RCMOS – Revista Científica Multidisciplinar O
Saber. ISSN: 2675-9128. São Paulo - SP.
Ano VII, v.1 2026 | submissão: 26/09/2026 | aceito: 03/10/2026 | publicação: 08/10/2026

Chemical control of Amphobotrys ricini on a castor bean hybrid

Controle químico de Amphobotrys ricini em híbrido de mamona

Control químico de Amphobotrys ricini en un híbrido de ricino

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Abstract:
Castor bean cultivation, recognized for its versatility and economic importance, faces significant phytosanitary challenges, particularly gray mold caused by the fungus Amphobotrys ricini. In this context, this study aimed to evaluate strategies for controlling A. ricini in castor bean plants, focusing on the efficacy of site-specific and multi-site fungicides, as well as a resistance inducer. The experiment was conducted at the IFTM Uberlândia Campus using a randomized complete block design with seven treatments — control, potassium silicate, tebuconazole, prothioconazole + trifloxystrobin, pyraclostrobin + epoxiconazole, azoxystrobin + cyproconazole, and mancozeb — and three replications. Sowing was carried out in February 2023 using the KS2019 hybrid. Planting fertilization was performed with the 08-28-16 formulation, corresponding to 90 kg/ha of P_2O_5. Top-dressing fertilization was performed with urea in two applications, at 20 and 40 days after crop emergence, with 45 kg/ha of N in each application. During the reproductive phase, at 55 days after emergence, the treatments were applied. Twenty-one days after the first application, gray mold incidence and disease severity were evaluated on the first and second racemes produced per plant. The lowest gray mold incidence was 81.3%, indicating the high susceptibility of the hybrid to the pathogen A. ricini. On a severity scale ranging from 0 to 9, the lowest severity scores on the primary and secondary racemes were observed with the application of prothioconazole + trifloxystrobin, although the values remained high (8.0 and 3.7, respectively). The secondary racemes showed greater protection in response to fungicide applications, indicating that crop protection was compromised when the treatments were applied after disease symptoms had appeared on virtually all primary racemes. Further studies are needed to evaluate the differential effectiveness of fungicides when applied preventively.

Keywords:
fungicides; gray mold; resistance inducers.

Resumo:
A cultura da mamona, reconhecida por sua versatilidade e importância econômica, enfrenta desafios fitossanitários significativos, com destaque para o mofo-cinzento causado pelo fungo Amphobotrys ricini. Nesse contexto, esta pesquisa teve como objetivo avaliar estratégias de controle de A. ricini em mamoneira, com foco na eficácia de fungicidas sítio-específicos e multissítios, bem como de indutor de resistência. O experimento foi conduzido no IFTM Campus Uberlândia, em delineamento de blocos casualizados, com sete tratamentos — testemunha, silicato de potássio, tebuconazol, protioconazol + trifloxistrobina, piraclostrobina + epoxiconazol, azoxistrobina + ciproconazol e mancozeb — e três repetições. A semeadura foi realizada em fevereiro de 2023, utilizando-se o híbrido KS2019. A adubação de plantio foi realizada com o formulado 08-28-16, correspondente à aplicação de 90 kg/ha de P_2O_5. A

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adubação de cobertura foi realizada com ureia, parcelada em duas aplicações, aos 20 e 40 dias após a emergência da cultura, com 45 kg/ha de N em cada aplicação. Na fase reprodutiva da mamoneira, aos 55 dias após a emergência, foram aplicados os tratamentos. Aos 21 dias após a primeira aplicação, foram avaliadas a incidência de mofo-cinzento e a severidade da doença no primeiro e no segundo racemos emitidos por planta. A menor incidência de mofo-cinzento foi de 81,3%, evidenciando a elevada suscetibilidade do híbrido ao patógeno A. ricini. Em uma escala de severidade de 0 a 9, as menores notas de severidade nos racemos primário e secundário foram observadas com a aplicação de protioconazol + trifloxistrobina, embora os valores tenham permanecido elevados (8,0 e 3,7, respectivamente). Os racemos secundários apresentaram maior proteção em resposta às aplicações dos fungicidas, indicando que a proteção fitossanitária da cultura foi comprometida quando os tratamentos foram aplicados após o surgimento da doença em praticamente todos os racemos primários. São necessários novos estudos para avaliar a efetividade diferencial dos fungicidas em aplicações preventivas.

Palavras-chave:
fungicidas; mofo-cinzento; indutores de resistência.

Resumen:
El cultivo de ricino, reconocido por su versatilidad e importancia económica, enfrenta desafíos fitosanitarios significativos, especialmente el moho gris causado por Amphobotrys ricini. En este contexto, la investigación tuvo como objetivo evaluar estrategias de control de A. ricini, centrándose en la eficacia de fungicidas de sitio específico y multisitio, así como de un inductor de resistencia. El experimento se realizó en el IFTM Campus Uberlândia, con un diseño de bloques completos al azar, siete tratamientos —testigo, silicato de potasio, tebuconazol, protioconazol + trifloxistrobina, piraclostrobina + epoxiconazol, azoxistrobina + ciproconazol y mancozeb— y tres repeticiones. La siembra se efectuó en febrero de 2023 con el híbrido KS2019. La fertilización de siembra se realizó con el formulado 08-28-16, correspondiente a 90 kg/ha de P_2O_5. La fertilización de cobertura se realizó con urea en dos aplicaciones, a los 20 y 40 días después de la emergencia, con 45 kg/ha de N en cada una. En la fase reproductiva, a los 55 días después de la emergencia, se aplicaron los tratamientos. A los 21 días de la primera aplicación se evaluaron la incidencia de moho gris y la severidad en los dos primeros racimos por planta. La menor incidencia fue del 81,3%, evidenciando la elevada susceptibilidad del híbrido a A. ricini. En una escala de 0 a 9, las menores puntuaciones en racimos primarios y secundarios se observaron con protioconazol + trifloxistrobina, aunque permanecieron elevadas (8,0 y 3,7, respectivamente). Los racimos secundarios mostraron mayor protección tras aplicar fungicidas, indicando que la protección fitosanitaria se comprometió al aplicar tratamientos después de aparecer la enfermedad en prácticamente todos los racimos primarios. Se necesitan nuevos estudios para evaluar la efectividad diferencial de los fungicidas en aplicaciones preventivas.

Palabras clave:
fungicidas; moho gris; inductores de resistencia.

1. Introduction

The species Ricinus communis (L.) is popularly known as castor bean. According to CONAB's (2022) July survey of the Brazilian grain harvest, Brazil recorded a 3.8% increase in the area planted with castor bean, reaching 48.8 thousand hectares. In the 2021/22 season,

average national yield reached 896 kg/ha, a 53.9% increase over the previous season. In the current season, CONAB estimates a 59.5% increase in castor bean grain production, representing 43.7 thousand tonnes. Data on castor bean production in Brazil reflect farmers' considerable interest in this crop, which has found a place in annual crop planning in different grain-producing regions.

Several studies have been conducted in recent years to improve castor bean management. However, longstanding phytosanitary problems such as gray mold have concerned growers. Because this is a frequent disease that attacks plant inflorescences, fruit production and, consequently, grain production are significantly reduced. Research investigating active ingredients to prevent damage to castor bean yield is therefore essential for sustainable production without problems arising from pathogen resistance to crop protection products. By knowing the most effective fungicides and the number available for application, growers can develop an action plan to prevent resistance through rotation of active ingredients with different modes of action against the fungus Amphobotrys ricini.

Given the limited number of active ingredients registered with the Ministry of Agriculture for castor bean, research has been undertaken to generate technical information supporting appropriate gray mold management recommendations. However, such research is still very scarce and, to date, only the fungicides fluazinam + thiophanate-methyl, in a ready-to-use mixture, are registered for castor bean (MAPA, 2022).

Over the past five years, only the work developed by Oliveira (2019) investigated strategies to control the pathogen A. ricini in castor bean. According to that author, only the fungicides carbendazim and picoxystrobin + cyproconazole were effective when applied 91 days after sowing the AG IMA 110204 hybrid.

Regarding resistance inducers against gray mold, virtually no published information is available.

In view of the information above, the objective of this study is to determine fungicides and resistance inducers effective in controlling A. ricini.

2. Materials and methods

The research was conducted in an experimental area at the IFTM Uberlândia Campus, located at 18°45′48″ south latitude, 48°17′21″ west longitude and an elevation of 648 m. The soil has a clayey texture and is classified as a dystrophic Red Latosol. The local climate is characterized as Aw according to Köppen-Geiger (PEEL; FINLAYSON; MCMAHON, 2007).

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The experiment used a randomized complete block design with seven treatments (control, potassium silicate, tebuconazole, prothioconazole + trifloxystrobin, pyraclostrobin + epoxiconazole, azoxystrobin + cyproconazole and mancozeb) and three replications.

The 08-28-16 fertilizer formulation was added to the sowing furrow to supply 90 kg/ha of P_2O_5. After fertilization, a thin soil layer was placed over the fertilizer, followed by sowing of the KS2019 hybrid. Twenty days after crop emergence, top-dressing fertilization supplied 45 kg/ha of N using urea as the nitrogen source. The same amount of urea was applied 40 days after emergence.

During the reproductive stage of castor bean, specifically 55 days after emergence, treatments were applied using a sprayer with a carbon dioxide cylinder and a boom equipped with four nozzles spaced 0.5 m apart. MAGNO 110 03 nozzles were used at a pressure of 30 lb/in². Treatments were reapplied 14 days after the first spraying.

Twenty-one days after the first application, gray mold incidence and disease severity on the first and second racemes produced per plant were measured. Incidence was calculated by evaluating 10 randomly selected plants in the usable area of each plot. Disease incidence percentage was calculated as the ratio between plants with gray mold symptoms and the total number evaluated. Severity was assessed using the rating scale proposed by Chagas (2009) (Figure 1).

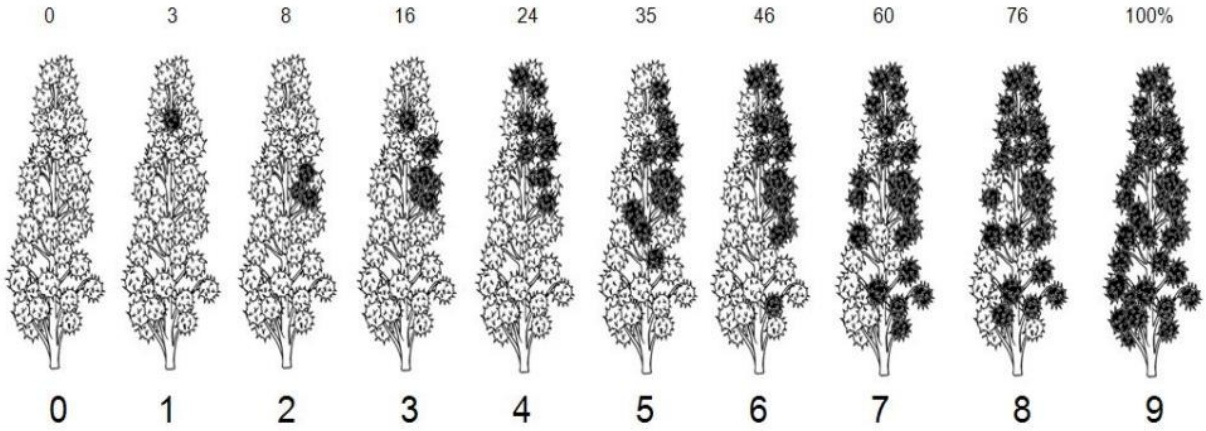


Figure 1. Severity rating scale for gray mold in castor bean.

The collected data were analyzed using the SISVAR statistical program, applying the analysis of variance F-test and Tukey's test, both at a 5% significance level.

3. Results and discussion

Gray mold incidence in the KS2019 hybrid did not differ between treatments, even after application of the control strategies. This demonstrates the genotype's susceptibility to A. ricini

and the low effectiveness of fungicides and potassium silicate in ensuring crop protection when sprayed two weeks after symptoms were detected on the primary raceme. On the secondary raceme, except for potassium silicate, all fungicides reduced gray mold severity by approximately 50% (Table 1).

Table 1. Gray mold incidence and severity rating in the KS2019 castor bean hybrid at 21 days after application as a function of control strategies.

Control strategies	**Incidence (%)[1]**	**Severity (1st raceme)[2]**	**Severity (2nd raceme)[2]**
Control	94.4	9.0 b	9.0 b
Potassium silicate	88.9	8.7 ab	9.0 b
Tebuconazole	85.2	8.1 ab	4.7 a
Prothioconazole + trifloxystrobin	81.5	8.0 a	3.7 a
Pyraclostrobin + epoxiconazole	83.3	8.7 ab	4.7 a
Azoxystrobin + cyproconazole	83.1	8.5 ab	4.3 a
Mancozeb	81.3	8.8 ab	3.7 a
CV (%)	6.9	3.5	8.2

[1]There were no differences between treatments according to the analysis of variance F-test at a 5% significance level; [2]Different letters in the column indicate differences between treatments according to Tukey's test ($p < 0.05$).

The fungicides prothioconazole + trifloxystrobin, pyraclostrobin + epoxiconazole, azoxystrobin + cyproconazole and mancozeb promoted a reduction in gray mold severity in the KS2019 hybrid. Potassium silicate did not contribute to reducing severity.

Control of A. ricini in castor bean requires further research to evaluate the efficacy of pathogen control strategies. Few fungicides are registered with the Ministry of Agriculture, Livestock and Food Supply for disease control in castor bean, and most registered active ingredients are restricted to protecting castor bean seeds and seedlings. For the reproductive stage, agronomically efficient products are lacking, particularly when information is sought for controlling the causal agent of gray mold.

Only Oliveira's (2019) work reports strategies for controlling A. ricini in castor bean. According to that author, only carbendazim and picoxystrobin + cyproconazole were effective when applied 91 days after sowing the AG IMA 110204 hybrid.

With the recent prohibition of carbendazim use in Brazilian agriculture, this situation has made phytosanitary management more difficult.

4. Conclusion

This study demonstrated that prothioconazole + trifloxystrobin, pyraclostrobin + epoxiconazole, azoxystrobin + cyproconazole and mancozeb reduce gray mold severity in the KS2019 castor bean hybrid. However, this effect was observed on secondary racemes. Applying these fungicides after disease occurrence was insufficient to eliminate the negative effects of A. ricini on castor bean, resulting in high severity values on primary racemes. Reduced severity on secondary racemes suggests that preventive applications of the aforementioned active ingredients can protect racemes, provided applications occur before disease symptoms appear in the crop.

Future work should therefore test new active ingredients and fungicide application timings, that is, before symptoms appear (preventively) or after the onset of gray mold symptoms.

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