Pests and diseases in coffee (*Coffea arabica* L.) production in two municipalities of the State of Puebla

Ramírez-Valverde, Benito[1]; Ramírez-Suárez, José Gustavo[1]; Juárez-Sánchez, José Pedro[1*]

[1] Colegio de Postgraduados Campus Puebla. Santiago Momoxpan, Municipio de San Pedro Cholula, Puebla, México. C. P. 72760.
* Correspondence: pjuarez@colpos.mx

ABSTRACT
Objective: To analyze the presence and impact of pests and diseases on coffee production in two indigenous communities in the state of Puebla.
Design/Methodology/Approach: Information was collected through interviews with 57 growers in Huehuetla and 52 in Cuetzalan.
Results: The coffee area sown in the region is made up of very small *minifundios* (very small plots, not big enough to produce profits), which reflects the challenging living conditions of coffee farming families. A statistically significant difference in yield was recorded between municipalities (t=2.348; p=0.021). The coffee varieties grown in the region include: Typica, Caturra, Mundo Novo, Garnica, and Bourbon. Pests and diseases were found in the plots of the farmers. The most prevalent pests and diseases were the coffee berry borer and the coffee leaf rust, found in 57 and 42.9% of the farms. In the case of coffee leaf rust, statistically significant differences were recorded (χ^2=3.906; p=0.048) between the two municipalities, with a higher prevalence in Cuetzalan (53.1%) than in Huehuetla (33.9%). Additional pests and diseases were identified, including American leaf spot (24.8%), pellicularia koleroga (7.9%), cercospora leaf spot (6.9%), coffee white stem borer (6.1%), root rot (6%), and coffee leaf miner (3%). Chemical treatments are used to control most of these pests and diseases.
Study Limitations/Implications: The detection of pests and diseases depended on the perception of the grower.
Findings/Conclusions: Coffee growers in these municipalities are among the poorest of the region. Furthermore, their crops are impacted by pests and diseases, which increase their already challenging living conditions.

Keywords: living conditions, chemical control, poverty.

Citation: Ramírez-Valverde, B., Ramírez-Suárez, J. G., & Juárez-Sánchez, J.P. (2024). Pests and diseases in coffee (*Coffea arabica* L.) production in two municipalities of the State of Puebla. *Agro Productividad*. https://doi.org/ 10.32854/agrop.v17i12.3192

Academic Editor: Jorge Cadena Iñiguez
Associate Editor: Dra. Lucero del Mar Ruiz Posadas
Guest Editor: Daniel Alejandro Cadena Zamudio

Received: June 28, 2024.
Accepted: November 13, 2024.
Published on-line: December XX, 2024.

Agro Productividad, 17(12). December. 2024. pp: 153-159.

INTRODUCTION

Coffee plays a key role in Mexican economy, society, culture, and environment. It is cultivated in twelve states across an area of approximately 800,000 hectares (Aguirre-Cadena *et al.*, 2012). Most coffee growers in Mexico are poor and live in indigenous regions. In addition, they operate under extreme *minifundio* conditions.

Coffee production in Mexico has declined in recent years. This situation is attributable to several factors, mainly pests and diseases. As a result of the coffee price crisis and off-farm employment increase, growers have reduced the time and attention they dedicate to coffee plantations, making them more vulnerable to pest and disease infestations, such as coffee leaf rust (Henderson, 2019). The objective of this research was to analyze the presence and impact of pests and diseases in the coffee cultivation areas of two municipalities in the state of Puebla.

MATERIALS AND METHODS

Study area

The two municipalities selected for this research were Cuetzalan del Progreso and Huehuetla. Both are located in northern Puebla.

Cuetzalan has 51,823 inhabitants, 33,308 out of which are Nahuatl. The area is highly marginalized and a large part of its population lives in extreme poverty (Secretaría del Bienestar, 2024a). It is located between 20° 02' and 20° 10' N and 97° 35' and 97° 40' W. Cuetzalan is located at an altitude ranging from 200 to 1,100 m.a.s.l. and has a temperature of 18-24 °C, with a precipitation of 2,900-3,600 mm. Its climate is semi-warm and humid with rainfall all year round (100%). Fifty-two-point-six percent of its soil is used for agriculture (INEGI, 2024a).

Huehuetla has 22,122 inhabitants, 13,755 out of which are Totonac. The area is highly marginalized and 83.62% of the population lives in poverty (Secretaría del Bienestar, 2024b). Huehuetla is located between 19° 57' and 20° 06' N and 97° 23' and 97° 35' W, at 180-1,600 m.a.s.l. The temperature of the area ranges between 18 and 25 °C, with a 1,900-4,100 mm precipitation. Huehuetla has a semi-warm humid climate with rainfall all year round (99.12%). Sixty-four percent of the land is used for agriculture (INEGI, 2024b).

Statistical analysis

A survey was conducted among coffee growers in the municipalities of Huehuetla (n=57) and Cuetzalan (n=52). Parametric and non-parametric tests were used for the statistical analysis, according to the scale of measurement of the variable.

RESULTS AND DISCUSSION

Coffee growers were 56.9 years old in Huehuetla and 55.1 years old in Cuetzalan. These results match those reported by Alvarado-Méndez *et al.* (2006).

Like most coffee growers in the country, the farmers of these municipalities grow coffee in small plots. In Huehuetla, most growers (84.2%) cultivate coffee in a single plot, with an average area of 1.32 ha (s=1.86). Meanwhile, coffee growers (67.3%) in Cuetzalan grow coffee in a single plot, with an average area of 1.56 ha (s=1.86). This result is consistent with the findings of Benítez-García *et al.* (2015), who reported that plots in Cuetzalan had a 1.57 ha average area. No statistically significant differences were identified between the area owned by growers in the two municipalities ($t=-0.679$; $p=0.499$). Coffee is the main crop of the region and the *minifundio* systems contributes to the poverty of the families that grow coffee as their main income.

Regarding tenure, all the growers in Huehuetla and 96.2% in Cuetzalan own their lands (private property), while the remaining 3.8% of the producers from Cuetzalan rent land to grow coffee.

Producers grow one, two, or three coffee varieties, accounting for 66.1%, 22.9%, and 9.2%, respectively. A comparison of the two municipalities reveals a high similarity between them. In Huehuetla, 70.2% of producers grow one variety, while 22.8% grow two varieties. Meanwhile, in Cuetzalan, 61.5% of producers grow one coffee variety and 23.1% grow two varieties.

Typica is the most popular variety (34.5% of the growers) in the two municipalities. Nearly a quarter (24.1%) of the farmers grow Caturra, while Mundo Novo accounts for a slight lower percentage (22.1%). The remaining percentage is covered by other coffee varieties grown in the area. In Cuetzalan, Typica and Caturra are the most cultivated varieties. In contrast, the interviewees from Huehuetla mainly mentioned Mundo Novo and Typica. In face of the emergence of coffee leaf rust, new varieties resistant to this fungal disease are being promoted in the area.

Agricultural practices

The prevalence of pests and diseases in the Sierra Norte de Puebla has prompted alterations in coffee production technology (Barrera *et al.*, 2021). In the study area, coffee is intercropped with seasonal and perennial crops, which are used as shade trees. An additional crop is grown on 28% of the plots. Two and three crops are grown along with coffee on 19.6 and 30.8% of the plots, respectively. Other polycultures include four (8.4%) and five (9.4%) additional crops. Finally, six different crops are grown on 3.7% of the plots. Some farmers grow staple food crops, including corn, beans, and chili. Regarding shade trees, chalahuite (*Inga spuria*) can be found in 31% of the plots, orange (*Citrus* spp.) in 19%, pepper (*Pimenta dioca*) in 15.7%, and banana (*Musa paradisiaca*) in 14.8%. Meanwhile, species such as bamboo (*Bambusa* spp.), mamey (*Pouteria sapota*), and red cedar (*Cedrela odorata*) can be found in the rest of the plots.

Only one-third of the surveyed growers applied fertilizers and 46.5% of them used chemical fertilizers. Most coffee growers (94.7%) used manual weed control methods, while 5.4% used herbicides.

Pests and diseases

The presence of pests and diseases is evident in the plots of the farmers. In a study conducted in the Sierra Norte de Puebla, Lugo-Morín *et al.* (2018) established that two pests (coffee berry borer and leaf miner) and three diseases (coffee leaf rust, cercospora leaf spot, and American leaf spot) cause the greatest economic losses.

Coffee berry borers were found in 57% of the farms (Table 1) and, according to Leyva (2010), they cause the greatest damage to the crop. This insect was found in 49.1% and 66% of the plots in Huehuetla and Cuetzalan, respectively. No statistically significant differences were found between the two municipalities ($\chi^2=3.096$; $p=0.059$).

A total of 80.3% growers were able to control the pest (89.3% in Huehuetla and 72.7% in Cuetzalan). Regarding control methods, 14.3% of coffee farmers used

Table 1. Pests and diseases of coffee crops in the municipalities of Huehuetla and Cuetzalan.

Pests / diseases	Huehuetla		Cuetzalan		Total		p
	F	%	F	%	F	%	
Broca del café (*Hypothenemus hampei*)	28	49.1	33	66	61	57	0.059^{χ}
Minador de la hoja (*Leucoptera coffeella*)	1	2	2	4.2	3	3	
Arañero (*Oligonychus coffeae*)	1	2	0	0	1	1	
Barrenador de tallo (*Xylosandrus compactus*)	1	2	5	10.4	6	6.1	
Roya del café (*Hemileia vastatrix*)	19	33.9	26	53.1	45	42.9	0.048^{χ}
Ojo de gallo (*Mycena citricolor*)	17	30.9	9	18	26	24.8	0.096^{χ}
Mancha de hierro (*Cercospora coffeicola*)	5	9.4	5	4.1	7	6.9	0.252^{F}
Mal de hilachas (*Pellicularia koleroga*)	4	7.7	4	8.2	8	7.9	0.608^{F}
Pudrición de la raíz (*Fusarium* spp.)	2	3.9	4	6.2	6	6	
Mal Rosado (*Corticium salmonicolor*)	1	1.9	1	2.1	2	2	

Note: Significance obtained by Chi-square test (χ) or Fisher's Exact Test (F). Source: field work.

traditional methods, 40.8% applied biological methods, and 44.9% implemented chemical procedures. The distribution of control methods across municipalities had a similar pattern. In Huehuetla, 16.7, 41.7, and 41.7% of growers used traditional control methods, chemical products, and biological control, respectively. In Cuetzalan, 12, 48, and 40% of growers used traditional control, chemical products, and biological control, respectively.

Most growers (82.3%) indicated that this insect causes minimal or regular damage to their crops. In contrast, the rest (17.7%) considered this pest a serious problem that causes substantial or severe damage to their coffee plots. The Mann-Whitney test ($U=327.00$; $p=0.804$) showed highly similar percentages in both municipalities, with no statistically significant differences between them. Furthermore, a lower incidence of other pests was reported in the municipalities under study, including the red spider mite (1%), the coffee leaf miner (3%), and the coffee white stem borer (6%).

Regarding diseases, coffee leaf rust has spread throughout the coffee producing states, impacting ≈256,973 ha. Coffee leaf rust is the most important disease, because it drastically reduces crop yield (Leyva, 2010).

Coffee leaf rust was found in 42.9% of the farms. A statistically significant difference ($\chi^2=3.906$; $p=0.048$) was established between the two municipalities. This disease was found in 33.9% and in 53.1% of the plots in Huehuetla and Cuetzalan, respectively. The coffee leaf rust infestation was higher in Cuetzalan; however, this percentage was lower than the percentage reported (92.5%) by Cardeña-Basilio *et al.* (2023) for the municipality of Hueytamalco, located in the Sierra Nororiental de Puebla.

A total of 69.6% of growers use some type of control against coffee leaf rust; no statistically significant differences were found between the two regions (68.4% in Huehuetla and 70.4% in Cuetzalan). Cardeña-Basilio *et al.* (2023) obtained similar results (71%) in Hueytamalco. Meanwhile, 14.7% of the producers interviewed for this research implemented traditional control measures to manage the disease (21.4% in Huehuetla and 10% in Cuetzalan). For

their part, 17.6% of the growers mentioned that they use biological control measures (21.4% in Huehuetla and 10% in Cuetzalan), while 67.7% reported the use of chemical fungicides (64% in Huehuetla and 70% in Cuetzalan). Escamilla (2016) pointed out that the use of fungicides is one of the strategies employed by governments and some growers as a short-term solution for the problem. However, the inappropriate application of fungicides may contribute to the increase of coffee leaf rust. This opinion is also shared by Cardeña-Basilio *et al.* (2019), who mentioned that chemical application is often haphazard and lacks the required technical support.

In terms of the impact of this disease on coffee plantations, 50% of growers indicated that the damage was still slight, 27.8% stated that it was regular, 16.7% reported that the damage was severe, and 5.6% mentioned that the impact on their coffee plantation was very severe. The Mann-Whitney test found no statistically significant differences between the two municipalities ($U=122.5$; $p=0.335$).

Additionally, other diseases were detected, including American leaf spot (24.8%), cercospora leaf spot (6.9%), pellicularia koleroga (7.9%), and root rot (6%). According to the information collected, most growers whose crops were infested faced diseases such as American leaf spot (57.7%), cercospora leaf spot (71.4%), and pellicularia koleroga (62.5%). Despite the relatively low incidence of root rot, 66.7% of the producers with infested crops said they made efforts to control it. Chemical control was the most frequently used method against the American leaf spot, accounting for 64.7% of the total cases. Nevertheless, 80% of growers implemented chemical control measures to control cercospora leaf spot, while 71.4% used fungicides to tackle pellicularia koleroga. Despite the limited number of plots impacted by these diseases, the use of chemicals increases the production costs of the crop. Additionally, the yield damage caused by these diseases in most cases ranged from minimal to regular (68.8% American leaf spot, 66% cercospora leaf spot, and 75% pellicularia koleroga).

Although the damage was relatively minor, diseases and pests had a significant impact on both production costs and yields. Consequently, implementing plans to increase productivity through the use of agrochemicals would offer short-term advantages. However, the economic cost and ecological damage of such plans would also be considerable (Aguirre-Cadena *et al.*, 2012). According to the survey, 14% of growers reported lack of increase in production during the last few years, while 2.8, 12.1, and 29.9% reported a notable, modest, and slight increase, respectively. Meanwhile, 29.9% of growers pointed out that coffee yields have suffered a slight decline and 41.1% believe that there has been a considerable decrease in coffee yields. The larger group of producers in the area live under the same challenging circumstances than other coffee farmers. No statistically significant yield differences were reported by the producers from the two municipalities (Mann Whitney $U=1{,}665.5$; $p=0.118$).

The yield obtained in Huehuetla and Cuetzalan was 1,473.75 and 742.94 kg/ha of cherry coffee, respectively. Statistically significant yield differences ($t=2.348$; $p=0.021$) were found between the municipalities. However, Jaramillo *et al.* (2022) had recorded annual variations that show yield changes: a 1.47 t/ha yield of cherry coffee in Cuetzalan. For their part, Benítez-García *et al.* (2015) recorded 2.06 kg/ha. Meanwhile, Ramírez

and Juárez (2008) reported yields of 1,178.64 kg/ha in Cuetzalan and 1,502.3 kg/ha in Huehuetla.

According to Alvarado-Méndez *et al.* (2006), coffee berry borer and coffee leaf rust impact a significant number of plots, consequently reducing yields. This situation is one of the factors that contributes to the reduction of the income of the growers. The annual income sometimes does not even cover production costs. In addition, the persistence of the crop can be attributed to the overexploitation of the family labor force. Likewise, Rivadeneyra and Ramírez (2006) highlighted that, some years, the costs of cultivation are not covered due to the low coffee prices. Consequently, pests and diseases increase in the abandoned plots. Ramírez and Juárez (2008) also pointed out that, as a consequence of the recurrent coffee crisis, pests and diseases have reappeared in coffee plantations, impacting the quality and income of coffee growers.

CONCLUSIONS

Coffee growers live under poverty conditions and practice agriculture under extreme minifundio conditions. These difficulties are exacerbated by the recurrent coffee price crises and the presence of pests and diseases that reduce production, perpetuating the difficult living conditions of farming families.

A multitude of pests and diseases impact crops. Chemical products increase production costs and have a negative impact on the environment. In addition, the lack of technical guidance hinders the appropriate use of these products. In conclusion, developing strategies for farmers to minimize the damage and to encourage a greater government support —including technical assistance and adequate resources— is fundamental for the effective control of pests and diseases in coffee plantations.

REFERENCES

Aguirre-Cadena, JF., Ramírez-Valverde, B., Trejo-Téllez, B., Morales-Flores, FJ, Juárez-Sánchez, JP. (2012). Producción de café en comunidades indígenas de México: beneficios sociales y ambientales. *Agroproductividad. 2*(5):34-41. https://revista-agroproductividad.org/index.php/agroproductividad/article/view/402

Alvarado-Méndez, C., Juárez-Tlamani. H., Ramírez-Valverde, B. (2006). La comercialización de café en una comunidad indígena: estudio en Huehuetla, Puebla. *Ra Ximhai 2.2*(2006): 293-318. https://www.redalyc.org/articulo.oa?id=46120201

Barrera, A., Ramírez, AG., Cuevas, V., Espejel, A. (2021). Modelos de innovación en la producción de café en la Sierra Norte de Puebla-México. *Revista de Ciencias Sociales (Ve), XXVII* (Número Especial 3), 443-458. https://doi.org/10.31876/rcs.v27i.36530

Benítez-García, E., Jaramillo-Villanueva, JL., Escobedo-Garrido, S., Mora-Flores, S. (2015). Caracterización de la producción y del comercio de café en el Municipio de Cuetzalan, Puebla. *Agricultura, Sociedad y Desarrollo, 12*(2), 181-198. https://doi.org/10.22231/asyd.v12i2.147

Cardeña-Basilio, I., Ramírez-Valverde, B., Sánchez, JP., Huerta, A., Cruz, A. (2019). Campesinos y sistema de producción de café ante el problema de la roya en el municipio de Hueytamalco, Puebla, México. *Espacio Abierto, 28*(2), 57-70. https://produccioncientificaluz.org/index.php/espacio/article/view/29574

Cardeña-Basilio, I., Ramírez-Valverde, B., Juárez-Sánchez, JP., Cruz-León, A. (2023). Roya del café en Hueytamalco, Puebla. *Revista Mexicana de Ciencias Agrícolas, 14*(spe29), e3540. 3. https://doi.org/10.29312/remexca.v14i29.3540.

Escamilla, E. (2016). Las variedades de Café en México ante el desafío de la Roya. *Boletín informativo: políticas públicas* 4. 1-10 pp. https://pmcarbono.org/pmc/descargas/proyectos/redd/Breves_de_Politicas_Publicas_No.4-Variedades_de_cafe_en_Mexico.pdf

Henderson, TP. (2019). La roya y el futuro del café en Chiapas. *Revista Mexicana de Sociología, 81*(2), 389-416. http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0188-25032019000200389&lng=es&tlng=es.

INEGI (2024a) Compendio de información geográfica municipal de los Estados Unidos Mexicanos Huehuetla, Puebla. https://www.inegi.org.mx/contenidos/app/mexicocifras/datos_geograficos/21/21072.pdf

INEGI (2024b) Compendio de información geográfica municipal de los Estados Unidos Mexicanos Cuetzalan del Progreso, Puebla. https://www.inegi.org.mx/contenidos/app/mexicocifras/datos_geograficos/21/21043.pdf

Jaramillo-Villanueva, JL., Guerrero-Carrera, J., Vargas-López, S., Bustamante-González, A. (2022). Percepción y adaptación de productores de café al cambio climático en Puebla y Oaxaca, México. *Ecosistemas y recursos agropecuarios, 9*(1), e3170. https://doi.org/10.19136/era.a9n1.3170

Leyva, G. (2010). Principales enfermedades del café (*Coffea arabica*). *Agro Productividad, 3*(2). https://revista-agroproductividad.org/index.php/agroproductividad/article/view/590

Lugo-Morín, DR., de Jesús DE., Fajardo, ML. (2018). Prácticas y saberes comunitarios en la Sierra Norte de Puebla: el caso del café, sus plagas y enfermedades. *Revista de Investigación Agraria y Ambiental, 9*(2), 77-88. https://doi.org/10.22490/21456453.2135

Ramírez, B., Juárez, JP. (2008). Opciones económicas y productivas de reestructuración de las unidades indígenas de producción de café ante la crisis agrícola: estudio en la Sierra Nororiental de Puebla, México. *Perspectivas Sociales, 10*(2), 115-138. http://eprints.uanl.mx/8724/1/art5%20%282%29.pdf

Rivadeneyra, JI., Ramírez, B. (2006). El comercio local del café a raíz de su crisis en la sierra norte de Puebla. *Revista Mexicana de Agronegocios, 10*(18), 0. https://www.redalyc.org/articulo.oa?id=14101807

Secretaría del Bienestar. (2024a) Informe anual sobre la situación de pobreza y rezago social 2023 Cuetzalan del Progreso. https://www.gob.mx/cms/uploads/attachment/file/794982/21043-CuetzalanDelProgreso23.pdf

Secretaría del Bienestar. (2024 b) Informe anual sobre la situación de pobreza y rezago social 2023 Huehuetla, Puebla. https://www.gob.mx/cms/uploads/attachment/file/795011/21072-Huehuetla23.pdf