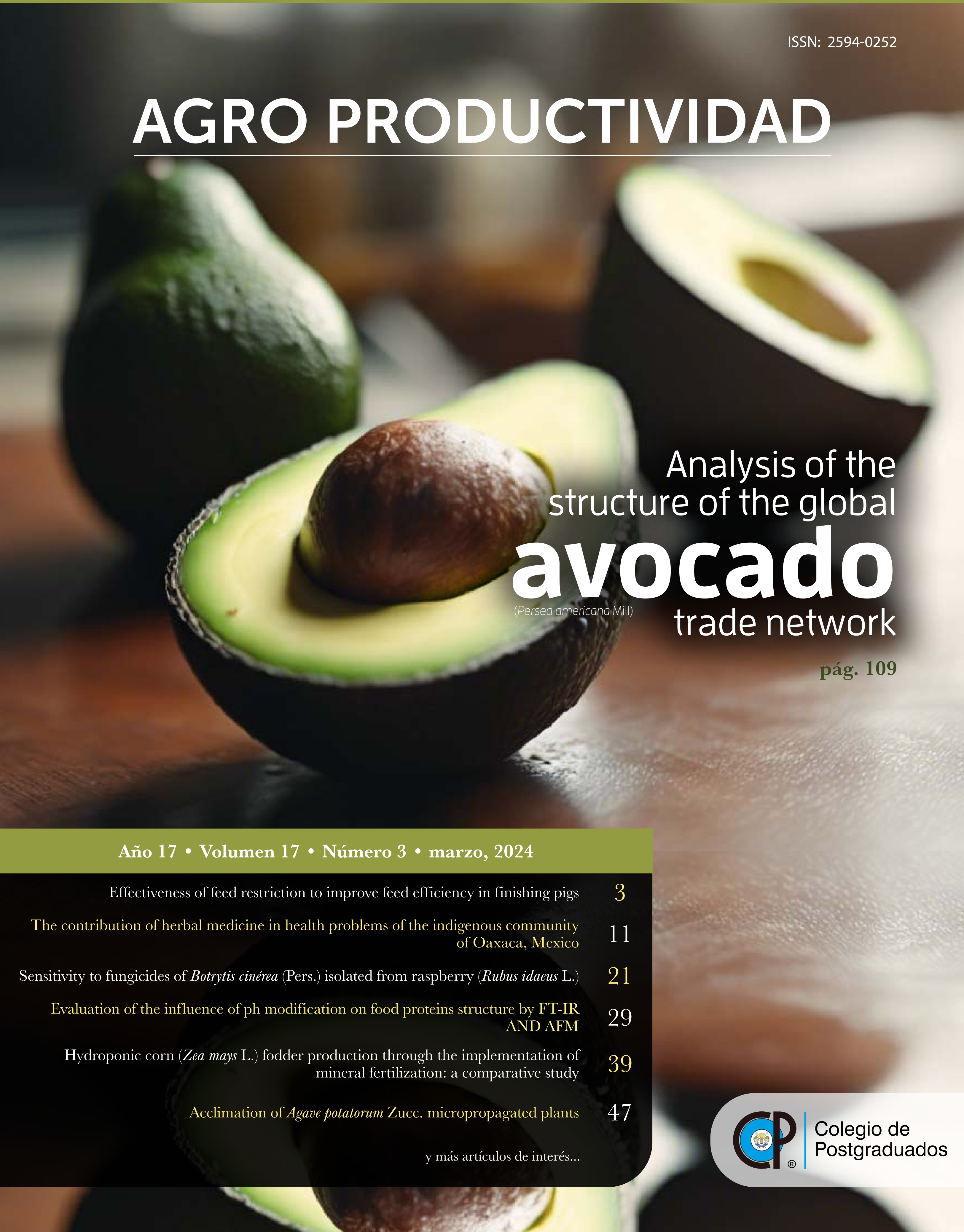

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# AGRO PRODUCTIVIDAD

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# Assessment of sustainability attributes of traditional and conventional maize cultivation in farmer agricultural systems

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**ABSTRACT**
**Objective**: To carry out a comparative analysis of the sustainability of traditional and conventional maize cultivation systems in Cuanacaxtitlán.
**Design/Methodology/Approach**: The proposal was implemented through a mixed method approach in which a qualitative research predominated. A sustainability assessment for the 23 farmer systems of maize production in Cuanacaxtitlán was carried out, according to the Indicator-Based Sustainability Assessment Framework (Marco para la Evaluación de Sistemas de Manejo Incorporando Indicadores de Sustentabilidad: MESMIS).
**Results**: The sustainability level between the two types of agroecosystems does not differ much. According to the chosen indicators, TMS is more sustainable in the environmental and economic aspect, while CMS is more sustainable in the social aspect. The average profitability of TMS is better as a result of the milpa profits.
**Study Limitations/Implications**: Family Production Units (FPUs) do not own their lands, which limits the improvement of profitability and sustainability in maize production. To this end, land distribution or support programs for landless farmers is important.
**Findings/Conclusions**: Among the 23 systems under analysis, critical values were obtained for two environmental indicators: fertilizer application and pesticide use. Therefore, improving the use of these inputs is an important task.

**Keywords**: farmer systems, MESMIS, sustainability, agroecology.

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## INTRODUCTION

Farmer agricultural systems produce food for more than 70% of the world's population [1]. Farmer mode of production is characterized by family farming focused on self-sufficiency, with a diversification strategy that follows an ecological rationality aimed at sustainable energies [2]. Sustainability is an important concept, because ecological principles guide production systems, determining the aim and type of agriculture. It also refers to the capacity of an agroecosystem to maintain its productivity, despite the ecological, social, and economic factors that may impact it [3]. Modern agricultural production lacks economic, social, and environmental sustainability. It is characterized by the use of packages that include improved seeds, pesticides, and synthetic fertilizers.

This production model —as a business controlled by transnational corporations— has strong economic connotations that threaten food security. People's right to healthy food is impacted by policies that break the relationship that farmers have with nature, encouraging dependence on the market. By displacing diversification-based ancestral methods, this dependency has a negative effect on the food self-sufficiency of farmer families. Therefore, the preservation of agroecological practices in farming ecosystems must be promoted [4]. These practices define productivity, stability, resilience, reliability, adaptability, equity, and self-management as basic attributes of a sustainable management system that must be capable of renewing itself while maintaining its productivity.

In conclusion, the objective of this study was to analyze and compare the sustainability of traditional and conventional maize management systems in Cuanacaxtitlán, Guerrero.

## MATERIALS AND METHODS

The study was carried out in Cuanacaxtitlán, a Mixtec town in the municipality of San Luis Acatlán, Guerrero. A mixed method approach was used to develop the project, with a predominance of qualitative research. A sustainability assessment for 23 maize production systems was carried according to the MESMIS proposed by Masera *et al.* (4), which includes the following six steps:

1. **Determination of the subject of the assessment**. The characterization of the 23 farming systems took into account their socio-environmental context, the internal and external flows affecting them, and their components and interactions. Ten maize production systems were identified with a predominance of Traditional Management Systems (TMS) and 13 with a predominance of Conventional Management Systems (CMS). These systems were classified according to the type of seed used, workforce, production objective, and technology employed. Subsequently, TMS and CMS were established as the reference management and as an alternate system, respectively.
2. **Determination of critical points**. This step consisted of identifying weaknesses and strengths of the management system. The determination of critical points was the result of the workshop "Problemáticas presentadas en la producción de maíz" ("Problems faced in maize production"), which included an analysis of the weaknesses, threats, strengths, and opportunities observed by the producers.
3. **Selection of indicators**. The information gathered in step 2 was assessed. Once the diagnostic criteria and indicators about sustainability properties and their social, economic, or environmental aspects were condensed, diagnostic criteria and indicators were defined based on critical points of the two production systems.
4. **Measurement and monitoring of indicators**. After establishing the indicators, a semi-structured questionnaire was applied to obtain information about crop management, including production, total costs, commercialization, organization, and environmental awareness. Subsequently, field visits were made to nearby plots and information was collected and processed in Excel.
5. **Presentation and integration of results**. A radial chart (known as a "spider" or "amoeba") was drawn, identifying critical aspects of both agroecosystems. The

results were presented to the producers during a workshop where an agreement was reached regarding actions for the improvement of maize production.

6. **Conclusions and recommendations**. Based on the assessment of indicators, a Comprehensive and Sustainable Action Plan (CSAP) was developed, defining priority actions, producer involvement, etc. The work plan is linked to the different stages of agroecological transition, which, according to López [5], is proposed in a non-linear sequence, generated according to the needs and motivations of the producers. Six training workshops were developed to implement the CSAP, addressing the following subjects: rescue and improvement of native maize, infiltration trenches, bokashi production, foliar fertilizers based on poultry manure and ant manure, natural insecticides, and vermiculture. These subjects were discussed in information exchange workshops focused on the farmer-to-farmer extension approach, which is "a participatory way of promoting and improving farmer production systems" [6].

## RESULTS AND DISCUSSION

An amoeba graph was developed according to the results of each indicator, showing critical aspects of both agroecosystems and detecting the points that should be strengthened (see Figure 1). Each indicator was assigned a value from 0 to 100, where 0 is the worst value and 100 is the optimum value of an agroecosystem. Optimal values (100%) are located in the periphery, while points that need to be strengthened are above 50% and critical values are shown below 50%.

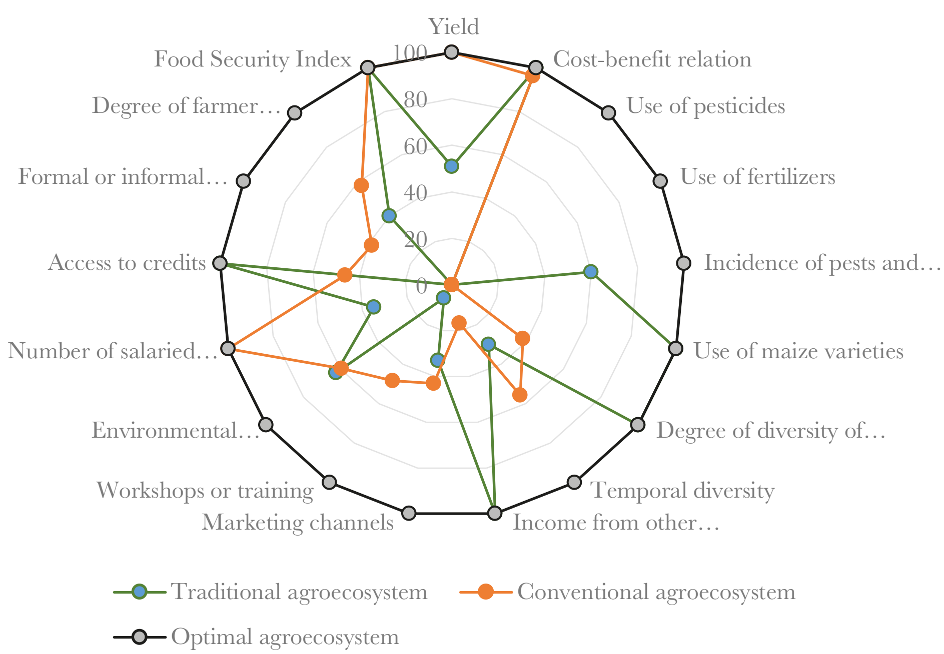


**Figure 1**. Amoeba graph for the comparison of the sustainability indicators in two maize management systems in Cuanacaxtitlán, Guerrero.

The results obtained were classified according to their sustainability attributes: productivity; stability, resilience, and reliability; adaptability indicators; and equity.

**Productivity**. The transition from the traditional to the conventional production system has been encouraged by such factors as the low yield of native maize, the difficulty in commercializing surpluses (as a consequence of the preference for hybrid maize), and intermediation as the main commercialization channel. Low yields observed in these systems may be associated with the intensity of soil management and the lack of crop rotation and organic matter application, as well as the unbalanced fertilization in each production cycle [7]. Fertilizer application on steep slopes generates runoff losses, while low organic matter favors leaching and soil acidity reduces the nutrient cycling. In the TMS, the average cost of production per hectare was $5,648 MXN, while in the CMS it was $15,815 MXN. In both production systems the highest cost is generated by the workforce, who are mainly hired for two reasons:

1) Production is done by hand using rustic tools; the low mechanization is related to the reduced areas that are sown and the steepness of the slopes.
2) Since Cuanacaxtitlán is a migrant community, the average family size is four people, which results in a limited availability of family workforce.

In this context, TMS had a slightly higher average profitability than CMS. Therefore, the milpa is a strategy that farmers can use to improve the profitability of their production, since the cultivation of different species and varieties reduces risks in the event of external changes [8].

**Stability, resilience, and reliability**. Both systems use commercial chemical products to control weeds. In TMS, the producers carry out a manual control of weeds before sowing and complement this practice with the application of herbicides, using an average of 6 liters per hectare. In CMS, an average of 9 liters of herbicides were used per hectare. In both systems, a small percentage of farmers used Foley® to control codling moth and Arrivo® against bean slugs. An excessive use of herbicides and pesticides may be associated with farmers' lack of knowledge about the correct handling of these products and the environmental and health damage they cause; therefore, attention should be paid to proper weed control and pesticide use. Fertilization in the systems analyzed is unbalanced: some systems over-fertilize, while others under-fertilize. In this context, managing and improving the use of inputs is necessary to positively impact the profitability of the crop. Native maize —such as olotillo, maizón, toro, sapo, and combinations thereof— are sown in TMS. Producers have preserved native seeds, as a result of their nutritional and cultural importance, as well as the lack of resources to switch to conventional production. Therefore, the preservation of native seeds is directly related to the poverty of family units, as well as to their cultural values. Toro maize is sown specifically to prepare pozole, a traditional and widely-recognized Mexican dish. Tecomache or cuarenteño maize, a short cycle variety, is one of the lost varieties mentioned by the producers. P4082W, P3966W, P4028W, and other Pioneer® hybrid maize varieties are sown in SMCs, which makes producers dependent on this input. Purchase of seeds represents an average expenditure of $2,491.52 MXN: 16.79% of the total cost of maize production per hectare. Therefore, the use of native seeds has certain advantages over hybrid seeds, as they have adapted to the location and are resistant to pests and diseases, while their production does not involve high costs, since they can be used in the next cycle. In the CMS, the native seed has been lost and producers only sow hybrid seeds as a monoculture or in association with other crops. Consequently, the use of improved varieties leads to the erosion of native seeds [9]. The simplification of diversity is one of the many consequences of the implementation of modern agricultural practices in rural communities. According to Toledo [10], the modernization process displaces the rural way of life, replacing it with specialization in all its dimensions, with its production aimed exclusively at the market. In Cuanacaxtitlán, farmer agricultural systems used to perform agroecological practices such as polycultures, manual weeding, living fences, sowing of native seeds, and conservation of medicinal and ornamental weeds; however, given the market exclusivity of hybrid maize, farmer systems have begun a transition process, gradually abandoning their traditional practices. Consequently, the food that makes up their diet is replaced by products from the market, which they can only acquire after the sale of their produce [11]. In Cuanacaxtitlán, the abandonment of the milpa has entailed the loss of an entire gastronomic legacy.

**Adaptability indicators**. The participation of farmers from both production systems in the workshops or training was low. A high percentage of farmers only speak Mixtec and consequently had difficulty understanding the indications given in the sessions. Additionally, the training was very theoretical regarding the technical handling of information and lacked practical support; therefore, the farmers prefer to continue sowing as they learned from their predecessors. In both production systems, farmers recognize that conventional practices pollute their resources, which backs up the decision to change their farming practices.

**Equity**. The high number of wage-earning workforce that participate in the production process represents a source of employment in the community. In 50% of the systems, expenditure on this heading accounts for more than 50% of their total expenses; additionally, migration limits the workforce, which demands increasingly higher wages, increasing costs and decreasing the net income obtained per producer. Dependency on external workforce puts the farmer system at a disadvantage, establishing an inequitable cost-benefit ratio. In CMS, high production costs generate dependency on financial resources, reducing net income. In CMS, the degree of satisfaction with the production is slightly higher than in TMS; producers consider that sowing hybrid maize should result in a much higher yield. The CMS has higher values in the FFSI; less than 10% is destined for self-consumption. In the TMS, more than 80% of the total production is destined for self-consumption; 50% of the producers do not have food security, which matches the conclusions of Damián *et al.* [12], who report that most maize producers do not have FFS. In Cuanacaxtitlán, the low FFS level in the TMS can be explained by the low yields obtained and the small area sown. Achieving food self-sufficiency is vital in the pursuit of sustainable agriculture; therefore, everyone involved must work on agroecological practices that optimize space and maintain acceptable yields in the long term. Given the socio-economic and environmental benefits of sowing maize under polyculture, traditional management systems are slightly more sustainable than conventional ones. The SMC are mixed agroecosystems where traditional practices (*e.g.*, crop association, crop rotation, and manual weeding during land preparation) are still practiced. These systems required the sowing of hybrid maize as an adaptation and innovation strategy for production and as a response to market demands to improve the profitability of the crop. The latter objective has not been achieved, as the profitability of CMS and TMS are similar. Two indicators which influence yield and production costs were reported in both agroecosystems: the application of fertilizer and the use of pesticides. Therefore, work must be done on the adequate management of inputs.

## CONCLUSIONS

The two types of agroecosystems have similar levels of sustainability. According to the selected indicators, TMS is more sustainable in the environmental and economic aspect, while CMS is more sustainable in the social aspect. In the 23 systems analyzed, critical values were obtained for two environmental indicators: fertilizer and pesticide use. CMS has a better average profitability due to the benefits of the milpa. The implementation of lore exchange workshops based on the farmer-to-farmer extension approach is very effective in the transmission of knowledge, promotes the exchange of experiences, and generates motivation and conviction about sustainable production.

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