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Efficiency of atrazine for weed control in grain sorghum

Diego Miguel Blanco Bertolo[1], Murilo Battistuzzi Martins[1], Eduardo Pradi Vendruscolo[1], Ítalo Ferreira Vetruve[1]

[1] Universidade Estadual de Mato Grosso do Sul, Unidade Universitária de Cassilândia, Cassilândia, Mato Grosso do Sul, Brasil. E-mail: diego_miguel_dm@hotmail.com, murilo.martins@uems.br, eduardo.vendruscolo@uems.br, ivetruve@gmail.com

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ABSTRACT

Sorghum is an important crop due to its resilience; however, the presence of weeds in cultivation areas can affect yield. This study aimed to evaluate the efficacy of atrazine for controlling weeds in sorghum (*Sorghum bicolor*) crops. The experiment was conducted at the State University of Mato Grosso do Sul, in Cassilândia. Three weed species, *Synedrellopsis grisebachii*, *Commelina benghalensis*, and *Digitaria insularis*, were considered to evaluate the effectiveness of atrazine control. The visual method was used to evaluate herbicide control, with scores ranging from 0% to 100% at 7, 14, and 21 days after spraying. At 7 days after application of the products, there was no significant difference for *C. benghalensis* and *S. grisebachii*. At 14 DAA, *S. grisebachii* showed high control, thereby significantly differentiating it from the other species. There was no significant difference in the control of *S. grisebachii* and *C. benghalensis* at 21 DAA. The results showed that atrazine is ineffective at controlling *D. insularis*. According to the vegetation cover treatments, none of the treatments differed significantly from each other. Atrazine provided 83% control of *S. grisebachii* after 21 days. It was observed that millet straw cover provided greater weed control, leading to better weed management and reduced product leaching. There was no satisfactory control for the other species studied.

Keywords: *Sorghum bicolor*, Herbicide, Mortality, Invasive plants.

Eficiência da atrazina para controle de plantas daninhas em sorgo granífero

RESUMO

O sorgo é uma cultura importante devido à sua resiliência, porém a presença de plantas invasoras em áreas de cultivo pode impactar a produtividade. O objetivo deste estudo foi avaliar a eficácia do herbicida Atrazina no controle de plantas invasoras em lavouras de sorgo (*Sorghum bicolor*). O experimento foi conduzido na Universidade Estadual de Mato Grosso do Sul, em Cassilândia. Três espécies de plantas daninhas, *Synedrellopsis grisebachii*, *Commelina benghalensis* e *Digitaria insularis*, foram consideradas para avaliar a efetividade do controle com atrazina. O método visual foi utilizado na avaliação, comparando o controle do herbicida, com escores variando de 0% a 100% de controle aos 7, 14 e 21 dias após a aplicação. Aos 7 dias após a aplicação dos produtos, não houve diferença significativa entre *C. benghalensis* e *S. grisebachii*. Aos 14 dias após a aplicação, *S. grisebachii* apresentou alto controle, diferenciando-se significativamente das demais espécies. Não houve diferença significativa no controle de *S. grisebachii* e *C. benghalensis* aos 21 dias após a aplicação (DAA). Os resultados mostraram que a atrazina não é eficaz no controle de *D. insularis*. De acordo com a cobertura vegetal, nenhum dos tratamentos diferiu significativamente entre si. O uso de atrazina para *S. grisebachii* apresentou controle de 83% das plantas daninhas após 21 dias. Observou-se que a cobertura com palha de milheto proporcionou maior controle, resultando em melhor manejo das plantas daninhas e evitando a lixiviação do produto. Não houve controle satisfatório para as demais espécies estudadas.

Palavras-chave: *Sorghum bicolor*, Herbicida, Mortalidade, Plantas invasoras.

1. Introduction

Sorghum (*Sorghum bicolor* L.) is a crop of great agronomic importance worldwide, cultivated on practically every continent as a food source for both human and animal consumption. It ranks as the fifth most produced cereal worldwide, and Brazil is among the ten largest producers, with production of approximately 6.102 million tons in the 2024/2025 crop year (Conab, 2026; Lopes et al., 2022).

Grain sorghum faces challenges related to the substantial weed pressure in most farmers' fields. Weeds represent a significant problem for sorghum cultivation due to the limited availability of selective herbicides for this crop (Bajwa et al., 2023).

Weed control poses a significant challenge in production, and most farmers opt for chemical control. However, there are other effective ways to reduce the incidence of unwanted species, including cultural, biological, mechanical, and physical controls (Costa et al., 2018).

The adoption of cover crops to form mulch on the soil is a strategy to mitigate weed invasion, as it deprives the crop of light and other resources during its growth period. Furthermore, this cover crop can release allelochemical compounds into the soil, which reduce weed populations through its residues (Wittwer et al., 2017; Lebreton et al., 2024).

The use of herbicides plays a fundamental role in weed control. According to Siqueira et al. (2023), applying herbicides before and after crop emergence significantly reduces weed infestation. Atrazine is commonly used in sorghum cultivation to control various annual broadleaf weeds and grasses in pre-emergent or post-emergent applications (Bararpour et al., 2019).

Atrazine application in sorghum can increase grain yield; however, the recommended rate must be carefully followed to ensure crop selectivity (Magalhães et al., 2023; Pimentel et al., 2022).

Atrazine directly inhibits photosynthesis in the thylakoid membrane of chloroplasts in photosystem II, blocking electron transport and consequently interrupting CO_2 fixation and ATP and NADPH production, which are important for plant growth (Oliveira Junior, 2021). Therefore, the objective of the study was to evaluate the efficacy of atrazine at different times after application for the control of *Synedrellopsis grisebachii*, *Commelina benghalensis*, and *Digitaria insularis* in sorghum (*Sorghum bicolor*) crops.

2. Material and Methods

The experiment was conducted at the State University of Mato Grosso do Sul, at the Cassilândia University Unit, located at 19º07’03” S, 51º43’47” W, at an altitude of 516 m, during the 2023/24 growing season. The soil was classified as Neossolo Quartzarênico, according to the Brazilian Soil Classification System (Santos et al., 2018). According to Köppen, as adapted by Alvares et al. (2013), the region's climate is characterized by rainy summers and dry winters, with average annual precipitation and temperature of 1520 mm and 24.1 °C, respectively. Temperature and precipitation data during the experimental period were obtained from a weather station installed at the Mato Grosso do Sul State University (UEMS) in Cassilândia, Mato Grosso do Sul, Brazil, and are presented in Figure 1.

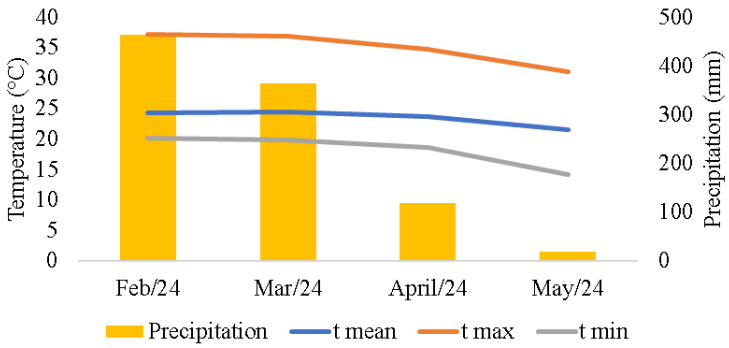

Figure 1. Maximum, mean, and minimum air temperature and precipitation recorded during the 2022/2023 experimental season.

Before sowing sorghum, the straw volume for each plant cover was determined at 5378, 5014, and 4543 kg ha^{-1} for corn, millet, and Brachiaria, respectively. Sorghum of the B1G211 cultivar was sown in a no-till area since 2020, adopting a spacing of 0.5 m between rows and 10 seeds per linear meter under different plant covers. Sowing was mechanized with a 5-row no-till seeder mounted on an agricultural tractor. The straw

remaining after harvesting the corn crop, the millet cultivar ADR 300, and the tannergrass cv. Marandú, after desiccation with glyphosate, was used to form the covers.

The experimental design was a randomized block design with three treatments and 12 replicates, using different plant covers: corn, millet, and brachiaria.

At the V4 phenological stage of the sorghum crop, a survey of weeds present in the experimental plots was conducted, namely *Synedrellopsis grisebachii*, *C. benghalensis*, and *Digitaria insularis*, which had developed 8 to 10 leaves, and the herbicide atrazine (1,250 g a.i. ha^{-1}) was applied in a spray volume of 200 L ha^{-1} to control them. A 20-liter electric backpack sprayer equipped with a JSF11003 fan nozzle and a constant pressure of 2.0 bar was used for spraying.

Visual assessments of weed control were performed at 7, 14, and 21 days after application (DAA). The visual method, as used by Velini et al. (1995), was used to evaluate weed control effectiveness, comparing treated plots with the untreated control. In this evaluation, a score between 0% and 100% control was given.

The collected data were subjected to analysis of variance (ANOVA) using the F test ($p < 0.05$), and the means were compared using the Scott-Knott (1974) test at the 5% significance level. The Sisvar software 5.6 was used for statistical analyses (Ferreira, 2011).

3. Results and Discussion

Figure 2 shows the results for weed control regardless of vegetation cover; there was no significant difference between *C. benghalensis* and *S. grisebachii*, and both achieved low weed control of 24.2%. For *Digitaria insularis*, no control was observed at 7 DAA, with only 0.5% control.

These results can be explained based on the phenological stage of the plants. In more advanced stages, some species produce cuticular waxes that prevent the product from penetrating, whereas in younger plants these layers are less noticeable, thereby contributing to control (Siqueira et al., 2023).

The low weed control efficacy at 7 DAA was also observed in other studies, such as that by Dias et al. (2023), using the herbicide atrazine for weed control in sorghum crops, which reported 11.25% control for species such as *C. benghalensis* and *S. grisebachii*, results lower than those found in the present study. In addition, weed species such as *Commelina* spp. can be difficult to control, thereby limiting initial control efficacy (Carvalho et al., 2015; Matte et al., 2018).

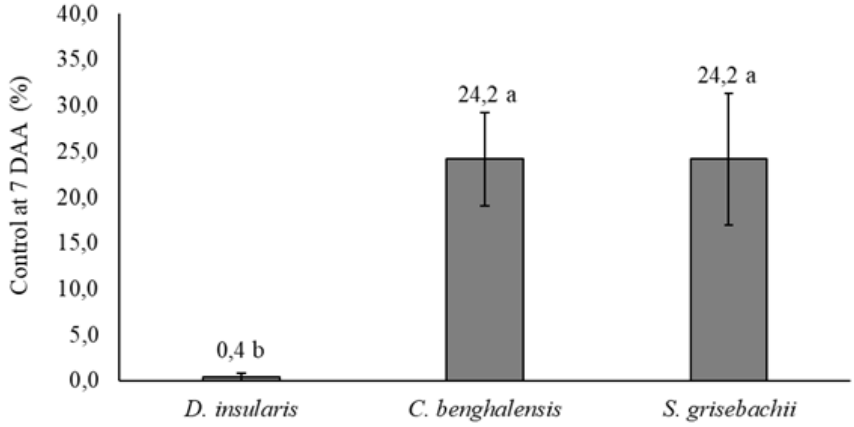

Figure 2. Percentage of weed control 7 DAA. Means followed by the same letter do not differ significantly from each other according to the Scott-Knott test at 5% probability.

At 14 DAA (Figure 3), *S. grisebachii* showed the highest control (82.5%), significantly higher than the other species, *C. benghalensis* and *Digitaria insularis*, with 49.6% and 5.6% control, respectively.

The low control rate of *Digitaria* spp. at 14 DAA with atrazine was also observed by Currie and Geier (2019) in other grass crops. However, for *C. benghalensis*, Bottcher et al. (2022) reported that using the herbicide terbuthylazine as an alternative to atrazine for weed control in glyphosate-tolerant corn did not achieve control, unlike this study, where relative control of 49.6% was observed.

The higher control observed in *S. grisebachii* may be related to its greater susceptibility to triazines, as part of this product can be degraded in species tolerant to the metabolism of its compounds, especially due to possible conjugation with glutathione in the leaves, hindering transport to the chloroplast (Oliveira Junior et al., 2021). This may be one of the factors that hindered the control of *C. benghalensis*.

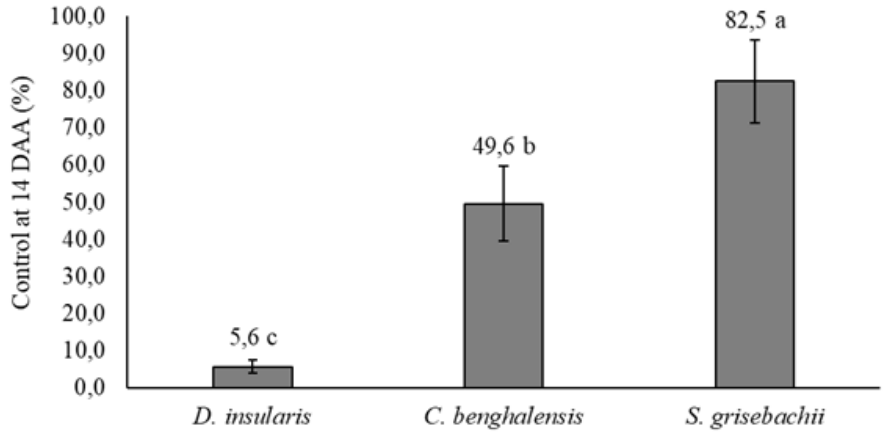

Figure 3. Percentage of weed control 14 DAA. Means followed by the same letter do not differ significantly from each other according to the Scott-Knott test at 5% probability.

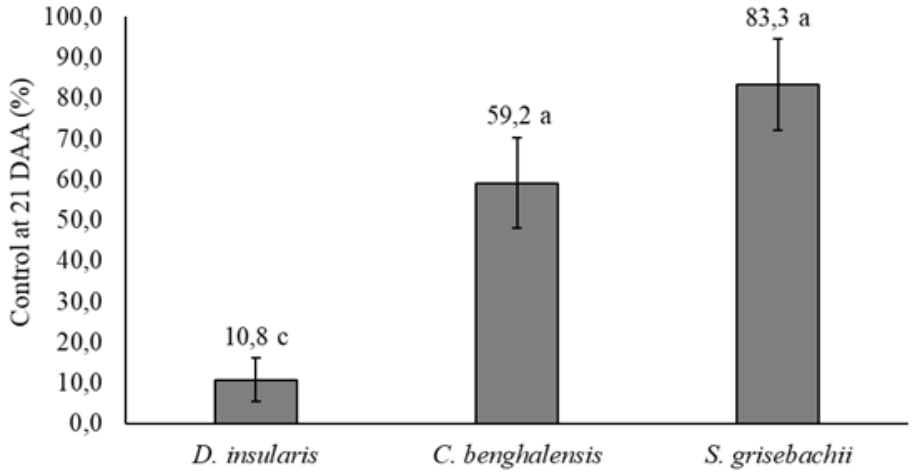

Figure 4. Percentage of weed control 21 DAA. Means followed by the same letter do not differ significantly from each other according to the Scott-Knott test at 5% probability.

There was no significant difference in the control of *S. grisebachii* and *C. benghalensis* at 21 DAA (Figure 4). The results showed that atrazine is ineffective at controlling *D. insularis*, indicating the need for alternative management.

Results like these help inform decision-making for controlling invasive species in sorghum crops. Pimentel et al. (2022) observed that, when applying atrazine, some hybrids were shorter, as plants first promote root growth and then increase their height, which can lead to production problems amid weeds.

It is essential to maintain strict weed control during the critical period of crop establishment, or until canopy closure, to avoid yield losses. This interval is called the Total Interference Prevention Period (TPIP), and as described by Rodrigues et al. (2010), in sorghum crops, interference should be prevented in the first 26 days after sowing. Thus, atrazine demonstrated high efficacy in controlling *S. grisebachii* and *C. benghalensis* during this period.

Figure 5 shows the percentage of weed species controlled by vegetation cover. Given the data presented, none of the treatments differed significantly from each other. However, plots with corn cover had greater control, followed by millet and brachiaria, which may be related to the greater amount of plant residue maintained on the soil surface, thereby maintaining herbicide residues for a longer period, since the incorporation of cover crops in an agricultural production system can help suppress weeds (Cholette et al., 2018).

Triazines have low to moderate soil sorption coefficients, moderate water solubility, and relatively high mobility, which may favor leaching and reduce weed control effectiveness (Albrecht et al., 2025).

The product's residual effect on the straw prevents herbicide dissipation and leaching by up to 50%, while atrazine degradation occurs via abiotic processes, including hydrolysis and photolysis. Thus, the presence of cover crop residues reduces herbicide dissipation,

thereby prolonging control (Liu et al., 2021; Aslam et al., 2015).

Based on the results obtained, there is a clear need to conduct further studies under different edaphoclimatic conditions, as well as to evaluate the effectiveness of atrazine against other weed species, to verify its efficacy against the diversity of species present in the field.

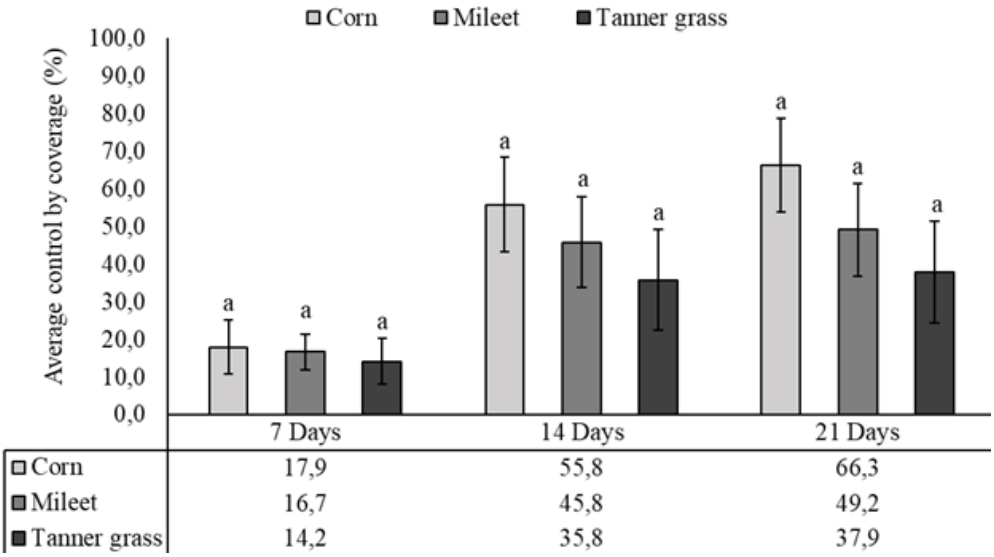

Figure 5. Infestation rate and weed control by vegetation cover. Averages with the same letter do not differ significantly from each other according to the Scott-Knott test at the 5% level.

4. Conclusions

Atrazine was effective in controlling *S. grisebachii* and *C. benghalensis* at 21 DAA, but it was not effective against *D. insularis* under the conditions of this experiment.

Authors' Contribution

Conceptualization and methodology: Diego Miguel Blanco Bertolo, Murilo Battistuzzi Martins; data collection and curation: Diego Miguel Blanco Bertolo, Ítalo Ferreira Vetruve; formal analysis: Murilo Battistuzzi Martins, Eduardo Pradi Vendruscolo; data interpretation: Diego Miguel Blanco Bertolo, Murilo Battistuzzi Martins, Eduardo Pradi Vendruscolo; project administration: Murilo Battistuzzi Martins, Diego Miguel Blanco Bertolo; supervision: Murilo Battistuzzi Martins, Eduardo Pradi Vendruscolo; preparation of the original draft: Diego Miguel Blanco Bertolo, Ítalo Ferreira Vetruve; writing - revision and editing: Diego Miguel Blanco Bertolo, Murilo Battistuzzi Martins, Eduardo Pradi Vendruscolo, Ítalo Ferreira Vetruve. All authors read and approved the final version of the manuscript.

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Bibliographic References

Albrecht, L.P., Albrecht, A.J.P., Bottcher, A.A., de Carvalho, M.G., Danilussi, M.T.Y., Silva, A.F.M., Larini, W.F., Torigoe, R.T. 2025. Terbuthylazine, atrazine, and atrazine + mesotrione for weed control in second-crop maize in Brazil. Revista Ceres, 72, e72002. https://doi.org/10.71252/2177-34912025720002

Alvares, C.A., Stape, J.L., Sentelhas, P.C., Gonçalves, J.D. M., Sparovek, G. 2013. Köppen's climate classification map for Brazil. Meteorologische Zeitschrift, 22(6), 711–728. DOI: https://doi.org/10.1127/0941-2948/2013/0507

Aslam, S., Iqbal, A., Deschamps, M., Recous, S., Garnier, P., Benoît, P. 2015. Effect of rainfall regimes and mulch decomposition on the dissipation and leaching of S-metolachlor and glyphosate: a soil column experiment. Pest management science, 71(2), 278-91. DOI: https://doi.org/10.1002/ps.3803

Bajwa, A.A., Nawaz, A., Farooq, M., Chauhan, B.S., Adkins, S. 2023. Herbicide Program to Control Parthenium hysterophorus in Grain Sorghum in an Arid Environment.

Crops, 3(4), 292-301. DOI: https://doi.org/10.3390/crops3040026

Bararpour, T., Hale, R.R., Kaur, G., Singh, B., Tseng, T.-M.P., Wilkerson, T.H., Willett, C.D. 2019. Weed Management Programs in Grain Sorghum (Sorghum bicolor). Agriculture, 9(8), 1-13. DOI: https://doi.org/10.3390/agriculture9080182

Bottcher, A.A., Albrecht, A.J., Albrecht, L.P., Silva, A.F., Freitas, J., Souza, T. 2022. Terbuthylazine herbicide: an alternative to atrazine for weed control in glyphosate-tolerant maize. Jounal of Environmental Science and Health, Part B, 57(8), 609-616. DOI: https://doi.org/10.1080/03601234.2022.2088015

Carvalho, F.P.; São José, R.H.; Lopes, L.C.M.; Ronchi, C.P. Benghal dayflower control with different glyphosate formulations. Revista Brasileira de Herbicidas, v.14, n.3, p.194-199, 2015. DOI: https://doi.org/10.7824/rbh.v14i3.419

Cholette, T.B., Soltani, N., Hooker, D.C., Robinson, D.E., Sikkema, P.H. (2018). Suppression of Glyphosate-resistant Canada Fleabane (Conyza canadensis) in Corn with Cover Crops Seeded after Wheat Harvest the Previous Year. Weed Technology, 32(3), 244–250. doi:10.1017/wet.2018.19

CONAB. COMPANHIA NACIONAL DE ABASTECIMENTO, 2025. Ministério da Agricultura, Pecuária e Abastecimento. Acompanhamento da Safra Brasileira de Grãos safra 2024/25, Brasília, décimo segundo levantamento, 133 p.

Costa, N.V., Rodrigues-Costa, A.C.P., Coelho, E.M.P., Ferreira, S.D., Barbosa, J.De.A. 2018. Métodos de controle de plantas daninhas em sistemas orgânicos: breve revisão. Revista Brasileira de Herbicidas, 17(1), 25 – 44. DOI: https://doi.org/10.7824/rbh.v17i1.522

Currie, R.S., Geier P.W. 2019. Comparisons of terbuthylazine and atrazine rates and tank mixtures in irrigated corn. Kans Agric Exp Stn Res Rep., 5(7), 1-7. DOI: https://doi.org/10.4148/2378-5977.7822

Dias, A.R., Corrêa, F.R., Da Silva, F.N.F., Cavalcante, W.S.Da.S., Ribeiro, D.F., Rodrigues, E. 2023. Efeitos do herbicida mesotriona aplicado em pós-emergência no sorgo cultivado em segunda safra na região Sudoeste de Goiás, Brasil. Brazilian Journal of Science, 2(2), 39-48. DOI: https://doi.org/10.14295/bjs.v2i2.262

Ferreira D.F. 2011. Sisvar: a computer statistical analysis system. Ciênc Agrotec., 35(6), 1039-1042. DOI: https://doi.org/10.1590/S1413-70542011000600001

Lebreton, P., Bedoussac, L., Bonnet, C., Journet, E.P., Justes, E., Colbach, N. 2024. Optimal species proportions, traits and sowing patterns for agroecological weed management in legume-cereal intercrops. Eur. J. Agron. , 159, 1-14. DOI: https://doi.org/10.1016/j.eja.2024.127266

Liu, J., Zhou, J.H., Guo, Q.N., Ma, L.Y., Yang, H. 2021. Physiochemical assessment of environmental behaviors of herbicide atrazine in soils associated with its degradation and bioavailability to weeds. Chemosphere, 262. DOI: https://doi.org/10.1016/j.chemosphere.2020.127830

Lopes, P.C., Souza, P.G.C., Santos, J.C.B., Borges, C.E., Araújo, F.H.V., Martins, J.C., Picanço, M.C., Soares, M.A., Veloso, R.V.S., Oliveira, J.R., Rossini L.C., Siqueira, F.C., Da Silva, R.C. 2022. Spatiotemporal distribution of Schizaphis graminum (Rondani) and its natural enemy Coccinella septempunctata (Linnaeus) in graniferous sorghum crops. Brazilian Journal of Biology, 84, 1-8. DOI: https://doi.org/10.1590/1519-6984.261972

Magalhães, H.F., Corrêa, F.R., Da Silva, N.F., Cavalcante, W.S.Da.S., Ribeiro, D.F., Rodrigues, E. 2023. Aplicação de mesotrione e atrazine em pós-emergência da cultura do sorgo. Brazilian Journal of Science, 2(2), 49-60. DOI: https://doi.org/10.14295/bjs.v2i2.277

Matte, W.D., Oliveira Jr, R.S., Machado, F.G., Constantin, J., Biffe, D.F., Gutierrez, F.S.D., da Silva, J.R.V. 2018. Eficácia de [atrazine + mesotrione] para o controle de plantas daninhas na cultura do milho. Revista Brasileira de Herbicidas, 17(2), 1-15. DOI: https://doi.org/10.7824/rbh.v17i2.587

Oliveira Júnior, R.S., Biffe, D.F., Machado, F.G., Silva, V.F.V. 2021. Mecanismos de ação de herbicidas. In: Barroso, A. A. M. & Murata, T. M. (Eds). Matologia: estudos sobre plantas daninhas. (pp. 7 – 37). Jaboticabal: Fábrica da Palavra. ISBN 978-65-00-16757-3.

Pimentel, G.V., Moraes, L.C., Moreira, S.G., Moreira, N.M. F., De Freitas, M.G.M.S. 2022. Seletividade de herbicidas na cultura do sorgo forrageiro. Revista Inova Ciência & Tecnologia. 8, 1 – 8. DOI: https://doi.org/10.46921/rict2022-1218

Rodrigues, A.C.P., Costa, N.V., Cardoso, L.A., Campos, C.F., Martins, D. 2010. Períodos de interferência de plantas daninhas na cultura do sorgo. Planta Daninha, 28(1), 23 - 31. DOI: https://doi.org/10.1590/S0100-83582010000100003

Santos, H.G., Jacomine, P.K.T., Anjos, L.H.C., Oliveira, V.Á., Lumbreras, J.F., Coelho, M.R., Almeida, J.A., De Filho, J.C.A., Oliveira, J.B., Cunha, T.J.F. (Eds). 2018. Sistema Brasileiro de Classificação de Solos Centro (5. Ed., pp. 356). Nacional de Pesquisa de Solos: Rio de Janeiro, Brazil. ISBN 978-85-7035-198-2.

Scott, A.J., Knott, M. 1974. A Cluster analysis method for grouping means in the analysis of variance. Biometrics. 30(3), 507 - 512. DOI: https://doi.org/10.2307/2529204

Siqueira, T.De.P., Corrêa, F.R., Da Silva, N.F., Cavalcante, W.S.Da.S., Ribeiro, D.F., Rodrigues, E. 2023. Efeito da aplicação de herbicidas como alternativa de manejo em pré e pós emergência na cultura do sorgo. Brazilian Journal of Science, 2(6), 27-37. DOI: https://doi.org/10.14295/bjs.v2i6.263

Velini, E.D., Osipe, R., Gazziero, D.L.P. (Eds). 1995. Procedimento para Instalação Avaliação e Análise de Experimentos Com Herbicidas, (pp. 42). Londrina: Sociedade Brasileira da Ciência de Plantas Daninhas.

Wittwer, R.A., Dorn, B., Jossi, W., Van Der Heijden, M.G.A. 2017. Cover crops support ecological intensification of arable cropping systems. Sci. Rep, 7, 1-12. DOI: https://doi.org/10.1038/srep41911