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Peanut Cultivation in Different Space Arrangements in the Paraibano Semi-arid

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This research was proposed to evaluate the results under different spacing and densities arrangements on growth, development and productivity of peanut plants, cultivate BR-1, in an agricultural area on the banks of the Piranhas River, located in the municipality of Pombal-PB. Therefore, the study was developed in the experimental field, of the Agri-Food Science and Technology Center, located in São João farm, distant 18 kilometers from the city Pombal. This experiment was carried out from february to may/2017 as a factorial experiment laid out in Complete Randomized Block Design (CRBD), with six repetitions. Include two factors, spaces (0.10x 0.50 m and 0.20x 0.50 m) and density (one seed per hole and two seeds per hole) totaling

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24 plots. The experimental unit was composed of three lines of 4 m, the central line being considered a useful area. Regardless of the sowing season, plant density or spacing are factors that most influence agronomic characteristics and pod productivity and grains of peanuts grown in the Sertao Paraibano. The number of immature fruits per plant was the only variable that significantly differed from the cultivation arrangements in relation to the others, showing better behaviors in the highest density of plants per hectare and in the largest spacing. Regardless of the sowing season, plant density or spacing are factors that most influence agronomic characteristics and in the productivity of pods and grains of peanuts grown in the Sertao Paraibano.

Keywords: Arachis hipogaea L.; planting settings; cultivar BR-1.

1. INTRODUCTION

The peanut (*Arachis hipogaea* L.) is a grain that has high levels of protein and oils, presenting utilization of around 40 and 50% in the extraction of oil and bran, since the grain is just roasted, even in sophisticated sweets, confectionery and dishes from Brazilian and other countries. It is a plant originally from South America, in the region between the latitudes of 10º and 30º south, with probable center of origin in the Gran Chaco region, including the Paraná and Paraguay River valleys [1,2].

Peanuts are grown more significantly in ten states. The biggest producer is São Paulo with 80% of the national production, followed by Bahia 3.6% and Mato Grosso 2.8%. The national production of peanuts expected for this harvest reach to 30.8 thousand tons, 12.8% higher than harvested in the previous harvest and an average productivity around around 1,523.00 kg.ha^{-1}. The highest productivity will be obtained in the state of São Paulo (3,016 kg. ha^{-1}), followed by Tocantins and Mato Grosso (3,000 and 2,450 kg.ha^{-1}, respectively). In Bahia, average productivity will be around 1,000 kg.ha^{-1}, smaller than other states, due to little use of inputs and technology [3,4].

The cultivar BR-1 was obtained from a bulk formed by three phenotypically similar genotypes, from the municipalities of Mogeiro, Itabaiana and Sapé, in Paraiba. Three mass selection cycles were performed to standardize the size and in the color of the seeds, production and cycle. In parallel, selection pressure for precocity was performed. It belongs to the Valencia group, erect in size, with a 35 cm main stem, purplish, with six lateral branches. The leaves are medium in size and characteristic dark green in color. The flowers have a gold yellow standard with wine-colored nerves in the center. The pods are medium in size, with little cross-linking and beak almost absent, having three to four red seeds, of medium size and rounded shape [5,6].

Despite being a widely explored culture in the Southeast, in the Northeast, peanuts are still little explored, either due to lack of knowledge or investments to implement this culture. Its exploration is mostly restricted, to small decapitalized producers who exploit this activity without adequate technical support, resulting in low productivity. In this sense, the adoption of planting configurations that allow for good crop management, a reduction in the initial costs for implementation and a greater financial return, can help make the cultivation of this important legume feasible [1,7].

Currently, among the advantages of reducing line spacing, the increase in competitiveness with weeds stands out, through the rapid closing of the canopy, increasing the superreading. Some research carried out under similar conditions, where the number of pods per plant is the component of production most affected by the plant population and shows an inverse relationship with plant density [8].

This research aimed to evaluate the results of different planting configurations in the development and productivity of peanut cultivar BR-1, in an agricultural area on the banks of the Piranhas River, located in the municipality of Pombal, state of Paraiba.

2. MATERIALS AND METHODS

The experiment was carried in period from february to may/2017, in farm São João, located 18 kilometers from city of Pombal-PB. Sob coordinates 6º46'12" S and 37º48'7" W, at an altitude of 184 m, inserted in the geoenvironmental unit of the hinterland depression, that represents the typical landscape of the northeastern semiarid. The region has a semi-arid climate (AW' hot and humid) second

Köeppen, precipitation and average annual temperature of 431.8 mm and 28°C, respectively, with rainy season that starts in November and Terminate in April. With regard to soils, they are characterized as fluvic vertisols [9].

The seeds of cultivar BR-1 were supplied by National Cotton Research Center (CNPA/EMBRAPA) and, after preparing the area (formation of spaced spikes of 0.50 m were sown manually, according to the treatments.

Sowing was carried out manually on February 3, 2017, according to each treatment related to its density and spacing as a factorial experiment laid out in Complete Randomized Block Design (CRBD), with six replicate. Include two treatments, spaces (0.10x 0.50 and 0.20x 0.50) and density (one seed per hole and two seeds per hole).

Sowing in furrows was carried out with 0.1 and 0.2 m spacing between plants, totaling 2 seeds per hole. When sowing with rattle, manual seeder widely used by small family farmers in the northeast region, which has regulation to deposit the amount of seed you want, this quantity being dependent on the size of the seeds and adjusting the outlet opening of these. For this research, the adjustment was made to deposit one seed per hole and two seeds per hole according to the type of arrangement.

Was applied a nitrogen fertilizer, using 80 kg of ammonium sulfate per hectare, after 30 days of planting, done manually according to the soil analysis that was performed at the Soil Laboratory of the Department of Soils and Rural Engineering (DSER) of UFPB/CCA (Table 1).

Cultural management was carried out by means of four weeding using the hoe whenever necessary. The shelled peanuts were harvested manually at the time when the plants expressed the appropriate maturation point, this period, 90 days after sowing. Subsequently, the material was subjected to sun drying so that the evaluations object of this study can be carried out.

To evaluating peanut production components, random samples of four plants per plot were used, according to the following procedures:

1. Number of gynophores per plant: Obtained by averaging the count of all existing gynophores in four plants, previously marked on each plot.
2. Number of normal fruits per plant: Obtained by averaging the count of all fruits completely formed in four plants, previously marked on each plot.
3. Number of immature fruits per plant: Obtained by averaging the count of all malformed fruits in four plants, previously marked on each plot.
4. Weight of pods per plant: Obtained by measuring the weight of all fruits in four plants, previously marked on each plot.
5. Weight of 100 pods: Obtained by multiplying the pod weight per plant by 100 and then dividing this value by the number of normal fruits.
6. Percentage of hatched pods: Obtained by multiplying the number of hatched pods by 100 and then dividing this value by the number of normal fruits.
7. Weight of 100 seeds: Obtained by multiplying the average weight of perfect seed of four plants by 100, previously marked on each plot.
8. Percentage of perfect seeds: Obtained by multiplying the number of perfect seeds by 100 and then dividing this value by the total number of seeds.
9. Productivity: Obtained by the total weight of the pods of the useful area of each plot, and the values were transformed into kilograms per hectare (kg. ha^{-1}).

The variables analyzed after the harvest were: Average number of gynophores per plant (NGP), Average number of normal fruits per plant (NFN), Average number of immature fruits per

Table 1. Result of soil analysis (0-20 cm of depth) of the area where the experiment was conducted. Pombal - Paraiba, 2017

Hp	SS	P	K^+	Na^+	H^++Al^{+3}	Al^{+3}	Ca^{+2}	Mg^{+2}	SB	CEC	V%	m	O.M
H_2O(1:2.5)		- mg/dm^3 -		----------------- cmolc/dm^3 --------------------							------ % -----		g/kg
5.91	1.23	58.6	57.1	0.16	1.44	0.00	1.82	0.82	3.0	4.58	65.92	0.00	7.1

Source: Soil laboratory - CCA/UFPB. Hp = hydrogenic potential; SB = Sum of bases; CEC = Cation exchange capacity; V% = Base saturation; m% = Aluminum saturation; O.M = organic matter; SS = soil salinity plant (NFI), Average pod weight per plant (PVP), Average weight of 100 pods (PCV), Percentage of hatched pods (PVC), Average weight of 100 seeds (PCS), Percentage of perfect seeds (PSP), Total productivity (PDT) evaluated over 90 days after sowing.

The masses were obtained by weighing all the plants and / or pods of the useful area of the plot on a precision semi-analytical balance. These response variables as a function of independent factors (plant spacing and density) were subjected to analysis of variance (SAEG 9.0), the comparison between the averages made through the tests F and the Tukey test, at the 5% probability level [10,11].

3. RESULTS AND DISCUSSION

The summaries of the analysis of variance for all the characteristics evaluated and the respective coefficients of variation are shown in Table 2. Was observed significant effect at 1% probability, by Test F, for the density factor in the characteristic number of immature fruits. Regarding the spacing, there was no significant effect for any of the studied characteristics. There was also no effect of studied interactions at either 1 or 5% probability by Test F.

3.1 Number of Gynophores per Plant (NGP)

The monthly average values of the air temperature, rainfall and relative humidity of the annual average air (data already mentioned) are presented as important factors with regard to the main climatic and growing conditions of the peanut by which the phenological cycles of this crop evolved, in each sowing time, spacing and density of the plants as in the case of the number of gynophore per plant (NGP).

In the present work, in Table 3, the number of gynophore did not show significant variation between the treatments studied by the Tukey test at the level of 5% probability. But there was a lower incidence in the spacing 0.1 and density 2. However, these data were tested in flavic vertisols.

The data presented in this work, do not demonstrate satisfactory performance and even the precocity regarding spacing and density studied. It was verified, by the development of the plant, during the evaluated period of 90 days, that the emission of gynophores occurred from the 50 days after sowing, not coinciding with the data presented by [12], that also verified in the Valencian type peanut plants (cultivar BRS 151-L7, developed by Embrapa Cotton), the appearance of these structures in the same period, but only 45 days after sowing. On the other hand, howeveressa, the BR-1 cultivar must be kept clean in the experimental area for the first 45 days, weeding can be done with a hoe, or with the help of a cultivator. During weeding it is recommended to pile up to facilitate the development of pods and their formation [13].

These values may have influenced by the pollen viability, affecting the reproductive phase of the crop in terms of the number of gynophores per plant (NGP), according [14] who studied the phenology of Valencia-type genotypes in summer and winter; these authors found that there is a greater emission of gynophores in the warmer period, and more flowers were pollinated, fertilized and developed in the summer.

Table 2. Summary of analysis of variance of data referring to: average number of gynophores per plant (NGP), average number of normal fruits per plant (NFN), average number of immature fruits per plant (NFI), average pod weight per plant (PVP), average weight of 100 pods (PCV), percentage of hatched pods (PVC), average weight of 100 seeds (PCS), percentage of perfect seeds (PSP), total productivity (PDT) evaluated over 90 days after sowing. Pombal - Paraiba, 2017

Variation	Medium squares									
sources	G.L.	NGP	NFN	NFI	PVP	PCV	PVC	PCS	PSP	PDT
Blocks	5	21.09^{ns}	44.02^{ns}	12.40^{ns}	126.92^{ns}	306.46^{ns}	10.27^{ns}	34.50^{ns}	28.20^{ns}	865414^{ns}
Spaces (S)	1	5.36^{ns}	223.10^{ns}	9.90^{ns}	355.40^{ns}	18.30^{ns}	9.92^{ns}	0.82^{ns}	0.15^{ns}	1368037^{ns}
Density (D)	1	1.70^{ns}	9.70^{ns}	62.54**	25.60^{ns}	4.40^{ns}	100.7^{ns}	11.80^{ns}	4.50^{ns}	250104^{ns}
S x D	1	27.60^{ns}	72.36^{ns}	0.44^{ns}	172.33^{ns}	45.25^{ns}	0.00^{ns}	3.19^{ns}	10.07^{ns}	1033350^{ns}
Residue	15	21.78^{ns}	55.90^{ns}	5.40^{ns}	104.64^{ns}	309.52^{ns}	27.77^{ns}	10.38^{ns}	26.14^{ns}	3288319^{ns}
C.V. %	--	41.10	34.50	33.60	36.78	13.85	20.05	9.6	6.42	14.64

*** Significant at 1% probability and ns not significant by the F test*

Table 3. Averages referring to the number of gynophores depending on the spacing and density of peanut plants, variety BR-1. Pombal-PB, 2017

Spacing	NGP
0.10	9.09 Aa
0.20	10.30 Aa
Density	-----------
1.0	10.2 Aa
2.0	8.60 Aa

Spacing 0.1 (0.10 x 0.50 m) and 0.2 (0.20 x 0.50 m). Density 1 (with one seed per hole) and 2 (with two seeds per hole). Means followed by equal letters in the column (upper case for Temperature, Period and lower case for Treatments) do not differ statistically by the Tukey test at 5% probability

Nunes et al. [15] used a spacing of 0.70 x 0.30 cm, leaving one seed per hole. The population density was 36 plants/plot. The data were collected from 15 plants selected at random. In this work, an average of 8.06 gynophores per plant was obtained, which was in real values close to those found in the present work.

3.2 Number of Normal Fruits per Plant (NFN)

Regarding the number of normal fruits per plant (NFN) of the BR-1 variety, analysis of variance revealed no significant differences for the isolated density factors (D<0.01) and plant spacing (E < 0.05) or even to study the E x D interaction between them (P <0.01), as shown in Table 3. The production of normal fruits per plant (Table 4) was greater in the greater spacing and greater planting density, however, if compared to plants with shorter spacing and lower density, production was observed and, consequently, lower productivity in the smallest spacing. However, even with density 2 showing a better performance in relation to density 2 (0.20 x 0.50 m), one must take into consideration the cost/benefit, since the difference in real values between densities was of 1.15 normal pods.

Even without significant differences between the arrangements composed of densities and spacing in the BR-1 variety, evaluated up to 120 days after sowing, it is possible to notice (Table 4) that in lower densities there were smaller numbers of normal fruits per plant in the value of 16.20 against 21.10 in the lower tested density. However, the opposite occurs with higher densities, probably due to less intraspecific competition and low density of plants.

Table 4. Averages referring to the Number of Normal Fruits (NFN) in function of the spacing and density of the peanut plants, variety BR-1. Pombal-PB, 2017

Spacing	NFN
0.10	16.20 Aa
0.20	25.89 Aa
Density	-----------
1.0	21.10 Aa
2.0	22.35 Aa

Spacing 0.1 (0.10 x 0.50 m) and 0.2 (0.20 x 0.50 m). Density 1 (with one seed per hole) and 2 (with two seeds per hole). Means followed by equal letters in the column (upper case for Temperature, Period and lower case for Treatments) do not differ statistically by the Tukey test at 5% probability

These results are inconsistent with those of other works presented by [8] and [16] in which it was verified that, among the production components, the number of pods per plant was the most affected by the plant population, observing an inverse relationship between them. The formation of the lowest number of pods in the largest populations is the result of competition between plants [17].

According to work carried out by [18], a short period of adverse weather in the pod filling phase results in a substantial difference in the number of pods. Already, the grain filling stage is less sensitive, due to the ability that plants have to vary the development of the formed fruits, in response to the altered supply of photoassimilates.

3.3 Number of Immature Fruits per Plant (NFI)

In Number of immature fruits per plant (NFI) were found significant differences in treatments when the Tukey test was applied at the level of 5% probability for spacing and density (Table 5). In spacing of 0.1, a lower incidence of immature fruits was obtained, which was 5.70 per plant, while at 0.2 spacing the average of immature fruits was 7.02 per plant. Regarding density 2, the highest average values per plant were obtained when using two seeds per hole (7.70 immature fruits per plant), but this was positive, because the smaller the amount of immature pods, the better the plant's performance in terms of productivity.

Santos et al. [12], mentioned that the length of the flowering period is very important for effective grain production, since, the shorter this period, which goes from the beginning to the end of flowering, the greater the utilization in the grain filling phase, by reducing the number of malformed grains by the greater uniformity of the flowering phase.

Table 5. Averages referring to the Number of Immature Fruits (NFI) as a function of spacing and density of peanut plants, variety BR-1. Pombal-PB, 2017

Spacing	NFI
0.10	5.70 Ab
0.20	7.02 Aa
Density	-----------
1.0	4.50 Ab
2.0	7.70 Aa

Spacing 0.1 (0.10 x 0.50 m) and 0.2 (0.20 x 0.50 m). Density 1 (with one seed per hole) and 2 (with two seeds per hole). Means followed by equal letters in the column (upper case for Temperature, Period and lower case for Treatments) do not differ statistically by the Tukey test at 5% probability

However, [19], observed that the production per area showed a behavior practically opposite to the production per plant, proving that the most important production component is the plant population. This confirms what happened in the present study, since the lower the density, the number of malformed pods was also lower.

3.4 Average Weight of Pods per Plant (PVP)

The average weight of pods per plant (PVP) is one of the main components of peanut production. By the average results obtained (Table 6), it was found that although there were no statistical differences by the Tukey test at 5% probability, even so, if it was obtained, average absolute values in the order of 0.2 for the spacing and for the tested plants regarding the density factor, the average value was of 2.0.

This characteristic may possibly be linked to heritability, in which the variations are minimal within the factors, although with some expressiveness regarding the aspects of average production of pods per plant, because both factors studied, spacing and density of peanut plants, variety BR-1.

Nakagawa et al. [20] studied the densities of 5, 8, 11, 14, 17, 20, 23 and 26 plants per meter, in spacing of 0.60 m between lines and obtained an average weight of pods per plant varying from 9.22 to 27.84 grams, thus presenting values lower than those found in the present work for spacing 0.2 (30.45 g).

Table 6. Averages referring to the average weight of Pod Per Plant (PVP) as a function of spacing and density of peanut plants, variety BR-1. Pombal-PB, 2017

Spacing	PVP – g plant^{-1}
0.10	21.45 Aa
0.20	31.40 Aa
Density	------------
1.0	25.00 Aa
2.0	27.75 Aa

Spacing 0.1 (0.10 x 0.50 m) and 0.2 (0.20 x 0.50 m). Density 1 (with one seed per hole) and 2 (with two seeds per hole). Means followed by equal letters in the column (upper case for Temperature, Period and lower case for Treatments) do not differ statistically by the Tukey test at 5% probability

These data are superior to those presented by [2], when checking the production of cultivars in the peanut crop planted in different spacing, found an average production of pods per plant of 26.57 in the Runner IAC 886 variety and with 0.50 m spacing.

3.5 Weight of 100 Pods (PCV)

For the weight of 100 pods per plant (PCV) no significant differences were found by the Tukey test at the 5% probability level (Table 7), but even so, the average weight of 100 pods is of the order of 123.32 g in the spacing of 0.10 m and the average weight of 124.44 g in the spacing of 0.2 m, even without showing statistically significant effects, greater average weight of pods was obtained in the largest population of plants and with greater spacing.

Table 7. Averages referring to the average weight of 100 Pods Per Plant (PCV) as a function of spacing and density of peanut plants, variety BR-1. Pombal-PB, 2017

Spacing	PCV - grams
0.10	123.32 Aa
0.20	124.44 Aa
Density	-------------
1.0	126.10 Aa
2.0	127.70 Aa

Spacing 0.1 (0.10 x 0.50 m) and 0.2 (0.20 x 0.50 m). Density 1 (with one seed per hole) and 2 (with two seeds per hole). Means followed by equal letters in the column (upper case for Temperature, Period and lower case for Treatments) do not differ statistically by the Tukey test at 5% probability

Unlike the results obtained here, [21] obtained significant differences for the weight of 100 pods, with higher weights in the smallest plant populations.

In previous works, no effects of sowing density were found on the weight of 100 pods, in a total of seven experiments [16], conducted under different environmental conditions, and the number of seeds per pod in two experiments out of three [16]. From these results, it can be inferred that these production components for cv. Armadillos are little affected by the plant population, especially the weight of 100 pods.

Barros et al. [22] evaluating the weight of one hundred pods, by the 0.10 m spacing, it obtained the result of 127.62 g, a value lower than that found here, being 164.58 g similar to the weight of 160 g obtained by [23,24]. However, in the spacing of 0.20 m the effects were very close.

3.6 Percentage of Hatched Pods (PVC)

The percentage of hatched pods did not differ significantly by the Tukey test at the level of 5% probability in the different configurations or planting arrangements of the BR-1 variety used in this experiment over 120 days after sowing (Table 8), however, a higher estimated average value of 24.91% was obtained in the 0.1 spacing and 29.32% in the 1.0 spacing. In absolute values, the lowest values were obtained when using two peanut seeds per hole and in the smallest spacing of 0.10 m (Table 8).

Table 8. Averages referring to the percentage of hatching pods (PVC) as a function of spacing and density of peanut plants, variety BR-1. Pombal-PB, 2017

Spacing	PVC - %
0,10	24,91 Aa
0,20	23,63 Aa
Density	------------
1,0	29,32 Aa
2,0	28,3 Aa

Spacing 0.1 (0.10 x 0.50 m) and 0.2 (0.20 x 0.50 m). Density 1 (with one seed per hole) and 2 (with two seeds per hole). Means followed by equal letters in the column (upper case for Temperature, Period and lower case for Treatments) do not differ statistically and by the Tukey test at 5% probability

The reduction in the percentage of hatched pods of the plants in the largest spacing and densities may have occurred due to the self-shading caused by the greater number of leaves in the higher plant populations, by decreasing the number of branches [2].

Santos et al. [13] found a percentage of chocha pods of 12% on average, using the spacing of 0.70 x 0.10 m with 1 seed per hole or 0.70 x 0.20 m with 2 seeds. In the present study, this component varied from 24.23% to 28.32%. For [23] this component ranged from 24.23% to 28.32%. In the evaluation of the present study, there was an oscillation from 4.78% to 13.96%.

3.7 Weight of 100 Seeds (PCS)

The variable weight of 100 seeds showed no significant difference by the Tukey test at the level of 5% probability (Table 9), being observed a small tendency of superiority in the arrangement of rows with the spacing 0.10 m and in the density 1, which corresponded to 33.23 and 32.32 g plant^{-1}, respectively. Work conducted by Santos et al. [13], if I obtained a weight of 100 seeds much higher (48 grams) when using the spacing of 0.70 x 0.10 m with 1 seed per hole or 0.70 x 0.20 m with 2 seeds per hole.

Table 9. Averages referring to the average weight of 100 seeds per plant (PCS) in function of the spacing and density of the peanut plants, variety BR-1. Pombal-PB, 2017

Spacing	PCS – g plant^{-1}
0.10	33.23 Aa
0.20	32.50 Aa
Density	-----------
1.0	32.31 Aa
2.0	31.70 Aa

Spacing 0.1 (0.10 x 0.50 m) and 0.2 (0.20 x 0.50 m). Density 1 (with one seed per hole) and 2 (with two seeds per hole). Means followed by equal letters in the column (upper case for Temperature, Period and lower case for Treatments) do not differ statistically by the Tukey test at 5% probability

For national consumption, this size is well accepted since several cultivars for commercial use have a weight of 100 grains similar to that obtained. However, the water deficiency suffered by peanut plants during the fruiting stage, before complementary irrigation, may have contributed to these results.

Coolbear [17] commented that, in general, with the increase in the density of plants there is a tendency to be an increase in the number of larger seeds; this is because the high competition between plants prevents the development of pods formed later, while the former is more successful in seed formation.

3.8 Percentage of Perfect Seeds (PSP)

For the percentage of seeds (PSP) or seed yield per peanut plant, which for the cultivar BR-1 is a national average of 84% [6]. The present work obtained a percentage of perfect seeds inferior ranging from 76.40% and 78.10% where the best performance was with density 2 and spacing 0.1 m (Table 10), even so, these data did not present significant effects or that did not present significant differences at the 1% probability level by the F test. By the results it is possible to indicate that, for each factor studied, there was an arrangement with a higher percentage of perfect seeds, that is, greater production of pods and grains, being the combination D_1E_1 (0.10 x 0.50 m) and in density 1 (with one seed per hole). This way, the farmer has a less expensive planting arrangement that he can choose according to the sowing time he chooses.

Table 10. Averages referring to the percentage of perfect seeds (PSP) in function of the spacing and density of the peanut plants, variety BR-1. Pombal-PB, 2017

Spacing	PSP - %
0,10	76,40 Aa
0,20	75,99 Aa
Density	------------
1,0	76,18 Aa
2,0	78,10 Aa

Spacing 0.1 (0.10 x 0.50 m) and 0.2 (0.20 x 0.50 m). Density 1 (with one seed per hole) and 2 (with two seeds per hole). Means followed by equal letters in the column (upper case for Temperature, Period and lower case for Treatments) do not differ statistically by the Tukey test at 5% probability

The ideal in a peanut plant is that it has concentrated flower production, with a flowering duration of around six weeks. This allows for greater uniformity in the number of mature pods at the end of the cycle, ensuring a reduction in losses in production [12,13].

3.9 Productivity (PDT)

In the present work, the best average productivity of peanut pods was obtained with the 0.1 spacing that obtained an average productivity of 4858.40 kg ha is a tendency^{-1} and with density 2 that was 3818.72 kg ha^{-1}, but even so, there was no significant difference by the Tukey test at the level of 5% probability (Table 11).

Table 11. Averages referring to total pod productivity (PDT) of peanut as a function of spacing and density of peanut plants, variety BR-1. Pombal-PB, 2017

Spacing	PDT – kg ha^{-1}
0,10	4858,40 Aa
0,20	3867,09 Aa
Density	--------------
1,0	3614,50 Aa
2,0	3818,72 Aa

Spacing 0.1 (0.10 x 0.50 m) and 0.2 (0.20 x 0.50 m). Density 1 (with one seed per hole) and 2 (with two seeds per hole). Means followed by equal letters in the column (upper case for Temperature, Period and lower case for Treatments) do not differ statistically by the Tukey test at 5% probability

The average productivity in all treatments was greater than the best national productivity average presented by the State of Minas Gerais in the amount of 3,570 kg ha^{-1} (2ª harvest of 2012). It is also interesting to note that the difference in real value presented between the spacing was 478 kg (in shell), that is, approximately 338 kg of seeds, which considering the value of R $ 8.00 per kilo of peanut seed, would give a total of R $ 2,704.00 - a very significant difference for a producer.

In the Northeast region, the cultivation of peanuts is basically an activity of small and medium producers, which use low technological level, being common the use and reuse of seeds of local populations, which results in low productivity and high production cost [22].

The plant population is one of the factors that stand out in affecting productivity, as it directly influences the production components. In peanuts, increases in the plant population cause higher pod yields; however, this is valid up to certain limits, varying according to the cultivar and the conditions of the environment [16].

4. CONCLUSION

The number of immature fruits per plant was the only variable that significantly differed from the cultivation arrangements in relation to the others, showing better behaviors in the highest density of plants per hectare and in the largest spacing.

At higher densities, the lower production of pods per plant was offset by the larger population of plants, resulting in better fruit production per plant.

Although there were no statistical differences for productivity, the highest absolute values were found in the smallest spacing between plants and with two seeds per hole, justifying the recommendation of this planting configuration.

Regardless of the sowing season, plant density or spacing are factors that most influence agronomic characteristics and in the productivity of pods and grains of peanuts grown in the Sertao Paraibano.

The productivity performance of cultivar BR-1 varies with spacing and population density, type of soil and planting time.

The choice of the spatial arrangement that expresses the highest yields of pods and grains depends on the commercial objective of the producer (volume or mass) and the time of sowing.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Peixoto CP, Gonçalves Já, Peixoto MFSP, Carmo DO. Agronomic characteristics and peanut yield in different spacing and sowing times in the Bahia region. Bragantia, Campinas. 2008;67(3):673-684.
2. Oliveira TMA, Queiroga RCF, Nogueira FP, Moreira JN, Santos MA. Production of decumbent peanut cultivars subjected to different spacing. Revista Caatinga, Mossoró. 2010;23(4):149-154.
3. Godoy IJ, Minotti D, Resende PL. Production of quality peanuts. Viçosa: Centro de Produções Técnicas. 2005;168.
4. Conab. Brazilian crop monitoring: Grains, Third Survey, December 2012/Companhia Nacional de Abastecimento. – ABICAB. Linhas básicas do Pró-Amendoim. Brasília: Conab; 2012.
5. Ambrosano EJ, Cantarella H, Ambrosano GMB, Schammas EA, Dias FLF, Rossi F, Trivelin PCO, Muraoka T, Sachs RCC, Azcón R. Sugarcane productivity after the cultivation of legumes. SsiELO Brasil, Bragantia, Campinas. 2011;70(4):810-818.
6. Embrapa – Brazilian Agricultural Research Company. Notícias – Study maps peanut production areas in Brazil to prevent coal disease.
(Publicado em 22/01/2019)
(Acesso em 16/06/2019)
Available:https://www.embrapa.br/busca-de-noticias/-/noticia/40697528/estudo-mapeiaareas-de-producao-de-amendoim-do-brasil-para-prevenir-doenca-do-carvao
7. Arruda IM, Moda-Cirino V, Buratto JS, Ferreira JM. Growth and productivity of peanut cultivars and lines subjected to water deficit. Pesq. Agropec. Trop., Goiânia. 2015;45(2):146-154.
8. Laurence RCN. Population and spacing studies with Malawian groundnut cultivars. Experimental Agricultural. 1974;10:177-184.
9. Embrapa - Brazilian Agricultural Research Company. Brazilian system of soil classification. Rio de Janeiro, EMBRAPA/CNPS, (EMBRAPA-Solos. Documento 15). 1999;412.
10. Banzatto DA, Kronka SN. Agricultural experimentation. 4. Ed. Jaboticabal: UNESP. 2008;247.
Available:https://livraria.funep.org.br/experimentac-o-agricola-4-edic-o.html
11. Barbosa JC, Maldonado Junior W. AgroEstat - System for statistical analysis of agronomic trials. Jaboticabal: FCAV/UNESP; 2015.
Available:https://livraria.funep.org.br/experimentac-o-agronomica-agroestat- sistema-para-analises-estatisticas-de-ensaios-agronomicos-acompanha-cd-com-software-agroestat.html
12. Santos RC, Melo Filho PA, Brito SF, Moraes JS. Phenology of peanut genotypes of the botanical types Valencia and Virginia. Brazilian Agricultural Research, Brasília. 1997;32(6):607-612.
13. Santos RC, Moreira JAN, Valle LV, Freire RM, Almeida RP, Araújo JM, Silva LC. Amendoim BR-1: Technical information for your cultivation. Campina Grande: Embrapa - Algodão, 2p. (1-Folder); 2009.
14. Choudhar SD, Udaykumar M, Sastry KSK. Physiology of bunch groundnuts (*Arachis hypogaea* L.). Journal of Agricultural Science, Cambridge. 1985;104:309-315.
15. Nunes LL, Cavalcanti RS, Silva JLF, Albuquerque PMF. Estimates of genetic parameters in peanut strains based on descriptors associated with gynophore. Revista Ciência Agronômica. 2010;41(1): 132-138.
16. Nakagawa J, Lasca DC, Neves JPS, Neves GS, Sanchez SV, Barbosa V, Silva MN, Rossetto CAV. Effect of sowing density on peanut production. Brazilian

Agricultural Research. 1994;29(10):1547-1555.
17. Coolbear P. Reproductive biology and development. In: SMART J, (Ed.) The groundnut crop. A scientific basis for improvement. London: Chapman & Hall. 1994;Cap.5:138-172.
18. Gonçalves JA. Spatial arrangement in peanut growth and yield in two sowing dates in Recôncavo Baiano. Dissertação (Mestrado em Ciências Agrárias) – Center for Agricultural and Environmental Sciences. Federal University of Bahia. 2004;97.
19. Bellettini NMT, Endo RM. Peanut behavior “of the waters”, *Arachis hypogaea* L., under different spacing and sowing densities. Acta Scientiarum, Maringá. 2001;23(5):1249-1256.
20. Nakagawa J, Lasca DHC, Neves JPS, Neves GS, Silva MN, Sanches SV, Barbosa V, Rosseto CAV. Plant density and peanut production. Scientia Agrícola, Piracicaba. 2000;57(1):67-73.
21. Silva AC, Freire RMM, Suassuna TMF. Peanut: The producer asks, The Embrapa responds. Brasília, DF: Embrapa Informação Tecnológica; 2009.
22. Barros MAL, Santos RC, Arayjo JM, Santos JW, Oliveira SRM. Diagnóstico preliminar da cultura do amendoim no Estado da Paraíba. In: EMBRAPA. Centro Nacional de Pesquisa de Algodão (Campina Grande, PB). Relatório Técnico Anual 1992-1 993. Campina Grande. 1994;384-386.
23. Lucena Neto A. Components of production of peanut, farming br-1, in different settings planting. Monografia (Graduação em Agronomia). Universidade Federal da Paraíba, Centro de Ciências Agrárias. 2013;31.
24. Carvalho LT. Peanut genotypes grown under no-till and conventional tillage under the water regime of Southwest Goiás. Revista Brasileira de Agricultura Irrigada, Ceará. 2014;8(6):432–443.

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