Revista Mexicana de Ciencias Agrícolas

DOI: https://doi.org/10.29312/remexca.v15i7.3663

Research note

Monkey's hand in corn in the central and western regions of Mexico

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Abstract

Monkey's hand is a disease that reduces the yield of corn grain. Its distribution is nationwide, and its etiology has not been determined. It is considered that the use of genetically tolerant germplasm is the only effective way to manage this phytosanitary problem. Therefore, this work aimed to evaluate its incidence in corn-growing regions and the tolerance of the materials available in Mexico. In the 2023 autumn-winter cycle, the incidence of this disease was evaluated in function of the altitude above mean sea level in commercial plots in the States of Mexico, Jalisco, Nayarit, Querétaro, San Luis Potosí, Zacatecas, Michoacán, and Guanajuato. Plants with symptoms were found in all evaluated states, with incidences of up to 96%. Native varieties had a greater incidence (38.15%) than improved ones (6.47%). A positive covariance and a highly significant correlation (r-42.32%) were detected between the incidence and altitude variables.

Keywords:

'bouquet ears', diseases in corn, 'mano de chango', proliferation.

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DOI: https://doi.org/10.29312/remexca.v15i7.3663

Due to the wide genetic variation of corn (*Zea mays* L.) races present in the Mexican Republic, Mexicans describe themselves as 'corn people' (Kato *et al*., 2009). Due to its use in food, this is considered to be the most important crop in Mexico. Nevertheless, it is estimated that by 2030, the gap between consumption and production will increase historically (CIMMYT, 2019).

Among the factors that lead to the increase in this gap is the disease known as 'mano de chango' (monkey's hand) (Figure 1), of unknown etiology and whose incidence can reach 100% (Farabaugh *et al*., 2019). Corn grain losses due to crop diseases in Mexico are estimated to be between 20 and 86% (Márquez *et al*., 2021), while in the United States of America, they vary from 35 to 91% (Ortez *et al*., 2022b).

Figure 1. Multiple proliferation of immature ears of corn, symptom of monkey's hand on corn ears.

Because the symptom develops below the main female inflorescence, some researchers hypothesize that its cause is related to various sources of stress (Mahrokh *et al*., 2022). Ciampiti (2018) mentions as a causal agent the high temperatures and applications of agrochemicals in stages V5 and V6 that extend to stage V15. Sravani *et al*. (2021) relates it to poor agronomic management. Ortez *et al*. (2022a), in their review of corn malformations, conclude that the appearance of multiple immature ears is due to an interaction between genetic, environmental, and crop management factors, which occur from the pollination period to the R1 stage.

As a consequence, the plant stops the normal development of the inflorescence, the apical dominance breaks, leading to the multiple development of female inflorescences (Sravani *et al*., 2021). To manage this problem, it has been considered to vary the planting density, control of

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possible vector insects (Farabaugh *et al*., 2019), modify the sowing dates (Singh and Pooja, 2008), use of fertilizers and herbicides (Mahrokh *et al*., 2022), application of other agrochemicals (Ciampiti, 2018), especially fungicides (Aguilar and Molina, 1996).

However, there is a concept that both incidence and severity are dependent on genotype (Ortez *et al*., 2022a), which leaves, until now, the choice of a tolerant variety as the only effective control method. This research aimed to estimate the incidence of monkey's hand in improved and native varieties of corn from the central, northern, and western regions of Mexico and to correlate its incidence with height above mean sea level.

During the 2023 autumn-winter agricultural cycle, in localities in the states of Mexico, Querétaro, Zacatecas, San Luis Potosí, Guanajuato, Nayarit, Jalisco and Michoacán (Table 1). Commercial corn sowing plots in phenological stage R1 or later were located, where it was necessary to have access to the identity of the genetic material grown.

Table 1. Incidence of corn plants with symptoms of 'monkey's hand' in different localities in Mexico.

State	Locality	Coordinate	Altitude (m)	Germplasm[*a]	Incidence*[b] ±SE
Querétaro	San Cristóbal	20° 33' 33.2" N 100° 14' 31.4" W	2 000	DK2020	3 ±0.193
Querétaro	Palo alto	20° 32' 09.2" N 100° 12' 24.5" W	2 090	DW130	8.25 ±0.198
Querétaro	Santa Rosa	20° 51' 21.6" N 100° 25' 22.6" W	2 100	Dekalb 2069	3.5 ±0.383
Zacatecas	Pinos	21° 53' 09.8" N 101° 30' 50.2" W	1 800	2646W	10.5 ±0.252
Zacatecas	Pinos	21° 53' 27.3" N 101° 33' 59.6" W	1 800	Native	12.25 ±0.334
SLP	Santa María	21° 37' 05.8" N 100° 44' 07.0" W	1 650	Pioneer	9.75 ±0.904
SLP	Villa de Arriaga	21° 55' 40.3" N 101° 21' 19.3" W	1 800	30726	2.25 ±0.619
SLP	Villa de Arriaga	21° 54' 21.8" N 101° 23' 20.0" W	1 800	32006	23 ±0.313
Guanajuato	Apaseo el Alto	20° 28' 48.2" N 100° 36' 07.6" W	1 850	Novasem NA731	10.5 ±0.777
Guanajuato	Villagrán	20° 31' 13.7" N 101° 02' 52.5" W	1 730	Pioneer 84G04	2.25 ±0.252
Guanajuato	Irapuato	20° 31' 18.4" N 101° 29' 16.4" W	1 730	Eagle 215W	10 ±0.267
Guanajuato	Manuel Doblado	20° 44' 23.9" N 101° 42' 23.2" W	1 700	DK2037	11.25 ±0.482
Guanajuato	Cuerámaro	20° 41' 53.5" N 101° 42' 25.0" W	2 100	Native	13.25 ±0.539
Guanajuato	Cuerámaro	20° 39' 20.1" N 101° 40' 50.5" W	1 600	CRM77	12.5 ±1.323
Nayarit	Santa María del Oro	21° 11' 50.4" N 104° 38' 48.6" W	900	NK921W	5.75 ±0.64
Nayarit	Tuxpan	21° 56' 58.6" N 105° 18' 48.1" W	10	Native	10 ±0.267

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State	Locality	Coordinate	Altitude (m)	Germplasm[*a]	Incidence*[b] ±SE
Jalisco	Ojuelos	21° 50' 00.5" N 101° 34' 00.3" W	2 100	30A60	8.5 ±0.238
Jalisco	El Arenal	20° 44' 04.4" N 103° 37' 20" W	1 840	NK912W	3.25 ±0.277
Jalisco	Tala	20° 39' 10.8" N 103° 44' 23.8" W	1 320	Aspros Supremo	3.25 ±0.179
Jalisco	Ameca	20° 31' 56.1" N 103° 59' 27" W	1 200	NB940	13.75 ±0.213
Jalisco	Ameca	20° 32' 07.7" N 103° 59' 54.6" W	1 200	Aspros Patriota	15.25 ±0.431
Jalisco	Los Pilares	20° 31' 37.5" N 104° 06' 12.7" W	1 290	Novasem NB723	1.5 ±0.276
Jalisco	Villa Hermosa	20° 30' 01.8" N 103° 59' 33.1" W	1 520	NK307	0.5 ±0.104
Jalisco	San Martín Hidalgo	20° 26' 54.5" N 103° 56' 48.9" W	1 250	Pioneer B3715	0
Jalisco	Autlán	19° 44' 26.2" N 104° 15' 34" W	1 280	Native	9 ±0.081
Jalisco	Tecolotlán	20° 12' 45.6" N 104° 04' 32.7" W	1 280	DK2037	2.5 ±0.153
Jalisco	Unión de Tula	19° 58' 59" N 104° 15' 47.7" W	1 350	DK4018	5.25 ±0.243
Jalisco	Autlán	19° 45' 16.7" N 104° 21' 44.6" W	980	Asgrow Alicante	4 ±0.267
Jalisco	Casimiro Castillo	19° 32' 01.9" N 104° 31' 14.6" W	360	DK2061	9.5 ±0.238
Jalisco	Poncitlán	19° 32' 01.9" N 104° 31' 14.6" W	1 550	P3075W	0
Jalisco	Jamay	20° 17' 40.5" N 102° 40' 16.2" W	1 560	B3715	2.25 ±0.121
Michoacán	Tanhuato	20° 16' 20.9" N 102° 25' 16.8"W	1 530	Asgrow Berrendo	6.75 ±0.193
Michoacán	La Piedad	20° 21' 53.8" N 102° 05' 12" W	1 670	Asgrow Camaleón	4.25 ±0.232
Michoacán	Ecuandureo	20° 09' 26.4" N 102° 13' 38.6" W	1 600	Ceres Galileo	1.25 ±0.121
México	C. of Postgraduates	19° 28' 00.3" N 98° 54' 03.9" W	2 240	Native	63 ±0.866
México	C. of Postgraduates	19° 28' 01.8" N 98° 53' 56.9" W	2 240	Native	47.25 ±1.028
México	C. of Postgraduates	19° 27' 53.6" N 98° 54' 05.0" W	2 240	Native	96.75 ±0.242
México	C. of Postgraduates	19° 28' 09.2" N 98° 54' 00.4" W	2 240	Native	53.75 ±1.71

* [a]= according to the interview with the owner of the plot; *[b]= average of four replications.

In each plot, four central rows were selected, on which 100 plants were evaluated. The total number of plants visually inspected and the number of plants showing multiple female inflorescences at the same node were recorded. The following formula was used to determine the incidence of the

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disease: I(%)= n/N * 100. Where: I= incidence; n= number of plants with symptoms and N= total of plants evaluated.

In each evaluated plot, geographical coordinates and altitude in masl were recorded, supported by the SAS analysis package, version 9.0. The effect of native germplasm was compared with those improved using Wilcoxon's test. All the plots evaluated in the sampled states of central, northern and western Mexico had the presence of monkey's hand (Table 1). This study and that by Márquez *et al*. (2021) found that the presence of monkey's hand in corn is distributed nationwide, affecting native and improved commercial varieties.

The incidence recorded reached up to 96%. Ortez *et al*. (2022b) observed that symptoms vary according to genetic material. In agreement with Márquez *et al*. (2022), the incidence of monkey's hand on commercial hybrids ($\bar{x}$= 6.4%) was statistically lower (Pr> Z= 0.0008, α= 0.05) than that presented in native germplasm ($\bar{x}$= 38.1%). Researchers have found that the use of seed from plants with symptoms increases the incidence of the disease in subsequent generations (Aguilar and Molina, 1996; Fernández *et al*., 2013).

This fact could explain why its incidence in native germplasm can reach 100%. Nonetheless, there is still no evidence that the causative agent is transmitted by seed (Frank and Hallauer, 1997). Sravani *et al*. (2021) relates the formation of multiple immature ears with inadequate agronomic management, nutritional deficiencies, and drought conditions (Ángeles *et al*., 2010). The variables incidence and altitude above mean sea level have positive covariance with a highly significant correlation of 42% (*p*-value= 0.008098), which indicates that monkey's hand has a higher incidence in areas with higher altitudes.

Conclusions

Monkey's hand is a disease with national distribution whose incidence increases as the altitude above mean sea level increases. Likewise, it was found that native corn has a higher incidence percentage than that found in hybrids or synthetics. For the latter, there were cases where no plants with symptoms were observed. This disease represents a growing phytosanitary problem for corn varieties native to Mexico.

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DOI: https://doi.org/10.29312/remexca.v15i7.3663

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Revista Mexicana de Ciencias Agrícolas

DOI: https://doi.org/10.29312/remexca.v15i7.3663

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Journal Information
Journal ID (publisher-id): remexca
Title: Revista mexicana de ciencias agrícolas
Abbreviated Title: Rev. Mex. Cienc. Agríc
ISSN (print): 2007-0934
Publisher: Instituto Nacional de Investigaciones Forestales, Agrícolas y Pecuarias

Article/Issue Information
Date received: 01 August 2024
Date accepted: 01 September 2024
Publication date: 13 December 2024
Publication date: Oct-Nov 2024
Volume: 15
Issue: 7
Electronic Location Identifier: e3663
DOI: 10.29312/remexca.v15i7.3663

Categories

Subject: Research note

Keywords:

Keywords:

'bouquet ears'
diseases in corn
'mano de chango'
proliferation

Counts

Figures: 1
Tables: 1
Equations: 0
References: 15
Pages: 0