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ADOPTION OF INNOVATIONS IN THE CULTIVATION OF CHILI IN THE HIGHLANDS OF SAN LUIS POTOSI

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Abstract: The objective was to calculate the Innovation Adoption Index (IAI) and the Innovation Adoption Rate (IAR) of chili producers in the Altiplano Potosino, through semi-structured surveys. The analysis of the Adoption Rate of Innovations showed that the most adopted innovations (100% of interviewed producers) were in the category of land preparation (disk plow and harrow), planting (transplanting dates and varieties recommended by the National Institute of Forestry, Agriculture and Livestock Research (INIFAP)), fertilization (use chemical fertilizer) and sustainable management (use of traps for pest control). The results showed that the most innovative producers adopted up to 81% of the evaluated innovations described in the catalog for the chili crop, while the least innovative made only 53%, generating a gap of 28%; it was also found that 60% of producers surveyed have a higher than average IAI (69%). The categories of the catalog of innovations studied, the most adopted were: fertilization, sanitation and harvesting.
Keywords: adoption, innovation, technologies, chili.

INTRODUCTION

Technological innovation results in well-being and organizational sustainability and sustainability for nations (Tejada *et al.,* 2019); therefore, countries must have research institutions that generate and promote the adoption of technology in the field. In 2022 Mexico ranked 58th out of 132 nations evaluated and third in Latin America, surpassed only by Chile and Brazil; the evaluation indicates that in knowledge creation it has 10.1 points, in knowledge dissemination 36.7 points, in impact of knowledge generated 26.1 and, in general, in research and development it has 29.9 points (Dutta *et al.*, 2022). The National Institute of Forestry, Agriculture and Livestock Research (INIFAP) is a public institution committed to scientific development in Mexico; its objective is to conduct research and generate technology for the development of forestry, agriculture and livestock, as well as the management and conservation of natural resources. Among the contributions of this institution is the development of technological packages for the integrated management of agricultural, livestock and forestry systems-products. INIFAP in the State of San Luis Potosí, in the agricultural area, has developed technological packages for the four zones (Huasteca, Middle, Central and Altiplano) of the State of San Luis Potosí through research on chile cultivation. Technological package of ancho, guajillo and other types of chili peppers with fertigation in the highlands of San Luis Potosí; serrano, jalapeño and other types of chili peppers with fertigation for the Huasteca plain; serrano and other types of chili peppers with fertigation in the middle zone of San Luis Potosí; ancho poblano chili peppers and other types of chili peppers with fertigation in the middle zone of San Luis Potosí.

In the state of San Luis Potosí, ancho, guajillo, and pasilla chile varieties are grown. The state ranks fourth in the country in chile production, which is grown in 28 municipalities located in the Altiplano, Central, Middle, and Huasteca zones; the total area planted is under irrigation conditions. In 2022, 24,835 hectares of chili were harvested, with a production of 150,664.90 tons and an average yield of 6.07 ton/ha, the production value was $ 5,198'704,000.00; the municipalities that stood out were Villa de Ramos (30,218.20 ton), Villa Guadalupe (13,646.45 ton), Venado (10,764.25 ton) in the High Plateau Zone and Ciudad Fernandez (20,399 ton) in the Middle Zone. The chile product is marketed in green and dry form. In 2022, the production of green chili was 104,896 tons and dry chili 45,768 tons (SIAP, 2023). Due to the impor-

tance of chili cultivation in the state, INIFAP has generated important technologies that, when implemented in the production system, have a favorable impact. To achieve adoption, there is a process of research, validation and transfer (SIAP, 2023).

Research and validation. INIFAP conducts scientific research and generates technologies that constitute a continuous multifactorial and dynamic process that occurs in a mega diverse environment, characterized by complex interactions between a range of diverse actors and conditions involved with rural development, consisting of a) Identification of the problem, b) Elaboration of a research project by specialists, c) Results are obtained through research, d) Validation of the technology, e) Dissemination through publications, events, etc., f) Adoption of the technology.

Transfer. Technology transfer is a collaborative process that allows scientific discoveries, knowledge and intellectual property to flow from creators to public and private users. It is the precise use of a given technology in the productive structure for the purpose of producing an object or service, (Aveldaño, 1999). The transfer of technology can be carried out through Field Schools, GGAVATT, etc. participatory models that INIFAP has generated (Cadena, 2015).

Adoption. There are several factors that determine adoption. Studies have identified the following as influential variables in the adoption of technology: age, schooling, relationship with agents of change (Cuevas et al., 2013). Sinde and Diéguez (2005), cite that the adoption of an innovation depends on: relative advantage, compatibility, complexity, cost, risk and uncertainty, expected profitability, communicability and testability. The relative advantage or degree to which the potential adopter perceives the new technology as superior to the one it replaces; the degree of compatibility or level at which the new technology can be incorporated; the complexity associated with the use of the new technology; the cost of the new technology; the risk and uncertainty associated with adoption; the expected profitability; the communicability or degree to which the results of using an innovation can be observed or described by others.

MATERIALS AND METHODS

The study was conducted in the agroecological region known as Altiplano Potosino, where the following municipalities are located: Villa de Arista located between parallels 22° 50' and 22° 30' north latitude; meridians 100° 39' and 100° 57' west longitude; altitude between 1,500 and 2,300 masl; dry semi-warm climate; average annual temperature of 18 °C and precipitation of 300-500 mm. Montezuma, located between parallels 22° 54' and 22° 30' north latitude; meridians 100° 49' and 101° 31' west longitude; altitude between 1,600 and 2,600 masl; semi-dry temperate climate; average annual temperature 18 °C and precipitation of 300-500 mm. Delegation of Bocas in the municipality of San Luis Potosí; Bocas is bordered to the north by Moctezuma and Villa de Arista.

Non-experimental transactional descriptive research was used and based on the Technological Packages generated and validated by INIFAP research personnel at the San Luis Experimental Field, a semi-structured survey was designed to be applied to the chili producers. The municipalities, localities and producers were selected through non-probabilistic sampling organized mainly to capture the agronomic management that the producers carry out in the chili crop, to later compare it with the recommendations given to them through the technological packages generated by INIFAP and authorized by the Ministry of Agriculture, which have been intensively disseminated since 2010 to date.

The survey was designed to collect information in two sections: A) General characteristics of the producer and the production unit; B). Technical-productive characterization or management of the production unit. The catalog of innovations was elaborated based on the management specifications suggested in each of the technological packages of the chili crop (Table 1), which allowed the calculation of the Innovation Adoption Index (IAI) and the Innovation Adoption Rate (IAR), using the methodology proposed by Muñoz *et al*. (2007).

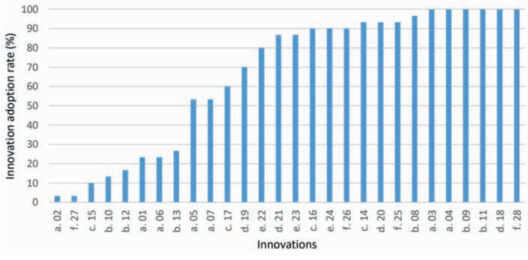
Category	Innovations
a. Land preparation	a. 01 Clean and weed; a. 02 Multi-ploughing/ Subsoiling; a. 03 Harrowing; a. 04 Furrowing; 05. Mulching; a. 06 80 or 100 gauge plastic; a. 07 Silver/black mulch.
b. Sowing	b. 08 Seedling production; b. 09 Transplanting date; b. 10 Seed treatment; b. 11 Variety recommended by INIFAP; b. 12 Single row planting; b. 13 Planting density (42,000 plants/ha; 30 cm between plants and 80 cm between rows);
c. Irrigation	c. 14 Uses irrigation tape; c. 15 Uses tensiometer; c. 16 Uses 5 or 6 mil gauge tape; c. 17 30 cm drippers.
d. Fertilization	d. 18 Uses chemical fertilizers; d. 19 Recommended dosage (180-90-00 kg/ha of phosphonitrate and 85 kg of phosphoric acid); d. 20 Fertigation; d. 21 Applies foliar fertilizers.
e. Sanitation	e. 22 Perform mechanical/manual weed control; e. 23 Perform chemical pest control; e. 24 Perform disease control.
f. Harvest	f. 25 Harvesting takes into account the color of the fruit; f. 26 Harvest (June-September); f. 27 Cutting intervals are 20-25 days; f. 28 Make two to three cuts.

Table 1. Catalog of innovations in chili production, municipalities of Villa de Arista, Moctezuma, Bocas, state of San Luis Potosí.

Application of the surveys: they were applied in person to the owners and/or managers (stewards) and, in some cases, to external technicians who advise the producers. Data analysis: the responses were systematized in an Excel database and the Innovation Adoption Index (IAI) and the Innovation Adoption Rate (IAR) were obtained for each of the crops. This was based on the application of the procedure and formulas for the estimation of the IAI and the IAR, described by Aguilar *et al*., (2020).

RESULTS AND DISCUSSION

The analysis of the Innovation Adoption Rate (IAR) showed that the most adopted innovations (100% of farmers interviewed) were in the category of land preparation (disk plowing and harrowing), planting (transplanting dates and varieties recommended by INIFAP), fertilization (using chemical fertilizer) and sustainable management (using traps for pest control). The innovations that registered the lowest adoption rate were multi-plowing/ subsoiling, which is within the category of land preparation, cutting intervals in the category of sustainable management, followed by the innovation of using a tensiometer in the category of irrigation and, in the category of planting, seed treatment; all of the above with less than 20% of the rate of adoption of innovations (Figure 1).



Adoption Rate of Innovations of chili producers, municipalities of Villa de Arista, Moctezuma, Bocas delegation, municipality of San Luis Potosi.

The results showed that the most innovative producers adopted up to 81% of the evaluated innovations described in the catalog for chili cultivation, while the least innovative made only 53%, generating a gap of 28% (Figure 2); it was also found that 60% of surveyed producers have a higher than average IAI (69%). It can be observed that, in general, producers

who grow chili adopt many of the innovations (minimum 53%), which is highly correlated with the investment for the application of the technological package for the cultivation of chili in the Altiplano Potosino, in 2023 is estimated at $191,000.00 per hectare and, a Benefit-Cost Ratio of 2.35. The highest cost of the technological package is applied in the health component with 33.0%, followed by innovations in the planting component with 22.3% and harvesting with 15.7%. The higher investment in crop health is related to what Barrón *et al.* (2020), where they indicate that there is a resurgence of viral diseases transmitted by whitefly *(Bimisia tabaci*) Biotype B, in the chili crop in central and northern Mexico despite the implementation of the integrated pest management strategy; therefore, the adoption rate of technologies is high (69% on average) in the chili crop, due to the susceptibility of the crop to pests and diseases in the first 50 days of establishment.

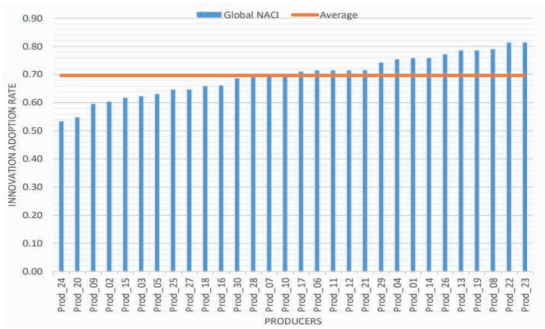
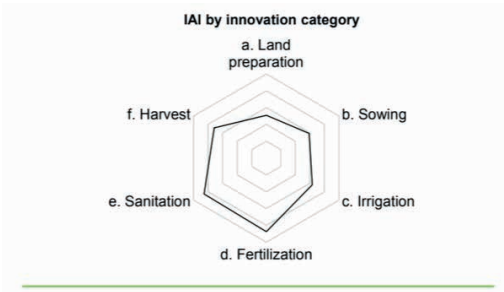


Figure 2. Innovation Adoption Index (IAI) of chili producers, municipalities of Villa de Arista, Moctezuma, delegation of Bocas municipality of San Luis Potosi.

Figure 3 shows that of the six categories in the catalog of innovations, the most adopted were: fertilization, sanitation and harvesting. On the other hand, the categories with the least adoption are those related to land preparation and planting; however, even though they are the least adopted, they maintain a degree of adoption of at least 50%, mainly the transplanting date and the varieties recommended by INIFAP, on which the production yield per hectare, estimated at 30 tons, will depend to a large extent.



Innovation Adoption Index by category, of chili producers, in the municipalities of Villa de Arista, Moctezuma, Bocas delegation, municipality of San Luis Potosi.

CONCLUSIONS

In the cultivation of chili, the Innovation Adoption Rate (IAR) indicates that not all innovations are fully adopted, however, some innovations suggested by INIFAP are used. The innovations with the highest adoption are in the category of land preparation (fallow and harrowing), planting (transplanting dates and varieties recommended by INIFAP), fertilization (using chemical fertilizer) and sustainable management (using traps for pest control). The Innovation Adoption Index (IAI) indicates that all farmers use the technologies suggested by INIFAP. However, these technologies are adopted partially, not completely. The categories of the catalog of innovations studied, the most adopted were: fertilization, sanitation and harvesting.

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