Fertilization of peanut (*Arachis hypogaea* L.): effects on production and economic profitability in the context of Orinda, Rosales, Chihuahua

Fertilización del cacahuate (*Arachis hypogaea* L.): efectos enla producción y rentabilidad económica en el contexto de Orinda, Rosales, Chihuahua

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DOI: 10.35429/EJROP.2023.16.9.15.21 Received January 15, 2023; Accepted June 30, 2023

Abstract

The peanut (*Arachis hypogaea* L.) is considered a nutritious food due to its nutritional value and is renowned as the most globally recognized snack. Chihuahua is one of the primary cultivating states of this crop in Mexico. In an effort to achieve global food security, agriculture developed and implemented new production practices to ensure increased productivity and food supply. However, finding a way to provide nutrients to peanut cultivation in an environmentally sustainable manner is crucial for the development of agricultural production in the region. The objective of this research was to determine the economic feasibility of peanuts (Virginia) in four fertilization scenarios in the community of Orinda in the municipality of Rosales, to identify the fertilization method that offers the best cost-benefit ratio. Four complete blocks were randomly established, each with five treatments and four repetitions for each treatment. Measurements of the plant and its fruits were taken from the establishment of the crop (April) to the harvest (September). Subsequently, the SAS statistical package was employed to obtain results through analysis of variance and Tukey's mean comparison test. The findings indicated that the mixed fertilization scenario provided the best results in terms of peanut production and profitability.

Soil, Nutrition, Production, Yield, Morphometric variables

Resumen

El cacahuate (*Arachis hypogaea* L.) es considerado un alimento con gran valor nutricional y es la botana más conocida a nivel mundial. Chihuahua es uno de los principales estados productores de este cultivo en México. En un afán de lograr la seguridad alimentaria en el mundo, la agricultura desarrolló e implementó nuevas prácticas de producción que garantizaran una mayor productividad y abastecimiento de alimentos. Sin embargo, encontrar una forma de proporcionar nutrientes al cultivo de cacahuate de forma ambientalmente sostenible, será significativo en la manera que se desarrolla la producción agrícola en la región. El objetivo de esta investigación consistió en determinar la factibilidad económica del cacahuate (Virginia) en cuatro escenarios de fertilización en la comunidad de Orinda en el municipio de Rosales, para identificar el método de fertilización que presenta la mejor relación costo beneficio. Se establecieron cuatro bloques completos al azar, con cinco tratamientos y cuatro repeticiones para cada tratamiento. Se realizaron mediciones de la planta y sus frutos, desde el establecimiento del cultivo (abril) hasta la cosecha (septiembre). Posteriormente, se empleó el paquete estadístico SAS para la obtención de resultados mediante análisis de varianza y la prueba de comparación de medias de Tukey. Obteniendo que el escenario de fertilización mixta es el que brinda mejores resultados de producción y rentabilidad en el cultivo de cacahuate.

Suelo, Nutrición, Producción, Rendimiento, Variables morfométricas

Citation: ONTIVEROS-GÓMEZ Samantha, ONTIVEROS-GÓMEZ, Guadalupe, ORTEGA-MONTES, Fabiola Iveth and RASCÓN-SOLANO, Joel. Fertilization of peanut (*Arachis hypogaea* L.): effects on production and economic profitability in the context of Orinda, Rosales, Chihuahua. ECORFAN Journal-Republic of Paraguay. 2023. 9-16:15-21.

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Introduction

The peanut (*Arachis hypogaea* L.) belongs to the legume family and is native to South America (Pattee and Young, 1982), it is considered a good food, due to its nutritional value, it provides B vitamins, proteins and carbohydrates (Aparicio Fernández and Espinosa Alonso, 2015). In addition, peanuts are considered the world's most popular snack (Sánchez Ríos and Gutierrez López, 2019).

According to FAOSTAT (2023), considering only official figures, in 2021 there was a world production of 59.56 million tonnes of peanuts. In Mexico, according to the Ministry of Agriculture and Rural Development (2023), the agricultural closure in 2022, showed a volume of 86,165.09 tonnes of peanuts. The main producing states of this oilseed are: Chihuahua, Sinaloa, Chiapas and Puebla, with a group production of 62,365.10 tonnes, representing 72.38 % of national production. The Ministry of Agriculture and Rural Development (2023), indicates that the state of Chihuahua produced in 2022 a volume of 16,776.44 tonnes of peanuts, where the municipality of Rosales is the main producer in the Delicias district with 1,965.60 tonnes, representing 48.58 % of the district's production. This district is made up of the municipalities of Delicias, Rosales, Saucillo, Meoqui, Julimes, Camargo, La Cruz and San Francisco de Conchos.

To achieve food security in a rapidly growing population, agriculture evolved and moved into production practices that would guarantee greater productivity and food supply (Grasso and Díaz Sorita, 2020). However, even though great achievements have been made, there have also been negative effects in the process, with the excessive use of chemical fertilisers wreaking havoc on the environment (González Ulibarry, 2019). The decrease in crop yield per area is one of its main losses (Legaz Paredes and Primo Millo, 1988). Due to the above, it is important to have information on the use of chemical and organic fertilisers, as this information is currently lacking for the peanut crop and there is no updated fertilisation recommendation for the Delicias district.

The municipality of Rosales has been one of the main producers of peanuts in the Delicias district, where the community of Orinda contributes significantly to peanut production. In order to contribute with information for the decision making of the producers, it is essential to know the effects of chemical and organic fertilisation, as well as the adequate doses that improve the quality and yield of the production. In this sense, the objectives of this research are: 1) to identify the fertilisation scenario that generates the highest production in the peanut crop; 2) to quantify the costs for each fertilisation scenario for the peanut crop and 3) to determine the economic profitability for each fertilisation scenario.

Methodology to be developed

The experiment was established in the community of Orinda, municipality of Rosales, Chihuahua. In an ejido plot located in the coordinates 28° 26'91.24"N and 105°56'36.13"W.

The experimental design used was a randomised complete block design with four replications. The experimental unit was eight rows by ten metres, four rows were eliminated on each side and two metres at the beginning and two metres at the end to avoid the border effect. A useful plot of two rows by six metres was considered, so that the experimental plot had 8,000 plants and the useful plot had 400 plants.

Agronomic management

Sowing was carried out on 17 April 2023 under rainfed conditions with five auxiliary irrigations. The fertilization doses used for treatment I (TT1) was 40-60-00 of N-P-K, for treatment II (TT2) 40-60-00-10s of N-P-K (plus ammonium sulphate, sulphur), for treatment III (TT3) was 40-60-00 with 50% chemical and 50% organic application and for treatment IV (TT4) it was 40-60-00 covered 100% organically, all in a single application at the time of sowing. Treatment V (TT5) did not undergo any manipulation (control). The weed control used was Trifluralin® in pre-emergence and Diler120® in post-emergence, both at a dose of 1 L ha^{-1}. Pest control (whitefly) was carried out with the insecticide Citlalli 350 F® at a dose of 1 L ha^{-1} and disease control with the fungicide (cercospora) Cymoxanil® 1 Kg $ha^{-1.}$

Article ECORFAN Journal-Republic of Paraguay
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Variables evaluated

The morphometric variables measured were plant height (cm) from stem base to tip, plant cover (cm) from north to south and east to west (average), fresh and dry pod weight (gr), peanut moisture percentage, number of peanuts (in four m), kilograms of peanuts per ha, fresh and dry foliage weight (gr), foliage moisture percentage and kilograms of forage per ha. The financial variable that was calculated was the rate of return (ROI) and beneficial cost BC.

Benefit-cost analysis

Once the best evaluated treatment was determined, a cost-benefit analysis was carried out. To achieve this analysis, the simplest formula was used, i.e. the b/c ratio was calculated, where b represents the benefit and c the cost. The benefit is determined as a percentage and its interpretation is: if the result is greater than 1, it is acceptable or profitable; if the result is equal to 1, there is no profit or loss; and if the result is less than 1, it is not profitable, so the treatment or project is rejected. Its formula:

$$\text{Benefit Cost } = \left(\frac{\text{Beneficio neto}}{\text{Costo neto}}\right) \times \ 100$$

Results

Table 1 shows the mean squares of the analysis of variance for the 11 variables measured for the peanut crop. Showing that there is significance in each of them.

Source	DF	MC	Fvalor	Pr > F
Fresh weight	4	107116.5	17.62	**
Dry weight	4	69649.7	24.16	**
Peanut moisture %	4	7.75027	65.7	**
Number of peanuts	4	10373.675	22.19	**
Plant height	4	4.41675	6.25	**
Plant width	4	69.5475	13.15	**
Peanut kilograms	4	680172.852	24.16	**
Fresh foliage weight	4	198618.8	13.82	**
Dry foliage weight	4	25734.2	21.45	**
Foliage moisture %	4	1.3089325	25.23	**
Fodder kilograms	4	251310.547	21.45	**

DF: degrees of freedom, MC: mean squares, Pr: probability value.
**: $P \leq 0.01$.

Table 1 Mean squares of the analysis of variance of the 11 measurement variables.

Peanut production

According to Tukey's test, for the variable kilograms per ha, treatments TT3 and TT2 do not show significant differences between them (figure 1), as they share the same group (group A). Treatments TT1 and TT4 do not differ significantly from each other, as they are both grouped together in group B. TT5 differs from all treatments. The treatment with the highest yield of kilograms per ha of groundnut with 4,054.7 is TT3.

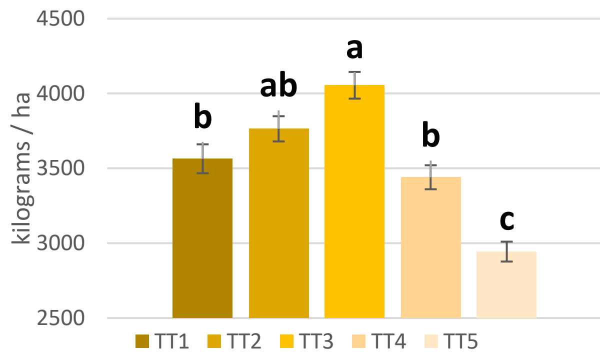

Figure 1 Kilograms of groundnut per hectare with determination of significant differences.

Fertilisation costs

Table 2 shows the costs associated with the different activities and concepts related to the establishment, growth and development of the crop. The costs are broken down for the five types of fertilisation (TT1, TT2, TT3, TT4 and TT5). TT5 by its nature has the lowest cost and of the treatments with some type of fertilisation it is TT1 that has the lowest cost. The treatment with the highest cost is TT4.

	TREATMENT COSTS				
Activity or concept	**TT1**	**TT2**	**TT3**	**TT4**	**TT5**
LAND RENT	$ 20,000.00	$ 20,000.00	$ 20,000.00	$ 20,000.00	$ 20,000.00
LAND PREPARATION	7,800.00	7,800.00	7,800.00	7,800.00	7,800.00
SOWING	10,620.00	10,620.00	10,620.00	10,620.00	10,620.00
IRRIGATION	4,200.00	4,200.00	4,200.00	4,200.00	4,200.00
FERTILIZATION	1,784.68	2,607.28	6,932.34	11,595.00	0
WEED CONTROL	5,265.00	5,265.00	5,265.00	5,265.00	5,265.00
PEST CONTROL	900.00	900.00	900.00	900.00	900.00
DISEASE CONTROL	675.00	675.00	675.00	675.00	675.00
HARVEST	13,595.71	14,485.18	15,078.69	13,257.99	12,076.67
TOTAL COSTS	**$ 64,840.39**	**$ 66,552.46**	**$ 71,471.03**	**$ 74,312.99**	**$ 61,536.67**

Table 2 Summarised costs for the 5 fertilisation treatments
Source: Own elaboration

Each of these results represents the total cost associated with all activities and concepts for that particular type of fertilisation. The costs include land rental, land preparation, seeding, irrigation, fertilisation, weed control, pest control, disease control, harvesting and transport.

ISSN-On line: 2414-4827

It is important to note that these costs are based on the unit cost and quantity values specified in the table, and may vary according to geographical location, plot size, inputs used and other factors specific to agriculture. These costs are an estimate for each type of fertilisation based on the data provided in the table.

Economic profitability

Estimates were made of prices that may occur in normal harvesting season, the prices range between $19.00, $21.00 and $23.00 per kilogramme. Table 3 shows the quantities of peanuts per ha and the possible income with the estimated selling prices. It shows that the highest income would be obtained with TT3. Similarly, table 4 shows the number of bales per ha and their possible selling prices, which range between $80.00, $90.00 and $100.00 per bale. TT2 obtained the highest number of bales with 96.51, only three bales above TT2 with 93.49. Very similar production.

		Price for groundnuts		
Treatment	Quantity	$19.00	$21.00	$23.00
TT1	3,564.1	$ 67,717.90	$ 74,846.10	$ 81,974.30
TT2	3,764.1	$ 71,517.90	$ 79,046.10	$ 86,574.30
TT3	4,054.7	$ 77,039.30	$ 85,148.70	$ 93,258.10
TT4	3,440.6	$ 65,371.40	$ 72,252.60	$ 79,133.80
TT5	2,943.8	$ 55,932.20	$ 61,819.80	$ 67,707.40

Table 3 Estimated selling prices for groundnuts
Source: Own elaboration

		Price for groundnut bales		
Treatment	Quantity	$80.00	$90.00	$100.00
TT1	81.41	$6,512.80	$7,326.90	$8,141.00
TT2	96.51	$7,720.80	$8,685.90	$9,651.00
TT3	93.49	$7,479.20	$8,414.10	$9,349.00
TT4	79.64	$6,371.20	$7,167.60	$7,964.00
TT5	78.85	$6,308.00	$7,096.50	$7,885.00

Table 4 Estimated selling prices for groundnut bales.
Source: Own elaboration

The total revenue in table 5 is the sum of the revenue with a selling price of peanuts of $21.00 per kilogram and $90.00 per bale of peanut fodder. RelBCTT1 shows a CBR of 1.27, which means that for every unit spent, .27 units in revenue are earned. RelBCTT2 has the highest CBR with a value of 1.32 and only one tenth below is RelBCTT3 with a CBR of 1.31.

The latter has the highest groundnut yield which gives it preference over TT2. RelBCTT4 and RelBCTT5 have slightly lower values, with 1.07 and 1.12 respectively. Although these are positive results, they suggest that, compared to the other cases, the inputs are slightly higher than the outputs.

Treatment	Total revenues	Total costs	Rel B/C
TT1	$ 82,173.00	$ 64,840.39	1.27
TT2	$ 87,732.00	$ 66,552.46	1.32
TT3	$ 93,562.80	$ 71,471.03	1.31
TT4	$ 79,420.20	$ 74,312.99	1.07
TT5	$ 68,916.30	$ 61,536.67	1.12

Table 5 Cost-benefit ratio for each treatment.
Source: Own elaboration

Table 6 shows that TT1 and TT3 share a rate of return of 34%, while TT2 obtained 35%. This represents the highest value; TT4 and TT5 show a positive rate of return, but have the lowest ROI values in the comparison. TT3 producing a higher amount of peanuts than TT2 is considered the more viable option over TT2, as the difference in ROI is minimal.

Treatment	Total revenues	Total costs	ROI
TT1	$ 82,173.00	$ 64,840.39	34%
TT2	$ 87,732.00	$ 66,552.46	35%
TT3	$ 93,562.80	$ 71,471.03	34%
TT4	$ 79,420.20	$ 74,312.99	17%
TT5	$ 68,916.30	$ 61,536.67	20%

Table 6 Rate of return (ROI) for each treatment
Source: Own elaboration

Acknowledgements

The research was possible thanks to the support of the Ontiveros Gómez family, who provided agricultural space, Dr. Sergio Guerrero Morales, retired research professor, who provided organic fertiliser and advice, as well as the Faculty of Agricultural and Forestry Sciences of the Autonomous University of Chihuahua, for carrying out the experiment.

Funding

This work has been funded by the Ontiveros Gómez family, Dr. Sergio Guerrero Morales and by the CONAHCYT grant.

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