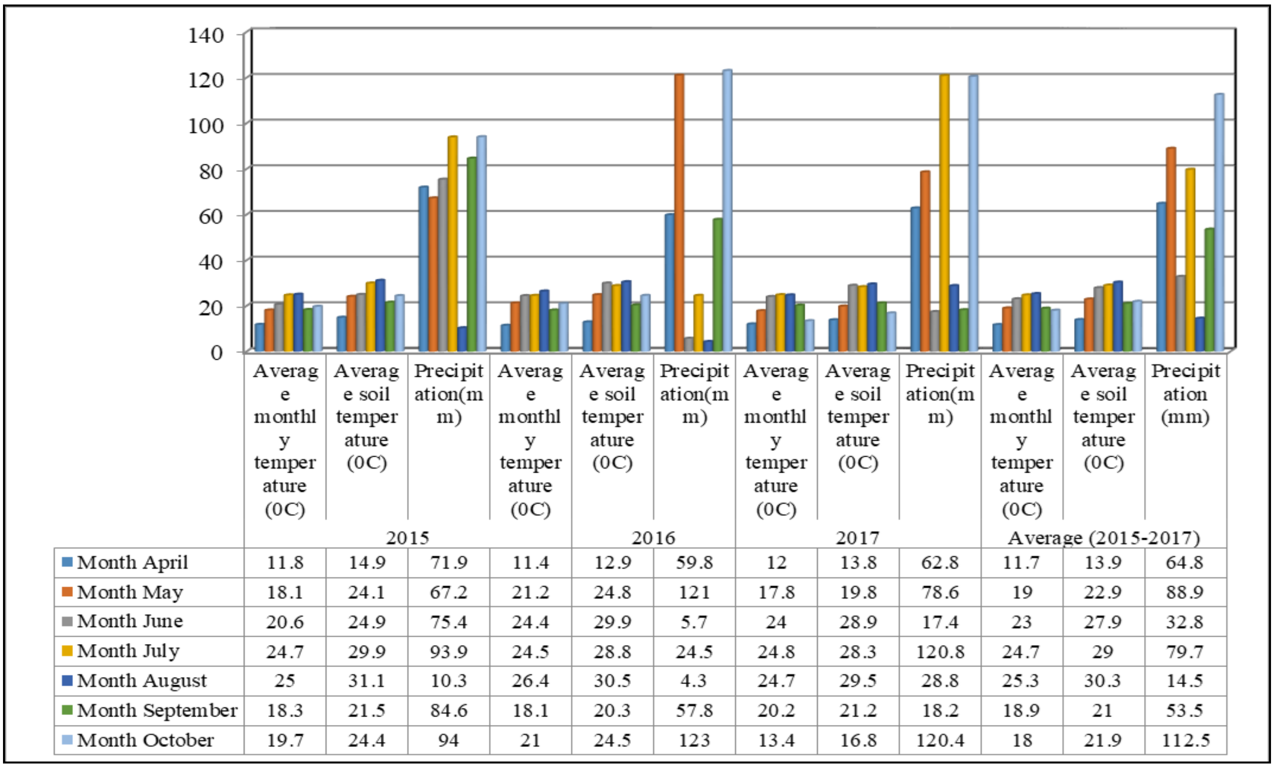

Figure 1. Climatic elements registered at the Meteorological Station of RDSPCS Dăbuleni during the peanut vegetation period (2015-2017)

Unlike areas with ordinary soils, sands by their nature have the property of warming and cooling slightly, giving rise to large temperature fluctuations between day and night. These large temperature fluctuations occur especially during April-May, having negative repercussions on seed germination and the development of young plants. Previous report showed that extended photoperiod may decrease reproductive growth leading in lesser pods formation, low pods settings and lower yield (Flohr et al., 1990; Kendabie et al., 2016; Kelly et al., 2021). In the months of April and May the temperature amplitudes have recorded in the air and on the ground are shown, for the period 2015-2017, when the two sowing times were established (Table 1).

Table 1. Amplitude of temperatures (°C) recorded in the air and on the ground during the sowing - emergence period

Specification			Temperature (°C)		
Month	Decade		2015	2016	2017
April	I	In the air	4.9-15.4	-0.5-11.7	5.8-12.6
		On the ground	7.3-19.3	0.7-12.9	0.9-12.9
	II	In the air	6.8-14.3	8.2-14.2	7.0-16.7
		On the ground	9.5-17.6	7.9-16.8	8.8-17.3
	III	In the air	8.4-17.8	11.7-20.8	7.1-19.9
		On the ground	10.9-21.8	13.4-21.8	12.8-21.3
May	I	In the air	15.3-19.4	20.1-24.2	13.7-18.9
		On the ground	19.1-27.1	22.2-28.2	18.5-22.6
	II	In the air	13.4-22.0	18.1-26.0	15.4-19.4
		On the ground	20.1-32.6	20.9-33.9	20.5-31.2
	III	In the air	15.1-25.2	15.9-22.6	16.8-22.7
		On the ground	13.7-29.5	15.9-27.3	14.8-26.7

Analyzing the temperatures recorded in the air and on the ground in April, for the period of experimenting with the two times for sowing peanuts (2015-2017), results in air fluctuations of the recorded temperatures, with values of: 4.9-17.8°C in 2015; -0.5-20.8°C in 2016; 5.8-19.9°C in 2017 (Table 1). On the ground, the recorded temperatures were higher, but the fluctuations remain within the limits: 7.3-21.8°C in 2015; 0.7-21.8°C in 2016 and 0.9-21.3°C in 2017.

The results obtained in the three years show that the sowing time had a distinctly significant influence on the production of pods, the pod number per plant and significant influence on the oil content. Regarding the influence of the cultivar, insignificant differences were observed in terms of some elements of productivity except for the production of pods and the pod number per plant, where distinctly significant differences were observed (Table 2).

Analyzing the interaction between the sowing time and the cultivar there were distinctly significant differences only in the production of pods (Table 2).

Table 2. Analysis of the variance for the production of pods and some productivity elements, oil and protein content of three cultivars of peanuts in 2015-2017

Year/ Sowing time/ Cultivar	Pod yield (kg/ha)	1000 grains mass (g)	No. of pods/ plant	Shelling percentage (%)	Oil content (%)	Protein content (%)
2015						
Sowing time	*	*	*	ns	*	ns
Cultivar	**	ns	**	ns	ns	ns
Sowing time x Cultivar interaction	ns	ns	*	ns	ns	ns
2016						
Sowing time	**	ns	**	ns	*	ns
Cultivar	**	ns	ns	ns	ns	ns
Sowing time x Cultivar interaction	**	ns	ns	ns	ns	ns
2017						
Sowing time	*	*	**	ns	*	ns
Cultivar	**	ns	*	ns	ns	ns
Sowing time x Cultivar interaction	**	ns	*	ns	ns	ns

ns - non-significant, *, ** significant at the 5 and 1% probability levels, respectively.

In 2015 and 2017, the Viviana and Dăbuleni cultivars achieved a significantly higher production of pods compared to the Viorica cultivar at both early sowing (the 25th April) and late sowing (the 5th May), while the Viorica cultivar had the lowest production of pods in 2016 and 2017 at late sowing (the 5th May). Regarding the interaction of the sowing time x cultivar in 2016, the highest production of pods was obtained by the cultivars Viorica and Viviana at early sowing, at 5500 kg/ha, respectively 5473 kg/ha (Table 3).

Table 3. The influence of the sowing time on the production of peanuts (kg/ha) according to cultivar (2015-2017)

Cultivar/ Sowing time	2015			2016			2017		
	Early sowing	Late sowing	Average	Early sowing	Late sowing	Average	Early sowing	Late sowing	Average
Dăbuleni	4877	3677	4277[a]	4477[b]	3471[c]	3974[b]	4802	3700	4251[a]
Viorica	4612	3309	3960.5[b]	5500[a]	3384[c]	4442[a]	4620	3378	3999[b]
Viviana	5261	3552	4406.5[a]	5473[a]	3705[c]	4589[a]	5250	3500	4375[a]
Average	4917[a]	3513[b]	4215	5150[a]	3520[b]	4335	4890.6[a]	3526[b]	4208.3
$LSD_{Sowing\ time}$		622			107			620.3	
$LSD_{cultivar}$		239			225			250.5	
$LSD_{cultivar\ x\ sowing\ time\ interaction}$					605				

[a] Letters that are different for sowing time and cultivar are significantly different by Tukey's HSD test (P > 0.05).

In the three years, the sowing time significantly influenced the pod number per plant. The pod number per plant decreased by up to 42%. Similar results on the influence of sowing time on the pod number per plant were reported by Canavar and Kaynak (2008) who attributed this to the shortening of the period of ripening of the pods in case of late sowing. Bell (1986) reported that the sowing time influenced the pod number per plant more than the production of pods. The average pod number per plant varied from 29.00 to 37.5 and was significantly influenced by genotype only in 2015, with Dăbuleni and Viviana cultivars having a higher pod number per plant than the Viorica cultivar. In 2016 and 2017, the Viorica cultivar had the highest pod number per plant in case of early sowing, although there was no statistically significant difference (Table 4). In the case of the sowing time x cultivar interaction in 2015, significant differences were observed in the pod number per plant, the Viviana cultivar having the highest pod number per plant at early sowing.

Table 4. The influence of the sowing time on the pod number per plant according to cultivar

Cultivar/ Sowing time	2015			2016			2017		
	Early sowing	Late sowing	Average	Early sowing	Late sowing	Average	Early sowing	Late sowing	Average
Dăbuleni	38[b]	30[bc]	34[a]	39	31	35	35.7	28.2	31.9
Viorica	32[c]	26[c]	29[b]	44	27	35.5	42.8	25.5	34.1
Viviana	46[a]	29[c]	37.5[a]	41	34	37.5	39.5	31.2	35.3
Average	38.6[a]	28.3[b]	33.5	41.3[a]	30.6[b]	36	39.3[a]	28.3[b]	33.7
$LSD_{Sowing\ time}$	8.8				0.72			0.65	
$LSD_{cultivar}$	6.5								
$LSD_{cultivar\ x\ sowing\ time\ interaction}$	9.8								

[a] Letters that are different for sowing time and cultivar are significantly different by Tukey's HSD test (P > 0.05)

The average of 1000 grains mass decreased from 715.3 g in the case of early sowing (25th April) to 648 g in the case of late sowing (5th May) in 2015 and from 1010 g in the case of early sowing (25th April) to 866.6 g for late sowing (5th May) in 2016. Thus, early sowing led to a 10.3% increase in the 1000 grains mass compared to late sowing in 2015, by 16.5% in 2016 and by 10.7% in 2017, due to the lower temperatures during the grain-filling period which led to delayed ripening in case of late sowing. This result confirms the conclusion of Bala et al. (2011) who reported that sowing later delayed flowering by 50% and peanut plants accumulated less dry matter.

In 2015 the average 1000 grains mass was between 675.5 g and 686.5 g, in 2016 in the range of 885-970 g and in 2017 in the range of 985.1-1080 g. The Viorica cultivar recorded the highest value of 1000 grains mass in the three years (Table 5).

Table 5. The influence of the cultivar on the 1000 grains mass (g) according on the time of sowing

Cultivar/ Sowing time	2015			2016			2017		
	Early sowing	Late sowing	Average	Early sowing	Late sowing	Average	Early sowing	Late sowing	Average
Dăbuleni	713	638	675.5	940	830	885	1015	955.2	985.1
Viorica	697	676	686.5	1080	860	970	1180	980	1080
Viviana	736	630	683	1010	910	960	1080	1020	1050
Average	715.3[a]	648[b]	681.7	1010	866.6	938.3	1091	985	1038.3
$LSD_{Sowing\ time}$		42.2							
$LSD_{cultivar}$									
$LSD_{cultivar\ x\ sowing\ time\ interaction}$									

[a]Letters that are different for sowing time and cultivar are significantly different by Tukey's HSD test (P > 0.05).

Regarding the shelling yield in any year, there were no significant differences for the sowing time, cultivar or the interaction of the sowing time x cultivar (Table 6). However, the shelling yield in the case of early sowing was higher than in the case of late sowing, especially in 2016. This may be related to the lower temperature during the grain filling period which led to the delay of maturity.

Regarding the cultivar, the Viviana cultivar had the highest shelling yield of 72% in 2016 and 62.3% in 2017, while in 2015 it had the lowest value (57.4%) (Table 6).

Table 6. The influence of the cultivar on shelling percentage (%) depending on the sowing time

Cultivar/ Sowing time	2015			2016			2017		
	Early sowing	Late sowing	Average	Early sowing	Late sowing	Average	Early sowing	Late sowing	Average
Dăbuleni	61.5	56.5	59	71.0	68.7	69.8	61.5	59	60.2
Viorica	60.9	54.6	57.7	73.2	70.6	71.9	63	61	62
Viviana	58.6	56.3	57.4	71.3	72.8	72	61.7	63	62.3
Average	60.3	55.8	58	71.8	70.7	71.2	62	61	61.5
$LSD_{Sowing\ time}$									
$LSD_{cultivar}$									
$LSD_{cultivar\ x\ sowing\ time\ interaction}$									

[a]Letters that are different for sowing time and cultivar are significantly different by Tukey's HSD test (P > 0.05).

Protein content was significantly influenced by sowing time in 2015. Unlike oil content, higher protein content was recorded in case of late sowing (Table 7). The research results from RDSPCS Dăbuleni regarding the influence of sowing time on protein content were consistent with the research conducted by Canavar and Kaynak (2013) who reported that the protein content of peanut seeds increased with the delay in harvesting time. Also, Golombek et al. (2001) indicated that decreasing temperature caused a decrease in grain protein content. In 2015 and 2017, the protein content of peanut decreased from 23.9 to 21.9% in the case of early sowing. Regarding the influence of the cultivar and the interaction of the cultivar x sowing time on the protein content, there were no significant differences. However, the Viviana cultivar recorded a lower protein content of 22.7% in 2015, 21.7% in 2016 and 22.5% in 2017, compared to the other varieties in both early and late sowing.

Table 7. The influence of the cultivar on the protein content (%) according to the sowing time

Cultivar/ Sowing time	2015			2016			2017		
	Early sowing	Late sowing	Average	Early sowing	Late sowing	Average	Early sowing	Late sowing	Average
Dăbuleni	22.6	23.5	23.0	21.6	22.4	22.0	22.7	23.5	23.1
Viorica	22.0	24.3	23.1	21.1	22.7	21.9	22.2	24.2	23.2
Viviana	21.3	24.2	22.7	21.5	22.3	21.9	21.1	24.0	22.5
Average	21.9[b]	23.9[a]	22.9	21.4[b]	22.4[a]	21.9	21.9[b]	23.9[a]	22.9
LSD$_{Sowing\ time}$		1.75						1.75	
LSD$_{cultivar}$									
LSD$_{cultivar\ x\ sowing\ time}$									

[a]Letters that are different for sowing time and cultivar are significantly different by Tukey's HSD test (P > 0.05).

The oil content is a genetic and plays a vital role in determining total oil yield per unit area. The results obtained regarding the oil content according to the sowing time showed a significant influence in both years. Early sowing resulted in significantly higher oil content compared to late sowing (Table 8). Higher temperatures during the grain-filling period until harvest result in high oil content in the grains.

The results obtained are consistent with the results obtained in rapeseed by Pritchard et al. (2000). Yousaf et al. (2002) and Ozer (2003), who reported a low oil content in the case of late sowing. However, the oil content was not significantly influenced by the cultivar, by the interaction of the sowing time x cultivar. Among the cultivars, the highest average oil content was obtained for the Viviana cultivar in 2016 and 2017 and the lowest average oil content was obtained for the Dăbuleni cultivar in the three years.

Table 8. The influence of the cultivar on the oil content (%) according to the sowing time

Cultivar/ Sowing time	2015			2016			2017		
	Early sowing	Late sowing	Average	Early sowing	Late sowing	Average	Early sowing	Late sowing	Average
Dăbuleni	49.5	47.3	48.4	50.5	48.3	49.4	51.6	49.2	50.4
Viorica	51.1	48.5	49.8	50.3	48.8	49.5	51.5	49.5	50.5
Viviana	50.2	48.6	49.4	51.5	48.8	50.1	52.8	49.6	51.2
Average	50.2[a]	48.1[b]	49.2	50.7[a]	48.6[b]	49.7	51.9[a]	49.4[b]	50.7
LSD$_{Sowing\ time}$		1.85			1.28			1.32	
LSD$_{cultivar}$									
LSD$_{cultivar\ x\ sowing\ time}$									

[a]Letters that are different for sowing time and cultivar are significantly different by Tukey's HSD test (P > 0.05).

CONCLUSIONS

The production results obtained for peanuts grown on sandy soils in southern Oltenia were significantly influenced by the sowing time, genotype and environment interaction.

The early sowing of the peanut crop led to the obtaining of a high production level and the highest oil content compared to the late sowing in all years of experimentation.

Regarding the cultivar tested, on average over the three years, in all genotypes the highest pod number per plant was recorded by sowing at the end of April (the 25th April), considering that the establishment of peanut cultivation around this date is the time optimal for sowing in sandy soils in southern Oltenia for higher yield and economic returns.

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