

Effect of planting distances and nitrogen fertilization on yield of *Arachis Hypogaea* L.

Published

Instituto Tecnológico superior Edwards
Deming. Quito - Ecuador

Periodicity

July - September
Vol. 1, Num. 26, 2025
pp. 17-35
<http://centrosuragraria.com/index.php/revista>

Dates of receipt

Received: May 22, 2025
Approved: June 20, 2025

Correspondence author

tito.arce@utelvt.edu.ec

Creative Commons License

Creative Commons License, Attribution-NonCommercial-ShareAlike 4.0 International.
<https://creativecommons.org/licenses/by-nc-sa/4.0/deed.es>

Professor of Agronomy at the Technical University "Luis Vargas Torres" of Esmeraldas. Mutile Campus. Km 20 via Esmeraldas - Tachina
e-mail: tito.arce@utelvt.edu.ec,
<https://orcid.org/0000-0002-3194-1263>

Professor of Agronomy at the Technical University "Luis Vargas Torres" of Esmeraldas. Mutile Campus. Km 20 via Esmeraldas - Tachina
e-mail: julissa.arcentales@utelvt.edu.ec,
<https://orcid.org/0000-0003-4424-2784>

Researcher Universidad Técnica Luís Vargas Torres de Esmeraldas:
angelica.angamarcap@gmail.com,
<https://orcid.org/0000-0001-9313-980X>

Researcher Universidad Técnica Luís Vargas Torres de Esmeraldas:
ana.camachol@gmail.com
<https://orcid.org/0009-0001-0792-2230>

Efecto de distancias de siembra y fertilización nitrogenada en el rendimiento de *Arachis Hypogaea* L.

Tito Arce Olivo¹
Julissa Arcentales Montalvo²
Angélica Angamarca Pigüave³
Ana Camacho Leyes⁴

Abstract: The research was conducted to evaluate the effect of three planting distances (60 cm x 30 cm, 50 cm x 25 cm and 45 cm x 18 cm) and three doses of nitrogen fertilizer (0, 30 and 60 kg N ha⁻¹) on the yield of peanut crop variety INIAP 382. A completely randomized block design with a 3 x 3 factorial arrangement was applied. The planting material and experimental methodology were provided by the Department of Oilseeds of the Instituto Nacional Autónomo de Investigaciones Agropecuarias (National Autonomous Institute of Agricultural Research). The statistical analysis was carried out with InfoStat software, using Tukey's 5% significance tests, considering the following variables: plant height, number of pods per plant, number of seeds per plant, weight of 100 seeds, yield (kg ha⁻¹) and economic analysis. The results obtained show that the highest yield is obtained with a planting distance of 45 cm between rows and 18 cm between plants (3928.05 kg ha⁻¹); however, the highest benefit-cost ratio is achieved by planting at 60 cm between rows and 30 cm between plants (3.01), in both cases applying 30 kg N ha⁻¹; in addition, both factors have a significant influence on the yield of the peanut crop under these agroecological conditions. However, it is necessary to evaluate the adaptation of this variety in other locations and to consider that soil moisture is in the optimum range to achieve the best use of nitrogen fertilizer by the plants.

Key words: Peanut crop; Fertilizer; Yield.

Resumen: La investigación se realizó con la finalidad evaluar el efecto de tres distancias de siembra (60 cm x 30 cm, 50 cm x 25 cm y 45 cm x 18 cm) y tres dosis de fertilizante nitrogenado (0, 30 y 60 kg de N ha⁻¹) en el rendimiento del cultivo de maní variedad INIAP 382. Se aplicó un Diseño en Bloques Completamente al Azar con arreglo factorial 3 x 3. El material de siembra y la metodología del experimento fueron proporcionados por el Departamento de Oleaginosas del Instituto Nacional Autónomo de Investigaciones Agropecuarias. El análisis estadístico se realizó con el software

InfoStat, mediante pruebas de significancia de Tukey al 5%, considerando las variables: altura de plantas, número de vainas por planta, número de semillas por planta, peso de 100 semillas, rendimiento (kg ha⁻¹) y el análisis económico. Los resultados obtenidos reflejan que el mayor rendimiento se obtiene con la distancia de siembra 45 cm entre calles y 18 cm entre plantas (3928.05 kg ha⁻¹); sin embargo, la relación Beneficio-Costo más alta se logra sembrando a 60 cm entre calles y 30 cm entre plantas (3.01), en ambos casos aplicando 30 kg N ha⁻¹; además, ambos factores, inciden significativamente en el rendimiento del cultivo de maní, en estas condiciones agroecológicas. Sin embargo, es necesario evaluar la adaptación de esta variedad en otras localidades y considerar que la humedad del suelo se encuentre en el rango óptimo para lograr el mayor aprovechamiento del fertilizante nitrogenado por parte de las plantas.

Palabras clave: Cultivo de maní; Fertilizante; Rendimiento.

Introduction

Arachis hypogaea is a vegetable source of protein and unsaturated fats highly appreciated by the Ecuadorian and world population (Guamán and Andrade, 2010). The peanut kernel is used for the preparation of certain food dishes (Garcés-Fiallos, Guamán, and Díaz-Coronel, 2011). The seeds are consumed raw, cooked or roasted, processed to produce butter or used for soups and sauces. Its consumption is not restricted because it does not generate massive production of cholesterol due to the high percentage (80%) of unsaturated fats (Martínez, 2007). It contains phytosterols that reduce bad cholesterol and provides minerals such as sodium, potassium, iron, magnesium, iodine, copper and calcium; it has antioxidant substances such as tocopherols that rejuvenate cells and tissues of the human body (Guamán and Andrade, 2010).

Among the main varieties grown on the Ecuadorian coast is INIAP-382 Caramelo, which belongs to the Runner commercial group. It flowers between 33 and 36 days and is harvested between 130 and 140 days; the plant height is 23 to 34 cm, has between 14 and 28 branches per plant; 25 to 35 grains per plant, 50 to 60 g as 100 seed weight and an average yield of 3341 kg ha⁽⁻¹⁾ (Guamán and Andrade, 2010).

The main problem for peanut producers is low yields per unit area (Chávez, 2007), because although the National Autonomous Institute

of Agricultural Research (INIAP) has provided varieties characterized by oil concentrations ranging from 45 to 48% and protein concentrations ranging from 28 to 30%, with yields exceeding 3 000 kg ha⁽⁻¹⁾ (Guamán and Andrade, 2010), but these results have not been validated in locations that have good potential for crop development and, therefore, producers do not benefit from these technologies (Vélez, 2011).

Planting time, plant population per hectare directly affects peanut crop yield and this, in turn, is determined by spacing (da Silveira et al., 2013). Regarding planting distances, larger planting distances can intercept more radiation compared to lower densities (Augusto et al., 2010). The planting distance of 0.45 m x 0.30 m is optimal for peanut planting to obtain higher yields (Abad, 2016). However, the varieties INIAP-380 and INIAP-381 Rosita, should be planted with a distance of 0.50 m between rows x 0.20 m between sites, placing 2 seeds, obtaining a population of 200000 plants per hectare (Naab et al., 2009). Briones (2021), considers that the best yields in peanuts are obtained by planting the Caramelo variety at distances of 50 cm x 15 cm; although the INIAP 383 variety with a population of 81 632 plants/ha obtained the highest number of pods/plant, the highest net economic benefit is achieved with the INIAP 308 variety, 62 500 plants/ha (Garcia 2016). The planting frames do not significantly influence the averages of days to flowering of the crop, number of pods per pod and weight of 100 seeds, however, the greater spacing between plants allowed obtaining plants of greater height and yield (Pallo (2021); in other agroecological conditions, the distance of 60 cm between rows and 20 cm between sites, allows obtaining greater fresh and dry weight of the seed (Dávila, 2021). In short, an appropriate plant density can significantly improve peanut yields under rainfed conditions (Pedelini, 2012), and the increase in population density can significantly increase the accumulated biomass and seed yield per unit area (Guamán and Andrade, 2010).

The peanut crop is not demanding to fertilization (Guamán and Andrade, 2010); however, soil analysis is essential to determine the fertilization program to follow in any commercial planting (Fundora et al., 2001)). The crop responds erratically to the direct application of nitrogen, potassium and phosphorus fertilizers (Naab et al., 2009). Although it is a legume and therefore has the ability to incorporate atmospheric nitrogen into the soil, it is recommended to apply 10 to 20 kg N ha⁻¹ for establishment (Martinez, 2007). In addition, under certain conditions it responds well to nitrogen fertilization with minor

elements (Chávez, 2019), and crop rotation and green manures can be used as alternatives (Alvarado, 2004). The lower percentage of empty grain contributes to increase seed crop yield Ibanez et al. (2018). Mora et al. (2019), affirm that the incorporation of organic fertilizers, has favorable effects on the variables pods per plant, grains per plant and peanut yield.

In evaluations conducted at the Experimental Station "Mútile" of the Technical University "Luis Vargas Torres" of Esmeraldas, the yield of the INIAP-382 variety stands out in relation to other materials (Gracia, 2010), so in this research the effect of planting distances and nitrogen fertilization on crop yield is studied, contributing to the rational use of inputs and increasing the economic income of producers.

Methodology

The experiment was carried out in a field located at the geographical coordinates 00°13'33" north latitude and 73°26'00" west longitude in the Quinindé canton, province of Esmeraldas, Ecuador. The average temperature is 26°C, average monthly rainfall is 93 mm and relative humidity is 86%. The soil is sandy loam with 31 ppm of N (medium), 25 ppm of P (high) and 0.13 meq/100 ml of K (low). A pH of 5.8 (medium acid). Peanut seed, variety INIAP-382, was provided by the Oilseed Department of the Litoral del Sur Experimental Station "Dr. Enrique Ampuero Pareja" of INIAP. Three planting distances were evaluated: 60 cm x 30 cm, 50 cm x 25 cm and; 45 cm x 18 cm; applying three levels of nitrogen fertilization (0, 30 and 60 kg of N ha⁻¹) to evaluate its effect on crop yield.

Considering the nature of the work and the characteristics of the site where the experiment was carried out, a Completely Randomized Block Design (CSBD) was applied, using three replications. The methodology applied was that recommended by the National Oilseed Program of INIAP (PRONAOL), considering the edaphoclimatic characteristics of the research site and the particularities of the peanut crop. Statistical analysis was performed using InfoStat software.

Land preparation consisted of two passes of plowing and one pass of harrowing. In addition, the field was furrowed considering the distances previously established in the experimental design. Sowing

was done manually, with a continuous jet, placing the seed at the bottom of the furrow at a depth of 4 cm. Thinning was carried out 12 days after sowing, eliminating the plants that were outside the row and those that showed little vigor, leaving the amount established according to the previously defined populations. Nitrogen fertilizer was applied 30 days after planting, applying the established doses for each treatment. For weed control, Gramilag herbicide (1 L ha⁻¹) was applied pre-emergence to the crop and then mechanical controls were carried out every 15 days. Control of codling moth (*Stegasta bosquella*) was carried out with the application of Chlorpyrifos (1 L ha⁻¹). The pods were harvested according to the maturity of the treatments studied, at 120 days.

The following variables were evaluated:

Plant height (cm): 40 days after sowing, measuring with a graduated ruler, from the ground to the apex of the central stem, taking 10 plants at random from each treatment and the result was expressed in centimeters.

Number of pods per plant: The number of pods on 10 randomly selected plants in the net plot was counted for each treatment and replication. Subsequently, the average was calculated for weighting.

Number of seeds per plant: The total number of seeds of 10 plants taken at random from the useful area of each plot and replication was counted. In addition, the percentage of pods having one, two and three seeds was determined.

Weight of 100 seeds (g): In the seeds harvested from the plants located in the net plot, 100 seeds were counted and weighed on a precision balance. This procedure was repeated three times and the average of these readings was taken as the value of this variable.

Total yield (kg ha⁻¹): This variable was evaluated by harvesting the net area in each treatment and replicate. Analyses were performed considering the area unit.

Economic analysis: Calculations were made of the net profit per treatment and the Benefit/Cost ratio. For this purpose, the costs of each treatment and the income from the sale of the product were determined (considering a reference market price at the date of harvest), which allowed establishing the economic convenience of the treatments in relation to the costs of commercial production of 1 ha of peanuts.

Results

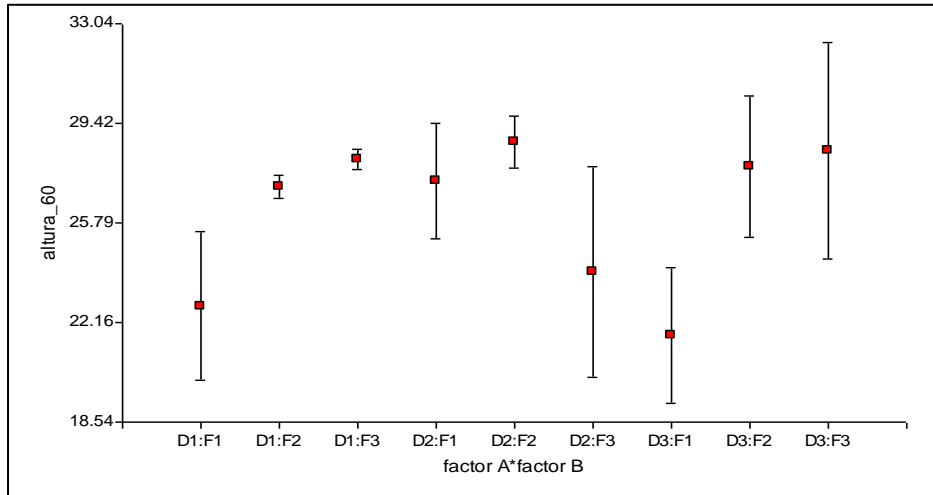
Plant height

The ANAVA for plant height at 40 days after planting showed no significant differences between the factors studied. Tukey's test at 95% probability presents a range of significance, being D2F2 the one that obtained the greatest height (28.73 cm), followed by D3F3 (28.43 cm), D1F3 (28.10 cm). The lowest height was obtained in D3F1 (21.77 cm) (Table 1).

Table 1. Tukey's test at 95% for plant height at 40 days, in the evaluation of the effect of planting distances and nitrogen fertilization on the yield of *Arachis hypogaea L.*

| <u>density means n</u> | | | |
|-------------------------|--------------|----------|----------|
| D3 | 25.98 | 9 | A |
| D1 | 25.99 | 9 | A |
| D2 | 26.68 | 9 | A |
| fertilization | | | |
| F1 | 23.91 | 9 | A |
| F3 | 26.84 | 9 | A |
| F2 | 27.89 | 9 | A |
| density x fertilization | | | |
| D3 F1 | 21.67 | 3 | A |
| D1 F1 | 22.77 | 3 | A |
| D2 F3 | 24.00 | 3 | A |
| D1 F2 | 27.10 | 3 | A |
| D2 F1 | 27.30 | 3 | A |
| D3 F2 | 27.83 | 3 | A |
| D1 F3 | 28.10 | 3 | A |
| D3 F3 | 28.43 | 3 | A |
| <u>D2 F2</u> | <u>28.73</u> | <u>3</u> | <u>A</u> |

Different letters indicate significant differences ($p \leq 0.05$).



Plant height at 40 days, in the evaluation of the effect of sowing distances and nitrogen fertilization on the yield of *Arachis hypogaea* L.

Number of pods per plant

The ANAVA for the number of pods indicates that there is a significant difference for fertilizer doses. Tukey's test at 95% shows three ranges of significance: in the first is D3F2 (24.40) and D3F1 (24.83); in the second range D2F3 (29.37), D2F1 (30.43), D3F3 (32.50), D2F2 (33.70), D1F3 (34.23) and, D2F2 (35.77). The last rank corresponds to D1F2 (39.73) (Table 2).

Table 2. Tukey test at 95% for the number of pods per plant, in the evaluation of the effect of planting distances and nitrogen fertilization on yield of *Arachis hypogaea* L.

density Means n

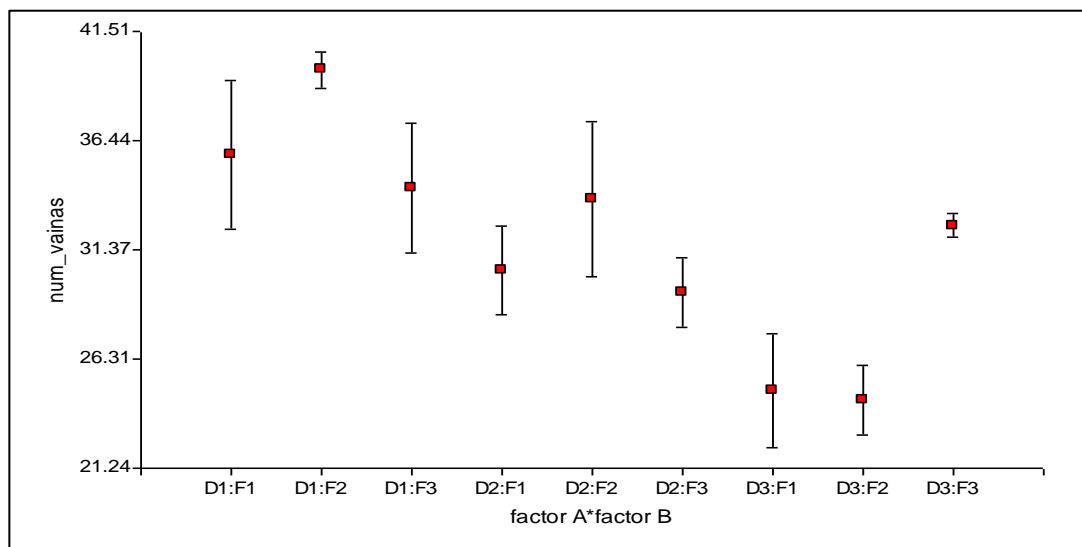
| | | | |
|----|-------|---|---|
| D3 | 27.24 | 9 | A |
| D2 | 31.17 | 9 | A |
| D1 | 36.58 | 9 | B |

fertilization

| | | | |
|----|-------|---|---|
| F1 | 30.34 | 9 | A |
| F3 | 32.03 | 9 | A |

| | | | | |
|-------------------------|-------|---|---|---|
| F2 | 32.61 | 9 | A | |
| density x fertilization | | | | |
| D3 F2 | 24.40 | 3 | A | |
| D3 F1 | 24.83 | 3 | A | |
| D2 F3 | 29.37 | 3 | A | B |
| D2 F1 | 30.43 | 3 | A | B |
| D3 F3 | 32.50 | 3 | A | B |
| D2 F2 | 33.70 | 3 | A | B |
| D1 F3 | 34.23 | 3 | A | B |
| D1 F1 | 35.77 | 3 | A | B |
| D1 F2 | 39.73 | 3 | | B |

Different letters indicate significant differences ($p \leq 0.05$).



Number of pods per plant, in the evaluation of the effect of sowing distances and nitrogen fertilization on the yield of *Arachis hypogaea L.*

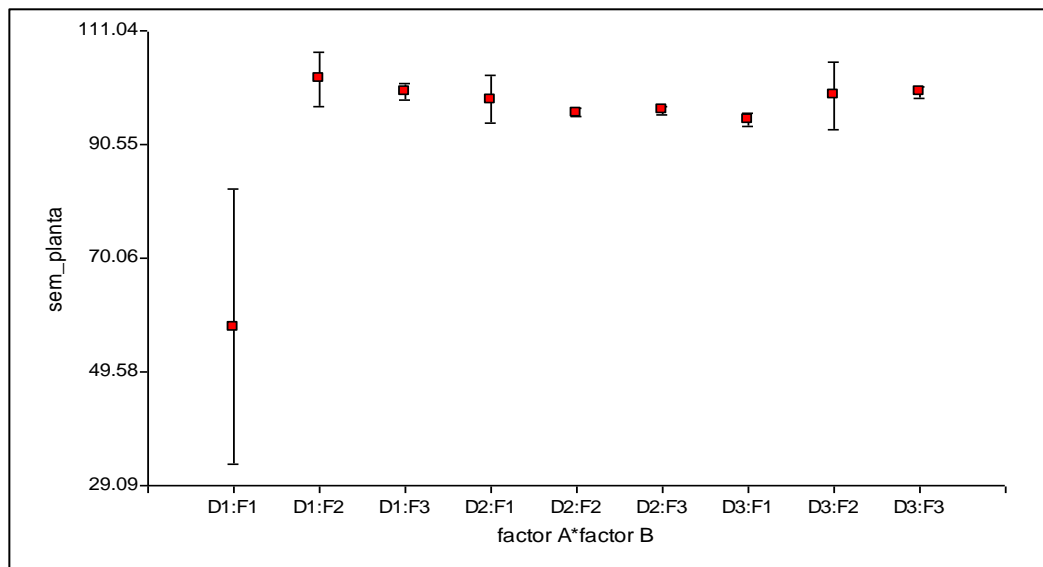
Seeds per plant

The ANAVA of seeds per plant indicates that there are no significant differences between the factors evaluated. Tukey's test at 95%, shows three ranges of significance: in the first is D1F1 (57.67); in the second range is D3F1 (95.00), D2F2 (96.33), D2F3 (96.67), D2F1 (98.67), D3F2 (99.33), D3F3 and D1F3 (100.00); and finally, in the third range is D1F2 (102.33) (Table 3).

Table 3. Tukey test at 95% for seeds per plant, in the evaluation of the effect of planting distances and nitrogen fertilization on yield of *Arachis hypogaea* L.

| <u>density</u> | <u>Means</u> | <u>n</u> | | |
|-------------------------|---------------|----------|---|----------|
| D1 | 86.67 | 9 | A | |
| D2 | 97.22 | 9 | A | |
| D3 | 98.11 | 9 | A | |
| fertilization | | | | |
| F1 | 83.78 | 9 | A | |
| F3 | 98.89 | 9 | A | |
| F2 | 99.33 | 9 | A | |
| density x fertilization | | | | |
| D1 F1 | 57.67 | 3 | A | |
| D3 F1 | 95.00 | 3 | A | B |
| D2 F2 | 96.33 | 3 | A | B |
| D2 F3 | 96.67 | 3 | A | B |
| D2 F1 | 98.67 | 3 | A | B |
| D3 F2 | 99.33 | 3 | A | B |
| D3 F3 | 100.00 | 3 | A | B |
| D1 F3 | 100.00 | 3 | A | B |
| <u>D1 F2</u> | <u>102.33</u> | <u>3</u> | | <u>B</u> |

Different letters indicate significant differences ($p \leq 0.05$).



Seeds per plant, in the evaluation of the effect of sowing distances and nitrogen fertilization on the yield of *Arachis hypogaea L.*

Weight of 100 seeds (gr)

The ANAVA for 100-seed weight showed statistical differences for the density factor. Tukey's test at 95% shows three ranges of significance: in the first is D2 (97.22), in the second D3 (98.11) and the highest value is obtained with D1 (104.44) (Table 4).

Table 4. Tukey test at 95% for the weight of 100 seeds (g), in the evaluation of the effect of sowing distances and nitrogen fertilization on the yield of *Arachis hypogaea L.*

density Means n

| | | | | |
|----|--------|---|---|---|
| D2 | 97.22 | 9 | A | |
| D3 | 98.11 | 9 | A | B |
| D1 | 104.44 | 9 | | B |

fertilization

| | | | |
|----|--------|---|---|
| F3 | 98.89 | 9 | A |
| F2 | 99.33 | 9 | A |
| F1 | 101.56 | 9 | A |

density x fertilization

| | | | |
|-------|--------|---|---|
| D3 F1 | 95.00 | 3 | A |
| D2 F2 | 96.33 | 3 | A |
| D2 F3 | 96.67 | 3 | A |
| D2 F1 | 98.67 | 3 | A |
| D3 F2 | 99.33 | 3 | A |
| D3 F3 | 100.00 | 3 | A |
| D1 F3 | 100.00 | 3 | A |
| D1 F2 | 102.33 | 3 | A |
| D1 F1 | 111.00 | 3 | A |

Different letters indicate significant differences ($p \leq 0.05$).

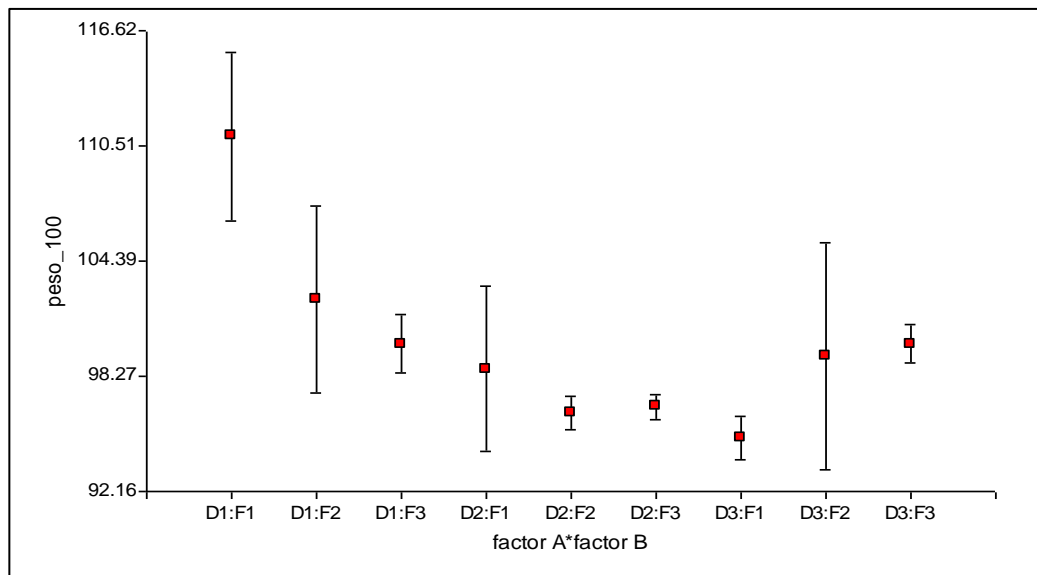


Figure 4. 100-seed weight (g), in the evaluation of the effect of sowing distances and nitrogen fertilization on the yield of *Arachis hypogaea* L.

Yield (kg ha⁻¹)

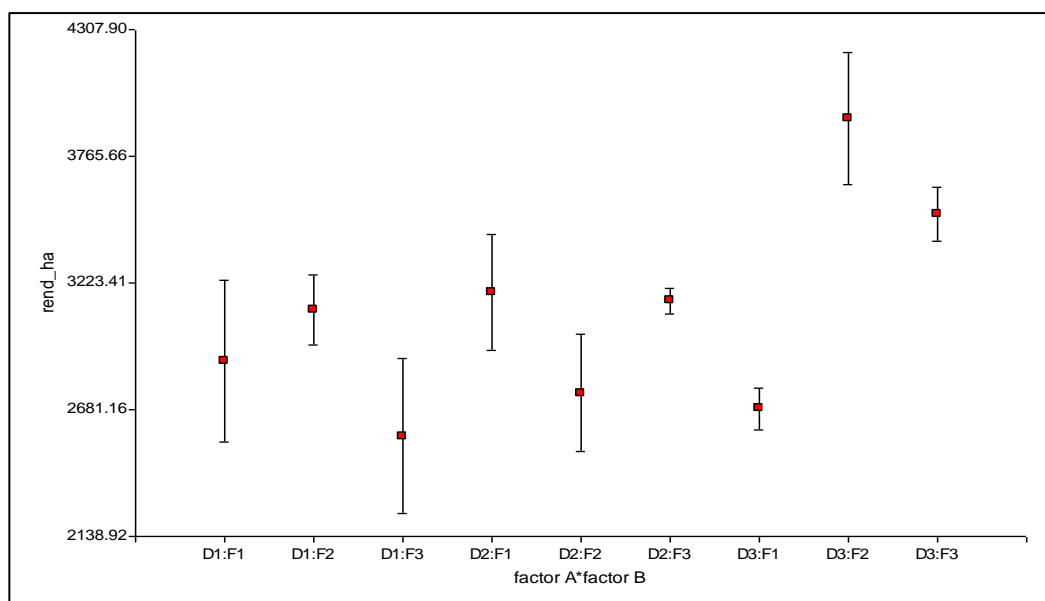
The ANAVA for yield per hectare shows significant differences between the sowing distances factor and for the interaction sowing distances by fertilization levels. The Tukey test at 95%, for the sowing distances factor shows three ranges of significance; in the first is D1

(2855.58), in the second D2 (3027.64) and finally D3 (3377.33). In the interaction of the DxF factors, three ranges of significance are observed; in the first is D1F3 (2567.63), D3F1 (2685.58) and D2F2 (2753.25); in the second range D1F1 (2890.63), D1F2 (3108.48), D2F3 (3146.89), D2F1 (3182.78), D3F3 (3518.37) and the third range, D3F2 (3928.05) (Table 5).

Table 5. Tukey test at 95% for yield (kg ha^{-1}), in the evaluation of the effect of sowing distances and nitrogen fertilization on the yield of *Arachis hypogaea L.*

| <u>distance</u> | <u>Means</u> | <u>n</u> | | |
|--------------------------------|--------------|----------|---|---|
| D1 | 2855.58 | 9 | A | |
| D2 | 3027.64 | 9 | A | B |
| D3 | 3377.33 | 9 | | B |
| <u>fertilization</u> | | | | |
| F1 | 2919.66 | 9 | A | |
| F3 | 3077.63 | 9 | A | |
| F2 | 3263.26 | 9 | A | |
| <u>density x fertilization</u> | | | | |
| D1 F3 | 2567.63 | 3 | A | |
| D3 F1 | 2685.58 | 3 | A | |
| D2 F2 | 2753.25 | 3 | A | |
| D1 F1 | 2890.63 | 3 | A | B |
| D1 F2 | 3108.48 | 3 | A | B |
| D2 F3 | 3146.89 | 3 | A | B |
| D2 F1 | 3182.78 | 3 | A | B |
| D3 F3 | 3518.37 | 3 | A | B |
| D3 F2 | 3928.05 | 3 | | B |

Different letters indicate significant differences ($p \leq 0.05$).



Yield (kg ha⁻¹), in the evaluation of the effect of sowing distances and nitrogen fertilization on the yield of *Arachis hypogaea* L.

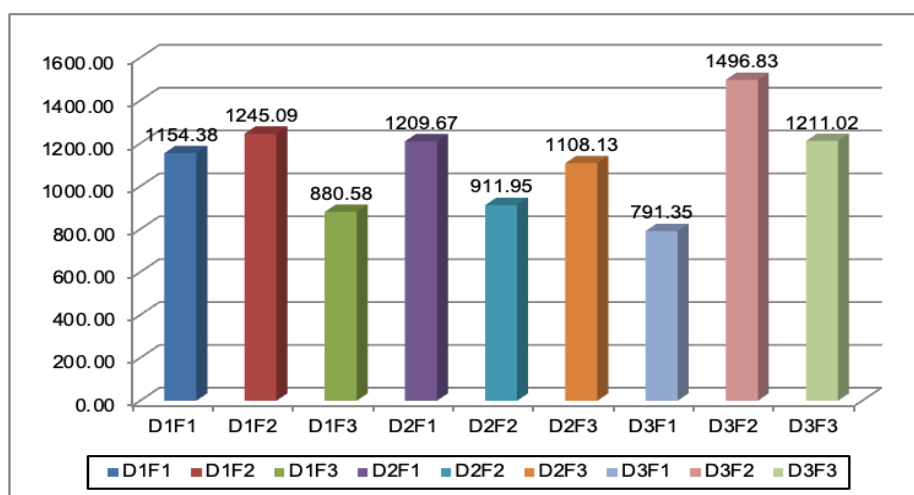
Economic analysis

Economic analysis for one hectare of the evaluated treatments indicates that the highest profit is obtained with D3F2 (1496.83), followed by D1F2 (1245.09), D3F3 (1211.02), D2F1 (1209.67), D1F1 (1154.38), D2F3 (1108.13), D2F2 (911.95), D1F3 (880.58), and finally, D3F1 (791.35). The highest Benefit/Cost ratio was obtained with D1F2 (3.01), followed by D1F1 (2.99), D3F2 (2.74), D2F1 (2.73), D2F3 (2.42), D3F3 (2.35), D1F3 (2.33), D2F2 (2.23), and finally D3F1 (1.97) (Table 7).

Table 6. Economic analysis, in the evaluation of the effect of sowing distances and nitrogen fertilization on the yield of *Arachis hypogaea* L.

| Treatments | Factors | Yield | Costs | Income | Profit | Rb/c |
|------------|---------|---------|--------|---------|---------|------|
| T1 | D1F1 | 2890.63 | 580.00 | 1734.38 | 1154.38 | 2.99 |
| T2 | D1F2 | 3108.48 | 620.00 | 1865.09 | 1245.09 | 3.01 |
| T3 | D1F3 | 2567.63 | 660.00 | 1540.58 | 880.58 | 2.33 |
| T4 | D2F1 | 3182.78 | 700.00 | 1909.67 | 1209.67 | 2.73 |
| T5 | D2F2 | 2753.24 | 740.00 | 1651.95 | 911.95 | 2.23 |
| T6 | D2F3 | 3146.89 | 780.00 | 1888.13 | 1108.13 | 2.42 |
| T7 | D3F1 | 2685.58 | 820.00 | 1611.35 | 791.35 | 1.97 |
| T8 | D3F2 | 3928.05 | 860.00 | 2356.83 | 1496.83 | 2.74 |
| T9 | D3F3 | 3518.37 | 900.00 | 2111.02 | 1211.02 | 2.35 |

Selling price = \$ 0.60 c/kg shell.



Economic analysis, in the evaluation of the effect of sowing distances and nitrogen fertilization on the yield of *Arachis hypogaea L.*

Plant height did not show significant differences after 40 days, with values between 21.77 and 28.73 cm; it is evident that the application of fertilizers (30 kg N ha^{-1}) did not increase plant growth by more than 5 cm, which coincides with Guamán and Andrade (2010), who point out that peanut only responds to the application of fertilizers in extremely poor soils. It should be mentioned that depending on the growth habit of the variety planted and the climatic and edaphic conditions, the results could vary.

The number of pods per plant obtained ranged between 24.40 and 39.73; the highest number of pods was obtained using D1 (60 cm between rows and 30 cm between sites), which is similar to the data reported by Guamán et al. (2010) who state that the average number of pods per plant is 14 to 28; coinciding with Gracia (2010) and Vélez (2011) who reported 28 and 38 pods per plant, respectively. D3 (45 cm between rows and 18 cm between sites), presented the lowest number of pods (24.40).

The number of seeds per plant is between 57.67 and 102.33, where it is observed that D1 (60 cm between rows and 30 cm between sites) stands out when nitrogen fertilizer is applied at doses of 30 and 60 kg ha^{-1} , coinciding with Vélez (2011) who obtained 78 grains, while Gracia (2010), reported an average of 47 grains. However, Guamán et al. (2010), characterizing agronomically the INIAP 382-Caramelo variety, estimated between 25 to 35 grains per plant.

The weight of 100 seeds was presented in a range of 95 gr to 111 gr, where D1 (60 cm between rows and 30 cm between sites) with applications and without application of nitrogen fertilizer stands out, clearly surpassing the value reported by Gracia (2010) with 87 gr, as well as Guamán et al. (2010), who point out that this parameter is between 50 to 60 gr; which differs with the statement of Pallo (2016). The evaluation of this variable, has as a particularity how key is an adequate planting distance so that the plant can take the necessary nutrients and develop its physiological processes normally, although in some agroecosystems populations of 200 000 plants per hectare are recommended (50 cm between rows and 20 cm, with two seeds per site) (Naab et al., 2009).

Yields per hectare ranged from 2567.63 kg to 3928.05 kg. It is observed that the highest yields are obtained with D3 (45 cm between rows and 18 cm between sites); followed by D2 (60 cm between rows and 30 cm between sites); surpassing that reported by Gracia (2010) with 1877.04 kg and coinciding with that recorded by Guamán et al. (2010) who reached yields with an average of 3348 kg ha^{-1} .

Furthermore, it is close to the yield achieved by Vélez (2011) with 4602.25 kg ha⁻¹. However, as stated by Garcés et al. (2015) and Pedelini (2012), stocking density can considerably increase yields per unit area.

The economic analysis considering a reference price of \$0.60/kg peanut in shell shows that the highest net profit is obtained with D3 (45 cm between rows and 18 cm between sites) applying 60 kg N ha⁻¹, followed by D1 (60 cm between rows and 30 cm between sites) with 30 kg N ha⁻¹, and very close D2 (50 cm between rows and 25 cm between sites) with 0 kg N ha⁻¹; However, the Benefit-Cost Ratio shows that it is more convenient, from this parameter D1 (60 cm between rows and 30 cm between sites) with 0, 30 and 60 kg N ha⁻¹, this could be explained by the effect of spacing (Augusto et al., 2010) and the high cost of fertilizers.

Conclusions

The most adequate population density according to the agronomic behavior and yield of the peanut variety INIAP-382 Caramelo, is 60 cm between rows and 30 cm between plants (two seeds per site). However, the distance of 45 cm between rows and 18 cm between plants (one seed per site) cannot be disregarded. The fertilization level that allows obtaining the best results in terms of agronomic performance and yield is 30 kg N ha⁻¹, this is evident in all planting distances used (45 cm x 18 cm; 50 cm x 25 cm; and 60 cm x 30 cm). The greatest utility from the economic point of view was achieved with the planting distance of 45 cm between rows and 18 cm between plants applying 30 kg N ha⁻¹; however, the best benefit/cost ratio was obtained with the distance of 60 cm between plants and 30 cm between rows with the application of 30 kg N ha⁻¹. Therefore, the application of nitrogen fertilizer and the adequate stocking density allows an increase of up to 20% in the economic income of the producers.

References

- Abad J. 2016. Influence of three sowing distances on the agronomic performance of three varieties of peanut (*Arachis hypogaea* L.) Graduate thesis. Guayaquil State University.
- Alvarado R. (2004). Effect of two levels of NPK and foliar fertilizer on the yield and quality of the peanut crop (*Arachis hypogaea* L.) in the Caserío Rama Blanca, Sipacate, La Gomera, Escuintla. Agricultural Engineer Thesis. Faculty of Environmental and Agricultural Sciences, Universidad Rafael Landívar.
- Augusto, J.; Brenneman, T.B.; Baldwin, J.A. and Smith, N.B. 2010. "Maximizing Economic Returns and Minimizing Stem Rot Incidence with Optimum Plant Stands of Peanut in Nicaragua", *Peanut Science*, vol. 37, no. 2, July 1, 2010, pp. 137-143, ISSN 0095-3679, DOI 10.3146/ PS09-016.1.
- Briones, N. 2021. Effect of population density on the productive behavior of two varieties of peanut (*Arachis hypogaea* L.) Balzar, Guayas. Undergraduate degree work. Agrarian University of Ecuador. Guayas, Ecuador.
- Chavez, K. 2019. Fertilization with nitrogen and micronutrients in the peanut crop (*Arachis hypogaea* L.) variety INIAP-380, Santa Ana canton province of Manabi. Thesis. Universidad Laica Eloy Alfaro de Manabí.
- Chávez E. 2007. Interaction foliar fertilizer - organic matter on the yield and quality of peanut (*Arachis hypogaea* L., Fabaceae) in Rama Blanca, Sipacate, La Gomera, Escuintla. Agricultural Engineer Thesis. Faculty of Environmental and Agricultural Sciences, Universidad Rafael Landívar.
- Dávila, A. 2021. Effect of five planting densities on peanut (*Arachis hypogaea* L.) crop yield. Degree thesis. Universidad Nacional Agraria de la Selva. Tingo Maria, Peru.
- da Silveira, P.S.; Peixoto, C.P.; Ledo, C.A. da S.; Passos, A.R.; Borges, V.P. and Bloisi, L.F.M. 2013. "Fenologia e produtividade do amendoim em diferentes épocas de semeadura no recôncavo sul baiano = Phenology and yield of peanut in different sowing seasons in southern bahia recôncavo", *Bioscience Journal*, vol. 29, no. 3, June 4, 2013, ISSN 1981-3163, [Accessed: 4 April 2015], Available at: <<http://www.seer.ufu.br/index.php/biosciencejournal/article/view/13437>>.

- Fundora, Z.; Marrero, Virginia; Sánchez, M.; Carrión, Miriam; Cañet, F.; Hernández, E.; Pozo, J.L.; Hernández Mercedes, Ortega, J.; Fresneda J. and Avilés R. 2001. Abbreviated Technical Instructions for Peanuts. Ministry of Agriculture, Cuba.
- García, C. 2016. Agronomic behavior of peanut varieties INIAP 382 and INIAP, with four planting densities in the Babahoyo area. Undergraduate degree thesis. Technical University of Babahoyo. Los Ríos, Ecuador.
- Guamán R. Andrade C. 2010. INIAP 382 - Caramelo, Runner type peanut variety for semi-dry areas of Ecuador. Boletín Divulgativo No. 380. Guayaquil. INIAP (8p).
- Garcés-Fiallos, F.R.; Guamán, R.E. and Díaz-Coronel, T.M. 2011. "Intensity of *Cercospora arachidicola* and *Pseudomonas spp.* and yield of peanut materials in the central zone of the Ecuadorian Litoral", *Tropical Plant Pathology*, vol. 36, no. supplement, 2011, p. 679, ISSN 1982-5676.
- Gracia T. 2010. Agronomic adaptation and yield of 13 peanut (*Arachis hypogaea L.*) cultivars at the "Mútilo" Experimental Station of the Technical University "Luis Vargas Torres".
- Ibáñez Jácome, S. S. S., Alcívar Soria, E. E., Cedeño Alcívar, L. L., & Caicedo Aldaz, J. C. (2018). Evaluation of the agronomic performance of 15 peanut lines of the Valencia group (*Arachis Hypogaea L.*). *Digital Science*, 2(1), 263-282. <https://doi.org/10.33262/cienciadigital.v2i1.18>
- Martínez, C.; (2007). Characterization of the agromorphological variability of peanut (*Arachis hypogaea L.*) cultivars, in the eastern region of Guatemala. University of San Carlos de Guatemala. Faculty of Agronomy. Institute of Agronomic Research. Graduation thesis.
- Mora, R., Rodriguez, D., Ramirez, J., Calderon, J., Salinas, T., Michay, G., ... Espinoza, P. (2019). Impact of organic fertilization on the yield of *Arachis hypogaea L.* crop in Orianga, Loja province, Ecuador. *Bosques Latitud Cero*, 9(1), 69-82. Retrieved from <https://revistas.unl.edu.ec/index.php/bosques/article/view/588>
- Naab, J.B.; Boote, K.J.; Prasad, P.V.V.; Seini, S.S. and Jones, J.W. 2009. "Influence of fungicide and sowing density on the growth and yield of two groundnut cultivars", *The Journal of*

Agricultural Science, vol. 147, no. 02, April 2009, pp. 179-191, ISSN 1469-5146, DOI 10.1017/ S0021859608008290.

Pallo, R. 2021. Agronomic response of two peanut (*Arachis hypogaea* L.) varieties to three planting frames in the Mocache area. Degree thesis. Quevedo State Technical University. Los Ríos, Ecuador.

Pedelini R. 2012. Practical guide for peanut cultivation. INTA General Cabrera. Agricultural Experimental Station Manfredi. Boletín de Divulgación Técnica N 2. Second Edition. 2-3 pp.

Vélez S. 2011. Agronomic evaluation of three varieties of peanut (*Arachis hypogaea* L.) with different population in the Quevedo area. Thesis. State Technical University of Quevedo. Quevedo, Ecuador.

Zapata, N.; Vargas, M. and Vera, F. Growth and productivity of two peanut (*Arachis hypogaea* L.) genotypes according to population density established in Ñuble, Chile, *Idesia (Arica)*, vol. 30, no. 3, December 2012, pp. 47-54, ISSN 0718-3429, DOI 10.4067/ S0718-34292012000300006.