ALLELOPATHY IN NATIVE SPECIES OF BRAZILIAN SAVANNAH

ALELOPATIA EM ESPÉCIES NATIVAS DO CERRADO

[1]Edilene Carvalho Santos Marchi, [2]Giuliano Marchi, [2]José Carlos Sousa-Silva,
[3]Fernanda Satie Ikeda, [4]Christopher William Fagg

[1] Instituto Federal de Educação, Ciência e Tecnologia de Brasília, IFB, Campus de Planaltina. Rod. DF-128, Km 21, Planaltina, DF, Brasil. 73380-900.
1667971@etfbsb.edu.br

[2]Embrapa Cerrados, Rod. BR 020, Km 18, CP 08223, Planaltina, DF, Brasil. 73310-970.
giuliano.marchi@embrapa.br; jose.sousa-silva@embrapa.br

[3] Embrapa Agrossilvipastoril, Rod. MT 222, km 2,5, CP 343, Sinop, MT, Brasil, 78550-970.
fernanda.ikeda@embrapa.br

[4] Faculdade de Ceilândia, Universidade de Brasilia – UnB, Centro Metropolitano, conjunto A, lote 01, Ceilândia, Brasília, DF, Brasil. 72220-275.
fagg@unb.br

Recebido: 18/08/2015 **Aceito:** 26/10/2016 **Publicado:** 28/02/2017
Received: 18/08/2015 **Accepted:** 26/10/2016 **Published:** 28/02/2017

ABSTRACT - In this review, allelopathic studies of 70 species native from Cerrado, distributed in 34 families and studied from 1992 until late 2008, were compiled in a list. The Cerrado Biome comprises several distinct landscape areas constituted by different phytophysiognomies, and is the most biodiverse savanna in the world. From the 12.000 species native to Cerrado, only a small amount of species have been studied. Few allelochemicals in leaves, flowers, shoots, and subterranean parts of plant species were identified in the restricted data. Isolated compounds from a few plants were shown in detail. The synthesis of those compounds was not identified for use in comprehensive control of plants and other organisms. Future studies should be directed to unknown and better known plants; identification of new compounds and their metabolism; synthesis and mode of action of those new compounds; agriculture effects and Cerrado plants establishment.
Keywords: Allelochemical. Brazilian Savanna. Future perspectives. Phytophysiognomy. New compounds.

RESUMO - Nesta revisão, estudos alelopáticos de 70 espécies nativas do Cerrado, distribuídas em 34 famílias e estudadas de 1992 até 2008 foram compiladas em uma lista. O Bioma Cerrado compreende várias paisagens distintas constituídas por diferentes fitofisionomias e é uma das biodiversidades mais ricas no mundo. Das 12.000 espécies lenhosas nativas do Cerrado, somente em uma pequena parte foram estudadas. Poucos aleloquímicos em folhas, flores, parte aérea e partes subterrâneas de espécies de plantas foram identificadas em dados restritos. Compostos isolados de poucas plantas foram mostrados em detalhes. A síntese desses compostos não foi utilizada para uso em controle de plantas daninhas e outros organismos. Futuros trabalhos poderiam ser direcionados para plantas estudadas e ainda não estudadas; a identificação de novos compostos e seu metabolismo; síntese e modo de ação daqueles compostos; efeitos na agricultura e no estabelecimento de plantas no Cerrado.
Palavras chaves: Aleloquímico. Savana brasileira. Perspectivas futuras. Fitofisionomia. Novos compostos.

INTRODUCTION

The Brazilian Cerrado is the second largest Biome in extension in the country, 2.036.448 km² (Anonymous, 2008), and the richest savanna in the world. It borders with the Atlantic Rainforest, Caatinga, Amazon Rainforest, and Pantanal Wetlands, which promotes important dynamics between them. The number of studies related to the establishment and development of species native to Cerrado is still small when compared to an array of more than 11 thousand species described (Mendonça et al., 2008). Currently the available studies about seed germination comprehend no more than 700 species (Sousa-Silva & Camargo, 2008).

A myriad of metabolites are produced by plant species in their growth and development. However, their physiological functions are still unknown (Zimdahal, 1993). These substances are normally secreted by the roots or released from dead tissues. They are products of secondary metabolism, such as terpenoids, phenolic compounds, and alkaloids (Silva et al., 2006). When produced by the plant or plant-associated microorganisms, these substances may interfere in the growth and development of another organism. This interference, when a chemical compound acts over another organism, is called allelopathy (Rice, 1984). Allelopathy has an important role in natural as well as in cultivated ecosystems. It interfears in species dominance, regulation of succession (Hilhorst & Karssen, 2000) and crop productivity as a natural alternative for weed control (Macías, 2007).

A more detailed knowledge will undoubtedly stimulate a better understanding of the environmental control of germination and emergence, of the species evolutive strategies, and some allelochemicals may ultimately lead to the development of alternative methods for weed control and management as well as models for new herbicides (Hilhorst & Karssen, 2000). Besides this has led to a situation of increasing complexity where phytochemical studies interact with many other disciplines, including plant physiology, pharmacy and drug design, medicine, palaeontology, ecology, and biochemistry. The results obtained from these studies can be applied in many fields such as pharmaceuticals, agrochemicals, evolutionary studies, paleobotany, ecosystem management and conservation and basic science (Macías, 2007).

Allelopathic species have being selected by evolutive pressure competing with species from neighborhood. These species have biochemical processes which spend energy to produce allelochemicals. The energy spent certainly is not a waste of energy because no species develops wasting its resources (Zimdahal, 1993), specially species native to Cerrado, where nutrients are, normally, scarce, and the rain occur at widely spaced intervals.

Mineral deficiencies (e.g. boron, calcium, magnesium, nitrogen, phosphorus, potassium, and sulphur) and hydric stresses are some of the factors which may affect allelochemical production (Rice, 1984). To these factors, peculiar of Cerrado, one could include aluminum toxicity effects, which leads plants, as a defense mechanism, to exude higher amount of low molecular weight organic acids (Schöttelndreier et al., 2001), and other compounds which could present allelopathic effects. For this reason, some species native to Cerrado, which are not endemic, but presented allelopathic effects when tested in other biomes (e.g., Maraschin-Silva & Aqüila, 2006a, b; Souza et al., 2005a, b), could produce higher amount of allelochemicals if grown at Cerrado region.

Allelopathic studies with species native to Brazil were brought together before by Ferreira et al. (1992). At that time, the amount of works was negligible, and there was no allelochemical characterization, and also a tendency in researching legume species whose are the most common plants in Cerrado. However, many studies were performed since that last review. The present document grouped allelopathic studies with species native to Cerrado Biome from 1992 until late 2008.

MATERIAL AND METHODS

THE CERRADO (BRAZILIAN SAVANNAH) REGION

The Brazilian Cerrado (Brazilian savannah) has no more than 60.5% of its original vegetation (Figure 1; Sano et al., 2008). This Biome comprises several distinct landscape areas constituted by different phytophysiognomies associated to physical and physiographical factors (Cochrane et al., 1985). It has one of the biodiversity hotspots of the world (Machado et al., 2008; Mendonça et al., 2008) although this Biome is severely threatened (Myers et al., 2000) and some studies still little explored like shrub-tree growth (Paulilo & Felippe, 1998). This is a rather dangerous situation once that the Cerrado biodiversity is directly connected to its water resources which are very important to the other Brazilian watersheds (Lima & Silva, 2008).

Agriculture has expanded rapidly in the Cerrado Biome since 1960's mainly because its natural resources were highly advantageous (Klink & Alho, 1995; Reatto & Martins, 2005). In spite of the actual huge occupation, Cerrado Biome is likely to get worse, with agriculture activities may reach 75% of the whole region (Machado et al., 2008).

The Cerrado Biome comprises many distinctive phytophysionomies which at the present time are frequently gathered in three major groups as savanna, field, and forest vegetation structures (Ribeiro & Walter, 2008). The main common phytophysionomies in the savanna vegetation are Cerrado *stricto sensu* (closed), Parque de Cerrado (open Cerrado park), Palmeiral (palm tree group) and Vereda (palms and grass form plants related to water springs). Field vegetation structure has its more common phytophysionogmies as Campo sujo (dirty field = scattered shrubs in a dense grassland), Campo limpo (clean field = grassland) and Campo Rupestre (rocky field = Trees associated to grassy plants on rocky areas above 1500 m sea level). Finally, Forest vegetation structure comprises of Mata de Galeria (gallery forest = associated to narrow rivers covering them completely), Mata Ciliar (riparian forest), Mata Seca (dry forest = not associated with water) and Cerradão (the augmentative of Cerrado). It is rather important to point out that the term Cerrado has the two following meanings, (a) Brazilian savanna vegetation in its generic sense, and (b) one particular form of this vegetation, i.e., the Cerrado *strito sensu* as mentioned before (Ratter et al., 1988; Ribeiro & Walter, 2008).

DATA COLLECTION

Species catalogued from scientific literature were classified as native to Cerrado following a compilation (Mendonça et al., 2008). According to these authors, there are 11.430 species in 195 families belonging to Cerrado's phanerogamic flora. Within these species were found allelopathic studies on 70 species in 34 families. The highest amount of allelopathic studies was found in the following

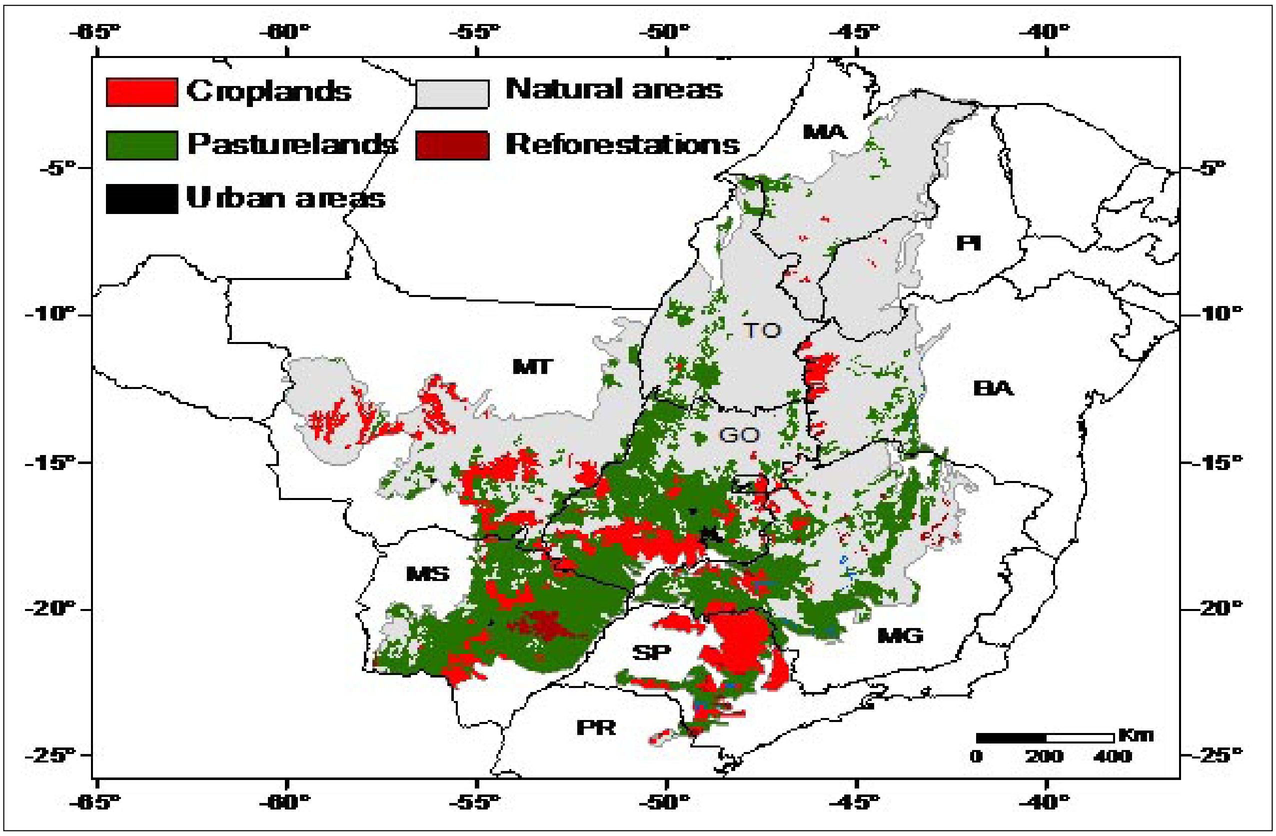

Figure 1. Location of the Cerrado biome in Brazil, and spatial distribution of land use classes in Cerrado Biome in 2002 (Sano et al., 2008). States: BA = Bahia; GO = Goiás; MA = Maranhão; MT = Mato Grosso; MS = Mato Grosso do Sul; MG = Minas Gerais; PR = Paraná; PI = Piauí; SP = São Paulo; and TO = Tocantins.

families: Leguminosae, Asteraceae, Orchidaceae, Poaceae, Melastomataceae, Eriocaulaceae, Rubiaceae, Euphorbiaceae, Myrtaceae, and Lamiaceae. Families such as Leguminosae, Asteraceae, Poaceae, Rubiaceae and Euphorbiaceae were the most studied and presented the highest number of species with positive (Table 1), and negative (Table 2) results regarding to allelochemical effects.

Table 1. Species native to Cerrado biome classified within families with allelochemical activity.

FAMILY (Subclass, Order) / SPECIE	Growth Habitat	Phytophysiognomy[1]	Studied Organ	Reference
ANACARDIACEAE (ROSIDAE, Sapindales)				
Anacardium humile Mart.	Shrub	a[##], b, d and e[##]	Leaves and stem	Periotto (2003)
Myracrodruon urundeuva Allem.	Tree	a[#], b, f and g	Leaves, flowers, and fruits	Oliveira et al. (2002b)
APOCYNACEAE (ASTERIDAE, Gentianales)				
Himatanthus phagedaenicus (Mart.) Woodson	Tree	a[#], e[#] and j	Leaves	Veloso (1996)
AQUIFOLIACEAE (ROSIDAE, Celastrales)				
Ilex paraguariensis A. St.-Hil.	Tree or small tree	b, f, and g**	Leaves, and fruits	Aqüila (2000), Miró et al. (1998)
Aristolochia esperanzae Kuntze	Shrubby vine	a[##], d, f and k	Leaves, stem, and roots	Gatti (2003; 2004)
ASTERACEAE (COMPOSITAE) (ASTERIDAE, Asterales)				
Achyrocline satureioides DC.	Perennial herb	a[#], c, d, e[#], j[§], m and n	Leaves, and inflorescence	Souza et al. (2005a)

Savannah Journal of Research and Development

FAMILY (Subclass, Order) / SPECIE	Growth Habitat	Phytophysiognomy[1]	Studied Organ	Reference
Baccharis dracunculifolia DC.	Erect shrub	a#, e#, j, n and o	Leaves	Gatti (2003); Verdi et al. (2005)
Baccharis trimera (Less.) DC.	Erect subshrub	b##, e#, g, j§, n and o	Leaves	Claudino & Carvalho (2004); Cruz et al. (2000); Torres et al. (2000); Verdi et al. (2005)
Eupatorium maximiliani Schrad. ex DC.	subshrub	a##, b, c, e# and o	Leaves	Corrêa et al. (2000)
Mikania glomerata Spreng.	Vine	j	Leaves, and inflorescence	Souza et al. (2005a)
Vernonanthura phosphorica (Vell.) H. Rob.	Shrub or subshrub	a##, d, f, g, j, n and o	Shoot, roots, and seeds	Souza Filho et al. (1996)
BIGNONIACEAE (ASTERIDAE, Scrophulariales)				
Anemopaegma arvense (Vell.) Stellfeld ex de Souza	Subshrub	a, d and e##	Leaves	Gatti (2003)
Memora peregrina (Miers) Sandwith	Subshrub	a##, b	Leaves, bark, and wood	Gatti (2003); Grassi et al. (2005)
CARYOCARACEAE (DILLENIIDAE, Theales)				
Caryocar brasiliense St. Hil.	Tree	a##, b, d, h and i	Seeds, and fruit parts (pulp, thorn and endocarp)	Melo & Gonçalves (2001); Rodrigues et al. (2006a, b)
CECROPIACEAE (HAMAMELIDAE, Urticales)				
Cecropia pachystachya Trécul	Tree	a#, f, g, j, n and p	Mature leaves	Maraschin-Silva & Aqüila (2006b)
CELASTRACEAE (ROSIDAE, Celastrales)				
Maytenus ilicifolia Mart. ex Reissek	Tree or shrub	a#, f and g*	Dry leaves	Souza et al. (2005b)
EUPHORBIACEAE (ROSIDAE, Euphorbiales)				
Sapium glandulatum (Vell.) Pax	Subshrub, shrub or tree	a##, c, d, e#, f, g, j, and n	Mature leaves	Maraschin-Silva & Aqüila (2006b)
FLACOURTIACEAE (DILLENIIDAE, Violales)				
Casearia sylvestris Sw.	Shrub or small tree	a##, b, d, h, j§ and p	Leaves	Gatti (2003); Souza et al. (2005a)
GLEICHENIACEAE				
Gleichenia pectinata (Willd.) Pr.	Subshrub	a#, j and o	Green leaves	Peres et al. (1998); Soares & Vieira (2000)
Dicranopteris flexuosa (Schrad.) Underw.	Terrestrial herb	a#, j, m and p	Leaves	Soares & Vieira (2000)
Sticherus bifidus (Willd.) Ching	Subshrub	a# and o	Leaves	Soares & Vieira (2000)

FAMILY (Subclass, Order) / SPECIE	Growth Habitat	Phytophysiognomy[1]	Studied Organ	Reference
Sticherus penniger (Mart.) Copel.	Subshrub terrestrial	e#, j and v§	Leaves	Soares & Vieira (2000)
HIPPOCRATEACEAE (ROSIDAE, Celastrales)				
Peritassa campestris (Cambess.) A. C. Sm.	Shrub	a##, c and f	Leaves, and roots	Gatti (2003); Lião et al. (2002)
LAURACEAE (MAGNOLIIDAE, Laurales)				
Ocotea odorifera (Vell.) Rohwer	Tree	j	Leaves	Gatti (2003); Souza et al. (2005a)
LEGUMINOSAE (ROSIDAE, Fabales)				
Amburana cearensis (Fr. Allem.) A. C. Sm.	Tree	g* and o	Seeds	Mano (2006)
Anadenanthera peregrina (L.) Speg.	Tree	a#, f, g, j and p	Leaves	Abreu, 1997); Silva et al. (2006)
Andira humilis Mart. ex Benth.	Shrub	a##, c, d and i	Leaves, and stem	Periotto (2003; 2004)
Caesalpinia pluviosa DC.	Tree or small tree	b and g	Leaves	Soares et al. (2002)
Clitoria fairchildiana R. A. Howard	Tree	a# and o	Leaves	Soares & Vieira (2000)
Copaifera langsdorffii Desf.	Tree	a#, b, f and j	Soil around the trunk	Dorneles et al. (2003)
Dipteryx alata Vog.	Tree	a##, b, g**, j and o	Leaves, and fruits	Silva et al (1996)
Erythrina speciosa Andrews	Tree	g and o	Leaves	(Faria et al. (2007); Soares et al. (2002)
Hymenaea stigonocarpa Mart. ex Hayne	Tree	a## and b	Bark, leaves, and fruits	Oliveira et al. (2002a)
Mimosa bimucronata (DC.) Kuntze var. Bimucronata	Tree or small tree	a# and j	Leaves	Astarita et al., 1996
Mimosa caesalpiniaefolia Benth.	Tree	a#	Green and dry leaves	Piña-Rodrigues & Lopes (2001)
Piptadenia gonoacantha (Mart.) J. F. Macbr.	Tree	g* and j	Leaves	Soares et al. (2002)
Stryphnodendron adstringens (Mart.) Coville	Tree	a## and b	Leaves	Barreiro et al., 2005); Silva et al. (2006)
MELASTOMATACEAE (ROSIDAE, Myrtales)				
Miconia albicans (Sw.) Triana	Small tree	a##, b, d, i, j, n and p	Leaves	Gorla & Perez (1997)
MORACEAE (HAMAMELIDAE, Urticales)				
Sorocea bonplandii (Baill.) W.C.Burger, Lanj. & Boer	Small tree	f and j	Mature leaves	Maraschin-Silva & Aqüila (2006b)
MYRISTICACEAE (MAGNOLIIDAE, Magnoliales)				
Virola surinamensis Warb.	Tree	a# and j	Leaves	Borges et al., 2007
MYRSINACEAE (DILLENIIDAE, Primulales)				

FAMILY (Subclass, Order) / SPECIE	Growth Habitat	Phytophysiognomy[1]	Studied Organ	Reference
Myrsine guianensis (Aubl.) Kuntze	Tree	a#, e#, f, g, h, j, n and p	Mature leaves	Maraschin-Silva & Aqüila, (2005; 2006a); Silva et al. (2006)
MYRTACEAE (ROSIDAE, Myrtales)				
Myrcia guianensis (Aubl.) DC.	Shrub	a##, d, e#, f, g, j and n	Fresh leaves, essential oil	Souza Filho et al. (2006)
OCHNACEAE (DILLENIIDAE, Theales)				
Ouratea spectabilis Engl.	Tree	a##, b, h and i	Leaves	Silva et al. (2006)
PTERIDACEAE				
Adiantopsis radiata (L.) Fée	Terrestrial herb or rupícola	f, j and q	Green leaves	Peres et al. (2004)
Adiantum serratodentatum Willd.	Terrestrial herb	j, a# and n	Green leaves	Peres et al. (2004)
Adiantum tetraphyllum Humb. & Bonpl. ex Willd.	Terrestrial herb	j	Green leaves	Peres et al. (2004)
Pityrogramma calomelanos (L.) Link	Terrestrial herb	a#, b, j, n, m, u and v	Green leaves	Peres et al. (2004)
RUBIACEAE (ASTERIDAE, Rubiales)				
Palicourea rigida H. B. & K.	Small tree or Shrub	a##, c, d, e##, h, i , j, n and p	Leaves	Gatti (2003)
Psychotria leiocarpa Cham. & Schltdl.	Shrub or subshrub	f, j and m	Dry leaves	Maraschin-Silva & Aqüila (2006b)
SAPINDACEAE (ROSIDAE, Sapindales)				
Dodonaea viscosa Jacq.	Small tree	e#	Leaves	(Maraschin-Silva & Aqüila, (2005)
SAPOTACEAE (DILLENIIDAE, Ebenales)				
Pouteria ramiflora Radlk.	Tree	a##, b, j, i, n and p	Leaves	Silva et al. (2006)
SOLANACEAE (ASTERIDAE, Solanales)				
Solanum crinitum Lam..	Shrub	a##, e# and j§	Green leaves, thorns	(Alves et al. (2003); Cornelius et al. (2004); Silva et al. (2003)
Solanum lycocarpum A. St.-Hil.	Small tree or Shrub	a##, d, n and o	Leaves and fruits	Aires et al., 2005); Borghetti & Pessoa (1997); Jerônimo (2006); Mola et al. (1997); Oliveira et al. (2004a, b)
TILIACEAE (DILLENIIDAE, Malvales)				

FAMILY (Subclass, Order) / SPECIE	Growth Habitat	Phytophysiognomy[1]	Studied Organ	Reference
Luehea divaricata Mart.	Tree	a[#], b, f, g and j	Leaves, inflorescence	(Maraschin-Silva & Aqüila, (2006a); Souza et al. (2005a)
WINTERACEAE (MAGNOLIIDAE, Magnoliales)				
Drimys brasiliensis Miers	Tree	e[#], j and n	Leaves	Gatti (2003)
Drimys winteri Forst.	Tree	f and g	Leaves	Gorla & Perez (1997)
VERBENACEAE (ASTERIDAE, Lamiales)				
Lantana camara L.	Subshrub	j	Leaves	Cruz et al. (2000); Gorla & Perez (1997)
Lippia alba N. E. Br. ex Britton & P. Wilson	Shrub	a	Leaves, inflorescence	Cruz et al. (2000); Souza et al. (2005a)
Lippia sidoides Cham.	Subshrub	a[##], f, k[§]	Mature leaves – essential oil	Alves et al., 2004
VOCHYSIACEAE (ROSIDAE, Polygalales)				
Qualea grandiflora Mart.	Tree	a[##], b, d, f, h, i, j[§] and p	Leaves	Silva et al. (2006)

[1] Phytophysiognomy: a = Cerrado; b = Cerradão (the augmentative of cerrado); c = Clean field; d = Dirty field; e = Rocky field; f = Riparian forest; g = Dry forest; h = Murundu field; i = Carrasco; j = Gallery forest; k = River bank; m = Swamp; n = Vereda (palms and grass form plants related to water springs); o = Anthropic área; p = Amazonic savanna; q = Babassu; u = Natural revegetated area; v = Stream. | [§] = border. | * deciduous; **semi-deciduous. | [#]lato sensu; [##] stricto sensu (closed).

Table 2. Species native to Cerrado classified within families without allelochemical activity.

FAMILY (Subclass, Order) / SPECIES	Growth Habit[1]	Phytophysiognomy[1]
APOCYNACEAE (ASTERIDAE, Gentianales)		
Aspidosperma tomentosum Mart.	Tree	a[##], b and g
ARALIACEAE (ROSIDAE, Apiales)		
Didymopanax vinosum Marchal	Tree	e
CLUSIACEAE / GUTTIFERAE (DILLENIIDAE, Theales)		
Kielmeyera variabilis Mart. & Zucc.	Tree	a[#], b and j
LEGUMINOSAE (ROSIDAE, Fabales)		
Anadenanthera falcata Speg.	Tree	a[#], b, g* and j
Machaerium villosum Vog.	Tree	a[#], b and j
Acosmium subelegans (Mohlenbr.) Yakovlev	Tree	a[#] and j
MALPIGHIACEAE (ROSIDAE, Polygalales)		
Byrsonima coccolobifolia H.B. & K.	Tree	a[##], b, d, h, j[§] and p
Byrsonima verbascifolia Rich. ex Juss.	Tree	a[##], d, e[#], h, j and p
STYRACACEAE (DILLENIIDAE, Ebenales)		
Styrax ferrugineus Nees & Mart.	Tree or small tree	a[##], b, h, j[§] and n
VOCHYSIACEAE (ROSIDAE, Polygalales)		
Vochysia tucanorum Mart.	Tree	a[#], f, j and n

[1] data extracted from Silva et al. (2006); The studied organ for this table were leaves;
[2] Phytophysiognomy: a = Cerrado; b = Cerradão (the augmentative of cerrado); c = Clean field; d = Dirty field; e = Rocky field; f = Riparian forest; g = Dry forest; h = Murundu field; i = Carrasco; j = Gallery forest; k = River bank; m = Swamp; n = Vereda (palms and grass form plants related to water springs); o = Anthropic área; p = Amazonic savanna; q = Babassu; u = Natural revegetated area; v = Stream. | [§] = border. | * deciduous; **semi-deciduous. | [#]lato sensu; [##] stricto sensu (closed)

RESULTS AND DISCUSSION

Allelochemicals

Brazilian researchers found several allelochemicals using plants native to Cerrado, however these substances were not, as a whole, synthesized and tested for weed control. According to this, we pointed out data related to the new substances detected.

Some alkaloids, extracted successively with hexane and ethanol, were found in leaves and flowers of *Erythrina speciosa* (Figure 2). In vitro bioassays with leave extracts of *E. speciosa* showed promising activity against *Trypanosoma cruzi*. The substances were not tested biologically (Faria et al., 2007).

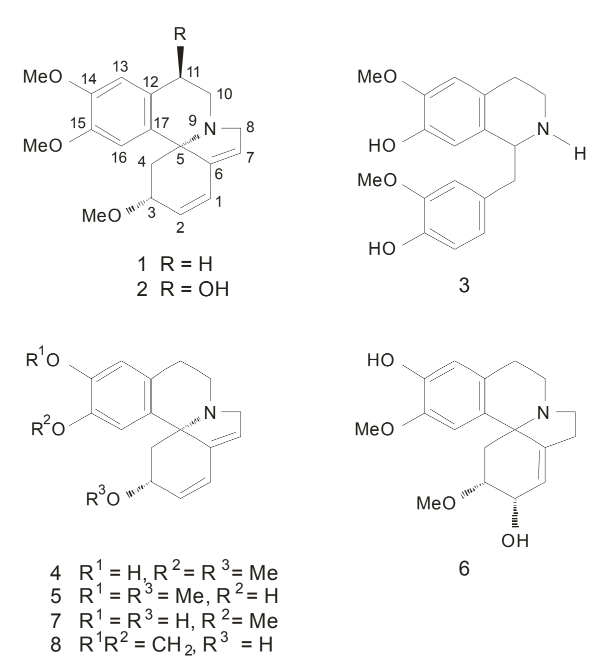

Figure 2. Alkaloids in leaves and flowers of *Erythrina speciosa* Andrews – 1: erysothrine; 2: erythrartine; 3: erythraline; 4: erysodine; 5: erysovine; 6: erysotine; 7: erysonine; 8: erythrocarine (Faria et al., 2007).

Ouratea spectabilis, Pouteria ramiflora, Qualea grandiflora and Stryphnodendron adstringens collected in the Cerrado Reserve in Mogi Guaçu, State of São Paulo, Brazil, showed inhibitory effects. As *S. adstringens* presented the greatest inhibitory effect, leaf extracts of this species were fractionated by liquid-liquid partition with use of different polarity solvents (hexane, chloroform, ethyl acetate, and n-butanol). Fractions were submitted to lettuce (*Lactuca sativa* L), maize (*Zea mays* L.), bean (*Phaseolus vulgaris* L), and beggar-ticks (*Bidens pilosa* L.) germination bioassays. Terpenoids, not detailed in the study, were found in chloroform and ethyl acetate fractions. (Silva et al., 2006).

In *Eupatorium maximiliani* Schrad. Ex DC. chloroform:methanol 2:1 extracts were applied to rice (*Oryza sativa* L. Cv. Caiapo, maize (*Zea mays* L. Cv. AG302A), beans (*P. vulgaris* Cv. Carioquinha) and-lettuce (*Lactuca sativa* Cv. Grand rapids) and two weed species [pigweed (*Amaranthus* spp) and hairy beggarticks (*Bidens pilosa* L.)]. The extract significantly reduced seed germination of lettuce, pigweed and hairy beggarticks, radicle elongation and shoot growth in lettuce, beans and rice and had no effect on maize. It was found, after a thin-layer chromatography analysis, through infra-red spectroscopy and Nuclear Magnetic Resonance (NMR ^{1}H, and ^{13}C), the following compounds: 5,6,7,3',4',5'-hexamethoxyflavone, and 5,6,7,3',4',5'-hexamethoxyflavanone. (Corrêa et al., 2000).

Ferreira et al. (1992) showed allelopathic activity of *Bacharis trimera* (Less.) DC. was measured in terms of inhibition of germination and radical growth of two varieties of *Lactuca sativa*. Later, from a compilation of the genus *Bacharis* (Verdi et al., 2005) it has been shown, in methanolic leaf extracts of *Baccharis trimera*, a Cerrado species (Tannus & Assis, 2004), three clerodane diterpenoids (Figure 3), and ten flavonoids identified. Among these flavonoids four were identified: 5,4'-dihidroxy-7-methoxyflavone (genkwanine) [1], 5,4'-dihidroxy-6,7-dimethoxyflavone (cirsimaritine) [2], 5,7,4'-trihidroxy-6-methoxyflavone (hispiduline) [3], and 5,7,4'-trihidroxyflavone (apigenine) [4]. In *Baccharis trimera* ethyl acetate leaf extracts, other three flavonoids were isolated: 3,5,7,3',4'-pentahidroxyflavone (quercetine) [5], 5,7,3',4'-tetrahidroxyflavone (luteoline) [6], and 5,7,3',4'-tetrahidroxy-6-methoxyflavone (nepetine) [7]. Here these compounds were not tested in plants, but, clerodane and flavonoids are known allelochemicals (Bisio et al., 2011; Rice, 1987).

The same compilation above showed also, in *Baccharis dracunculifolia* leaf extracts, two flavo-

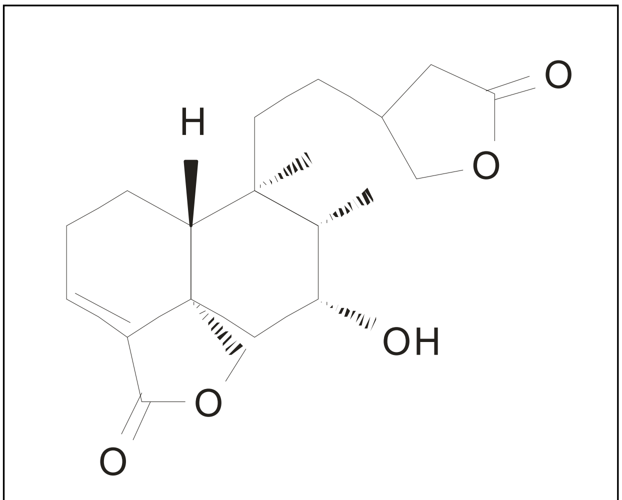

Figure 3. Clerodane diterpene in [Baccharis trimera (Less.) A. DC.] (Torres et al., 2000).

nes [8-OH flavone; 3,5,7-OH-6,4'-OMe flavone (betuletol)], a flavanone, and a triterpene isolated from, another weedy species from Cerrado Biome.

From roots of *Peritassa campestris* (Cambess.) A. C. Sm., collected in São Carlos, State of São Paulo – Brazil (Figure 1), methanolic extracts were isolated two triterpenoids, campestrine-I and -II (Figure 4). (Lião et al., 2002). Many different natural quinones from plants inhibit PSII (Duke & Dayan, 2006).

Chromatographic studies from thorns, shoots and fruits of *Solanum crinitum* isolated the following flavonoids: tiriloside [3-O-(6”-trans--cinamoil-glycopyranosyl)], astragaline (3-O-β-D-glycopyranosyl), and kaenpherol (Figure 5). Alkaloids were extracted with a sephadex column and, from green fruit extracts, solasonine was isolated. Isolated substances were, then, analyzed by infra-red spectroscopy, NMR ^{1}H, and ^{13}C (Cornelius et al., 2004).

Several compounds (alantoine, 6β-hidroxy polyamide, hiperine, 3’-O-methyl-hiperine, 4-hidroxy-N-

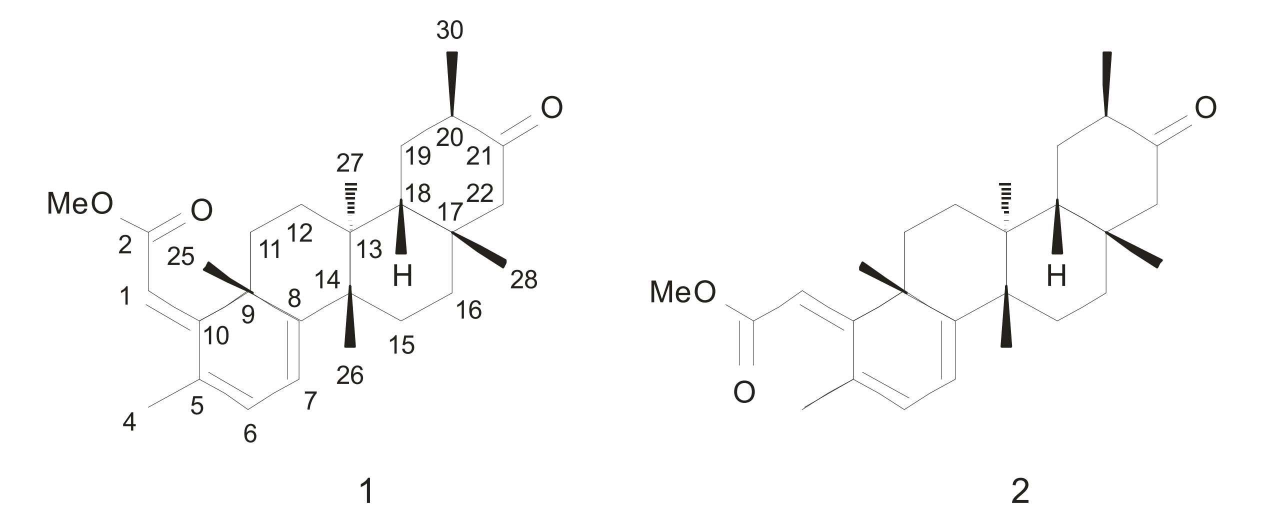

Figure 4. Isolated terpenoids in Peritassa campestris (Cambess.) A. C. Sm methanolic extracts: 1) campestrine-I and 2) campestrine-II (Lião et al., 2002).

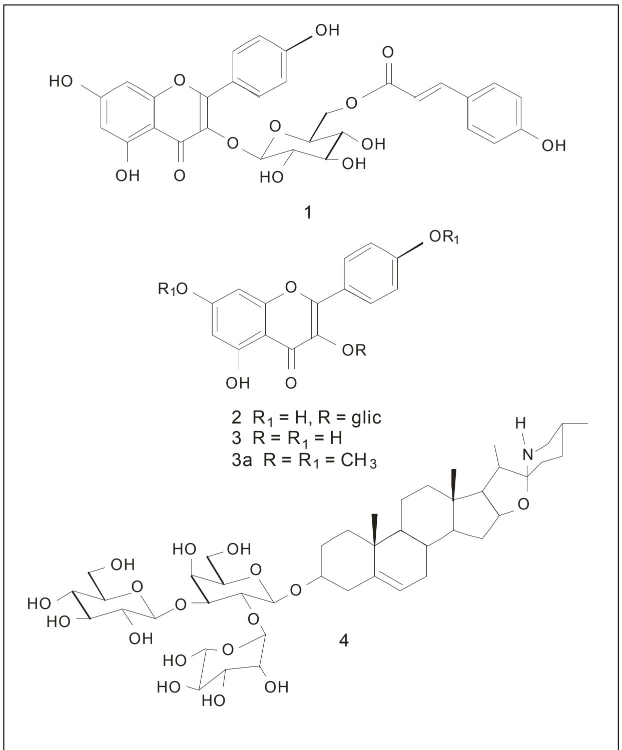

Figure 5. Structure of isolated components of *Solanum crinitum* Lam.: 1) tiriloside; 2) astragaline; 3) kaenpherol; 3a) metilation with diazomethane, and 4) solasonine (Cornelius et al., 2004).

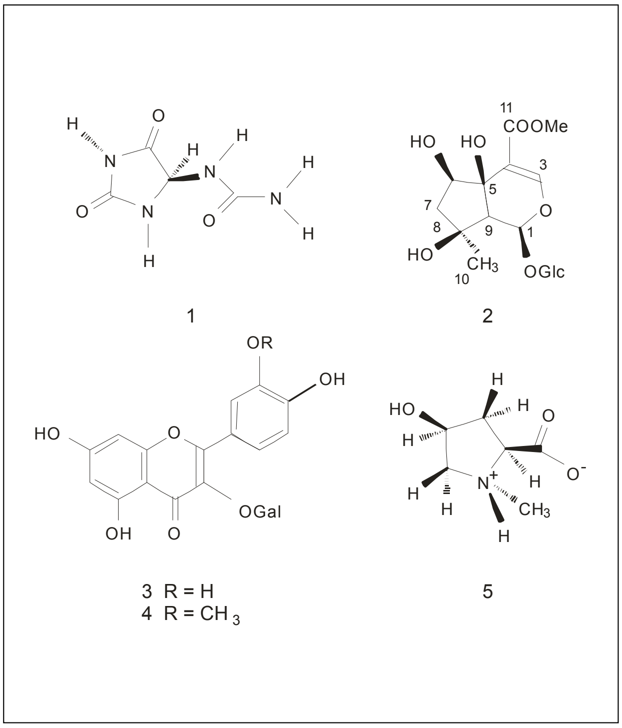

Figure 6. Isolated compounds of *Memora peregrina* (Miers) Sandwith: 1) alantoine; 2) 6β-hidroxypolyamide; 3) hiperine; 4) 3’-O-methyl-hiperine; 5) 4-hidroxy-N-methylproline (Grassi et al., 2005).

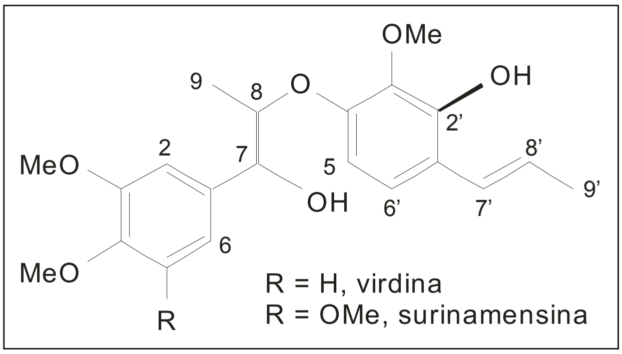

Figure 7. Isolated chemical substances structures from leaves of *Virola surinamensis* Warb. (Borges et al., 2007).

-methylproline, α-amirine, β-amirine e lupeol, Figure 6) from the leaves, and subterranean parts of *Memora peregrina*, such as bark and wood were identified. The allelochemical effects of these substances induced lettuce seed germination, and produced a moderated activity in *Anagasta kuehniella* (Lepidoptera) larvae development. (Grassi et al., 2005).

Chemical substances obtained from *Virola surinamensis* extracts were isolated and identified. The process involved use of organic solvents and NMR ^{1}H, ^{13}C and ^{13}C-DEPT), COSY and HETCOR spectrum in order to identify two neolignane compounds: surinamensine and aviroline (Figure 7). In spite of this plant have been collected from the Rainforest, *V. surinamensis* is a tree also found in Cerrado biome (Mendonça et al., 2008). Three weed species were used to test *V. surinamensis* allelochemicals: *Mimosa pudica* L., *Senna obtusifolia* (L.) H. S. Irwin & Barneby, and *Senna occidentalis* (L.) Link. This study represented a further step in relation to the allelopathic studies with Cerrado plants. Surinamensine and viroline were isolated, and tested. Surinamensine presented higher potential in the inhibition of seed germination, and radicle and hypocoltyl development than viroline. (Borges et al., 2007)

FUTURE RESEARCH PERSPECTIVES

Most of the results obtained in allelopathic studies cannot be explained in terms of a single disciplinary approach. The present review gathered information about allelopathy studies performed with 71 species native to Cerrado. Leaves were more studied than any other plant parts. More attention is necessary to study root leachates. According to the related allelopathic studies it was possible to detect some compounds like alkaloids, terpenoids, phenolic compounds and others. Most of these results were reached on seed germination studies in laboratory, though isolated from the environmental conditions. This situation was part of the process related to the establishment of Cerrado plants. Studies were rather superficial, small in number, and scattered in the literature. Besides this critical situation, there were no attempts for establishing connections among the results reached. In 1992, Ferreira et al. had pointed in their review many results and inconsistencies on allelopathy research. This situation has not changed until nowadays. We hope that the present survey can contribute to more detailed and applied studies with Cerrado species. The main targets to be reached are the following: a) to promote more sophisticated studies with unknown and better known plants; b) to identify other compounds and their own metabolism; c) to synthesize those new compounds; d) to study the mode of action of the synthesized compounds; e) to test those compounds in agriculture conditions; f) to investigate the compound effects in the establishment strategies of Cerrado plants and for agricultural proposals too.

REFERENCES

ABREU, J.C. **Potencial alelopático do angico-vermelho (“*Anadenanthera peregrina*” (L.) Speg.): efeitos sobre a germinação de sementes e ciclo mitótico de plântulas de alface (“*Lactuca sativa*” L.) e canafístula (*Peltrophorum dubium* (Spreng.) Taub.) [Allelopathic effect of angico-vermelho (*Anadenanthera peregrina* (L.) Speg.) on seed germination and mitotic cycle of lettuce (*Lactuca sativa* L.) and canafístula (*Peltrophorum dubium* (Spreng.) Taub.) seedlings].** 1997. 55p. Thesis (Ph.D) - Universidade Federal de Lavras, Lavras, Brazil

AIRES, S.S.; FERREIRA, A.G.; BORGHETTI, F. Efeito alelopático de folhas e frutos de *Solanum lycocarpum* A. St.-Hil. (Solanaceae) na germinação e crescimento de *Sesamun indicum* L. (Pedakuaceae) em solo sob três temperaturas [Allelopathic effect of leaves and fruits of *Solanum lycocarpum* A. St.-Hil. (Solanaceae) in the germination and growth of *Sesamun indicum* L. (Pedakuaceae) in soil under three temperatures]. **Acta Botânica Brasílica**, v.19, p.339-344, 2005.

ALVES, C.C.F.; M.ALVES, J.; SILVA, T.M.S.; CARVALHO. M.G.; JACOB NETO, J. Atividade alelopática de alcalóides glicosilados de *Solanum crinitum* Lam. [Allelopathic activity of glicosilated alcaloids of *Solanum crinitum* Lam.] **Floresta e Ambiente**, v.10, p.93-97, 2003

ALVES, M.C.S.; MEDEIROS FILHO S.; INNECO, R.; TORRES, S.B. Alelopatia de extratos voláteis na germinação de sementes e no comprimento da raiz de alface [Volatile extracts in the lettuce seed germination and root lenght]. **Pesquisa Agropecuária Brasileira**, v.39, p.1083-1086, 2004

ANONYMOUS. Mapa de Biomas do Brasil: primeira aproximação: escala 1:5.000.000 [Map of Brazilian Biomes: 1:5.000.000 scale]. 2008. IBGE/Instituto Brasileiro de Geografia e Estatística, Rio de Janeiro, Brazil.

AQÜILA, M.E.A. Efeito alelopático de *Ilex paraguariensis* A. St.-Hil. na germinação e crescimento inicial de *Lactuca sativa* L.[*Ilex paraguariensis* A. St. -Hil. allelopathic effects in *Lactuca sativa* L growth and initial development]. **Iheringia, Série Botânica**, v.53, p. 51-66, 2000

ASTARITA, L.V.; FERREIRA, A.G.; BERGONCI, J.I. *Mimosa bimucronata*: allelopathy and osmotic stress. **Allelopathy Journal**, v.3, p. 43-50, 1996

BARREIRO, A.P.; DELACHIAVE, M.E.A.; SOUZA, F.S. Efeito de extratos de parte aérea de barbatimão (*Stryphnodendron adstringens* (Mart.) Coville) na germinação e desenvolvimento da plântula de pepino [Barbatimão (*Stryphnodendron adstringens* (Mart.) Coville) shoot extracts effect in cucumber seedling development]. **Revista Brasileira Plantas Medicinais**, v.8, p.4-8, 2005

BISIO, A.; DAMONTE, G.; FRATERNALE, D.; GIACOMELLIA, E.; SALIS, A.; ROMUSSIA, G., CAFAGGIA, S.; RICCIC, D.; TOMMASID, N. de. Phytotoxic clerodane diterpenes from Salvia miniata Fernald (Lamiaceae). Phytochemistry, v.72, p.265-275, 2011.

BORGES, F.C., SANTOS, L.S.; CORRÊA, M.J.C.; OLIVEIRA, M.N.; SOUZA FILHO, A.P.S. Potencial alelopático de duas neolignanas isoladas de folhas de *Virola surinamensis* (Mytisticaceae) [Allelopathic potential of two neolignane compounds isolated from *Virola surinamensis* (Mytisticaceae) leaves]. **Planta Daninha,** v.25, p.51-59, 2007.

BORGHETTI, F.; PESSOA, D.M.A. Autotoxicidade e alelopatia em sementes de *Solanum Lycocarpum* St. Hil. (Solanácea) [Autotoxicity and allelopaty in seeds of *Solanum Lycocarpum* St. Hil. (Solanaceae)]. In: LEITE, L.L.; SAITO, C.H. (Eds.). 3° CONGRESSO DE ECOLOGIA DO BRASIL, Brasília, **Proceedings.** Brazil, DF, Brasília: Universidade de Brasília, 1997. p.54-58.

CLAUDINO, G.; CARVALHO, R.I.N. Efeito alelopático de extratos de carqueja e confrei em sementes de soja e milho [Allelopathic effect of carqueja and confrei extracts in seeds of soy and maize]. **Revista Acadêmica: ciências agrárias e ambientais,** v.2, p.29-40, 2004.

COCHRANE, T.T., L.G. SÁNCHEZ, L.G. DE AZEVEDO, J.A. PORRAS & C.L. GARVER. **Land in tropical América. A guide to climate, landscapes, and soils for agronomists in Amazonia, the Andean Piedmont, Central Brazil and Orinoco.** CIAT - Centro Internacional de Agricultura Tropical: Cali Colômbia; Embrapa – CPAC: Centro de Pesquisa Agropecuária dos Cerrados, Planaltina, Brazil. V.1, 1985.

CORNELIUS, M.T.F.; ALVES, C.C.F.; SILVA, T.M.S.; ALVES, K. Z.; CARVALHO, M.G.; BRAZ-FILHO, R.; AGRA, M.F. Solasonina e flavonóides isolados de *Solanum crinitum* Lam [Solasonine and flavonoids isolated from *Solanum crinitum* Lam]. **Revista Brasileira de Farmacologia,** v.85, p. 57-59, 2004.

CORRÊA, J.F.; SOUZA, I.F.; LADEIRA, A.M.; YOUNG, M.C.M.; ARAGUSHI, M. Allelopathic potential of *Eupatorium maximiliani* Schrad. Leaves. **Allelopathy Journal,** v.7, p.225-234, 2000.

CRUZ, M.E.S.; NOZAKI, M.H.; BATISTA, M.A. Plantas medicinais: plantas medicinais e alelopatia [Medicinal plants and allelopathy]. **Biotecnologia Ciência & Desenvolvimento**, v.15, p. 28-34, 2000.

DORNELES, M.C.; MUSTAFÁ, P.C.V.; RANAL, M.A.; SANTANA, D.G.; BERNARDES, K.M.. Ação alelopática de *Copaifera langsdorffii* Desf. na germinação de sementes de *Brassica chinensis* L. var. parachinensis (Bailey) Sinskaja [*Copaifera langsdorffii* Desf. allelopathic action in the germination of *Brassica chinensis* L. var. parachinensis (Bailey) Sinskaja seeds]. **Informativo ABRATES**, v.13, p. 71, 2003

DUKE, S.O; DAYAN, F.E. Modes of action of phytotoxins from plants. In: REIGOSA, M.J.; PEDROL, N.; GONZÁLEZ, L. (Eds.). **Allelopathy: A physiological process with ecological implications**. Netherlands: Springer, 2006. 511-536 p.

FARIA, T.J.; CAFÊU, M.C.; AKIOSHI, G.; FERREIRA D.T.; GALÃO, O.F.; ANDREI, C.C. Alcalóides de flores e folhas de *Erythrina speciosa* Andrews [Alcaloids in leaves of *Erythrina speciosa* Andrews]. **Química Nova,** v.30, p. 525-527, 2007.

FERREIRA, A.G.; AQÜILA, M.E.A.; JACOBI, U.S.; RIZVI, V. Allelopathy in Brazil. In: RIZVI, S.J.H.; RIZVI, V. (Eds.). **Allelopathy: basic and applied aspects.** , London, United Kingdom: Chapman & Hall, 1992. p. 243-250.

GATTI, A.B. **Atividade alelopática de extratos aquosos de "*Aristolochia esperanzae*" O. Kuntze e "*Icotea odorífera*" (Vell.) Rohwer na germinação e crescimento de "*Lactuca sativa*" L. e "*Raphanus sativus*" L. ["*Aristolochia esperanzae*" O. Kuntze and "*Icotea odorífera*" (Vell.) Rohwer aqueous extracts allelopathic activity in the germination and growth of "*Lactuca sativa*" L. e "*Raphanus sativus*" L].** 2003. 148p.Thesis (Ph.D) - Centro de Ciências Biológicas e da Saúde da Universidade Federal de São Carlos, São Carlos, Brazil

GATTI, A.B.; PEREZ, S.C.J.G.A.; Lima, M.I.S. Atividade alelopática de extratos aquosos de *Aristolochia esperanzae* O. Kuntze na germinação e no crescimento de *Lactuca sativa* L. e *Raphanus* *sativus* L [*Aristolochia esperanzae* O. Kuntze aqueous extracts allelopathic activity in the germination and growth of *Lactuca sativa* L. and *Raphanus sativus* L. **Acta Botânica Brasílica, v.**18, p.459-472, 2004.

GORLA, C.M.; PEREZ, S.C.J.G.A. Influência de extratos aquosos de folhas de *Miconia albicans* Triana, *Lantana câmara* L., *Leucaena leucocephala* (Lam.) de Wit e *Drimys winteri* Forst, na germinação e crescimento inicial de sementes de tomate e pepino [*Miconia albicans* Triana, *Lantana câmara* L., *Leucaena leucocephala* (Lam.) de Wit e *Drimys winteri* Forst aqueous leaf extracts on the germination and initial developing of tomato and cucumber]**. Revista Brasileira de Sementes,** v.19, p.260-265, 1997.

GRASSI, R.F., U.M. RESENDE, W. SILVA, M.L.R. MACEDO, A.P. BUTERA, E.O. TULLI, F.P. SAFFRAN & J.M. SIQUEIRA. Estudo fitoquímico e avaliação alelopática de *Memora peregrina* – "ciganinha" – Bignoniaceae, uma espécie invasora de pastagens em Mato Grosso do Sul [Phytochemical study and allelopathic evaluation of Memora peregrina – "ciganinha" – Bignoniaceae, a pasture alien species in Mato Grosso do Sul]. **Química Nova**, v.28, p.199-203, 2005.

HILHORST, H.W.M.; KARSSEN, C.M. Effect of chemical environment on seed germination In: Fenner, M. (Ed.). **The ecology of regeneration in plant communities**. CAB International Wallingford. 2000. pag. 309.

JERÔNIMO, C.A. **Efeitos do extrato aquoso de folhas e *"Solanum lycocarpum*" St. Hil. no desenvolvimento inicial e na síntese protéica de plântulas de "*Sesamum indicum"* L. [*"Solanum lycocarpum"* St. Hil. aqueous extracts effects on de initial development and the proteic synthesis of seedlings of *"Sesamum indicum*" L].** 2006. 75p. Thesis. (Ph.D.) - Departamento de Botânica do Instituto de Ciências Biológicas da Universidade de Brasília, Brasília, Brazil.

KLINK, C.A.; ALHO, C.J.R. De grão em grão o Cerrado perde espaço [Cerrado loses its space from grain and grain]. WWF/Fundo Mundial para a Natureza, Brasília, Brazil, 1995. p. 66.

LIÃO, L.M.; VIEIRA, P.C.; RODRIGUES-FILHO, E.; FERNANDES, J.B.; SILVA, M.F.G.F. Isomeric triterpenoids from *Peritassa campestris*. **Zeitschrift für Naturforschung**, **Tübingen,** v.57, p.403-406, 2002.

LIMA, J.E.F.W.; SILVA, E.M. Recursos hídricos do Bioma Cerrado: Importância e situação [Cerrado Biome hydric resources: Importance and situation]. In: SANO, S. M.; ALMEIDA, S. P. de; RIBEIRO, J. F. (Eds.). **Cerrado: ecologia e flora.** Brasília, DF: Embrapa Informação Tecnológica; Planaltina, DF: Embrapa Cerrados, 2008. cap. 4, p. 89-308.

MACHADO, R.B.; AGUIAR, L.M.S.; CASTRO, A.A. J.F.; NOGUEIRA, C.C.; RAMOS NETO, M.B. Caracterização da Fauna e Flora do Cerrado [Cerrado, fauna and flora characterization]. In: FALEIRO, F.G.; FARIAS NETO, A.L. (Eds.). **Savanas: Desafios e estratégias para o equilíbrio entre sociedade, agronegócio e recursos naturais [Savanas: chalenges and strategies for equilibrium among society, agrobusiness, and natural resources].** Planaltina, DF, Brazil: Embrapa Cerrados, 2008. p.285-300.

MACIAS F.A., J.M.G. MOLINILLO, R.M. VARELA & J.C.G. GALINDO. Allelopathy—a natural alternative for weed control. **Pest Management Science**, v.63, p.327–348, 2007.

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 [Allelopathic effect of aqueous extracts of cumaru ("*Amburana cearensis*" S.) seeds on the germination of lettuce, beggar ticks, and bur seeds, development and growth of seedlings].** 2006. 102p. Thesis. (Ph.D.) - Universidade Federal do Ceará, Fortaleza, Brazil.

MARASCHIN-SILVA, F.; AQÜILA, M.E.A. Potencial alelopático de *Dodonaea viscosa* (L.) Jacq. [Allelopathic potential of *Dodonaea viscosa* (L.) Jacq.]. **Iheringia, Série. Botânica**, v.60, p.91-98, 2005

MARASCHIN-SILVA, F.; AQÜILA, M.E.A. Contribuição ao estudo do potencial alelopático de espécies nativas [Contribution to the study of allelopathic potential from native species]. **Revista Árvore**, v.30, p.547-555, 2006a.

MARASCHIN-SILVA, F.; AQÜILA. M.E.A. Potencial alelopático de espécies nativas na germinação e crescimento inicial de *Lactuca sativa* L [Allelopathic potential of native species in *Lactuca sativa* L germination and initial growth]. (Asteraceae). **Acta Botânica Brasílica**, v.20, p.61-69, 2006b.

MELO, J.T.; GONÇALVES, A.N. **Inibidores de germinação em frutos e sementes de pequi** [Germination inhibitors in fruits and seeds of pequi]. Brazil, DF, Planaltina: Embrapa Cerrados, 2001. 11 p.
MENDONÇA, R.C., JFELFILI.M., WALTER B.M.T., SILVA JÚNIOR M.C., REZENDE A.V., FILGUEIRAS T.S., NOGUEIRA P.E. & FAGG C.W.. Flora vascular do Bioma Cerrado: checklist com 12.356 espécies

[Cerrado vascular flora]. In: SANO, S.M.; ALMEIDA, S.P.; RIBEIRO, J.F. (Eds.). **Cerrado: ambiente e flora.** Brazil, DF, Planaltina: Embrapa Cerrados, 2008. p.417-1279.

MIRÓ, C.P.; FERREIRA, A.G.; AQÜILA, M.E.A. Alelopatia de frutos de erva-mate (*Ilex paraguaiensis*) no desenvolvimento do milho [Allelopathy of erva-mate (*Ilex paraguaiensis*) fruits in maize development]. **Pesquisa Agropecuária Brasileira,** v.33, p. 1261-70, 1998.

MOLA, J.L., ARAÚJO E.R. & MAGALHÃES G.C. Solasodina em espécies de *Solanum* do Cerrado do Distrito Federal [Solasodine in *Solanum* species from Distrito Federal Cerrado. **Química Nova**, v.20, p.460-462, 1997.

MYERS, N.; MITTERMEIER, R.A.; MITTERMEIER, C.G.; FONSECA, G.A.B.; KENT, J. Biodiversity hotspots for conservation priorities. **Nature**, v.403, p.853-858, 2000.

OLIVEIRA, M.N.S.; MERCADANTE, M.O.; LOPES, P.S.N.; GOMES, I.A.C.; GUSMÃO, E.; RIBEIRO, L.M. Efeitos alelopáticos dos extratos aquoso e etanólico de jatobá do Cerrado [Allelopathic effects of aqueous and ethanolic extracts of jatobá do Cerrado]. **Unimontes Científica,** v.4, p.1-12, 2002a.

OLIVEIRA, M.N.S.; MERCADANTE, M.O.; LOPES, P.S.N.; GUSMÃO, E.; OLIVEIRA, M.R.; GOMES, I.A.C.; RIBEIRO, L.M. Efeitos alelopáticos de aroeira sobre germinação e desenvolvimento de plântulas [Aroeira allelopathic effects on germination and developing of seedlings]. In: SIMPÓSIO SOBRE ECOLOGIA E BIODIVERSIDADE DO CERRADO: PERSPECTIVAS E DESAFIOS PARA O SÉCULO 21, Brasília. **Proceedings**. Brazil, DF, Brasília: Embrapa Sede, 2002b, p.18.

OLIVEIRA, S.C.C.; FERREIRA, A.G.; BORGHETTI, F. Effect of *Solanum lycocarpum* fruit extract on sesame seed germination and seedling growth. **Allelopathy Journal**, v.13, p.201-210, 2004b

OLIVEIRA, S.C.C., FERREIRA, A.G.; BORGHETTI, F. Efeito alelopático de folhas de *Solanum lycocarpum* A. St.-Hil. (Solanaceae) na germinação e crescimento de *Sesamum indicum* L. (Pedaliaceae) sob diferentes temperaturas [Allelopathic effect of *Solanum lycocarpum* A. St.-Hil. (Solanaceae) leaves on the germination and growth of *Sesamum indicum* L. (Pedaliaceae) under different temperatures]. **Acta botânica brasiliense,** v.18, p. 401-406, 2004a.

PAULILO, M.T.S.; FELIPPE, G.M. Growth of the shrub-tree of the Brazilian cerrados: a review. **Tropical Ecology**, v.39(2), p.165-174, 1998.

PERES, M.T.L.P.; PIZZOLATTI, M.G.; QUEIROZ, M.H.; YUNES, R.A. Potencial de atividade alelopática de *Gleichenia pectinata* Willd (PR.) [Allelopathic potential of *Gleichenia pectinata* Willd (PR.)]. **Pesquisa Agropecuária Brasileira,** v.33, p.131-137, 1998.
PERES, M.T.L.P.; SILVA;, L.B.; FACCENDA, O.; HESS, S.C. Potencial alelopático de espécies de *Pteridaceae* (Pteridophyta). **Acta Botânica Brasílica**, v.18, p.723-730, 2004.

PERIOTTO, F. **Efeito alelopático de "*Andira humilis*" Mart. ex Benth. E de "*Anacardium humile*" Mart. na germinação e no crescimento de "*Lactuca sativa*" L. e de "*Raphanus sativus" L* [Allelopathic effect of "*Andira humilis*" Mart. ex Benth on the germination and growth of "*Lactuca sativa*" L. and "*Raphanus sativus"* L].** 2003. 64p. Thesis. (Ph.D) - Centro de Ciências Biológicas e da Saúde, Universidade Federal de São Carlos, São Carlos, Brazil.

PERIOTTO, F., PEREZ, S.C.J.G.A.; LIMA, M.I.S. Efeito alelopático de *Andira humilis* Mart. ex Benth na germinação e no crescimento de *Lactuca sativa* L. e *Raphanus sativus* L [Allelopathic effect of *Andira humilis* Mart. ex Benth on the germination and growth of *Lactuca sativa* L. and *Raphanus sativus* L]. **Acta Botânica Brasiliense**, v.18, p.425-430, 2004.

PIÑA-RODRIGUES, F.C.M.; LOPES, B.M. Potencial alelopático de *Mimosa caesalpinaefolia* Benth sobre sementes de *Tabebuia alba* (Cham.) Sandw [Allelopathic potential of *Mimosa caesalpinaefolia* Benth on seeds of *Tabebuia alba* (Cham.) Sandw]. **Floresta e Ambiente**, **v.**8, p.130-136, 2001.

RATTER, J.A.; LEITÃO FILHO, H.F.; ARGENT, G.; GIBBS, P.E.; SEMIR, J.; SHEPHERD, G.; TAMASHIRO, J. Floristic composition and community structure of a southern Cerrado area in Brazil. **Notes of the Royal Botanic Garden of Edinburg,** v.45, p.137-151, 1988.

REATTO, A.; MARTINS, E.S. Classes de solo em relação aos controles das paisagens do bioma Cerrado [Cerrado Biome soil classification related to landscape]. In: Cerrado: *Ecologia, biodiversidade e conservação* (Eds. A. Scariot, J.C. Souza-Silva and J.M. Felfini) , 2005. pag. 49-54. Embrapa Cerrados, Brasília, Brazil.

RIBEIRO, J.F.; WALTER, B.M.T. Fitofisionomias do bioma Cerrado [Cerrado Biome phytophisiognomies. In: SANO, S.M.; ALMEIDA, S.P.; RIBEIRO, J.F. (Eds.) **Cerrado: ecologia e flora.** Brazil, DF, Planaltina: Embrapa Cerrados, 2008. p.151-212.
RICE, E.L. **Allelopathy**. 2nd. Academic: Orlando, USA. 1984, 422p.

RICE, E.L. Allelopathy: an overview. In: WALLER, G.R. **Allolochemical, role in agriculture and for-**

estry. Washington, D.C.: American Chemical Society, 1987. (ACS. Symposium Series, 330).

RODRIGUES, I.M.I.; OLIVA, M.A.; OLIVA. K.M.F. Efeito alelopático do extrato metanólico de *Caryocar brasiliense* sobre a germinação e crescimento inicial de *Brachiaria brizantha* e *Zea mays* [Metanolic extracts of *Caryocar brasiliens* effects in inicial growth of *Brachiaria brizantha* and *Zea mays*]. In: XXV CONGRESSO BRASILEIRO DE CIÊNCIA DAS PLANTAS DANINHAS, Brasília. **Proceedings**. Brazil, Brasília: Embrapa Cerrados, 2006a

RODRIGUES, M.C.; HERNANDEZ-TERRONES, M.G.; OLIVA, M.; OLIVA, K.F. Efeito alelopático do extrato metanolico de *Caryocar brasiliense* nas trocas gasosas de *Bidens pilosa* e *Zea mays* [Metanolic extracts of *Caryocar brasiliens* effects in gaseous changes of *Bidens pilosa* and *Zea mays*]. In: XXV CONGRESSO BRASILEIRO DA CIÊNCIA DAS PLANTAS DANINHAS, Uberlândia. **Proceeding.** Uberlândia, MG, Brazil. 2006b.

SANO, E.E.; ROSA, R.; BRITO, J.L.S.; FERREIRA, L.G. Mapeamento semidetalhado do uso da terra do Bioma Cerrado [Semi-detailed mapping of land use from Cerrado Biome]. **Pesquisa Agropecuária Brasileira**, v.43, p.153-156, 2008.

SCHÖTTELNDREIER, M.; NORDDAHL, M.M.; STRÖM, L.; FALKENGREN-GRERUP U. Organic acid exudation by wild herbs in response to elevated Al concentrations. **Annals of Botany**, v.87, p.769-775, 2001.

SILVA, A.T.; SOUZA A.F.; OLIVEIRA, A.N.; ROSADO, S.C.S. Avaliação dos exsudatos alelopáticos em extratos de Barú (*Dipterix alata* Vog.) [Evaluation of allelopathic exsudates in Baru (*Dipterix alata* Vog.) extracts]. In: 4° SIMPÓSIO INTERNACIONAL SOBRE ECOSSISTEMAS FLORESTAIS. Belo Horizonte, **Proceedings.** Brasil, MG, Belo Horizonte, 1996.

SILVA, G.B.; MARTIM, L.; SILVA, C.L.; YOUNG, M.C.M; LADEIRA, A.M. Potencial alelopático de espécies arbóreas nativas do Cerrado [Allelopathic potential of arboreal species native to Cerrado]. **Hoehnea**, v.33, p.331-338, 2006.

SILVA, T.M.S.; CARVALHO, M.G. Ocorrência de flavonas, flavonóides e seus glicosídeos em espécies do gênero *Solanum* (Solanaceae) [Flavones, flavonoids and its glycosides in species of *Solanum* (Solanaceae)]. **Química Nova,** v.26, p.517-522, 2003.

SOARES, G.L.G.; VIEIRA, T.R. Inibição da germinação e do crescimento radicular de alface (cv. "grand rapids") por extratos aquosos de cinco espécies de gleicheniaceae [Inhibition of lettuce (cv. "grand rapids") germination and root growth by aqueous extracts of five species of gleicheniaceae]. **Floresta e Ambiente**, v.7, p.180-197, 2000.

SOARES, G.L.G.; SCALON V.R., PEREIRA, T.O.; VIEIRA, D.A. Potencial alelopático do extrato aquoso de folhas de algumas leguminosas arbóreas brasileiras [Allelopathic potential of aquous extracts of leaves of some arboreal leguminous]. **Floresta e Ambiente**, 9, Pag. 119-126. 2002.

SOUSA-SILVA, J.C.; CAMARGO, A.J.A. A flora e a fauna do Cerrado. In: Albuquerque A.C.S. & SILVA A.G. (Eds.). **Agricultura Tropical: Quatro décadas de inovações tecnológicas, institucionais e políticas [Tropical agriculture: Four decades of technological, institutional, and political inovation].** Brazil, DF, Planaltina: Embrapa Cerrados, 2008. p.149-201.

SOUZA FILHO, A.P.S.; RODRIGUES, L.R.A.; RODRIGUES, T.J.D. Efeitos de extratos aquosos de assa-peixe sobre a germinação de três espécies de braquiária [Assa-peixe aquous extracts effects on seeds germination of three *Brachiaria* species] **Planta Daninha**, v.14, p.93-101, 1996.

SOUZA FILHO, A.P.S.; SANTOS, R.A.; SANTOS, L.S.; GUILHON, G.M.P.; SANTOS, A.S.; ARRUDA, M.S.P.; MULLER, A.H.; ARRUDA, A.C. Potencial alelopático de *Myrcia guianensis* [*Myrcia guianensis* allelopathic potential]. **Planta Daninha**, v.24, p.649-656, 2006

SOUZA, S.A.M.; CATTELAN, L.V.; VARGAS, D.P.; PIANA, C.F.B.; BOBROWSKI, V.L.; ROCHA, B.H.G. Efeito de extratos aquosos de plantas medicinais nativas do Rio Grande do Sul sobre a germinação de sementes de alface [Aqueous extract effects of medicinal plants native to Rio Grande do Sul on lettuce seeds germination]. **Publicatio UEPG: Ciências Biológicas e da Saúde**, v.11, p.29-38, 2005a.

SOUZA, S.A.M.; CATTELAN, L.V.; VARGAS, D.P.; PIANA, C.F.B.; BOBROWSKI, V.L.; ROCHA, B.H.G. A Atividade alelopática e citotóxica do extrato aquoso de espinheira-santa (*Maytenus ilicifolia* Mart. ex Reiss.) [Allelopathic and citotoxic activity from aqueous extract of espinheira-santa (*Maytenus ilicifolia* Mart. ex Reiss.)] **Publicatio UEPG: Ciências Biológicas e da Saúde**, v.11, p.7-14, 2005b.

TANNUS, J.L.S.; ASSIS, M.A. Composição de espécies vasculares de campo sujo e campo úmido em área de cerrado, Itirapina – SP, Brasil. **Revista Brasileira de Botânica**, v.27, p.489-506, 2004.

TORRES, L.M.B.; GAMBERINI, M.T.; ROQUE, N.F.; LIMA-LANDMAN, M.T.; SOUCCAR, C.; LAPA, A.J. Diterpene from *Baccharis trimera* with a relaxant effect on rat vascular smooth muscle. **Phytochemistry**, v.55, p.617-619, 2000.

VELOSO, M.P. **Estudo químico das raízes de "*Himatanthus phagedaenicus*" (Mart.) Woodson e dos efeitos alelopáticos dos iridoides isolados ["*Himatanthus phagedaenicus*" (Mart.) Woodson root chemical estudies and allelopathic effects of isolated iridoides].** 1996, 126p. Thesis. (Ph.D) - Universidade Federal de Viçosa, Viçosa, Brazil.

VERDI, L.G.; BRIGHENTE, I.M.C.; PIZZOLATTI, M.G. Gênero *Baccharis* (Asteraceae): aspectos químicos, econômicos e biológicos [Gennus *Baccharis* (Asteraceae): chemical, economic and biological aspects]. **Química Nova**, v.28, p.85-94, 2005.

ZIMDHAL, R.L. **Fundamentals of weed science**. California, USA: Academic Press, 1993. p. 450.