Revista Mexicana de Ciencias Agrícolas

DOI: https://doi.org/10.29312/remexca.v16i7.3836

Investigation note

# Sensitivity of bean and corn *Rhizoctonia* species to chemical fungicides

Karen Rabago-Zavala[1]
Fernando Alberto Valenzuela-Escoboza[1,§]
Blanca Elvira López-Valenzuela[1]
Quintín Armando Ayala-Armenta[1]
Juan Luis Pérez-Mora[1]

1 Facultad de Agricultura del Valle del Fuerte-Universidad Autónoma de Sinaloa. Avenida Japaraquí s/n y Calle 16, Juan José Ríos, Sinaloa, México. CP. 81110.

Autor para correspondencia: fernando.vzla@favf.mx.

## Abstract

In the northern region of Sinaloa, the fungus *Rhizoctonia* spp. causes plants to dry and rot in beans and corn, affecting germination, growth, and roots. This weakens and causes death in plants. Farmers often seek to mitigate the disease by applying chemical fungicides; however, the effectiveness of these treatments is often limited. This is due to inappropriate selection of fungicides, incorrect dosing during application, and pathogens' potential acquired resistance to these compounds, among other factors. The purpose of this study was to evaluate the *in vitro* sensitivity of *Rhizoctonia* isolates from beans and corn to four synthetic fungicides (Azoxystrobin, Benomyl, Methyl thiophanate and Tebuconazole). A completely randomized design was performed, using the commercial dose of each fungicide and a control, with three replications per treatment. The conventional fungicide tebuconazole proved to be the most effective against all *Rhizoctonia* species evaluated, inhibiting growth by 100%. Effectiveness tests on the sensitivity of *Rhizoctonia* isolates to fungicides allow us to know the variability of behavior and facilitate the monitoring of isolates that present resistance to fungicides in the pathogen population. This is essential for the development of effective control strategies for Rhizoctoniasis.

## Keywords:

fungicides, resistance, *rizoctoniasis*, tebuconazole.

Revista Mexicana de Ciencias Agrícolas

DOI: https://doi.org/10.29312/remexca.v16i7.3836

# Introduction

The fungus *Rhizoctonia* is an economically important pathogen that reduces the productivity of crops, such as beans (*Phaseolus vulgaris*) and corn (*Zea mays*), in the world and some regions of Mexico, such as the state of Sinaloa. *Rhizoctonia* is classified into multinucleate species, such as *R. solani* and *R. zeae*, and binucleate species, such as binucleate *Rhizoctonia* (Perdomo, 2007; González, 2013; Yang *et al*., 2015). In beans and corn, Rhizoctoniasis infection results in crusty lesions and dark cankers at the base of stems and roots, affecting both plant growth and yield (Rabago *et al*., 2024).

Bean and corn producers employ strategies such as crop rotation, biocontrol agents, and certified pathogen-free seeds to control Rhizoctoniasis. Nevertheless, the use of chemical fungicides remains the most common practice in Sinaloa and other producing regions (Hernández *et al*., 2018). The use of chemical fungicides is not a sustainable solution due to their environmental impact and the resistance that pathogens can develop, as reported in *R. solani* in rice paddies in Louisiana (USA) and Henan (China). In addition, the different anastomosis groups (AGs) of *Rhizoctonia* show variable sensitivity to fungicides according to studies conducted in several countries, such as the United States of America, France, and Mexico (Muzhinji *et al*., 2018).

The FRAC (2024) warns that the repeated use of fungicides with a single mode of action increases the risk of pathogen insensitivity and constant monitoring of sensitivity is key to early detection of cases of resistance. Therefore, this study evaluated the *in vitro* sensitivity of *Rhizoctonia* isolates from beans and corn to four synthetic fungicides (Azoxystrobin, Benomyl, Methyl thiophanate and Tebuconazole).

# Materials and methods

## Origin of *Rhizoctonia* isolates

*Rhizoctonia* isolates were collected in the 2020-2021 autumn-winter cycle in northern Sinaloa, subjected to pathogenicity tests and morphological and molecular identification, and preserved at 25 °C in tubes with sterile soil (Rabago *et al*., 2024). The following six species from beans and corn were reactivated in PDA medium and studied: *R. solani* AG-4 HGI, *R. solani* AG-4 HGIII, *R. solani* AG-7, binucleate *R.* AG-A, binucleate *R.* AG-G, and *R. zeae*.

## Fungicide sensitivity test

The effectiveness of the following four commercial fungicides was evaluated: azoxystrobin, benomyl, methyl thiophanate and tebuconazole, for the control of the species *Rhizoctonia solani* AG-4 HGI, *Rhizoctonia solani* AG-4 HGIII, *Rhizoctonia solani* AG-7, binucleate *Rhizoctonia* AG-A, binucleate *Rhizoctonia* AG-G and *Rhizoctonia zeae*. Commercial doses of each fungicide (0.05 L ha-1 azoxystrobin, methyl thiophanate, tebuconazole, and 0.5 kg ha-1 benomyl) were incorporated into freshly sterilized PDA medium at 45 °C, which was then poured into sterilized Petri dishes of 8 cm diameter. Once the medium solidified, a 0.8 cm slice of mycelium-agar of each species was placed in the center of each dish.

## Experimental design

The control treatment consisted of PDA without fungicide. The experimental design was completely randomized, using Petri dishes inoculated with the fungus as the experimental unit. Four treatments and the control were applied, with three replications per treatment and an additional replication of the experiment. The effect of the treatments was evaluated by measuring the radius of the colony (cm) of the fungus at 24, 48 and 72 h. The data were transformed into homogenize variances (Little and Hills, 1989) and analyzed using Anova. The means were compared with the Kruskal-Wallis test ($p < 0.05$) using InfoStat and the susceptibility of the isolates was determined by the percentage of inhibition of fungal growth.

Revista Mexicana de Ciencias Agrícolas
REMEXCA
DOI: https://doi.org/10.29312/remexca.v16i7.3836

## Results

The biological effectiveness of the conventional fungicides evaluated, at 24, 48 and 72 h, showed significant differences between treatments. In the medium with Tebuconazole, the smallest radius of the colony ($p < 0.05$) was recorded in the isolates *Rhizoctonia solani* AG-4 HGI, AG-4 HGIII, AG-7, binucleate *Rhizoctonia* AG-A, AG-G and *Rhizoctonia zeae*, which were susceptible to this fungicide according to the results by Pérez *et al*. (2019), who reported that the genus *Rhizoctonia* is susceptible to this product.

*Rhizoctonia solani* AG-4 HGIII and *Rhizoctonia solani* AG-7 showed sensitivity to all fungicides evaluated. In contrast, *Rhizoctonia zeae* and *Rhizoctonia solani* AG-4 HGI demonstrated tolerance to Methyl thiophanate and Benomyl. Likewise, binucleate *Rhizoctonia* AG-A and AG-G were tolerant to Azoxystrobin. In cultures without fungicide, fungi completely occupied the dishes at 72 h. Fungicide-tolerant species showed a behavior similar to the control, without presenting significant differences (Table 1).

**Table 1. Growth of the diameter of the colonies (cm) of *Rhizoctonia* species from beans and corn in media with different chemical fungicides.**

| ***Rhizoctonia* species** | **Chemical fungicide (ai)** | **24 h exposure** | **48 h exposure** | **72 h exposure** |
|---|---|---|---|---|
| *Rhizoctonia solani* AG-4 HGI | Methyl thiophanate | 1.56 B | 2.27 B | 2.83 B |
| | Azoxystrobin | 0.7 A | 0.7 A | 0.7 A |
| | Benomyl | 0.7 A | 1.22 AB | 1.56 AB |
| | Tebuconazole | 0.7 A | 0.7 A | 0.7 A |
| | Control | 1.58 B | 2.1 B | 2.63 B |
| *Rhizoctonia solani* AG-4 HGIII | Methyl thiophanate | 0.7 A | 0.7 A | 0.7 A |
| | Azoxystrobin | 0.7 A | 0.7 A | 0.7 A |
| | Benomyl | 0.7 A | 0.7 A | 0.7 A |
| | Tebuconazole | 0.7 A | 0.7 A | 0.7 A |
| | Control | 1.44 B | 2.44 B | 3 B |
| *Rhizoctonia solani* AG-7 | Methyl thiophanate | 0.7 A | 0.7 A | 0.7 A |
| | Azoxystrobin | 0.7 A | 0.7 A | 0.7 A |
| | Benomyl | 0.7 A | 0.7 A | 0.7 A |
| | Tebuconazole | 0.7 A | 0.7 A | 0.7 A |
| | Control | 1.51 B | 2.44 B | 2.92 B |
| Binucleate *Rhizoctonia* AG-A | Methyl thiophanate | 0.7 A | 0.7 A | 0.7 A |
| | Azoxystrobin | 0.7 A | 0.83 AB | 1.62 AB |
| | Benomyl | 0.7 A | 0.7 A | 0.7 A |
| | Tebuconazole | 0.7 A | 0.7 A | 0.7 A |
| | Control | 1.22 B | 1.59 B | 2.64 B |
| Binucleate *Rhizoctonia* AG-G | Methyl thiophanate | 0.7 A | 0.77 AB | 0.77 AB |
| | Azoxystrobin | 0.7 A | 0.89 AB | 1.26 AB |
| | Benomyl | 0.7 A | 0.7 A | 0.7 A |
| | Tebuconazole | 0.7 A | 0.7 A | 0.7 A |
| | Control | 1 AB | 1.54 B | 3 B |
| *Rhizoctonia zeae* | Methyl thiophanate | 1.18 B | 1.94 B | 2.66 B |
| | Azoxystrobin | 0.7 A | 0.7 A | 0.7 A |
| | Benomyl | 1.03 AB | 1.35 AB | 1.81 AB |
| | Tebuconazole | 0.7 A | 0 A | 0.7 A |
| | Control | 1 AB | 1.89 B | 2.69 B |

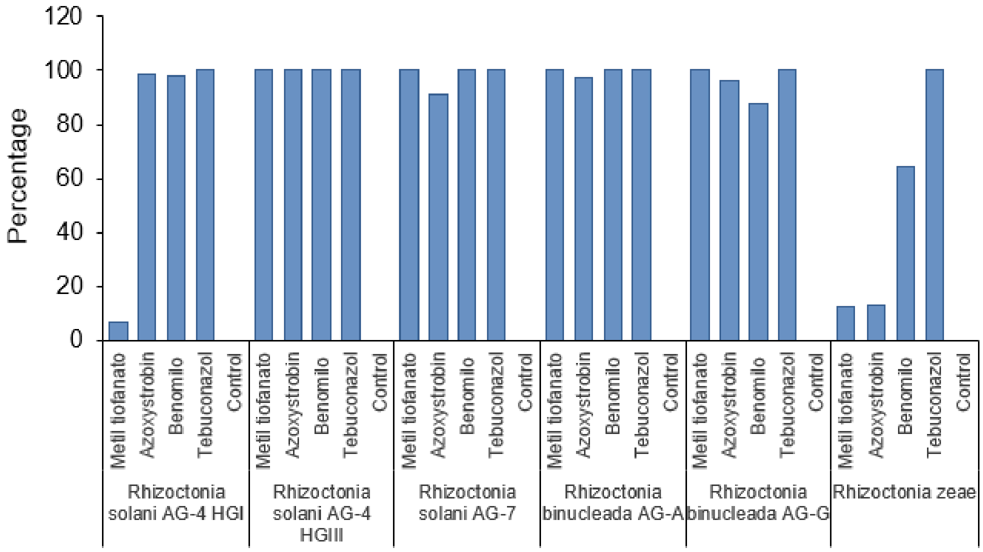
The data were transformed into square root (√x+0.5) before analysis. Means with the same letter in each column are not significantly different (Kruskal Wallis $p < 0.05$).

DOI: https://doi.org/10.29312/remexca.v16i7.3836

These results coincide with the findings by Alburqueque and Gusqui (2018), who documented the tolerance of *Rhizoctonia* isolates to Azoxystrobin. Nonetheless, the work by Muzhinji *et al*. (2018) reported the susceptibility of *Rhizoctonia* isolates to this same fungicide under *in vitro* conditions, which underscores the genetic variability of the pathogen.

At 92 h, Tebuconazole achieved 100% growth inhibition of all isolates, whereas the other treatments showed variable results (Figure 1). This coincides with what González (2013) pointed out about the heterogeneity of *Rhizoctonia*, which allowed it to adapt to different conditions.

**Figure 1. Percentage of inhibition of *Rhizoctonia solani* AG-4 HGI, AG-4 HGIII, AG-7, binucleate *Rhizoctonia* AG-A, AG-G and *Rhizoctonia zeae* from beans and corn with conventional chemical fungicides.**




## Conclusions

The study highlights the variability in response to the sensitivity of bean and corn *Rhizoctonia* species to different fungicides. The isolates tested showed sensitivity to Tebuconazole, which completely inhibited growth in 92 h. *R. solani* AG-4 HGIII, *R. zeae*, binucleate *R.* AG-A and G showed insensitivity to fungicides such as Methyl thiophanate, Benomyl and Azoxystrobin. This shows the genetic diversity of the isolates, which can affect their adaptation and response to treatments. The need for continuous surveillance and integrated strategies to manage this disease and the appropriate selection of fungicides according to the species and concentration to optimize its control in agricultural crops is emphasized.

## Bibliography


1 Alburqueque, A. D. y Gusqui, M. R. 2018. Eficacia de fungicidas químicos para el control *in vitro* de diferentes fitopatógenos en condiciones controladas. Arnaldoa. 25(2):489-498. http://doi.org/10.22497/arnaldoa.252.25209.

2 FRAC. 2024. Fungicide resistance action committee. Fungicide Resistance Management *Home*.

DOI: https://doi.org/10.29312/remexca.v16i7.3836


3 González, D. 2013. Identification, molecular characterization, and evolution of group I introns at the expansion segment D11 of 28S rDNA in *Rhizoctonia* species. Fungal Biology. 117(9):623-637. https://doi.org/10.1016/j.funbio.2013.06.006.

4 Hernández-Pérez, D.; Díaz-Castellanos, M.; Quiñones-Ramos, R.; Santos-Bermúdez, R.; Portal-González, N. y Herrera-Isla, L. 2018. Control de *Rhizoctonia solani* en frijol común con rizobacterias y productos naturales. Revista Centro Agrícola. 45(2):55-60.

5 Little, T. M. y Hills, F. J. 1989. Métodos estadísticos para la investigación en la agricultura. Ed. trillas 2a edición. México, DF. 125-143 pp.

6 Muzhinji, N.; Woodhall, J. W.; Truter, M. and Van-Waals J. E. 2018. Variation in fungicide sensitivity among *Rhizoctonia* isolates recovered from potatoes in south Africa. Plant Disease. 102(8):1520-1526. pdis-09-17-1470-re.

7 Perdomo, R. D.; Hernández, A. J.; González, A. D.; Pineda, J. B. y Alezones, J. M. 2007. Caracterización y evaluación de virulencia en aislamientos de *Rhizoctonia solani* Kühn, causante de la mancha bandeada en maíz. INCI. 32(1):48-54.

8 Pérez-Rodríguez, L. R.; Pérez-Moreno, L.; Guzmán-Mendoza, R.; Sanzón-Gómez, D. y Belmonte-Vargas, J. R. 2019. Sensibilidad *in vitro* de hongos fitopatógenos causantes de enfermedades en fresa a controladores biológicos y fungicidas, en el estado de Guanajuato, México. Acta Universitaria. 29:1-11. https://doi.org/10.15174/au.2019.2339.

9 Rabago-zavala, K.; Valenzuela-Escoboza, B. E.; Lizarraga-Sánchez, G. J. and Valenzuela-Escoboza, F. V. 2024. Morphological, molecular and pathogenic caracterization of *Rhizoctonia solani* isolate associated whit been drying in Northern Sinaloa, Mexico. AgroProductividad. 17(11):253-261. https://doi.org/10.32854/agrop.v17i11.3143.

10 Yang, Y. G.; Zhao, C.; Guo, Z. J. and Wu, X. H. 2015. Characterization of a new anastomosis group (AG-W) of Binucleate *Rhizoctonia*, causal agent for potato stem canker. Plant Disease. 99(12):1757-1763. https://doi.org/10.1094/PDIS-01-15-0036-re.

# Sensitivity of bean and corn *Rhizoctonia* species to chemical fungicides


| 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:** 1 October 2025 |
| **Date accepted:** 1 November 2025 |
| **Publication date:** 25 November 2025 |
| **Publication date:** Oct-Nov 2025 |
| **Volume:** 16 |
| **Issue:** 7 |
| **Electronic Location Identifier:** e3836 |
| **DOI:** 10.29312/remexca.v16i7.3836 |

**Categories**

**Subject:** Investigation note

**Keywords:**

**Keywords:**

fungicides
resistance
rhizoctoniasis
tebuconazole

**Counts**

**Figures:** 1
**Tables:** 1
**Equations:** 0
**References:** 10