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Adoption of the composting practice in the farmer field school of San Mateo Piñas, Oaxaca, Mexico

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Abstract: The adoption of agricultural technology is a process that involves the participation of various stakeholders. Evaluating this process is important for identifying factors that either limit or promote the use of new technologies in rural areas. The objective of this research was to estimate the degree of adoption of compost technology, as well as the variables that influence the use of this agroecological practice among small rural producers from a field school in the municipality of San Mateo Piñas, Oaxaca, Mexico. Using probabilistic sampling, 36 producers from a field school focused on coffee production were selected. A questionnaire was applied, covering topics related to socioeconomic and productive aspects, along with a technical sheet to evaluate the variables related to the adoption of compost. A total of 96% of producers reported being familiar with the technology, 88% had prepared and tested it in the field, and 54% had adopted it in the coffee production process. Additionally, a positive and moderate correlation was found, with a value of $r(21)=.456$, $p=.029$, between adoption and the variable related to the individual preparation of compost. The technical support provided through the field school approach facilitated the individual adoption of compost technology and identified areas of opportunity that could allow for greater degrees of adoption of new technologies.
Keywords: *Biofertilizers, Coffee, Extension, Learning by Doing, Training.*

1. Introduction

The Farmer Field School method was developed in Asia as an alternative to traditional technological training models, with a practical orientation focused on learning by doing [1], as well as actions related to food security and adaptation to climate change [2]. It has also been used to facilitate sustainable management, through the handling of surface organic matter when opening new lands for cultivation [3]. Other references have documented agroecological management to improve the production of various crops [4], demonstrating its application to a wide range of topics.

Based on the Farmer Field School methodology, since 2019, a program has been developed in Mexico that provides training and technical support to producers of various crops located in marginalized and indigenous areas of the country. This study refers to this method of technology transfer for coffee production, aimed at improving producers' knowledge and skills in production with an agroecological orientation, allowing them to improve their living conditions. In other words, the working methodology is based on Field Schools [5].

Various authors highlight the main characteristics of Farmer Field Schools, with the most important being the "learning by doing" approach, which gives it a practical, hands-on connotation, fully engaging the senses. This makes it suitable for adult populations with no or low levels of education [6]. The training process is participatory, emphasizing the sharing of knowledge and experiences. Activities

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are carried out in the producers' plots, where the training sessions and regular group meetings of the Farmer Field School take place [7] [8] [9] [10] [11] [12]

The Farmer Field School model, in addition to the participation of the professional technical team, includes a farmer actor with an innovative orientation in their daily activities, referred to as promoters, who have the role of learning and sharing their knowledge with their neighbors. According to Rogers and Shoemaker [13], these are individuals who have the ability to informally influence the attitudes and behaviors of others in a desired direction. That is, being part of the same group, they exhibit some characteristics typical of innovative individuals, such as having more external communication, being more cosmopolitan, and being more innovative. Once trained and convinced, they take on the role of promoters of new technologies, based on their own experience. They carry out this activity within their own communities, where they know their neighbors, generating greater trust among local producers. Additionally, they are available in the afternoons, on weekends, and during holidays [14].

After the Farmer Field School session, the field technician, along with the promoter, schedule and carry out the replication of the practice conducted, now with the working group from neighboring communities where the promoter belongs. After the replication, the field technician visits the producers at their plots to support them in the application of the practiced technologies, and, if necessary, provide advice on other topics related to the production process.

This article references the concepts of innovation and technology adoption. Initially, Rogers, in his diffusion of innovations theory published in 1962 [15], assumed that innovation is any new idea. However, this conception was subsequently redefined by various authors, understanding that innovation occurs in production processes when they have been adopted and, therefore, are generating economic resources. Moreover, it is recognized that the concept of innovation is diverse, encompassing organizational aspects, products, services, processes, marketing, among others [16] [17]

Regarding technology adoption, Cadena *et al.* [18] assume that it is a series of actions an individual goes through to decide whether to adopt or reject a technology. Sagustasme [19] emphasizes cognitive change as a key element in the decision to adopt or reject a technology. Rogers [15], in his diffusion of innovations theory, states that four elements must be present for the adoption of new ideas: Innovation, 2) Communication channels, 3) Time, and 4) Social system, and the process leading to adoption involves the actions of awareness, persuasion, decision, and confirmation [13].

Hoyo and Henao [20] present other methodological options for measuring adoption, highlighting the Technology Acceptance Model, which indicates that attitude, perceived usefulness, and perceived ease of use are fundamental elements for change.

Meanwhile, Damián *et al.* [21] have estimated the technology appropriation index using the complexity level of the technology as a weighting factor to estimate this index.

Finally, Sagustame *et al.* [19] propose viewing adoption as a process, considering initial aspects such as the acceptability index, followed by the acceptance index, adoption index, and finally impact studies. The latter is an interesting proposal as it allows for understanding the development of the adoption process, this is whether producers are aware of new technologies, if they are interested, if they are testing them in their production units, and ultimately if they are adopting them. Thus, understanding acceptance or rejection in the process allows for making the necessary adjustments in the way of working with producers.

The adoption process has various factors that limit or favor it. From Foster's [19] appreciation in his classic book "Traditional Cultures and Technical Change," he highlights the influence of human factors on technological development, such as cultural, social, and psychological barriers. This broadens the perspective regarding changes, which are not strictly technical but are related to the human aspect.

Other characteristics that are considered to influence adoption are: a) relative advantages, which refer to the perceived superiority of the innovation over the idea it replaces; b) compatibility, which is the degree of consistency between the innovation and existing values, previous experiences, and the needs of the recipients; c) complexity, which relates to the level of difficulty in understanding and using a new idea; d) trialability, understood as the degree to which it can be tested; and e) observability, which refers to the degree of visibility of the results of an innovation [15].

Rogers and Svenning [23] point out other factors, such as age, cosmopolitanism, empathy, and exposure to media. The CIMMYT Economics Program [24] adds the influence of farm size and availability of agricultural machinery.

Other factors have also been considered, such as the producer's attitudes towards technology, perceived usefulness and ease of use, access to production factors, traditional practices, migration, technical assistance, age, education level, household size, producer experience, contact with extension agents, socioeconomic conditions, characteristics of production systems, agricultural aspects, equipment availability, consideration of producers' needs, and the skills promoted in training [20] [25] [26] [27] [28] [29] [30]

Jiménez *et al.* [31] present a proposal that links the adoption of new technologies with networking, stating that no one can innovate beyond what their relationships allow, that is, the network connections of each person. Monge and Hartwich [32] agree, noting that those who have more contacts with other producers will have higher adoption rates.

Finally, other observations attribute the results of adoption to the working methods used in the Field Schools, namely, the learn-by-doing approach, the practical sense, and the training of promoters (Ramos *et al.*, 2018; Simba *et al.*, 2018; Noriega *et al.*, 2019; Villota *et al.*, 2023).

The aforementioned citations frame the understanding that adoption is a mental, individual process, consisting of a series of decisions leading to either the use or rejection of a given technology, influenced by various limiting or favorable factors.

With the reviewed literature, along with personal experience, the methodology used in this study has been structured and will be described in the corresponding section.

The objective of this research was to estimate the degree of adoption of composting technology, as well as to explore some relationships between adopting producers and various variables within the framework of the training and technical support program in the municipality of San Mateo Piñas, Oaxaca.

2. Materials and Methods

The study was conducted in 2024 in four communities within the municipality of San Mateo Piñas, Oaxaca. From a total of 67 producers, the sample was estimated using the formula proposed by Rendón and González (1989), which is specifically designed for studies where surveys are applied.

$$n = \frac{N\,K^2}{(N - 19\,)\delta^2 + K^2}$$

Where:
n = Sample size for multiple purposes.
N = Population size.
δ = Relative precision with respect to the population standard deviation (σ), a value between 0 and 1.
K = Value from the Z or t tables, when the distribution of the estimator is normal or approximately normal.

With the described formula, a sample of 36 producers, representing 54% of the total population, was selected. These producers were randomly chosen, and the interviews were conducted in their communities of residence.

Regarding the technology, compost, Sader [38] defines it as a solid, stable, and healthy organic fertilizer, derived from the degradation of any biodegradable waste (composting), where bacteria, fungi, actinomycetes, among others, participate. It is primarily composed of pre-humified organic matter, essential nutrients for plants and soil, as well as beneficial microorganisms.

The reference for correctly applying the technology was based on a technical sheet prepared by the technical team. This sheet described the way the producers were trained, considering the basic aspects of composting: the ingredients, quantities, preparation method, time required for it to be ready, and the characteristics indicating that the compost is ready for use. Additionally, it included recommendations for its use in the field.

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In this study, the premise is that the adoption determined will be attributed to this technical assistance initiative, as there had not been any previous systematic training or technical support from a field technician residing in the community. Therefore, the results will reflect the before-and-after scenario regarding the use of composting technology.

The methodology used to estimate adoption was based on the following aspects:

Whether producers are familiar with the technology, its functions, and the ingredients required for its preparation.

Whether they participated in group training courses conducted by the technical team, if they learned how to prepare it, if they know the timing of the process for its use, and their understanding of the conditions that indicate when it is ready for use. Additionally, whether producers have prepared compost individually in their homes or production units.

Whether producers are currently using the technology, if they will continue to use it, if they have shared information with other producers, and if they have made changes to the preparation method they learned from the technical team.

Based on the technical sheet prepared by the technical team, as well as the mentioned aspects, a weighting was made to assess the contribution of each aspect to the overall adoption (from zero to 100%), by specialists in the field of technology transfer and adoption, as follows: If the producer correctly knows the technology, including the ingredients, 20 points were assigned; if they participated in group preparation, learned how to prepare it, know when and how it is ready for use, have individually prepared it, and have applied the compost to their land, this accounts for 50 points; if they are now using it regularly and will continue using it, have shared it with other producers, and have made modifications to the preparation process, the value is 30 points, making a total of 100 points.

Field information was obtained through the use of two instruments: a) general participant data and b) data on compost technology.

The general data questionnaire included questions about personal aspects, participation in the training program, attendance at the trainings, visits by the technical team to the plots, attendance at exchange tours among producers, and the use of mobile communication devices (cell phones).

The information was recorded in Excel ©, and the analysis was carried out in SPSS © using descriptive statistics, given that most of the data are nominal and ordinal. The Spearman non-parametric correlation test was used.

3. Results and Discussion

The interviewed producers have an average age of 49 years, with the oldest being 80 years old and the youngest 21. An average age of 49 years is considered a productive stage. This age is similar to the national average [39] and higher compared to the average age of producers in the state of Oaxaca, which is around 45 years [40].

The education level of the producers is sixth grade of primary school, which corresponds to complete primary education, while those with higher education have completed secondary school. The education level of the producers in this study is lower compared to the state average, which is second grade of secondary school, and the national average, which is completed secondary school [41].

Gender participation is exceptional, as the participation of women exceeds that of men, with 65% women compared to 35% men. In other studies, it is common to find that male participation is higher, as noted by Morales *et al.* [6], where the proportion is 80% men and 20% women, while the national participation rate is 84% men and 16% women [40]. The reasons for the higher participation of women in this case are attributed to local customs that promote greater involvement of women in productive activities and the fact that technical support is provided by a woman.

Most of the interviewees live with partners; 50% are married, 28% are in cohabiting unions, and 22% are young singles. Only 6% of the interviewees speak the indigenous Zapotec language, even though the region is classified as indigenous. In this community, the indigenous language has practically become extinct.

The training and technical assistance program has been operational for five years. In the case of the interviewees, the average participation is three years; only three cases indicated that they have been

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involved for five years, which coincides with the program's operational period. The difference between the years of operation and participation is assumed to be due to the voluntary nature of the program, as it attracts producers who wish to learn new technologies, given that they do not receive any financial support.

Regarding the training sessions offered in the territory, the interviewed producers mentioned up to 33 different courses. The most frequently mentioned courses were those on composting (27), leachates (21), basic biol (18), traps for coffee borer beetles (10), coffee pruning (9), and coffee seedling production (6). Other courses mentioned less frequently included vermicomposting, control of coffee rust, transplanting, control of fall armyworm, preparation of liquors, sulfur-calcium broth, ash broth, terrace formation, grafting, Bordeaux mixture, mountain microorganisms, pest control, coffee management, coffee roasting, organic insecticides, and selective coffee harvesting, among others. From this total, the producers individually reported having participated in an average of seven courses.

Regarding the training format, specifically the working method of the Field Schools, which consists of the steps of theory, practice, and reflection-agreements, in the study, 88% of the producers correctly described the training procedure outlined for the Field Schools, while 12% did not recall the procedure.

As a complement to the training process, at the end of each session, the delivery of a written report containing information on the topic covered is considered. In this regard, the majority have not received the mentioned copy (58%), while 42% indicated that they have received it sporadically. It is assumed that the delivery of such a report is not a common practice of the field technician. The provision of the report allows producers to remember the doses and procedures, among other relevant aspects of the technologies.

After the group training, the field technician and the promoter carry out replication in neighboring communities, and subsequently, a visit by the technician to the producers' plots is scheduled. In this case, 86% of the interviewees indicated that they have received a visit from the technician at their plots, which is a high proportion, given that the territory is very dispersed and has long distances. Regarding the number of visits to the plots, producers reported that they have received the technician's visit, on average, four times, suggesting that good technical support is being provided in this territory.

Another activity considered in the methodology is the events called Exchange Tours of Experiences among producers. From the information obtained, it was found that the technical team is confused about this concept, as they organize training courses in one community and invite producers from other communities. Therefore, the work program consists of training conducted by the technical team, and as a result, the exchange of experiences among producers does not take place. This should be a good opportunity to strengthen the capacities developed in their respective communities under a farmer-to-farmer process [42] [43]

An innovative aspect of the study is the exploration of the use of mobile phones by producers in the process of training and technology dissemination. In the interviews, it was found that 67% of the respondents use mobile phones, and of those, 92% use the WhatsApp application. However, only 54% receive videos with agricultural information, which mainly comes from family members and other unspecified sources. Among those who use WhatsApp, 46% have recorded the training sessions, and of these, 82% have shared their recordings with other colleagues from the Field Schools and family members, primarily. Additionally, 55% claim they have received requests to share the videos. Some experiences indicate that in rural areas, there are limitations due to poor signal reception, which negatively affects the dissemination of information through this means [44].

In the case of the promoters or innovative producers, whose role is to support the field technician and act as a link with the producers, this study found that 50% of the respondents are familiar with the innovative producer, while the other half are not. This situation indicates that the field technician has not worked regularly with the promoter or innovative producer.

Adoption of the technology

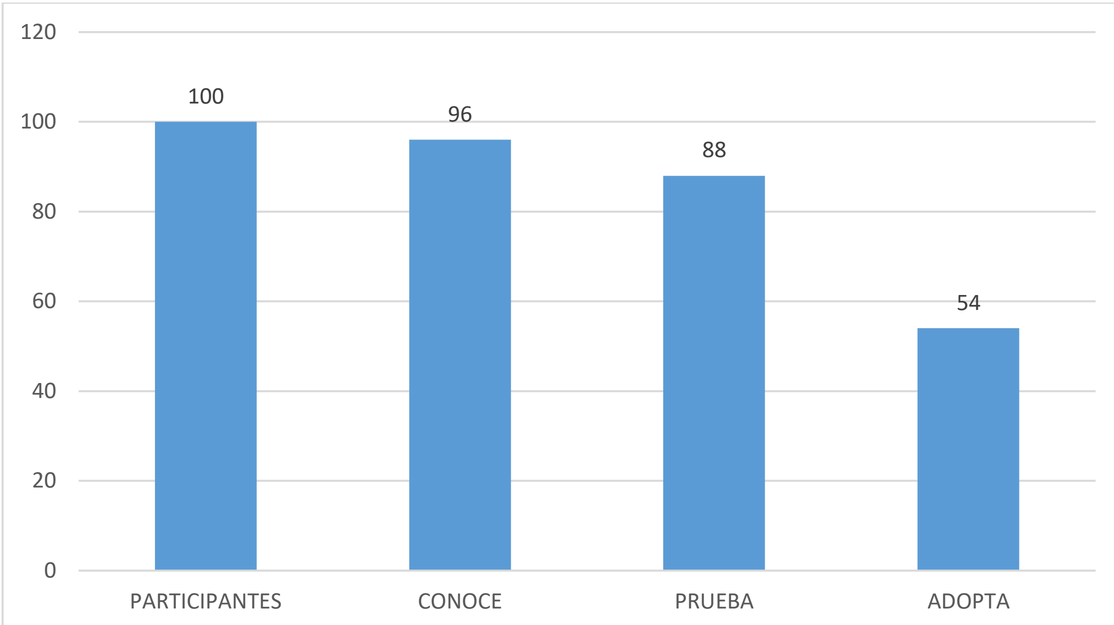

Figure 1.
Adoption process in percentage of compost technology among coffee producers in San Mateo Piñas, Oaxaca. 2024.

The results regarding the adoption process of compost technology can be seen in Figure 1. Out of 54 producers participating in the training for this agroecological technology, 96% indicated that they are familiar with the technology, 88% have produced and tested it in the field, and 54% of the producers reported that they have adopted and used it in the coffee production process in the municipality of San Mateo Piñas, Oaxaca. This percentage is higher than the work conducted by Barba et al. [44], who, in a study following the promotion of technologies for agroecological pest management in watermelon cultivation, found that 80% of producers had adopted less than 50% of the technological components, with the rest at less than 25% adoption.

While it is important to understand the results of training and technology promotion actions, it is considered even more relevant to know the prevailing situation in the process. That is, how many producers have a greater understanding of the technology? How many participate in group training? Above all, how many conducts individual trials, ultimately identifying or measuring how many producers move on to the adoption or rejection stage of the technology?

In this way, it was found that out of 100% of the participating producers, 96% are aware of compost, its functions, and the ingredients required for its preparation. In the stage of understanding the technology, the interviewees demonstrated that they know what compost is for, are familiar with the ingredients and the quantities needed. There are very few individuals who do not know the technology, suggesting that there was a good start to the training and adoption process for compost technology.

In the next stage, which is the testing phase, through collective training and learning, as well as individual testing, the proportion decreased to 88% of the participants. The producers at this stage are individuals who attended the training events organized and conducted by the field technician. Therefore, they accurately describe the process of preparing compost, the order in which the ingredients are mixed, the time that must pass for the product to be suitable for use, as well as the characteristics of smell and color that the compost should exhibit as indicators of whether it is ready for use.

It is important to describe this stage since it is an activity scheduled and directed by the technical team, which organizes the participation of attendees to form workgroups and carry out the necessary activities during the practice and the following days to provide the necessary care for the product to

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meet the required timelines. To achieve this, they schedule visits to turn and water the prepared product until it reaches the desired characteristics for use.

From the amount prepared, it is distributed among all the participants, who take it to their homes or production units for use. This practice is done as many times as the workgroup and the technical team consider necessary. In this group, the producers who prepared and used the compost individually in their production units are considered.

The final stage of the process is the adoption of the technology. Fifty-four percent of the participating producers adopted the technology for the preparation and use of compost. Thus, the adopting producers indicated that, based on group training and individual trials, they were convinced of the effectiveness of the product produced, especially when applied to plants, as results are seen immediately.

Regarding the **46%** of producers who did not adopt the technology, they are characterized by attending group training irregularly and occasionally making preparations individually. They mentioned that they find it difficult to obtain the necessary inputs, as well as the high prices associated with them. Another aspect of interest in the adoption of technologies relates to when adopters share their experiences with other producers. In this case, it was found that **32%** of those who have adopted the technology have shared their experiences with other producers, demonstrating their conviction towards the product.

It was also noted that three producers have made changes to the original method they learned for preparing compost. The changes mentioned include using other plant species and mixing manures from different animal species. This indicates that when individuals master a certain technology, they may adapt it, essentially reinventing the technologies.

To determine whether there is a relationship between the qualitative variable of compost adoption and the other variables recognized in the literature as influencing technology adoption, the Spearman correlation test was conducted. The results showed that, for this study, there is no correlation between compost adoption and the variables of age, gender, education level, marital status, years of participation in the program, number of courses attended, whether they received copies of the courses, whether they have received visits from the technician in their plots, whether they use mobile phones and WhatsApp, and whether they have recorded and shared videos of the practices.

Only the variable "has prepared compost individually" showed statistical significance ($p<0.05$). Thus, the results of the correlation between compost technology adoption and the variable related to individual compost preparation were moderate, with a value of $r_{(21)}=.456$, $p=.029$.

Table 1.
Spearman correlation results between the variables "adopted" and "has prepared the compost individually" among coffee producers in San Mateo Piñas, Oaxaca. 2024.

			Has prepared the compost individually	**Adopted**
Rho de spearman	Has prepared the compost individually	Correlation coefficient	1.000	0.456*
		Sig. (Bilateral)	.	0.029
		N	23	23
	Adopted	Correlation coefficient	0.456*	1.000
		Sig. (Bilateral)	0.029	.
		N	23	27

Note: *. The correlation is significant at the 0.05 level (bilateral).

It is assumed that the action of carrying out the practice individually, after the group training, triggers a series of questions for the person regarding the decision to adopt or reject the technology. Among the aspects that stand out are the usefulness of the technology, the potential for generating profits or savings, the ease or complexity of its preparation, the availability of the materials required for its preparation, the cost of inputs, and how easy or difficult it is to apply the technology, among others (Rogers and Svenning, 1973; Hoyos and Henao, 2022).

4. Conclusions

The training and technical support process based on the Field Schools enabled the adoption of the technology for the preparation and use of compost. Additionally, it was found that there are areas of opportunity that could allow for greater degrees of technology adoption.

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