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MILPA INTERSPERSED WITH FRUIT TREES: REVIEW AND STUDY CASE IN CAÑÓN DEL USUMACINTA, TABASCO, MEXICO

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ABSTRACT

The Milpa Interspersed with Fruit Trees (MIAF for its Spanish acronym), resulting from an interdisciplinary process, is based on the traditional milpa in small-scale production units under rainfed and slope conditions. A bibliographic review was carried out from January 2005 to February 2021 of the free access material in the internet on the MIAF. Based on this, its implementation and adaptation in Cañón del Usimacinta, Tabasco (Mexico), by the Sembrando Vida program and recipients, was examined from an anthropological approach. The bibliographic review included MIAF and *Milpa Intercalada con Árboles Frutales* in different search engines. The publications obtained were organized by: geographical area, climate, institution of origin, year of publication, disciplines, methods used, keywords in publication titles, gender, research line of authors, and conclusions. The implementation and adaptation of the MIAF in Cañón del Usumacinta was analyzed through ethnographic documentation in 2020-2021. In the publications it was found that the MIAF has advances regarding the agronomic and edaphoclimatic principles. An important absence of studies from the humanities was detected, as well as a limited participation of women in the publications. The MIAFs established in Canón del Usumacinta show advances in their implementation, although it is urgent to consider the agronomic principles originally proposed, as well as contemporary peasant knowledge. This study proposes the incorporation of the theoretical framework of Participative Action Research for development of the MIAF with epistemological, ontological and methodological foundations based on the humanities for its scaling.

Keywords: contemporary knowledge, humanities, transdisciplinary research, Sembrando Vida program.

INTRODUCTION

Traditional agriculture in Mexico is an important source of food production, and cultural re-appropriation and reproduction (González-Santiago, 2008). It includes the milpa systems, which are agroecosystems where corn is planted interspersed or in association with other annual species, fruit trees or other species, under irrigation or rainfed. The importance of the diversity of milpa systems lies in that they are the basis for the design of sustainable community production systems (Lara-Ponce *et al.*, 2012; Martín-Castillo, 2016), and they allow the strengthening of agroecological strategies in the territories.

In southeastern Mexico, according to Lara-Flores and Sánchez-Saldaña (2017), the surfaces destined to agriculture after the Mexican Revolution suffered an unequal spatial

distribution with implications in poverty and marginalization. Facing this scenario, the federal government promoted social programs to counteract them (Appendini-Kirsten *et al*., 1983), which were combined with colonization policies in the 1950s and 1960s, the Livestock Law in the 1970s, and the clearing and modernization plan in the 1980s (Isaac-Márquez *et al*., 2008; Lazos-Chavero, 1995). In the livestock sector, their promotion and expansion happened at the expense of rainforest areas and subsistence agriculture surfaces (Sosa-Cabrera, 2014).

In 2015, this scenario caused for extensive livestock production to have a predominant presence in the Area for Flora and Fauna Protection of Cañón Usumacinta in Tabasco, and small rainfed corn surfaces were identified (Comisión Nacional de Áreas Naturales Protegidas, 2015). The implementation by the federal government of the Sembrando Vida Program started in the year 2019, whose objective is to reduce the vulnerability of people by increasing the productivity of rural zones and to provide support to the agrarian subjects (Secretaría de Bienestar, 2020). The social backwardness index was considered in the operation rules of Sembrando Vida; that is, the program concentrates in marginalized communities and in priority attention sites for the restoration and conservation of biodiversity (Cotler *et al*., 2020; López-Bárcenas, 2020).

The objective was a bibliographic review of the free access material in the internet about MIAF and, based on this, its implementation and adaptation in Cañón del Usumacinta in Tenosique, Tabasco (Mexico), by Sembrando Vida and recipients, was examined. Considering the elements contributed from the bibliographic review and anthropological analysis, the pertinence of Participatory Action Research (PAR) for scaling of the MIAF is presented, contributing with these elements from the humanities to the multi-objective technology.

THEORETICAL FRAMEWORK

Milpa Interspersed with Fruit Trees (*Milpa Intercalada con Árboles Frutales*, MIAF) and its basic premises based on a transdisciplinary approach

The MIAF is an agroforestry system constituted by the fruit tree (epi-crop), corn (meso-crop), and bean or other low bearing species (soto-crops). Its purpose is the production of corn and bean with the agronomic management of the milpa and fruit trees. The fruit tree has the function of being an economic activator in addition to functioning as live barrier against erosion and capturing carbon (Ruiz-Corral *et al*., 2012; Albino-Garduño *et al.,* 2015; Turrent-Fernández *et al*., 2017). This proposal has the framework of the existing agroforestry systems in Mexico and includes Pre-Hispanic practices. Moreno-Calles *et al.* (2013) documented 20 systems in use used by the Nahua, Mepha´s, Ñiusavi, and Maya indigenous groups, as well as mestizos and others.

In particular, the MIAF had its origin in traditional agriculture of peasants in Puebla, who planted fruit trees in rows in the milpa systems (Huesca-Mariño *et al.,* 2019), and the Live Wall Terrace technology developed by the National Institute of Forestry, Agricultural and Livestock Production Research (*Instituto Nacional de Investigaciones Forestales, Agrícolas*

y Pecuarias, INIFAP). By 1994, with financing from the World Bank and the Mexican government through Colegio de Postgraduados (COLPOS) and INIFAP, they designed the Program for Sustainable Management of Slopes in peasant communities of the Sierra Mazateca and Mixe in the state of Oaxaca, and the MIAF was proposed for this program. The MIAF takes the traditional milpa as a basis and redesigns it with agronomic principles as a polycrop system (fruit trees, corn and shrub bean), with the aim of increasing their efficiency.

This has had a strong boom as a result of the Sembrando Vida program, from the federal government, which promotes its establishment in various states of the country.

Despite recent efforts, the research groups focused on the study of peasant agriculture in Mexico are dominated by unidisciplinary views. That is, academics have been instructed to see the world from the discipline that they belong to, as well as the history and culture from where it is produced (Paz-Reverol and Valbuena-Chirinos, 2023). Meanwhile, as consequence of humanism, transdisciplinarity is linked with social causes to give alternatives to the crises derived from Neoliberalism (Torija-Aguilar, 2022), which have dangerous biocultural consequences in rural populations.

Paradigms of the humanities: PAR used to strengthen the MIAF

The PAR method is based on researching to understand the processes that determine the problems and actions of change (Soliz and Maldonado, 2010). Ocampo-López (2008) retakes Freire's idea when he says that human beings must be considered as a subject and can become a subject when they reflect on themselves, identify themselves, and have awareness of their social, economic and, in this case, environmental situation.

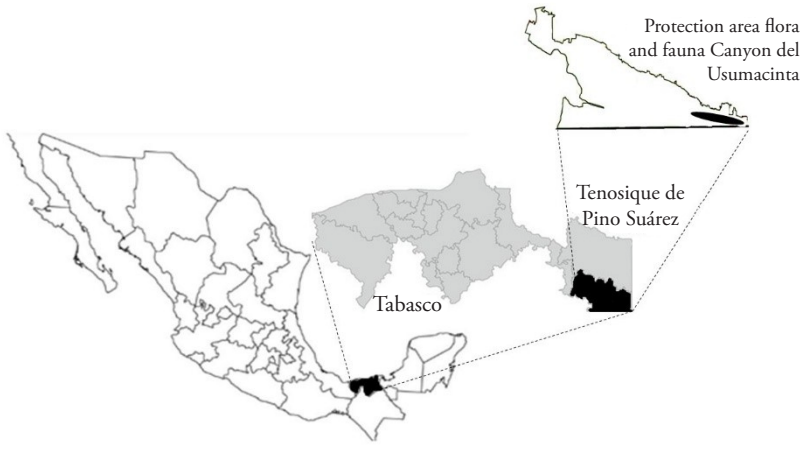
In a PAR, the researcher, academic or other social actor, while performing their work or study, place their social commitment at the service of people through mediation, reconciliation, service and others (Urdapilleta-Carrasco and Limón-Aguirre, 2019). The RAP and its systematization is a means of action to transform realities, which demands useful and significant studies (Rahman-Anisur and Fals-Borda, 1992; González-Santiago, 2018). In addition, as epistemological framework, it allows a mutual benefit, integral view for collective construction, not only from the stance of a technician, researcher, public servant, producer, but rather by blending all those views to achieve relationships with reciprocity (Urdapilleta-Carrasco and Limón-Aguirre, 2019).

METHODOLOGY

A bibliographic review was carried out (Gómez-Luna *et al*., 2014) about studies on the MIAF from January 2005 to February 2021, of free access in the web with the use of the search engines Google, Academic Google, the metasearcher from El Colegio de la Frontera Sur (ECOSUR), and Redalyc. The criterion for search period was based on the information available about the MIAF to serve as guide for the technical team and people interested on the issue, when implementing Sembrando Vida in the Mexican southeast. The keywords used were MIAF and *Milpa Intercalada con Árboles Frutales*.

These were organized in a database according to the geographic area, type of climate, institution of origin, year of publication, disciplines for the approach, methods used, keywords in the titles of publications, gender and profile of authors. The titles of the publications were analyzed based on a word cloud with the help of the application WordCloud. Then, the publications were classified according to the scientific area from which they were approached: agronomic, natural, social sciences, and the humanities. The main results of the studies reviewed in each of these areas were reported and analyzed, as well as the implications of the characteristics they have. Later, the spatial design of fruit trees and corn by Sembrando Vida and recipients in Cañón del Usumacinta was documented ethnographically (Figure 1), and it was contrasted with the original spatial and agronomic design of the MIAF from an anthropological framework.

Documentation included attending informative meetings in eight peasant learning centers, attending four training workshops in 2020, and accompanying a productive technician to visit 18 MIAF systems (between February and October, 2020) and three in 2021 (March to July). Likewise, semi-structured interviews were conducted (Ardón, 2000; Álvarez and Jurgenson, 2003; Geilfus, 2013). The variables considered for the documentation were the types of corns planted (Creole or hybrid), the diversity of milpas (species grown), the condition of the land (flat-slope-floodplain), the topological arrangements, and the farming practices (for example, the consideration of moon cycles, primarily the waning moon to perform corn sowing). Later, the information gathered was codified for its analysis (Geilfus, 2013); the main code used was the strategies of recipients for the transformation of their production systems. Lastly, considering the elements found from the bibliographic review and the anthropological analysis, the pertinence of PAR is suggested.



Source: prepared by the authors.

Figure 1. Geographic location of the Flora and Fauna Protection Area of Cañón del Usumacinta in Tenosique, Tabasco, Mexico.

RESULTS

Publications that refer to the development of the MIAF

In the development of the MIAF from January 2005 to February 2021, 34 publications were found: 26 scientific articles, four congress proceedings, one manual, a report-manual from a government ministry, a thesis, and a book chapter. From these publications, it was found that the states in which most studies have been conducted are Oaxaca (36 %), followed by Estado de México (23 %), then Mexico City (13 %), Puebla (13 %), Chiapas (6 %), Veracruz (6 %) and Nicaragua (3 %). The type of climate where most work has been done is the sub-tropical (44 %), followed by temperate (32 %), tropical (12 %) and undefined (12 %).

The institutions that work in this theme are COLPOS Campus Montecillo (34 %), COLPOS Campus Puebla (18 %), INIFAP (15 %), Universidad Intercultural del Estado de México (UIEM) (9 %), Universidad Autónoma Chapingo (UACh) (6 %), and with 3% each, Benemérita Universidad de Puebla (BUAP), Universidad Veracruzana (UV), ECOSUR, Universidad Autónoma Metropolitana (UAM), Universidad Autónoma de Nicaragua, and the Ministry of Agriculture, Livestock Production, Rural Development, Fishing and Food (*Secretaria de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación*, SAGARPA). In the titles of the publications, the outstanding terms are Mexico, MIAF, soils, slopes and corn (Figure 2).

From the methods used in the research, 56% belong to the quantitative scope, 32% to qualitative and quantitative studies, 6% to the qualitative method, and in 6% of the publications the methods are not defined. Of the publications, 56% belong to agronomic and natural sciences, and 44% to social sciences. The disciplinary approaches of the natural sciences are those related to agronomy, plant science, soil science, geography, animal

Source: prepared by the authors with the application WordCloud.
Figure 2. Word cloud with the terms used most frequently in the titles of the publications.

science, horticulture, and fruit culture. In the social sciences, the approaches are directed at economy and rural and sustainable development. In the case of researchers involved, 75% were men and 25% women. The specialization profiles of the men and women authors are in plant science, fruit culture, soil science, agroecology, rural development, economy, agronomy and agricultural sciences in general.

The results from the publications reviewed reaffirm that polycrops present higher productive efficiency in time, compared to monocrops, and that the small production units can make better spatial use of the surface cultivated with three species together, interspersed, and in furrows and fruit rows (Albino-Garduño *et al.*, 2015; Molina-Anzures *et al.*, 2016; Cadena-Iñiguez *et al.*, 2018). The MIAF is a productive reconversion option, which allows recovering the ecosystem function of the harvests and offers the possibility of obtaining income from fruit production. When diversifying crops, the families can increase yields and the cost/benefit rate (Salazar-Conde *et al.*, 2004; Santiago-Mejía *et al.*, 2008; Juárez-Ramón and Fragoso, 2014).

The results from the social sciences are not conclusive, although contributions have been made to the educational and correlational aspect, such as the one between the UIEM and Mazahua peasants in Estado de México. In the process, it was understood that the professional link with the families and the recognition of their knowledge in the development of experiments in the family plots, allows students to give answers to real problems and to develop capacities in production, organization, and trade (Santiago-Mejía *et al.,* 2017).

Another contribution was the application of participatory methodologies such as Field Schools and the promotion of the Institutional and Organizational Articulation Network (*Red de Articulación Institucional y Organizacional*, RAIO) (López-Gaytán *et al.*, 2008; Orozco-Cirilo *et al.*, 2008, 2009). The methodologies were used when implementing the subproject of Training and Dissemination of the Sustainable Slope Management Project in 1999, coordinated by COLPOS (López-Gaytán *et al.*, 2008) and included a training project to disseminate the agronomic results of the MIAF through peasant schools. It was understood that the rejection or adaptation of certain components was conditioned by the sociocultural and economic structure of the peasantry (Ruiz-Corral *et al.*, 2012). In this case, the analysis of variables was carried out from a quantitative view, which limited delving into the theme. The RAIO was fostered in Veracruz (2010 to 2012) to improve the relationships of collaboration, cooperation, institutional association, and to address the technological innovation in economic and social development of small-scale producers with MIAF.

The RAIO was promoted with participative strategies (Zambada-Martínez *et al.*, 2013) that were focused on the economic and social development of the rural productive sector and excluded factors such as knowledge of families and integration of women with a gender approach. The study conducted by Juárez-Paulin *et al.* (2018) in Chiapas showed the duality that women face when they become incorporated into projects, since at the same time that they question and renegotiate their situations of gender, they face the subordination reproduced by organizational dynamics.

Original spatial and agronomic design of the MIAF

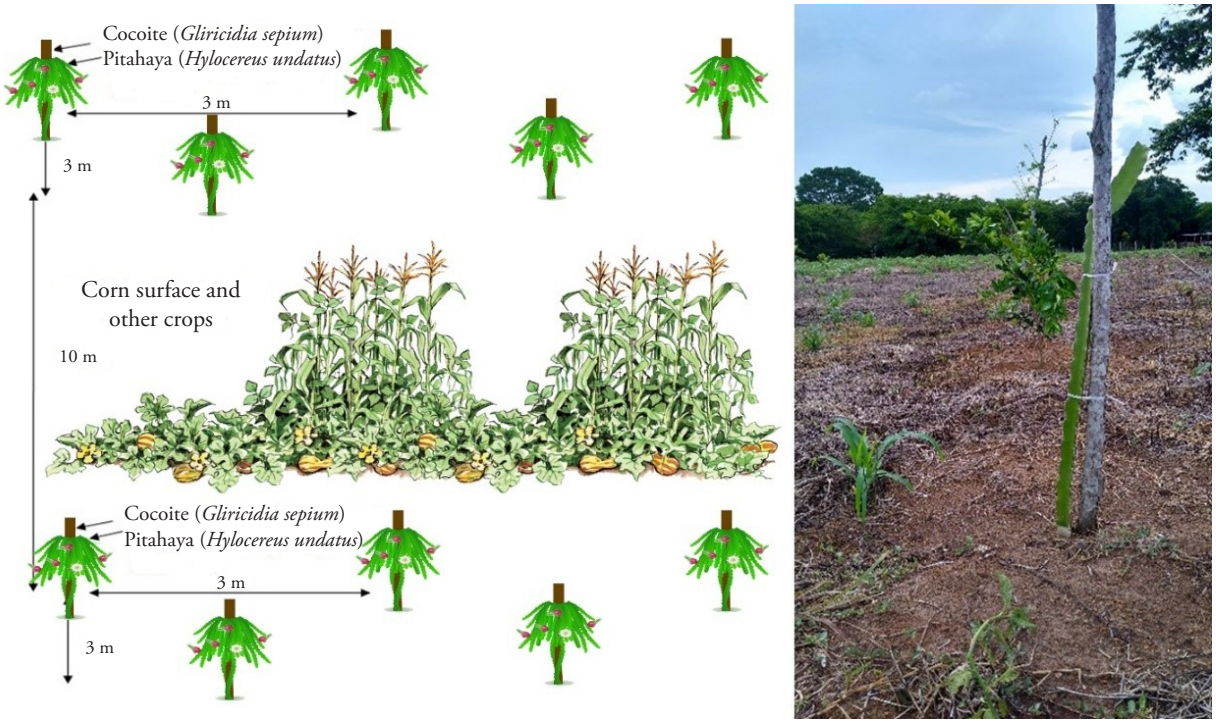
The design of the MIAF in lands with slope lower than 20% has three contiguous strips each 4.8 m wide. Each lateral strip is occupied by corn or bean, at a distance of 2.8 m from the fruit tree trunk in both sides of the strip (Cortés-Flores *et al.*, 2005). The agronomic principles considered are: one line of fruit trees on level curves planted at 1 m of separation, under irrigation and rainfed conditions, in lands with slope or flat. The fruit trees must be planted with just one branch of structure alternately through a conduction system, Tatura type pruning and height of 3 m (Cortés-Flores *et al.*, 2005). These principles allow efficient solar interception, the production of biomass, and guarantee the availability and amount of nutrients for crops in the root zone, as well as the decrease in water runoff and its filtration (Camas-Gómez *et al.,* 2012; Albino-Garduño *et al.*, 2016).

From an ecosystem view, the planting of four furrows of corn and bean with a distance of 0.80 m, between parallel furrows of fruit trees and in topological arrangements, allows for the crop interspersed in strips at the level of soil stratum explored to have a broad distribution of roots for the absorption of nutrients and nitrogen fixation. In the aerial part, it allows an efficient interception of solar radiation and with it, higher production of biomass and an increase in yield (Albino-Garduño *et al.*, 2015). The topological arrangement consists in the spatial positioning of plants, their planting density, and the distance between furrows and between plants (Luján-Favela and Chávez-Sánchez, 2003). The topological arrangement of a meso-crop furrow alternating with a soto-crop furrow for temperate climates allows the increase in corn grain yield due to the higher number of cobs per plant, grains per cob line, and grain weight and size (Albino-Garduño *et al.*, 2016).

Spatial design of fruit trees adapted by Sembrando Vida and recipients

The design of the MIAF adapted by the Sembrando Vida team in the region stemmed from its previous experiences in the zone, from listening to the interests of recipients, and from the guidelines of Sembrando Vida to maintain in the system the amount of 2000 fruit and timber-yielding trees per hectare. By February 2020, in eight meetings in the peasant learning centers, the suggestion was made to people to plant the cocoite tree (*Gliricidia sepium*) for the establishment of pitahaya (*Hylocereus undatus*) in the MIAFs. The proposal of pitahaya is based on its market value. The cocoite system consists in two lines in triangular plantation of these trees to serve as support for pitahaya. The distance in triangle between the trees is 3x3 m and the distance between a line and the next one is 10 m (Figure 3).

When the meetings ended, participants were allowed to decide whether they opted for this system. Then, in field visits in eight of the systems between March and June of the same year, it was found that there were still no fruit trees in the MIAFs. Five people mentioned that the moon was not in its phase to transplant the fruit trees. A person mentioned that they would plant lime (*Citrus sp.*), while two others indicated that they would sow bitter



Source: prepared by the authors.
Figure 3. Cocoite system (*Gliricidia sepium*) implemented and adapted in the MIAF by the "Sembrando Vida" team in Cañón de Usumacinta, Tabasco.

orange (*Citrus aurantium*), mango (*Mangifera indica*), and avocado (*Persea americana*). During September and October of the same year, another seven systems were visited. Cocoite branches had been planted in four of them, and fruit trees in the three other systems. The cocoite system was proposed for flat zones and with slope in the study region. In the case of lands with slope, training was offered to determine the level curves. In other systems with fruit trees, the main problem was the death of trees after transplant, due to the long drought period, and the short but abundant rainy period. This was addressed with seed germination and transplants, and in other cases they bought fruit trees.

Another type of arrangement determined by the recipient in 2021 for lands with flat and floodplain relief included orange, mango, avocado, jícara (*Crescentia cujete*) and tamarind (*Tamarindus indica*). It was found that the distance between lines of fruit trees was 10 m and the distance between fruit trees within the line was 3 m. On the edges of the plot, wind-break curtains were established (tree lines of different heights), and here is where they planted 'tresbolillo' caoba (*Swietenia macrophylla*) and macuili (*Tabebuia rosea*). In another system with the same relief, it was found that the line of fruit trees was substituted by timber-yielding species such as tinto (*Haematoxylum campechianum*), macuili and caracolillo (*Albizia longepedata*). The distance between tree lines was 10 m

and the distance between trees was 5 m. In a slope system, the following were found: orange, lime, mandarin (*Citrus reticulata*), chicozapote (*Manilkara zapota*), mango, chestnut (*Artocarpus camansi)*, tamarind, soursop (*Annona muricata*), cacao (*Theobroma cacao*), avocado and achiote (*Bixa orellana*) in triangle planting ('tresbolillo') at a distance of 3×3 m and 10 m between lines of fruit trees.

Spatial design of corn adapted by Sembrando Vida and recipients

In 2020 in the field visit to 18 MIAFs, it was found that 11 were planted with hybrid corn known as enano and seven with the corn races Dzit Bacal, blanco, amarillo and criollo blanco. It is important to mention that 11 people did not cultivate milpa before Sembrando Vida. Out of the 18 systems, 88.8% were under slope conditions and 11.1% on flatland, and in every case there was use of agrichemicals, 10 systems were in polycrops with species like cassava, bean and in two cases watermelon. The rest of the systems (eight) were planted in monocrop: corn field or bean field. All of the MIAFs had their sowing and harvesting times defined, in addition to considering the moon phases for farming tasks.

When maintaining and reproducing the monocrops, there is danger of basic crops losing value, as documented with two recipients who shared that their interest over cultivating corn lies in livestock feed. The rest of the recipients (16) coexist with the uncertainty of obtaining low or null production, which has not generated conflict, since the milpa was not cultivated anymore, so that the production obtained in a cultivation cycle is an achievement.

In 2021, another visit was made to three systems. In one, Dzit bacal corn was found under the surface destined to the MIAF in a strip 10 m wide between every two lines of fruit trees, and bean and squash dispersed on the edges. Another system was documented in flat and floodplain relief where the corn surface should also be 10 m, but it was not possible to cultivate because the surface was flooded. The last system was on a slope, the corn surface was a 10 m wide strip and there was squash, cilantro, cassava, sweet potato, macal, hibiscus and parsley.

DISCUSSION

Lessons in the development and implementation-adaptation of the MIAF

According to the bibliographic review from January 2005 to February 2021, the MIAF has an agronomic foundation strengthened from natural sciences and its quantitative methods. The preponderance of research centers such as COLPOS Campus Montecillo can be appreciated. It was found that in the academic and research development about the MIAF there is dominance of masculine presence. Pessina-Itriago (2020) points out that the incorporation of women is important to have a healthy science and to contribute to break with the intellectual masculinized hegemony that dominates science.

In the years reviewed there is also evidence of the absence of studies that address a theme from the humanities, so this effort represents an approach to the MIAF and its implementation, from the anthropological stance. It should be noted that the qualitative

change in the reflections around the MIAF can be appreciated from June 2021 to July 2023, with some publication titles such as: "From soto-crops for the MIAF system to dialogue of knowledge in a Mazahua community: A transdisciplinary journey (June 2021)"; "Learning community in two native peoples in Estado de México (October 2021)"; "MIAF as a motor of sustainable development in the Mazahua region in the northwest of Estado de México (November 2021)"; "Adaptation of annual species in the MIAF (November 2021)"; and "Biocultural elements as the basis for the adaptation of the MIAF system in a Mazahua zone of Estado de México (November 2022)".

González-Santiago (2008) proposed the search for significant learning forms, such as "learning by doing", based on the practice to be theorized and then, return to the practice, and with it, exceed the descriptive and quantitative limit in studies from the social sciences, which include techniques like surveys, questionnaires, and interviews where data analysis is done with the usual parameters of descriptive statistics.

The bibliographic review indicates the need for integral and transdisciplinary studies. The great challenge is to incorporate the proposals from other paradigms such as naturalism, sociocritical and of complexity, which are developed from the social sciences and particularly the humanities (Kumatongo and Muzata, 2021).

The proposal of this study is for pedagogical and anthropological strategies to be designed and implemented with the contributions from diverse paradigms, which allow co-production of knowledge based on collaboration relationships to foster for professionals to perform with the consideration of cultural frameworks, previous knowledge and people's voices (Campos-Hernández *et al.,* 2003). The strategies must go beyond the institutional scope. In the research, it is necessary to consider the participation of indigenous and mestizo families in the stages of planning, implementing and returning results, as well as the incorporation of their current knowledge. This concept includes the beliefs, the knowledge, the feelings and their corresponding practices in constant production and reproduction in spatial and temporal scales (Aldasoro-Maya, 2012; Tapia-Hernández *et al*., 2021; Aldasoro-Maya *et al*., 2023).

In the adaptations of the MIAF by Sembrando Vida and recipients in Cañón del Usumacinta, at the beginning of the current Federal Government administration, the public servants from the Ministry of Welfare resorted to the research team of the MIAF. The team elaborated a training plan for agricultural technicians and Sembrando Vida producers. In an interview documented in the webpage of Scientists Committed with Society (*Científicos Comprometidos con la Sociedad*; González-Hernández, 2019), the team suggested two proposals to integrate the MIAF to the program, which included training and experimentation. The public servants responded that they would have to analyze the proposal due to budget cuts, but there were no further advances.

The team's worry when the system was implemented under the operation rules of Sembrando Vida is the demand for integrated knowledge. This was because the families understand the management of basic crops and fruit trees, but separately and not exactly to increase their yields. They understand the management required by their interaction in

the same system only in a few regions (Huesca-Mariño *et al*., 2019). The ideal would be for results and lessons from the studies that have been conducted in some regions to be taken advantage of in other regions. This study identified the lack of studies in the states of Yucatán, Campeche, Quintana Roo, Guerrero and Tabasco, where the program has actually been implemented.

When the MIAF was adapted by Sembrando Vida for the Mexican southeast, it should be focused on small production units under the agronomic principles that it was created with, in collaboration with the families, exploring it in an organized and systematized way. Therefore, integrating epi, meso and soto crops in spatial and temporal arrangements, according to the needs and interests of the families, their tasks and biocultural practices, their contemporary knowledge, and the edaphoclimatic conditions. If this is the way to proceed, with the economic contribution of the program and the technical advice, it would be possible to respond to the demand for agronomic knowledge in the establishment of crops with an agroecological view and not only directed at production.

However, the reality in several communities is different from this, as is the case of what happens in these regions in Tabasco, where the MIAF has been adapted and redesigned to respond to the guidelines of Sembrando Vida. This is even more worrying when considering that Tabasco is one of the states that has more problems in its ability to produce and to supply foods (Martínez-Valdés *et al.,* 2020), and where corn production had a decrease in the sowing surface of 62.62% from 1991 to 2020 (SIAP, 2020). According to CONANP (2015), in the *ejidos* that make up Cañón del Usumacinta, close to one thousand hectares of milpa were planted, the sites were permanent for the same crops and located in relatively flat lands and exclusive areas for cassava, sweet potato and squash, and in adjacent zones there were areas destined to growing bean and corn for subsistence, so that the milpa crops in areas with slope were itinerant and corn was accompanied by bean.

There is the precedent that in 2017, under the FORDECyT-USUMACINTA project, 34 surveys were applied in ten *ejidos* of Cañón del Usumacinta, where it was found that 24% did not cultivate milpa anymore. In the family systems, the main crops were corn, bean, cassava, sweet potato, banana and squash, and the corn yield reported by the families was less than one ton per hectare (close to 800 kg).

In 2018, in the characterization of 28 systems in the same *ejidos*, it was found that cassava and corn were the only species cultivated so the systems were categorized as being in a process of simplification and abandonment in the region. In 2019, when Sembrando Vida was implemented, there was a reactivation and reappropiation process induced in the systems. In 2022, taking into account the 1,000 hectares planted in 2015 in 22 *ejidos* of Cañón del Usumacinta, and the surfaces sown by Sembrando Vida, there would be 2,000 ha of milpa, so the calculation is that the surface of milpas was doubled. The previous piece of data is obtained when calculating two facilitators of the program in the region, by the number of technicians under their lead (5 social and 5 productive).

For their part, the families that still planted milpa adapted to the guidelines from Sembrando Vida in order to receive the economic resource, while the rest of the families

opened *acahual* surface or made use of pastures or abandoned grasslands to enter the program, which led them to reactivate, reappropriate and adapt to corn growing under the Sembrando Vida program. From the point of view of the families, the traditional milpa and the one proposed by Sembrando Vida is the same, although the latter is more organized and includes fruit trees, while the timber-yielding trees that represent good wood are tolerated in traditional milpa.

The designs implemented and adapted in Cañón del Usumacinta, although stemming from the experience of technicians and recipients, increased the demand for nutrients, labor hours, workforce, inputs, constant maintenance in the long term, and they interfered in solar interception since they did not receive the adequate management through tree pruning, which becomes difficult when there is a combination of timber-yielding and fruit trees in the MIAF lines and as windbreak barriers. It should be said that many of these trees are local, which has guaranteed their survival despite edaphoclimatic adversities.

Facing this scenario, management strategies that consider the productive, biocultural, socioeconomic and environmental use and viability are necessary (with particular attention to edaphoclimatic conditions) of fruit and timber-yielding trees, without forcing milpa rotation with their growth or ceasing to cultivate it at the end of the program, as was mentioned in interviews with recipients and non-recipients in the territory. In June 2023, there was opening of corn cultivation areas under the slash-and-burn system in Cañón del Usumacinta, since the production of corn grain in the MIAFs adapted to the program was limited.

There are factors to analyze about Sembrando Vida in indigenous and mestizo family agriculture, such as: a) the number of species proposed for the MIAFs, b) the spatial arrangements between corn plants, soto-crops, fruit trees and forest trees. In some of the MIAFs visited, the height of the trees and some soto-crops is worrying, since they are sometimes at the same height as corn, which can limit its development and increase competition over nutrients, c) the constant clearing of weeds that leads to the intensive use of herbicides in two cultivation cycles (the year's milpa and the *tornamil*), and d) the regulation of the origin of basic crops, primarily corn.

In the last point, it should be mentioned that the native varieties of corn in Cañón del Usumacinta were confirmed to present transgenic markers (P35S and T-NOS) (Tapia-Hernández *et al.,* 2022), which leads the families to a state of food insecurity in the view of different authorities such as the Ministry of Welfare through Sembrando Vida, the Ministry of Rural Development (*Secretaria de Desarrollo Rural*, SADER), the Commission of Biosafety of Genetically Modified Organisms (*Comisión de Bioseguridad de Organismos Genéticamente Modificados*, CIBIOGEM), the National Commission of Protected Areas (*Comisión Nacional de Áreas Protegidas*, CONANP), among others.

Milpa, intersectorial dialogues, and social fabric

Corn is a crucial part of Mexico's history and the life of communities (Estrella-Canché, 2022), although in some regions of the Mexican southeast, the decrease of surfaces fosters

for it to be abandoned (Estrada-Medina and Álvarez-Rivera, 2021). In this study, it could be seen that its biocultural significance is easily taken up again when its cultivation is promoted by Sembrando Vida, which is not exempt of edaphoclimatic problems.

In Mexico, subsistence farming is an important producer of foods and agrobiodiversity; however, it faces economic, social and ecological challenges due to climate change (Turrent-Fernández *et al*., 2017). Therefore, adaptations of systems in each region to its agro-environmental and biocultural characteristics are necessary and valid. However, when the adaptations are made to adjust to the needs of a program, and not to respond to the problems of the farmland, the principles and contributions are denied in the scientific learning developed by educational and research institutions, as well as the current knowledge of the families, with which pertinent decisions should be made based on a reflective dialogue.

In Cañón del Usumacinta there is a limited dialogue between the institutional part and the recipients of the program, and in most of the cases the communication is reduced to sowing to comply, even when there is no production. The contrary scenario implies retaking the lessons from academia and indigenous and mestizo families to make pertinent decisions and advance in the knowledge of food production. This is limited if the programs are focused on attaining goals and the technology transference happens through imposition and economic conditioning. In the case of some technicians with critical thinking, what happens is that they struggle between the guidelines of the program and the needs of the farmland, and sadly it is frequent that they opt for the first, in the interest of keeping the job.

Presently, the program is being executed in the farmland and it is necessary to comply in order to remain in it and receive the economic benefit. In this context, it is crucial to keep in mind that corn and the agrobiodiversity that is still found in some milpa systems are linked to culture and to dietary habits (Ruiz-Corral *et al*., 2011), in addition to considering that each milpa system is a family that is not separate from the *ejido* collective, since if a resource is lacking in an *ejido*, it is obtained in others. In the field, it was seen that neither people nor *ejidos* exist in isolation, the requirements of labor and seeds are complemented between one another.

The production and exchange of corn has a relationship with the collectivity, the interaction, the harmonious dependency between *ejidos*, and community organization. The influence of programs can foster the social rupture where community organization has not been lessened by complex sociohistorical circumstances. Theoretical frameworks such as RAP stem from the humanities, based on the dialogue of knowledge and the "dialogic awareness raising" proposed by Freire (1971), which results from the tension between theory and practice, and which is constituted by cycles of reflection-action (Fals-Borda, 2008; Soliz and Maldonado, 2010; Villarroel and Cravero 2015); and in this way, to strengthen the community organization and the transference of technology from the horizontal and dialogic, rather than from the vertical, the imposing, and from convenience (Figure 4).

In the paradigms used by the humanities, it is considered that new ways of conceiving scientific knowledge appear in social restructuring and this is reflected in the relationships

Figure 4. Dialogue of contemporary knowledge about native corns with indigenous and mestizo families in Cañón del Usumacinta, Tabasco.

between physical, biological, psychological and anthropological systems (Torija-Aguilar, 2022), and with it, the openness to the dialogue of knowledge. In the ecology of knowledge, for example, the utopia of inter-knowledge is to learn other pieces of knowledge without forgetting your own (Santos, 2011).

Resorting to theoretical frameworks that foster social co-responsibility strengthens the coproduction processes of knowledge with social usefulness and biocultural pertinence, and with it, the epistemologies and ontologies of participants, which allows an appropriation of processes and prevents the abandonment of new cultivation techniques when the program that promoted them ends.

CONCLUSIONS

The MIAF has advantages regarding the agronomic and edaphoclimatic principles, although an important absence of studies from the humanities was detected. The MIAFs implemented and adapted by Sembrando Vida and recipients in Cañón del Usumacinta show advances in their implementation, although it is urgent for the agronomic principles proposed originally to be considered, as well as the current peasant knowledge.

The low consideration of agronomic principles of the original MIAF can cause the abandonment of milpa systems as a result of the reduction of the sowing space for meso and sotocrops. The main factors for this abandonment are the scarce management of fruit and timber-yielding trees that allows increasing shade over the compatible, the demand for labor time, and the increase in workforce, the necessary inputs and their costs.

This study proposes the incorporation of the Participatory Action Research for the development of the MIAF with epistemological, ontological and methodological foundations from the humanities for their scaling with biocultural pertinence.

It is necessary to monitor and provide tools for the families to strengthen reflection and decision making in the long term, since the presence of genetically modified corn accentuates the loss of food autonomy in Cañón del Usumacinta. The Sembrando Vida program can strengthen this monitoring since one of its goals is to achieve food self-sufficiency.

The trans-disciplinary collaboration between rural populations, government sectors and academia is urgent with the aim of stopping the advance of contamination of native corns, as well as researching and understanding its effects on the native corn varieties, in the environment and in human beings. This is possible based on theoretical-methodological frameworks that allow the participation of rural populations as full subjects in research-action processes.

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