ALLELOPATHY AND HERBICIDES: A COMPREHENSIVE REVIEW

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Maria Elizete Machado Generino
Regional University of Cariri, Department of Biological Sciences, Crato, CE
http://lattes.cnpq.br/0777413376782312

Fabio Caboclo Moreira
Regional University of Cariri, Department of Biological Sciences, Crato, CE
https://lattes.cnpq.br/1372375588097799

Maria Jeane Silva Lacerda
Regional University of Cariri, Department of Biological Sciences, Crato, CE

José Weverton Almeida-Bezerra
Regional University of Cariri, Department of Biological Sciences, Crato, CE
http://lattes.cnpq.br/5570296179611652

Rafael Pereira da Cruz
Regional University of Cariri, Department of Biological Sciences, Crato, CE
http://lattes.cnpq.br/3675589918865790

Angélica Rodrigues de Souza Costa
Regional University of Cariri, Department of Biological Sciences, Crato, CE
http://lattes.cnpq.br/4238899399296199

Maria Eliana Vieira Figueroa
Pernambuco State Secretariat
http://lattes.cnpq.br/9551086188725906

Rita Helanny Viana Eugênio
Regional University of Cariri, Department of Biological Sciences, Crato, CE
http://lattes.cnpq.br/6009566964850424

Amanda Maria Tavares Moreira
Regional University of Cariri, Department of Biological Sciences, Crato, CE
http://lattes.cnpq.br/2371233987733428

Cicero Dos Santos Leandro
Regional University of Cariri, Department of Biological Sciences, Crato, CE
http://lattes.cnpq.br/7323619730656059

Marcos Aurélio Figueirêdo dos Santos
Regional University of Cariri, Department of Biological Sciences, Crato, CE
http://lattes.cnpq.br/8643818710205791

Maria Arlene Pessoa da Silva
Regional University of Cariri, Department of Biological Sciences, Crato, CE
http://lattes.cnpq.br/3836224227922749

ABSTRACT: This article comprehensively reviews the field of allelopathy, addressing its historical evolution, contemporary definitions, and practical applications. It begins with an analysis of the ancient origins of allelopathy, dating back to observations

from the 5th century BC until its formalization as a concept in the 20th century. The processes of production and release of allelochemicals by plants are explored, highlighting the mechanisms involved and their impacts on interactions between plants and microorganisms. Furthermore, the use of herbicides in agriculture is examined, with an emphasis on atrazine and its environmental implications and weed resistance. Finally, the future prospects of allelopathy are discussed, especially the potential of bioherbicides to promote more sustainable agricultural practices. This article contributes to the general understanding of allelopathy and its role in modern agriculture by highlighting promising research areas for developing more effective and environmentally responsible weed control strategies.
KEYWORDS: Plant-microorganism, Bioherbicides, Weeds, Allelochemicals.

ALELOPATIA E HERBICIDAS: UMA REVISÃO ABRANGENTE

RESUMO: Este artigo revisa abrangentemente o campo da alelopatia, abordando sua evolução histórica, definições contemporâneas e aplicações práticas. Inicia-se com uma análise das origens antigas da alelopatia, remontando às observações do século V a.C. até sua formalização como conceito no século XX. São explorados os processos de produção e liberação de aleloquímicos pelas plantas, destacando os mecanismos envolvidos e seus impactos nas interações entre plantas e microrganismos. Além disso, examina-se o uso de herbicidas na agricultura, com ênfase na atrazina e suas implicações ambientais e na resistência de plantas daninhas. Por fim, são discutidas as perspectivas futuras da alelopatia, especialmente o potencial dos bioherbicidas para promover práticas agrícolas mais sustentáveis. Este artigo contribui para o entendimento geral da alelopatia e seu papel na agricultura moderna, destacando áreas de pesquisa promissoras para o desenvolvimento de estratégias de controle de plantas daninhas mais eficazes e ambientalmente responsáveis.
PALAVRAS-CHAVE: Planta-microrganismo, Bioherbicidas, Plantas daninhas, Aleloquímicos.

INTRODUCTION

Allelopathy is seen as an influence, positive or negative, between plants from allelochemicals produced in various parts of them. Allelochemicals originate from secondary metabolism and their production is regulated by several environmental factors, such as temperature, light intensity, availability of water and nutrients, soil texture and microorganisms present (CHOU; KUO, 1986; CARMO et al., 2007).

Weeds have the ability to inhibit the development of other plants, and bring several losses to commercial crops, leading farmers to use synthetic herbicides to combat them, such as the herbicide atrazine, which according to Mendonça (2014), is widely used in several annual and perennial crops, such as corn, sugar cane, sorghum, coffee, cocoa, bananas, tea, pineapple, rubber trees and sisal.

Even though this chemical control implies several losses, such as soil and water pollution, risk to human health, resistance in weed species. An alternative that has been studied, with the purpose of complementing traditional management methods, minimizing the use of herbicides, is the allelopathic action, inherent to several plant species, which through the release of substances (allelochemicals) poses fewer risks to human health. and the environment combined with the growing demand for healthy food products free from pesticide residues (CORRÊA; SALGADO, 2011).

Thus, the growing desire to reduce the use of synthetic chemical inputs in the sustainability of production systems and the conservation of natural vegetation, as they represent a biological alternative with specific action and less harmful to the environment (TUR et al., 2010).

REVIEW

Allelopathy: history and concept

Although allelopathy is a recent science, the first record of an allelopathic effect was reported in the 5th century BC by Democritus, who referred to the inhibitory action caused by some plants on others (ALMEIDA, 1985). Later, Theophatus (300 BC), a disciple of Aristotle, observed that *Cicer arietinum* L. (chickpea) did not allow other plants to establish themselves in the soil, in addition to affecting the development of invasive plants (RICE, 1984).

Pliny, in the 1st century AD, reported the negative effects of *Juglans nigra* and *J. regia* on the development of seedlings cultivated in their proximity (VYVYAN, 2001). And a Japanese document, written about 300 years ago, demonstrated evidence of probable allelopathic effects attributed to *Pinus densiflora* Siebold & Zucc. (FERREIRA; AQUILA, 1999).

In 1882, De Candolle theorized that plant roots had, in addition to the function of absorption, that of excretion, and their excrement would be poisonous to plants of the same species, genus or family, but at the end of the 19th century his theory was challenged and abandoned (MANO, 2006). In 1909, work produced by Shorey proved for the first time the existence of toxins in soils previously cultivated and left fallow (ALMEIDA, 1990).

Despite all the evidence of a phenomenon that caused certain plants in the presence of others to not reproduce through the germination of their seeds or not to develop their seedlings, it was only in 1937 that the term “allelopathy” was created by the German researcher Hans Molisch, with the combination of the Greek words “allélon” and “pathos”, which respectively mean mutual and harm. According to Molisch, allelopathy is “the ability of plants to produce chemical substances that, when released into the environment of others, influence their development favorably or unfavorably” (FERREIRA; AQUILA, 2000).

One of the most accepted definitions for allelopathy is attributed to the International Allelopathy Society (IAS), which considers the phenomenon as “the science that studies processes involving secondary metabolites produced by plants, algae, bacteria and fungi that influence the growth and development of agricultural systems and biological” (MACÍAS et al., 2007). Being characterized as a new science that becomes more important every day in most developed countries (MACÍAS et al., 2006).

Allelochemicals are produced by the secondary metabolism of plants and are responsible for the transmission of information between plants, in addition to acting in interactions between plant-plant, plant-insect and plant-microorganism (BOGATEK; GNIAZDOWSK; ZAKRZEWSKA, 2006). There are several classes of secondary metabolites found in plants, such as flavonoids, alkaloids, tannins, phenols, among others.

Production and means of release of allelochemicals

The production and accumulation of allelochemicals can occur in different parts of the plant such as: root, stem, leaf, flower and fruit, with a tendency for accumulation in the leaves (SOUZA FILHO et al. 2009). The release of these secondary compounds occurs through processes such as root exudation, leaching, volatilization and waste decomposition.

In root exudation, a large number of allelopathic compounds are released into the surrounding rhizosphere and can act directly or indirectly on plant-plant interactions and the action of microorganisms (INDERJIT; DAKSHINI, 1992; 1994). Putnam (1983) reports that exudation can also occur from the fruits.

In leaching, chemical substances are removed from the aerial parts and roots of living or dead plants by the action of rainwater, dew or fog (ALVES, 1992). In volatilization aromatic compounds are volatized from leaves, flowers, stems and roots, and can be absorbed by other plants such as carbon dioxide (CO2), ammonia (NH3), ethylene and terpenoids (INDERJIT; DAKSHINI, 1992; 1994).

In the decomposition of residues, parts of the plant fall to the soil and, through the action of microorganisms and climatic conditions, they release allelochemical substances (MALHEIROS; PERES, 2001). According to Almeida, Zucolotoz and Zetum (2008), this type of process allows the release of a large number of compounds that impose toxicity on neighboring microorganisms, such as cyanogenic glycosides, phenolic acids, agropyrenes, coumarins and flavonoids.

Allelopathic compounds, after being released, can cause direct or indirect effects on other plants. Direct effects are characterized by changes in the plant's metabolism and growth, affecting: cytological and ultrastructural structures; hormones, both by altering their concentrations and the balance between different hormones; membranes and their permeability; absorption of minerals; stomatal movement, pigment synthesis and photosynthesis; breathing; protein synthesis; enzymatic activity; water relations and driving; genetic material, inducing changes in DNA. Indirect effects include changes in soil properties, interfering with the absorption of nutrients, as well as the population and activity of microorganisms (PIRES; OLIVEIRA, 2001).

The procedures used to evaluate the allelopathic activities inherent to different species are bioassays, in which global parameters such as germination, growth and development of seedlings or adult plants and more specific parameters can be evaluated, such as the activity of some physiological processes, such as , for example, photosynthesis, respiration and chlorophyll content (SOUZA-FILHO; ALVES, 2002).

Use of herbicides and consequences

With the increasing advancement of agriculture, mainly due to its important participation in the economy of many countries, several methods are used so that large-scale production occurs without much damage, including chemical methods. In chemical control, the use of herbicides is used with the purpose of inhibiting the development and/or causing the death of weed plants, however, this method must be associated with other control practices, the most important being cultural control (SILVA et al., 2002).

A herbicide can be defined as any chemical product that kills or inhibits the development of weeds (LORENZI, 1990). They are applied in convenient doses directly to the vegetation for foliar absorption (post-emergence treatment), or to the soil for absorption by tissues formed after seed germination before the plant emerges on the surface (pre-emergence treatment) (BLANCO, 2008). The doses of herbicides normally recommended on labels are established by manufacturers at high levels to ensure efficient control of species over a wide range of management and environmental conditions (DEVLIN et al., 1991).

However, the application of these compounds, depending on the active ingredient or formulation, the dose used, the microorganisms present and their sensitivity to the different products (ROYUELA et al., 1998), the climatic conditions and the type of soil (SILVA et al. , 2003), can bring undesirable consequences.

In addition to damaging human health, current herbicides have caused changes in the populations of invasive species, increasing resistance to these compounds and causing a risk of environmental contamination (OLOFSDOTTER; MADSEN 2000; DUKE et al. 2000). Problems of weed resistance to herbicides emerged in the 1980s, with the development and repetitive use, over several years, of highly efficient and selective products, contributing to the selection of weeds resistant to them (CARVALHO, 2004). Ohmes and Kendig (1999) distinguish two ways in which resistance can arise in a population: mutation through the intensity of recurrent selection, which changes a susceptible population to a resistant population, generation after generation; and preexistence of genes in the population.

In addition to inducing resistance, herbicides can alter the physicochemical properties of water and soil. Ahmad and Malloch (1995) report a reduction of up to 40% in the bacterial population of a soil, creating a biological void and thus increasing the availability of nutrients for soil-dwelling phytopathogens, causing a significant increase in the incidence of diseases.

The herbicide Atrazine

Atrazine (2-chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine), a pre- and post-emergent herbicide with low reactivity and solubility, is an important representative of the triazine group. Herbicides in this group comprise around 30% of global pesticide production (CABRAL et al., 2003). S-triazines normally have a heterocyclic ring with six members, whose C and N atoms are symmetrically located (PACAKOVA; STULIK; JISKRA,1996). Atrazine is a contact herbicide, absorbed by leaves and roots and acts by inhibiting photosystem II of photosynthesis, blocking the flow of electrons, leading to the production of excess singlet oxygen, which results in the destruction of chlorophyll lipids (PRESTON; MALLORY- SMITH, 2001).

It is indicated for the annual control of weeds in a wide variety of crops, with 500 g L-1 of active ingredient, including corn, sugar cane, sorghum and pine. Its residues and metabolites can be found in soils and groundwater after a long period of application (COUTINHO, 2006), with its average lifespan varying from 20 to more than 100 days.

Bioherbicides and allelopathy

Most allelopathic substances come from secondary metabolism, because in the evolution of plants they represented some advantage against the action of microorganisms, viruses, insects, and other pathogens or predators, either by inhibiting their action or by stimulating the growth or development of plants (WALLER, 1999).

Given the growing global concern about the preservation and conservation of the environment and the use of oil, the raw material for some herbicides, the proposal to introduce bioherbicides as a way to combat weeds is growing every year. Thus, allelopathy is configured as a research area of great importance, as it allows the search for substances of plant origin with bioherbicide attributes for the control of invasive plants in agriculture, reducing or eliminating environmental contamination, preserving natural resources and ensuring the supply of quality products (SOUZA FILHO; ALVES, 2002).

Several species have the potential to be used as bioherbicides, such as *Dieffenbachia picta* Schott (Apocynaceae), considered toxic because its leaves contain cardiotoxic glycosides called oleandrin and neriantin (BARG, 2004), it has negative allelopathic activity on seeds of *Lactuca sativa* and *Bidens pilosa* (HOFFMANN et al., 2007). Oats, due to phenolic, ferulic, coumaric, syringic, vanillic and p-hydroxybenzoic acids (GUENZI; MCCALLA, 1966; GUENZI; MCCALLA; NORSTADT, 1967) and scopoletin (FAY; DUKE, 1977) have a negative effect on germination and the development of undesirable seedlings. *Leucaena leucocephala* (leucena) mulch has weed control properties, due to the presence of allelochemicals in the aerial part of the plant (BUDELMAN, 1988). Among these substances, the allelopathic potential of leucaena is mainly attributed to the allelochemical mimosine.

Sorghum bicolor L. (sorghum), due to its recognized allelopathic action, has been used in intercropping systems in an attempt to reduce the use of chemical herbicides (SANTOS et al., 2012). One of its compounds, sorgoleone, acts by inhibiting photosynthesis (CZARNOTA et al., 2001; YANG et al., 2004). It also plays a role in mitochondrial electron transport, interfering with the activity of H^+-ATPase and also in the capture of water from the soil (HEJL; KOSTER, 2004; DAYAN et al., 2009).

CONCLUSIONS

In short, allelopathy emerges as a promising and sustainable alternative in weed control, mitigating the negative impacts associated with the excessive use of synthetic herbicides. Understanding the mechanisms of production and release of allelochemicals by plants, combined with advances in bioherbicide research, stands out as an effective approach for the integrated management of invasive plants. The use of plant species with allelopathic potential, as a source of bioherbicides, not only contributes to the preservation of the environment and natural resources, but also promotes sustainable agricultural production, in line with the growing demand for healthy foods free from pesticide residues. In this context, allelopathy represents an important resource for modern agriculture, offering innovative solutions that are less harmful to the environment.

REFERENCES

AHMAD, I.; MALLOCH, D. Interaction of soil microflora with the bioherbicide phosphinothricin. **Agriculture, Ecosystems and Environment**, v. 54, n. 3, p. 165-174, 1995.

ALMEIDA, A. R. P. A defesa das plantas: alelopatia. **Ciências Hoje**, v. 11, n. 62, p. 38-45, 1990.

ALMEIDA, F. S. Influência da cobertura morta na biologia do solo. **A Granja**, São Paulo, v. 4, n. 451, p. 52-67, 1985.

ALMEIDA, G. D; ZUCOLOTOZ, M; ZETUM, M. C. Estresse oxidativo em células vegetais mediante aleloquímicos. **Revista Facultad Nacional de Agronomia Medillín**, v. 61, p. 4237-4247, 2008.

ALVES, C. A. Interações alelopáticas entre plantas daninhas e hortaliças. Simpósio: Manejo integrado de plantas daninha em hortaliças, **Botucatu**, p. 19-43, 1992.

BARG, D. G. **Plantas tóxicas. Instituto Brasileiro De Estudos Homeopáticos**. Monografia (Graduação em Ciências da Saúde) - Faculdade de Ciências da Saúde de São Paulo, São Paulo, 2004.

BLANCO, F. M. G. Manejo das plantas daninhas na cultura de batata. **Biológico**, São Paulo, v. 70, n. 1, p. 19-24, 2008.

BOGATEK, R; GNIAZDOWSK, A; ZAKRZEWSKA, S. W. Allelopathic effects of sunflower extracts on mustard seed germination on seedling growth. **Biologia Plantarum**, v. 50, n.1, p. 156-158, 2006.

BUDELMAN, A. The performance of the leaf mulches of *Leucaena leucocephala*, *Flemingia macrophylla* and *Gliricidia sepium* in weed control. **Agroforestry Systems**, v.6, p.137-145, 1988.

CABRAL, M. F.; SOUZA, D.; ALVES, C. R.; MACHADO, S. A. S. Estudo do comportamento eletroquímico do herbicida ametrina utilizando a técnica de voltametria de onda quadrada. **Eclética Química**, v. 28, n. 2, p. 41-47, 2003.

CARMO, F. M. S.; BORGES, E. E. L.; TAKAKI, M. Allelopathy of Brazilian sassafras (*Ocotea odorifera* (Vell.)) Rohwer aqueous extracts. **Acta Botanica Brasilica**, v. 21, p. 697-705, 2007.

CARVALHO, J. C. **Mecanismo de ação dos herbicidas e sua relação com a resistência a herbicidas**. In: CHRISTOFFOLETI, P. J. Aspectos de resistência de plantas daninhas a herbicidas. Campinas: HRAC-BR, p. 23-48, 2004.

CHOU, C. H.; KUO, Y. L. Allelopathic research of subtropical vegetation in taiwan. III. Alelopathic exclusion of understrory by Leucaena leucocephala (Lam.). **Journal Chemical Ecology**, v. 12, p. 1431-1448, 1986.

CORRÊA, J. C. R.; SALGADO, H. R. N. Atividade inseticida das plantas e aplicações: revisão. **Revista Brasileira de Plantas Medicinais**, v.13, n.4, p.500-506, 2011.

COUTINHO, C. et al. Pesticidas: mecanismo de ação, degradação e toxidez. **Revista de Ecotoxicologia e Meio Ambiente**, v.15, n.10, p. 61-72, 2006.

CZARNOTA, M.A. et al. Mode of action, localization of production, chemical nature, and activity of sor¬goleone: a potent PSII inhibitor in *Sorghum spp.* root exudates. **Weed Technology**, v.15, p.813-825, 2001.

DAYAN, F. E.; HOWELL, J. L.; WEIDENHAMER, J. D. Dynamic root exudation of sorgoleone and its in planta mechanism of action. **Journal of Experimental Botany**, v.60, n.7, p.2107-2117, 2009.

DEVLIN, D. L.; LONG, J. H.; MADDUX, L. D. Using reduced rates of postemergence herbicides in soybeans (Glycine max). **Weed Technology**, v.5, p.834-840, 1991.

DUKE, S.; DAYAN, R.; ROMAGNI, J.; RIMANDO, A. Natural products as sources of herbicides: current status and future trends. **Weed Research**, v. 40, p.99-111, 2000.

FAY, P. K.; DUKE, W. B. An Assessment of Allelopathic Potential in Avena Germplasm. **Weed Science**, v.5, p.224-228, 1977.

FERREIRA, A. G.; AQUILA, M. E. A. **Alelopatia: uma área emergente da ecofisiologia**. In: VII Congresso Brasileiro de Fisiologia Vegetal, DF. Laboratório de Fisiologia Vegetal, Departamento de Botânica, Brasília, 1999.

FERREIRA, A. G; AQUILA, M. E. A. Alelopatia: uma área emergente da ecofisiologia. **Revista Brasileira de Fisiologia Vegetal**, v.12, p.175-204, 2000.

GUENZI, W. D.; MCCALLA, T. M. Phenolic Acids in Oat, Wheat, Sorghum, and Corn Residues and Their Phytotoxity. **Agronomy Journal**, v.58 p. 303-304, 1966.

GUENZI, W. D.; MCCALLA, T. M.; NORSTADT, F. A. Presence and Persistence of Phytotoxic Substances in Wheat, Oat, Corn, and Sorghum Residues. **Agronomy Journal**, v.59, p.163-165, 1967.

HEJL, A. M.; KOSTER, K. L. The allelochemical sorgoleone inhibits root H+-ATPase and water uptake. **Journal of Chemical Ecology**, v.30, n.11, p.2181-2191, 2004.

HOFFMANN, C. E. F. et al. 2007. Atividade alelopática de *Nerium oleander* L. e *Dieffenbachia picta* Schott em sementes de *Lactuca sativa* L. e *Bidens pilosa* L. **Revista de Ciências Agroveterinárias**, v. 6, n. 1, p. 11-21, 2007.

INDERJIT.; DAKSHINI, K. M. M. Interference potencial o *Pluchea lanceolata* (Asteraceae): growth and physiological responses of asparagus bean, Vigna unguiculata var. sesquipedalis**. American Journal of Botany**, v. 79, p. 977-981, 1992.

INDERJIT; DAKSHINI, K. M. M. Allelopathic effect of *Pluchea lanceolata* (Asteraceae) on characteristics of four soils and tomato and mustard growth. **American Journal of Botany**, v. 81, p. 799-804, 1994.

LORENZI, H. **Manual de identificação e controle de plantas daninhas: plantio direto e convencional**. Nova Odessa-SP. 3ª ed. Editora Plantarum, 339 p, 1990.

MACÍAS, F. A. et al. Bioactive steroids from *Oryza sativa* L. **Steroids**, v. 71, p. 603-608, 2006.

MACÍAS, F. A. et al. Review: allelopathy: a natural alternative for weed control. **Pest Management Science**, v. 63, p. 327-348, 2007.

MALHEIROS, A. **Estudos químicos, farmacológicos e alelopáticos das espécies *Drimys angustifolia* e *Drimys brasiliensis* (Winteraceae).** Tese (Doutorado em Química Orgânica) - Universidade Federal de Santa Catarina, Florianópolis, 2001.

MANO, A. R. O. **Efeito alelopático do extrato aquoso de sementes de cumaru (Amburana cearensis S.) sobre a germinação de sementes, desenvolvimento e crescimento de plântulas de alface, picão-preto e carrapicho**. Dissertação (Mestrado em Agronomia) - Universidade Federal do Ceará, Fortaleza, 2006.

MENDONÇA, J. E. Atrazina, um veneno à solta no mundo. **Planeta Sustentável**. Disponível em: http://planetasustentavel.abril.com.br/blog/planeta-urgente/atrazina-um-veneno-a-solta-no-campo/. Acesso: 20 jan. 2014.

OHMES, G. A.; KENDIG, J. A. Inheritance of an ALScross- resistant common cocklebur (Xanthium strumarium) biotype. **Weed Technology**, v. 13, n. 1, p. 100-103, 1999.

OLOFSDOTTER, M.; MADSEN, B. E. Herbicide resistant rice (*Oryza sativa* L.): global implication for weedy rice and weed management. **Annals of Applied Biology**, v. 137, p. 279-295, 2000.

PACAKOVA, V.; STULIK, K.; JISKRA, J. High-performance separations in the determination of triazine herbicides and their residues. **Journal Chromatography A**, v. 754, n. 1-2, p. 17-31, 1996.

PIRES, N. M. et al. Efeito do estrato aquoso de leucena sobre o desenvolvimento, índice mitótico, e atividade da peroxidase em plântulas de milho. **Revista Brasileira de Fisiologia Vegetal**, v.13, n.1, p.55-65, 2001.

PRESTON, C.; MALLORY-SMITH, C. A. **Biochemical Mechanisms, Inheritance, and Molecular Genetics of Herbicide Resistance in Weed**. In: STHEPHEN, B. P.; DALE, L. S. Herbicide Resistance and World Grain. Boca Raton: CRC, 2001. p. 34-76.

RICE, E. L. **Allelopathy**. 2 ed. New York: Academic Press. 1984. 422 p.

ROYUELA, M. Imazethapyr inhibition of acetolactate synthase in Rhizobium and its symbiosis with pea. **Pesticide Science**, v. 52, p. 372-380, 1998.

SANTOS, I. L. V. L. et al. Sorgoleone: benzoquinona lipídica de sorgo com efeitos alelopáticos na agricultura como herbicida. **Arquivos do Instituto Biológico**, v.79, n.1, p.135-144, 2012.

SILVA, A. A. **Controle de plantas daninhas**. Brasília: ABEAS, módulo 3, 2003. 260p.

SILVA, A. A.; WERLANG, R. C.; FERREIRA, L. R. **Controle de plantas daninhas em pastagens**. In: SIMPÓSIO SOBRE MANEJOESTRATÉGICO DA PASTAGEM, 2002, Viçosa. Simpósio...Viçosa: UFV, 2002. p. 279 -310.

SOUZA FILHO, A. P. S et al. Análise comparativa do potencial alelopático do extrato hidroalcoólico e do óleo essencial de folhas de cipó-d´alho (Bignoniaceae). **Plantas Daninha**, Viçosa, v. 27, n. 4, p. 647-653, 2009.

SOUZA FILHO, A. P. S.; ALVES, S. M. **Alelopatia: princípios básicos e aspectos gerais.** Belém: Embrapa Amazônia Oriental, 2002.

TUR, C. M.; BORELLA, J.; PASTORINI, L. H. Alelopatia de extratos aquosos de Duranta repens sobre a germinação e crescimento inicial de *Lactuca sativa* e *Lycopersicum esculentum*. **Biotemas**, v. 2, n. 23, p. 13-22, 2010.

VYVYAN, J. R. Allelochemicals as leads for new herbicides and agrochemicals. **Tethahedron**, v. 58, p. 1631-1646, 2001.

WALLER, G. R.; FEUG, M. C.; FUJII, Y. **Biochemical analysis of allelopathic compounds: plants, microorganisms, and soil secondary metabolites**. In: INDERJIT; DAKSHINI, K.M.M.; FOY, C.L. (Eds.) Principles and practices in plant ecology. Boca Raton, CRC Press, p.75-98, 1999.

YANG, X.; SCHEFFLER, B.E.; LESLIE, A. Weston SOR1, a gene associated with bioherbicide production in sorghum root hairs. **Jornal of Experimental Botany**, v.55, n.406, p.2251-2259, 2004.