

Dragon fruit (*Hylocereus undatus*) crop yield: an analysis of innovations

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ABSTRACT

Objective: to analyze the impact of innovations on the productivity of pitahaya cultivation in the state of Puebla, Mexico.

Design/Methodology/Approach: twenty-six pitahaya producers were surveyed in seven municipalities of Puebla. The profiles of producers were analyzed in terms of education and age. Thirty activities that influence crop productivity were evaluated, and the innovation adoption indices (InAI) and innovation adoption rates (IAR) were calculated.

Results: the average IAR (innovation adoption rate) is below 40%. The application of organic matter as a soil amendment is the most widely adopted practice, while management and financial record-keeping are areas that producers have neglected. Crucial activities for improving productivity that producers should implement were identified, such as post-harvest fruit handling, pollination management, and genetic management. Our results suggest that these activities may be poorly executed.

Limitations/Implications of the study: the low availability of time of the producers and the large size of the area, generate difficulties for face surveys or more extent and frequent field visits.

Findings/Conclusions: a trend was found, although not universal, indicating that higher InAI is associated with higher crop yield. Therefore, the correct implementation of innovative activities is crucial for improving yield.

Keywords: innovation adoption index, innovation adoption rate, indexes, productivity, pitahaya, nutraceutical fruits.

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INTRODUCTION

Dragon fruit (*Hylocereus undatus*), called pitahaya in Mexico, is an exotic fruit with sweet pulp that has gained popularity in international markets in recent decades, due to its flavor and nutraceutical contributions (Ramírez, 2007).



In Mexico, pitahaya cultivation has experienced a notable increase in production, as observed in the state of Puebla (ASERCA, 2000). This phenomenon is largely due to innovations in cultivation techniques and agricultural management, which have significantly contributed to improving the quality and quantity of the fruit in this region (Ortiz-Hernández, 2000; Nerd *et al.*, 2002; Santacruz-Vázquez *et al.*, 2009).

Puebla, a state located in central Mexico, offers ideal climatic and geographic conditions for dragon fruit cultivation (Valiente-Banuet *et al.*, 2007). Warm temperatures and moderate altitude provide a favorable environment for the development of this species, which has fostered steady growth in dragon fruit production in the region (SIACON, 2023). Furthermore, cultivation techniques and agricultural practices have evolved significantly over the years (Meraz-Alvarado *et al.*, 2003).

This study aimed to investigate and analyze in depth the influence of various innovations in agricultural management on the productivity of dragon fruit cultivation in Puebla. Advances in cultivation techniques, pest and disease management, irrigation systems, fertilization, and harvesting practices, among other relevant aspects, were examined. Through this analysis we intend not only to document the progress made in dragon fruit cultivation in the region, but also to understand the role these innovations have played in this crop expansion and consolidation as a strategic agricultural activity.

Furthermore, we seek to highlight the relevance of dragon fruit as a crop with high potential to contribute to the sustainable development of agriculture in Puebla and to generate new economic opportunities in other parts of the country. For all the above, the objective was to analyze the impact of innovations on the productivity of dragon fruit cultivation in the state of Puebla, Mexico.

MATERIALS AND METHODS

An environmental analysis was conducted to identify the largest and most productive areas for this crop in the state of Puebla. The information sources consulted for this analysis belong to institutions, universities, and research centers such as USDA (2022), SIACON (2023), and INIFAP (2023).

The methodology was based on the recommendations made by Brandenburger and Nalebuff adapted by Muñoz & Santoyo (2011), starting with the design of a baseline survey that included categories of personal data and some details of the activity, such as the influence it has on their income and the time they have managed this crop; questions related to the dynamics of sales and the different technologies they implement in the cultivation systems were included.

Twenty-six dragon fruit producers from seven municipalities in the state of Puebla were interviewed. The 'snowball' sampling method proposed by Goodman (1961) was used. The baseline survey focused on 36 basic activities for optimal crop development, classified into seven categories: nutrition, health, reproduction, establishing and management of plantations, types of trellising systems, administration, harvesting, and post-harvest handling.

Once the information was systematized, the values of the innovation adoption index (InAI) and the innovation adoption rate (IAR) were determined using the methodology of Muñoz *et al.* (2007) with the following equations:

$$InAI_{jk} = \frac{\sum_{i=1}^n Innov_{jk}}{n}$$

where: $InAI_{ik}$ is the innovation adoption index of the i -th producer in the k -th category; $Innov_{jk}$ is the presence of one innovation of the k -th category in the management of a j -th producer; n is the total number of innovations in the k -th category.

$$IAR = \frac{\text{Number of producers adopting the X innovation}}{\text{Total number of innovations}} \times 100$$

where: IAR is the innovation adoption rate, which is equal to the number of producers adopting the X innovation divided by the total of interviewed producers that adopt innovation, then this quotient is multiplied by 100 to get the value in percentage. These values were proposed to determine the innovative capacity of producers by quantifying the number of practices implemented by one producer at a given time, in regard to the total number of practices that must be done to achieve efficiency.

Graphs were prepared to allow comparisons and analysis of trends and behaviors presented by the parameters of the research, based on the information collected in the surveys.

RESULTS AND DISCUSSION

The implementation of 30 activities was evaluated, which influenced crop productivity of dragon fruit. The information obtained shows that the surveyed producers have varied profiles. The highest level of education is doctorate, but junior-high education accounts for the majority of respondents (26). The average age of producers is 42 years. Regarding the innovation adoption index, InAI values ranged from 0.15 to 0.7, with an average of 0.37 for this index (Figure 1).

In the innovation adoption rate (Figure 2), the overall IAR average was below 40%. The practice with the highest adoption rate is the incorporation of organic matter into the

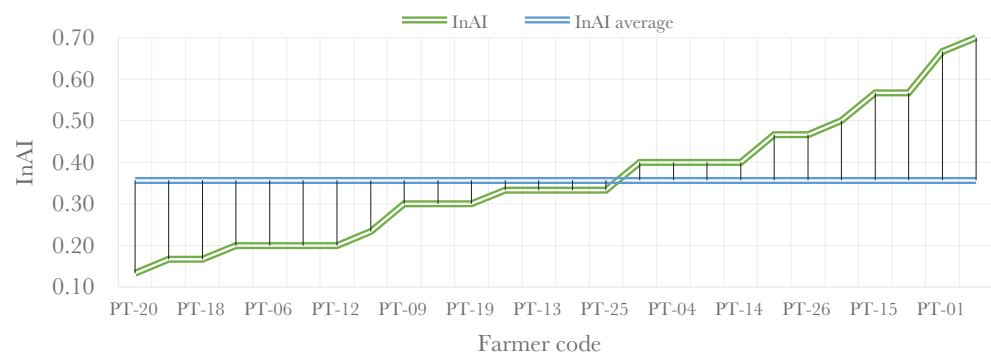


Figure 1. Innovation adoption index (InAI) for each of the producers interviewed in the state of Puebla, Mexico. Eje X: Producer; Eje Y: InAI; Legend: InAI, InAI average

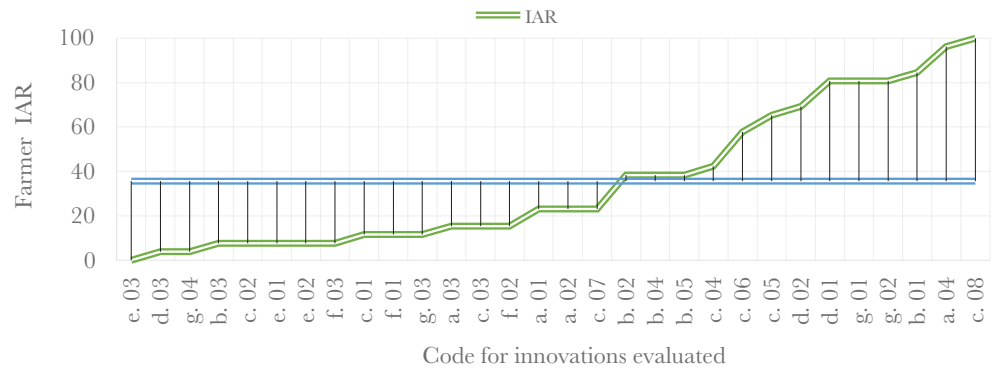


Figure 2. Innovation adoption rates (IAR) of 26 producers of dragon fruit (*Hylocereus undatus*) in the state of Puebla, Mexico. Eje X: Innovations evaluated; Eje Y: IAR of the producers.

soil, while key activities such as agricultural management, financial and administration record-keeping are completely neglected by all the producers (100%).

The analysis made it possible to identify fundamental practices to address persistent problems in the production system, including the proper handling of ripe fruit on the plant to avoid damage by birds, an efficient pollination system, and germplasm management. All of which are aimed at improving productivity and strengthening an integrated pest and disease control.

Regarding these three critical areas, although all producers claim to be taking steps to address them, the results we obtained are varied. This suggests that, while there is a general awareness of the importance of these aspects, many producers may lack the necessary technical information to implement them correctly; this leads to variability in the levels of productivity achieved.

For the group of producers interviewed, results show an overall trend in which a higher innovation adoption index (InAI) is associated with increased crop yield. However, cases were also identified where this relationship was not consistently observed (Figure 3). This situation suggests that, although producers may implement innovative practices, these may not be executed properly, limiting their effectiveness and preventing them from generating a positive impact on dragon fruit yield.

Based on the InAI values related to the different innovation categories, reclassified by municipality (Figure 4 and Figure 5), we observed that even though 96% of producers reported taking action on crop nutrition, those with the best yield results focused their innovations on nutrition (Figure 4). These improvements were achieved throughout management, through technical assistance, soil analysis, and organic and chemical-based nutrition. Whereas, producers with low yields mentioned that they added organic matter only at the time of planting.

Lira (2011) evaluated the effect of different organic fertilizers and nutrient solutions on dragon fruit plant growth, obtaining significant effects on its vegetative development. According to the graph curves, in these municipalities it is also necessary to address plant health (Figure 5), focusing on integrated pest and disease management. It is key, as well,

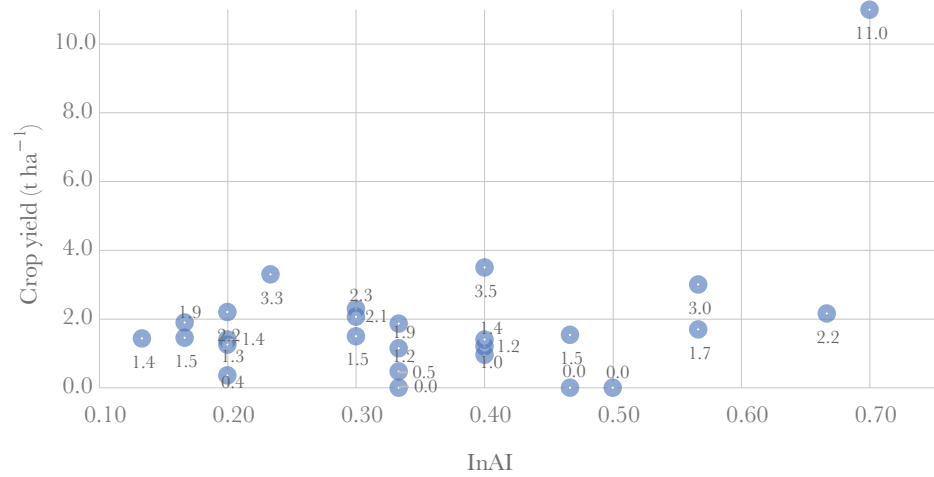


Figure 3. Relation of the innovation adoption index (InAI) to crop yield of dragon fruit (*Hylocereus undatus*) for producers in the state of Puebla, Mexico. Eje Y: Crop yield (t ha⁻¹); Eje X: InAI.

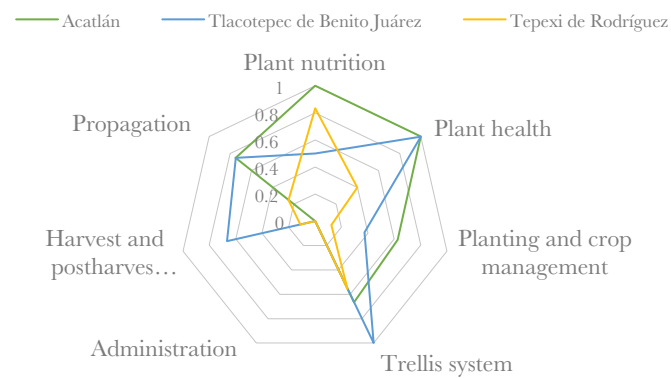


Figure 4. Innovation Adoption Index (InAI) by innovation category of the most outstanding municipalities in dragon fruit (*Hylocereus undatus*) yield in the state of Puebla, Mexico.

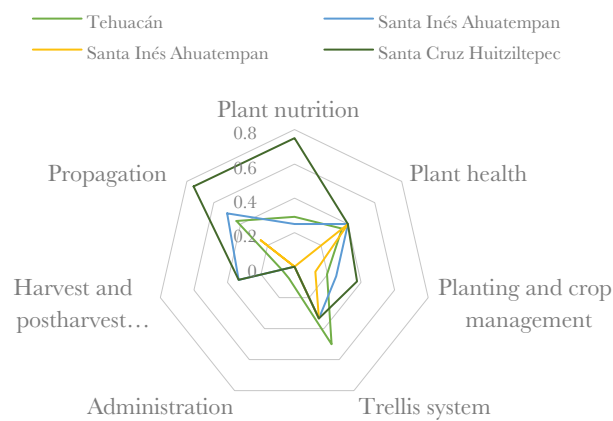


Figure 5. Innovation Adoption Index (InAI) by innovation category of the least outstanding municipalities in dragon fruit (*Hylocereus undatus*) production in the state of Puebla, Mexico.

to improve trellising systems for optimal pruning practices; also for sanitation pruning and pruning to increase number of fruits.

Alongside to the data obtained in the analysis, the surveys applied allowed us obtaining comments from producers that suggest apathy towards receiving technical knowledge that would support them in the development of the innovation categories determined in this analysis as keys for the development of crop yield. These issues on attitudes are important, since failures in technical knowledge tend to limit the appropriate adoption of the innovations.

CONCLUSIONS

The results indicate that dragon fruit yield among the interviewed producers does not depend solely on the number of innovations adopted. Since adopting innovative practices alone does not guarantee an increased yield. Moreover, type of innovation and proper implementation were the determining factors.

Innovations with the greatest impact are those that focused on key aspects such as crop nutrition, pest & disease control practices, and improvement of trellising systems; these aspects directly affect production efficiency and sustainability of this agricultural crop.

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