Colegio de Postgraduados

Socio-productive characterization of peanut (*Arachis hypogaea* L.) producers in Chiapas, Mexico

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ABSTRACT

Objective: To characterize the production conditions, main constraints and willingness of small-scale peanut producers in Mérida, Cintalapa, Chiapas, regarding the potential utilization of peanut shells as a by-product.

Design/methodology/approach: A quantitative, non-experimental, cross-sectional study with descriptive and exploratory aims was conducted. Data were collected using a local census approach, including all active peanut producers identified in the community (n=14). Structured surveys were used to gather information, which was analyzed using descriptive statistics, Spearman's rank correlation, the Mann-Whitney U test and Fisher's exact test.

Results: Producers operated on a small scale, with a predominance of family-based learning and self-saved seed use. Drought, pests, and economic problems were the main constraints affecting the system. The cultivated area and farming experience were positively associated with production but negatively associated with yield. This indicates that production depends more on expanding the cultivated area than improving efficiency within it. Although most producers expressed an interest in marketing peanut shells, collective organization remained limited.

Research limitations/implications: The study focused on the 14 producers who make up the local peanut-producing population in the Mérida community. Despite its local scope, the findings provide valuable empirical evidence for understanding the conditions, constraints, and organizational restrictions of small-scale farming.

Findings/conclusions: Peanut production in Mérida is sustained by small-scale units characterised by family-based learning and the predominant use of self-saved seeds. Under this production logic, production volume depends more on expanding the area than improving yield. The system's efficiency and the potential for using peanut shells as a by-product are limited by the identified constraints in production and organization.

Keywords: family farming; crop yield; productive organization; by-product valorization; Chiapas.

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INTRODUCTION

Peanut (*Arachis hypogaea* L.) cultivation constitutes a substantial component of Mexico's agricultural sector, encompassing both commercial and subsistence farming

methodologies. The nation cultivates peanuts across roughly 47,500 hectares, generating over 70,000 tonnes, with an average yield of approximately 1.75 tonnes per hectare (SIAP, 2024). This underscores the crop's significance within diverse agricultural contexts. In Chiapas, peanuts continue to be a vital agricultural commodity in numerous locales, serving as a critical income source for rural agriculturalists.

Cintalapa de Figueroa is one such municipality where peanut production is integral to local economic strategies (SIAP, 2024; Estudillo Pérez, 2021).

In small-scale farming contexts, peanut cultivation is an economic activity sustained by local knowledge, family-based learning, and inherited management strategies. In this region, peanuts are mainly cultivated by family farming units as part of broader crop diversification and peasant household reproduction arrangements, often alongside other regionally important crops such as maize.

Conversely, peanut cultivation is subject to a range of limitations, encompassing drought conditions, pest infestations, inadequate resource availability, inefficiencies in post-harvest handling, and a lack of cohesive organizational structures. These challenges can impede the efficacy of the crop and restrict opportunities for diversification and value enhancement within production entities (Liverpool-Tasie *et al.*, 2020; Fierros & Ávila-Foucat, 2017; Mouratiadou *et al.*, 2024).

Beyond the edible part of the peanut plant, its cultivation produces by-products, particularly peanut shells, whose potential uses have been somewhat overlooked locally. Recent studies indicate that these materials have practical and technological applications in fields such as manufacturing, environmental protection, and agriculture (Capanoglu *et al.*, 2022).

Peanut shells have been proposed for various applications, including the creation of biochar to improve soil, the production of adsorbent materials, and other uses that are beneficial in terms of productivity, the environment, or agro-industry (Liu *et al.*, 2019; Toledo-Jaldin *et al.*, 2023; Gerber & Roberts, 2024; Sawargaonkar *et al.*, 2024).

These alternatives suggest that peanut shells could be seen as more than just agricultural waste, but also as by-products with potential for value creation.

Despite the productive relevance of peanut cultivation and the potential uses reported for peanut shells, local empirical evidence remains limited regarding the conditions under which small-scale producers operate, the constraints affecting their production systems, and the organizational context that could support the use of this by-product. In small-scale rural territories, the potential use of peanut shells depends not only on the availability of technical alternatives but also on production conditions, producers' knowledge, management practices, and organizational capacity. Therefore, before proposing strategies for the valorization of peanut shells, it is necessary to understand the production context, the main constraints faced by farmers, and their willingness to consider possible uses for this by-product.

Therefore, this study aimed to describe the production methods, main challenges, and willingness of small-scale peanut farmers in Mérida, Cintalapa de Figueroa, Chiapas, to use peanut shells.

MATERIALS AND METHODS

Study design

The study adopted a quantitative, non-experimental, cross-sectional design with descriptive and exploratory objectives. Nonparametric bivariate analyses were employed to identify correlations among productive, technical and organizational variables. The study also had an applied focus, seeking to generate empirical evidence on peanut production conditions and the willingness of small-scale family farmers to use peanut shells. The analysis was based on information obtained directly from active producers in the community via a census survey conducted once during the 2023-24 agricultural cycle.

Study area and study population

The study was conducted in the community of Mérida in the municipality of Cintalapa in the state of Chiapas in Mexico (see Figure 1). This rural area is characterized by peanut cultivation, which is an important activity for small-scale producers, primarily under traditional management schemes and on relatively small plots. The area's agroecological and socioeconomic conditions make it pertinent to analyze production constraints, management practices, and the potential use of agricultural by-products.

The reference population consisted of all active peanut producers identified in the community during the study period. A total of 14 producers were recorded; therefore, data collection covered the entire available study population.

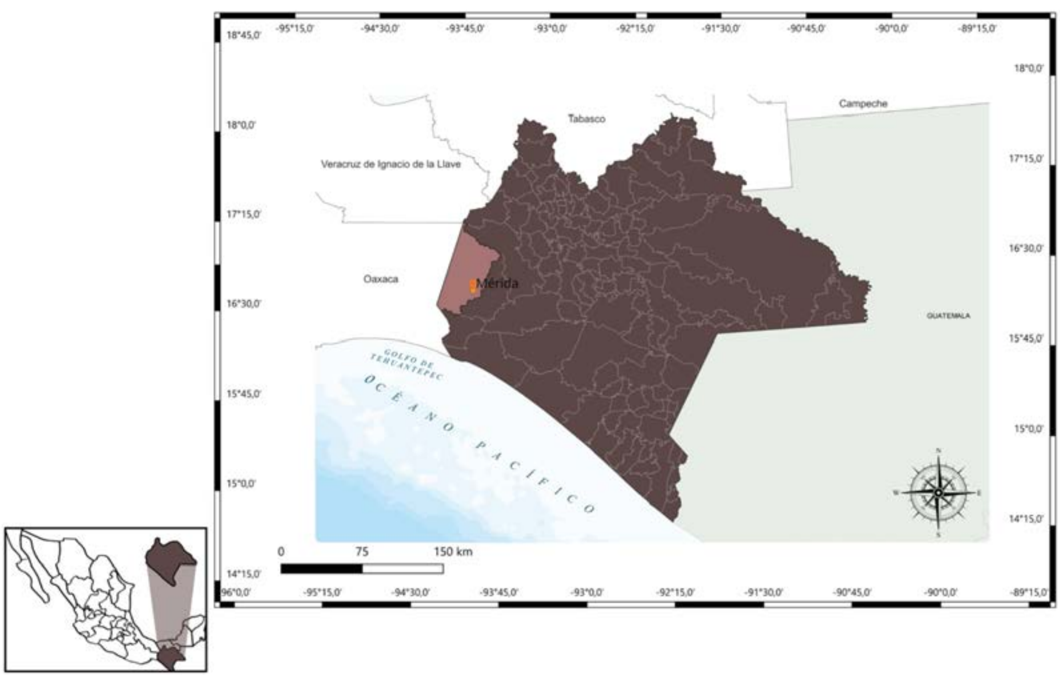

Figure 1. Location of Mérida community, Cintalapa municipality, Chiapas, Mexico. Source: Elaborated by the authors based on INEGI (2024).

Variables, survey instrument, and data collection

Information was obtained through a structured survey administered directly to the producers. The instrument included questions on productive characteristics, management practices, system constraints, and aspects associated with knowledge and the potential use of peanut shells. Responses were subsequently organized into a producer-level data matrix. Variables were grouped into four dimensions: productive, technical and management, system constraints, and organizational and utilization-related (Table 1). This organization made it possible to structure the analysis consistently with the study objective and to facilitate interpretation of the results.

The productive dimension included farming experience, expressed in years; cultivated area (ha); production (t); and yield, calculated as the ratio between production and cultivated area (t ha^{-1}). The technical and management dimension comprised variables associated with the use of organic fertilizer, pesticide use, fertilizer use, product grading, training, and type of storage. The system constraints dimension included the presence of pests, drought, economic problems, labor shortage, and a derived variable termed total number of problems, obtained by summing the main reported constraints. Finally, the organizational and utilization-related dimension included variables related to the source of learning, seed source, satisfaction with the activity, nutritional knowledge of the crop, knowledge of peanut shell uses, interest in marketing peanut shells, and attempts to form a cooperative.

To facilitate the analysis and reduce category dispersion in a small dataset, some categorical variables were recoded into more synthetic groups. Learning sources were grouped into two categories: family-based and non-family-based. Nutritional knowledge was reorganized into low and high knowledge. Satisfaction was grouped into low and high. Storage was regrouped into warehouse and household storage. These recodings allowed for clearer description and more consistent analytical organization.

Data were collected through direct contact with producers during the study period, and the information was reviewed and cleaned before statistical analysis. The final data matrix consisted of 14 observations and the variables selected for the study.

Table 1. Analytical dimensions and variables.

Dimension	Variables
Productive	Farming experience, cultivated area, production, and yield
Technical and management	Use of organic fertilizer, pesticide use, fertilizer use, product grading, training, and storage
System constraints	Presence of pests, drought, economic problems, labor shortage, and total number of problems
Organizational and utilization-related	Learning source, seed source, satisfaction, nutritional knowledge, knowledge of peanut shell uses, interest in marketing peanut shells, and cooperative attempt

Note. The productive dimension included continuous quantitative variables; in the remaining dimensions, dichotomous categorical variables predominated. Learning source, nutritional knowledge, satisfaction, and storage were recoded into synthetic groups.

Statistical analysis

Descriptive statistics were calculated for quantitative variables using measures of central tendency and dispersion, whereas absolute frequencies and percentages were obtained for categorical and binary variables. These analyses were used to characterize the producers' productive, technical, and organizational profile.

Associations among quantitative variables were explored using Spearman's rank correlation coefficient, which is appropriate for small samples and for data that do not require strict normality assumptions (Conover, 1999). The relationships examined included cultivated area with production, cultivated area with yield, farming experience with production, farming experience with yield, and total number of problems with yield.

To compare yield between two groups defined by dichotomous management practices, the Mann-Whitney U test was used, given the small sample size and the nonparametric nature of the data. For each comparison, the number of observations per group (n), median yield, the U statistic, and the significance level (p) were reported (Conover, 1999).

The associations between binary categorical variables were assessed using Fisher's exact test, which is appropriate for contingency tables with small samples and low expected frequencies (Agresti, 2002). Specifically, the association between pest presence and pesticide use was analyzed. Other variables related to peanut shell utilization and productive organization were analyzed descriptively because of the marked imbalance in response distribution.

RESULTS AND DISCUSSION

Productive profile of farmers

Peanut producers in the community of Mérida had an average of 24.64 years of farming experience, with a median of 21.00 years and a range from 5.00 to 60.00 years, reflecting the coexistence of both relatively recent and long-established farming experience among producers (Table 2).

These results indicate that peanut cultivation is part of a locally rooted productive tradition, although the degree of accumulated experience varies among farmers. Cultivated area had a mean of 1.76 ha and a median of 1.65 ha, with values ranging from 1.00 to 3.40 ha, confirming that the system operates through small-scale production units. Consistent with this, average production was 1.70 t per farmer, with a median of 1.66 t and a range

Table 2. Descriptive statistics for quantitative variables recorded in peanut farmers from Mérida, Cintalapa, Chiapas, Mexico.

Variable	Mean	Median	Standard deviation	Min-max
Farming experience (years)	24.64	21.00	15.79	5.00-60.00
Cultivated area (ha)	1.76	1.65	0.64	1.00-3.40
Production (t)	1.70	1.66	0.37	1.10-2.33
Yield (t ha^{-1})	1.00	1.03	0.13	0.69-1.18
Total number of problems	2.29	2.00	0.91	1.00-4.00

Min-max = minimum-maximum.

of 1.10 to 2.33 t, indicating a limited productive base consistent with peasant farming schemes.

Average yield was 1.00 t ha^{-1}, with a median of 1.03 t ha^{-1} and relatively limited variation among farmers (0.69-1.18 t ha^{-1}), indicating that, despite differences in experience and plot size, performance per unit area remained within a relatively homogeneous range. Finally, the total number of problems had a mean of 2.29 and a median of 2.00, with values ranging from 1.00 to 4.00, showing that farmers face recurrent constraints, although with variable intensity.

Socio-productive, organizational, and knowledge-related characteristics

From a socio-productive perspective, learning of the farming activity showed a clear predominance of the family component, as 78.6% of the farmers reported having acquired this knowledge within the household, whereas 21.4% reported a non-family source of learning. Consistent with this pattern, 92.9% used self-saved seed, evidencing marked autonomy in seed supply and low dependence on external sources (Table 3).

This pattern is consistent with what has been documented for other peasant farming systems in the Frailesca region, where productive reproduction relies on the family-based management of knowledge and the persistence of local materials. It is also consistent with findings on informal seed systems among small-scale producers, in which the selection, conservation, and use of self-saved seed form part of a management logic grounded in local experience (Hlatshwayo *et al.*, 2021).

In contrast, nutritional knowledge of the crop was predominantly low, as 78.6% of the farmers fell into this category, indicating that the productive relevance of peanut does not

Table 3. Frequencies and percentages of socio-productive, organizational, and knowledge-related variables in peanut farmers.

Variable	Category	sample (n)	Value (%)
Learning source	Family-based	11	78.6
	Non-family-based	3	21.4
Seed source	Self-saved	13	92.9
	Purchased	1	7.1
Nutritional knowledge	Low	11	78.6
	High	3	21.4
Satisfaction with the activity	High	12	85.7
	Low	2	14.3
Storage	Household	7	50.0
	Warehouse	7	50.0
Knowledge of peanut shell uses	Yes	11	78.6
	No	3	21.4
Interest in marketing peanut shells	Yes	13	92.9
	No	1	7.1
Attempt to form a cooperative	Yes	1	7.1
	No	13	92.9

necessarily translate into broad appropriation of its food-related attributes or its valorization potential. Likewise, 85.7% reported a high level of satisfaction with the activity, suggesting that, even in small-scale production units, the crop retains practical value and continuity within local productive experience.

Regarding postharvest conditions and by-product use, storage was evenly distributed between household storage and warehouse storage (50.0% in each case). In addition, 78.6% of the farmers reported knowledge of possible uses of peanut shells, and 92.9% expressed interest in marketing them. However, only 7.1% indicated having attempted to organize into a cooperative.

These results indicate a willingness to use the by-product, although this possibility rests on a limited organizational base, a situation consistent with what has been described in groundnut value chains, where weak articulation among producers constrains value addition and collective marketing (Posey *et al.*, 2024).

Management practices and production constraints

Beyond socio-productive and organizational traits, crop dynamics are also expressed through the management practices used and the constraints that farmers face during the production cycle. For this reason, a set of technical and constraint-related variables was examined to identify the main factors shaping the practical functioning of the peanut production system (Figure 2).

In terms of management, pesticide use was the most frequent practice, reported by 78.6% of the farmers, followed by product grading and training, both at 64.3%. In contrast, the use of organic fertilizer (35.7%) and synthetic fertilizers (28.6%) was less common. This pattern suggests a management approach oriented more toward phytosanitary control and activities related to product conditioning or commercial improvement than toward strengthening the nutritional status of the crop.

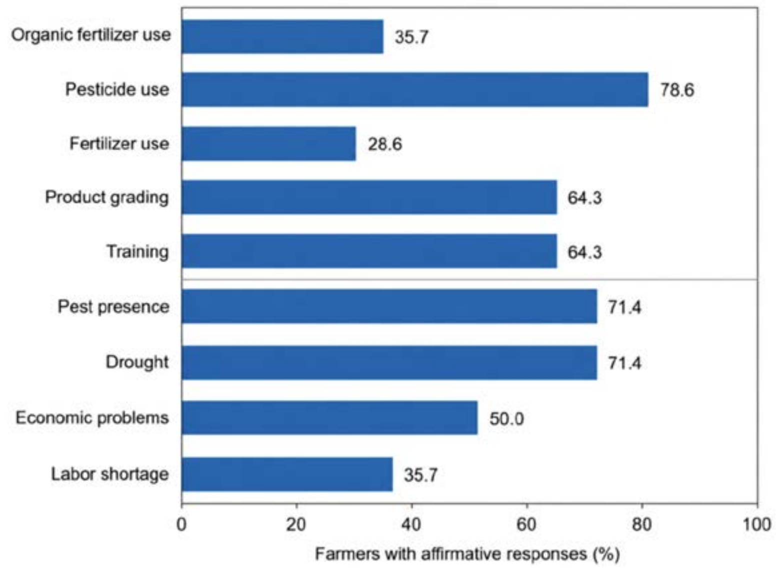

Figure 2. Technical variables and production constraints for peanut farmers in Mérida, Cintalapa, Chiapas.

Regarding constraints, pest presence and drought emerged as the main problems, both reported by 71.4% of the farmers. These were followed by economic problems, mentioned by 50.0%, and, to a lesser extent, labor shortage, reported by 35.7%. These results show that peanut production develops under both biophysical and socioeconomic pressures, in which water stress and phytosanitary problems constitute the main constraints affecting the system.

The prevalence of pests and drought, coupled with the limited use of both organic and synthetic fertilizers, aligns with findings concerning small-scale peanut production systems. High input costs, water scarcity, and phytosanitary issues are often identified as significant constraints on productivity (Sinare *et al.*, 2021; Gelaye *et al.*, 2024). Within this framework, the frequent application of pesticides in Mérida appears to prioritize the immediate resolution of phytosanitary concerns, as opposed to integrated crop management. This approach diverges from strategies that advocate for more comprehensive methods, such as integrated pest management and climate stress adaptation (Gelaye *et al.*, 2024).

In addition, the relatively high presence of product grading and training, together with the intermediate weight of economic problems and the lower incidence of labor shortage, suggests that the system faces not only agronomic constraints but also commercial, technical, and operational tensions. This pattern indicates that peanut management in the community is oriented more toward responding to immediate crop pressures than toward consolidating long-term, integrated strategies for nutrition, prevention, and productive strengthening.

Associations between structural variables and productive performance

Associations between cultivated area, farming experience, and problem pressure and the main productive indicators were explored (Table 4). Cultivated area was strongly and positively associated with production ($r_s=0.960$; $p<0.001$), but negatively associated with yield ($r_s=-0.796$; $p=0.001$). Farming experience showed the same pattern, with a positive association with production ($r_s=0.820$; $p<0.001$) and a negative association with yield ($r_s=-0.605$; $p=0.022$). In contrast, the total number of reported problems was not significantly associated with yield ($r_s=0.208$; $p=0.475$).

These results suggest that neither cultivated area nor accumulated farming experience, by themselves, guarantee better relative crop performance. This pattern suggests that some

Table 4. Association between structural variables, experience-related variables, and problem pressure variables and productive indicators.

Association evaluated	Spearman's rank correlation coefficient (r)	Significance level (p)
Cultivated area - Production	0.960	<0.001
Cultivated area - Yield	−0.796	0.001
Farming experience - Production	0.820	<0.001
Farming experience - Yield	−0.605	0.022
Total number of problems - Yield	0.208	0.475

farmers have responded to production constraints by expanding cultivated area rather than by improving productivity per unit area.

Accumulated farming experience does not appear to translate automatically into innovation or more effective practices. This observation aligns with existing research on peasant farming systems in the Frailesca region. These systems maintain productivity through intricate sociotechnical pathways. These pathways are influenced by constrained financial resources, the integration of local farming methods with elements of agricultural modernization, and the continued use of locally sourced or self-saved materials. This reflects the regional approach to sustaining production (Fonseca-Flores *et al.*, 2025).

The absence of a substantial correlation between the aggregate number of reported issues and yield further implies that the simple acknowledgment of limitations does not adequately account for productive output. Conversely, yield seems to be contingent upon a more intricate interplay of structural, technical, and contextual elements. In this sense, the observed pattern indicates that in Mérida, peanut farming operates on a small scale. Therefore, increases in total production depend more on expanding the area used for farming than on improving the number of peanuts produced per unit of land.

According to the 2024 SIAP municipal agricultural statistics, Cintalapa de Figueroa led Chiapas in both harvested area, with 2,061 hectares, and peanut production, yielding 3,544.92 tons. However, its average yield (1.72 t ha^{-1}) was lower than that recorded in municipalities with a smaller production scale, such as Frontera Comalapa (2.88 t ha^{-1}), Chicomuselo (2.81 t ha^{-1}), and La Trinitaria (2.74 t ha^{-1}). This contrast suggests that the leading productive position of Cintalapa de Figueroa is supported mainly by the extent of cultivated area rather than by greater efficiency per unit area.

The results of the present study are consistent with this pattern. Cultivated area was positively associated with production but negatively associated with yield, indicating a logic of extensive rather than intensive growth. In the community analyzed, production is also sustained largely by family-based learning, the predominant use of self-saved seed, and inherited management practices, all within a context of weak organizational articulation and limited technical intensification. These elements suggest that the relatively low productivity seen in Cintalapa de Figueroa is not just a local issue, but rather a specific example of a larger trend in peanut farming throughout Chiapas.

From this perspective, peanut should not be understood as an isolated crop. Instead, it should be viewed as part of a regional strategy for diversifying production and adapting to changing conditions. This understanding aligns with existing research on other peasant agroecosystems in central Chiapas. In these systems, peanuts are part of rotation, association, and spatial distribution practices. These practices are determined by seasonal changes, local conditions, and the management choices of farming families (Pizaña Vidal *et al.*, 2026).

It also agrees with recent studies in the region that show differentiated forms of agroecosystem adaptation and management in response to temporality and unequal resource availability (Gómez-Padilla *et al.*, 2026).

This pattern may also be interpreted through the concept of the yield gap (Yg), which recognizes that observed field productivity is conditioned not only by crop potential, but also by biophysical, technical, and socioeconomic limitations (van Ittersum *et al.*, 2013). In small-scale peanut systems, constraints such as drought, pests, diseases, and high fertilizer costs limit productivity and shape adaptive responses under resource-restricted conditions (Sinare *et al.*, 2021). From a systemic perspective, this is consistent with a dynamic of limited relative efficiency and with an organizational base that remains too weak to support value-added uses of by-products and collective responses to system-level problems.

Yield differences according to management practices

Yield differences were also evaluated across groups of farmers according to specific management practices (Table 5).

The comparisons did not reveal significant yield differences associated with organic fertilizer use, training, or fertilizer use. Although some groups showed slight differences in median yield, these did not reach statistical significance, suggesting that, in the sample analyzed, the presence of these practices alone was not sufficient to explain variation in yield. This finding reinforces the idea that yield responds to a more complex interaction of structural, technical, and contextual factors.

Descriptively, although most farmers reported having received training, the non-use of inputs such as organic and synthetic fertilizers also predominated. This pattern suggests a gap between access to training and the effective adoption of management practices within the production system.

This does not imply that technical management lacks significance in peanut production; instead, the practices documented within the analyzed sample proved inadequate to account for yield disparities. Biological alternatives, including indigenous arbuscular mycorrhizal fungi and vermicompost leachate, have been shown to enhance yield and crop quality in field settings during peanut cultivation (Sánchez-Roque *et al.*, 2022). Consequently, the impact of management is contingent upon the specific practices employed and their effective incorporation into the overall system.

The results indicate that peanut production in Mérida, Cintalapa de Figueroa, is sustained by small-scale units in which family-based learning, inherited practices, and limited productive intensification converge. Although the crop retains local economic importance and producers expressed willingness to consider the potential use of peanut shells, weak organizational articulation and the production constraints identified limit the consolidation of value-added alternatives.

Table 5. Comparison of yield by management practices using the Mann-Whitney U test.

Grouping variable	Group	Farmers (n)	Median yield (t ha^{-1})	test statistic (U)	significance level (p)
Organic fertilizer use	Yes	5	1.03	25.0	0.79
	No	9	1.06		
Training	Yes	9	1.03	30.0	0.35
	No	5	1.07		
Fertilizer use	Yes	4	0.99	22.0	0.83
	No	10	1.03		

Accordingly, the prospects for by-product valorization depend not only on technical feasibility, but also on the socio-productive conditions under which the system currently operates. On this basis, future research should examine more closely the barriers to cooperative organization, the adoption of agroecological or management practices aimed at improving yield, and the local mechanisms that could support improvement processes consistent with the productive and ecological logic of the territory.

CONCLUSION

Peanut production in Mérida, Cintalapa de Figueroa, Chiapas, is sustained by small-scale farming units characterized by family-based learning, the predominant use of self-saved seed, and the continuity of local agricultural knowledge. Cultivated area and farming experience were positively associated with production but negatively associated with yield, indicating that output depends more on area expansion than on improvements in efficiency per unit area, which reflects an extensive production pattern. The productive and organizational constraints identified limit both collective action among farmers and the potential use of peanut shells as a value-added by-product. Under these conditions, the prospects for peanut shell valorization depend not only on its technical feasibility but also on the socio-productive context and local organizational capacity in which the system operates.

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