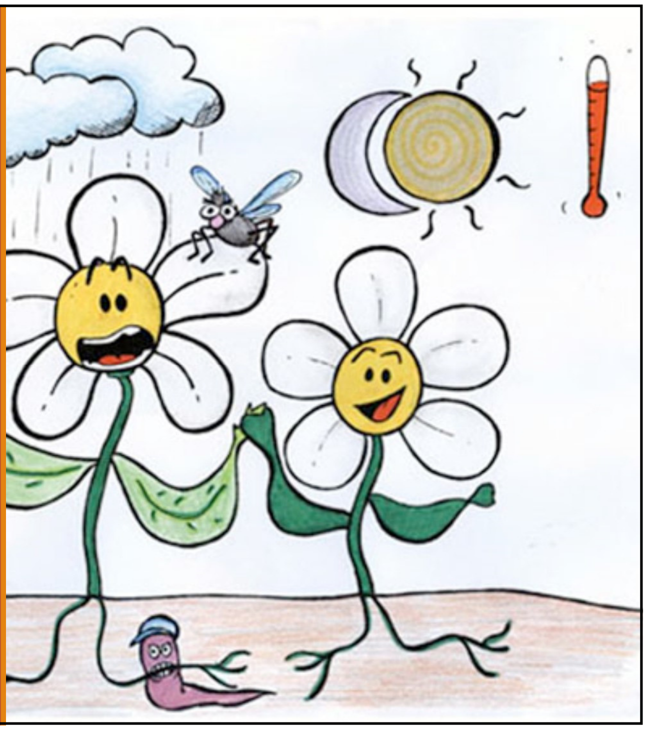
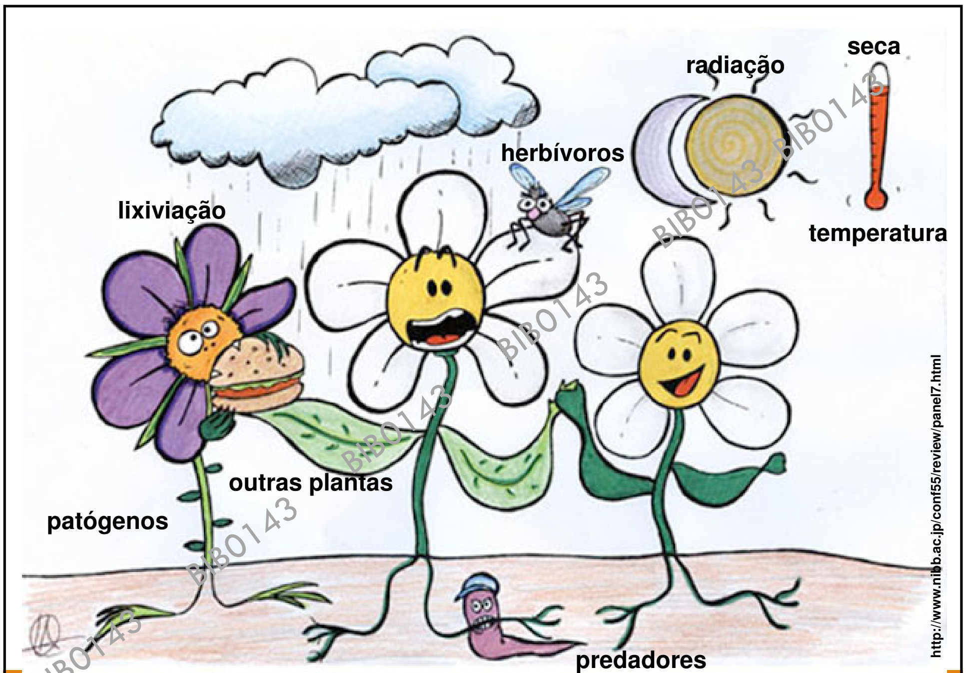
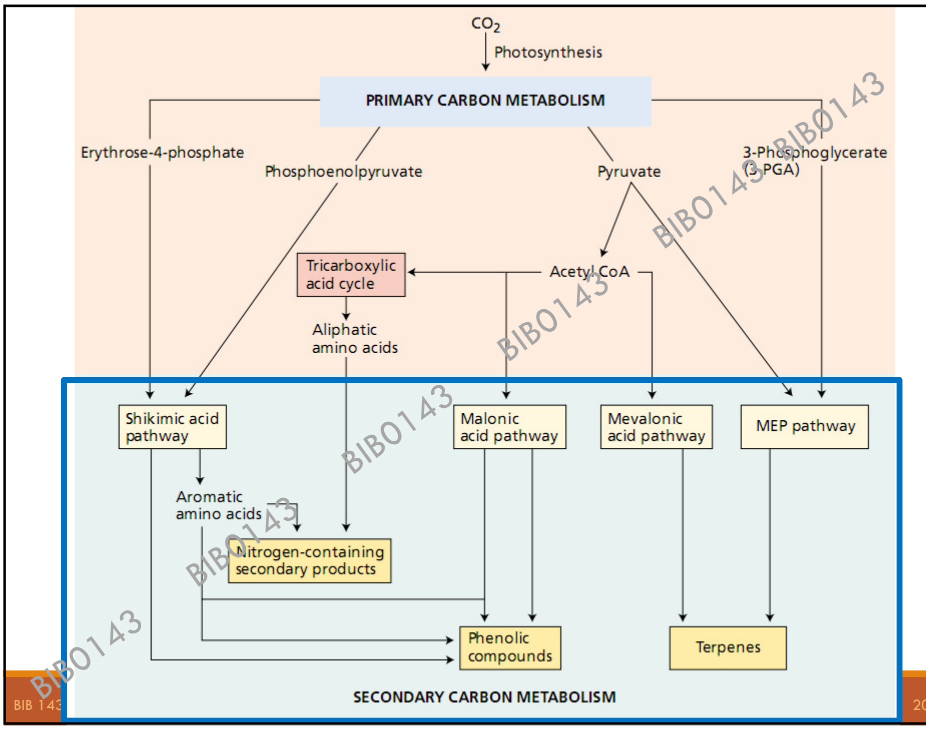
Interações planta-ambiente/ herbívoros: aspectos econômicos e ecológicos

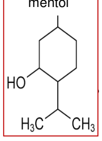
Déborah Yara A. C. dos Santos
dyacsan@ib.usp.br

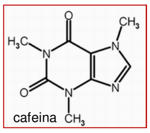




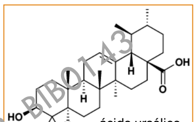


adaptado de Taiz & Zeiger 2009

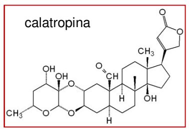

mentol

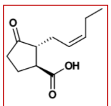

cafeina

METABÓLITOS SECUNDÁRIOS


ácido ursólico

Promovem proteção contra herbívoros (insetos) como dissuasores alimentares, redutores de crescimento, toxinas, etc

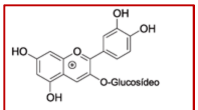

calatropina


ácido jasmônico

Interferência bioquímica com outras plantas - alelopatia

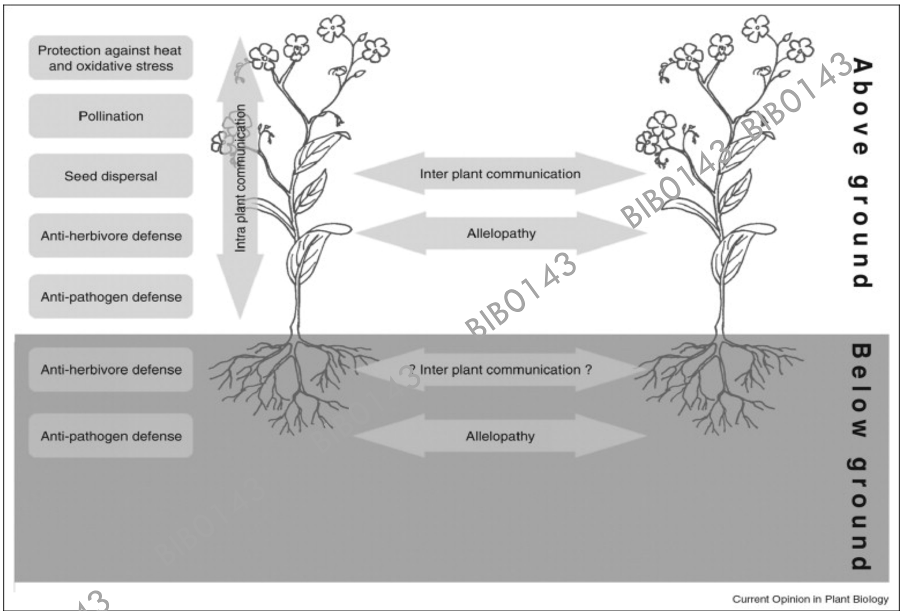
Proporciona proteção contra patógenos (fungos) - fitoalexinas

- Podem servir como sinalisadores para nodulação em leguminosas e para polinizadores


cianidina-3-*O*-glucosídeo

- ....

Metabólitos secundários são substâncias que NÃO participam dos processos de formação de protoplasto e geração de energia; são MEDIADORES em processos de interação das plantas com o ambiente; NÃO são UNIVERSAIS; apresentam ampla diversidade estrutural.



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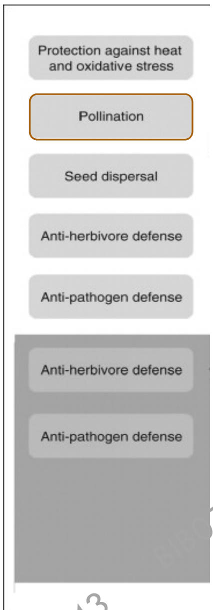


INTERAÇÕES COM FATORES BIÓTICOS

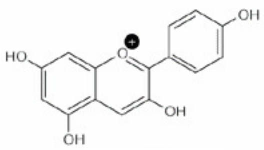
POLINIZAÇÃO

Sybille B Unsicker , Grit Kunert , Jonathan Gershenzon. 2009. Protective perfumes: the role of vegetative volatiles in plant defense against herbivores. **Current Opinion in Plant Biology** 12(4): 479 – 485.

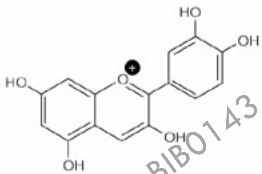
POLINIZAÇÃO

- ✓relação benéfica aos dois envolvidos: animal – néctar e pólen; planta – transferência do pólen;
- ✓a reprodução sexuada nas plantas envolve a polinização;
- ✓a polinização, em especial a cruzada, amplia e garante a variabilidade genética dos vegetais;
- ✓a relação entre o agente polinizador e a planta pode ser generalista ou especialista;
- ✓os agentes polinizadores mais abundantes em angiospermas são os insetos.

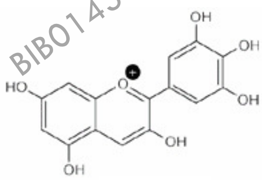
Como os metabólitos secundários estão envolvidos no processo de polinização?



pelargonidina



cianidina



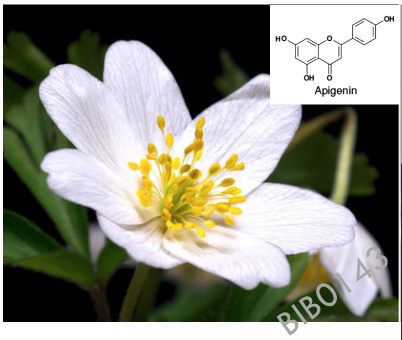
delfinidina

Pelargonium (Geranium)

Rosa (Rose)

Delphinium (Larkspur)

visão humana



visão abelha

http://www.dailymail.co.uk/sciencetech/article-473897/A-bees-eye-view-How-insects-flowers-differently-us.html

Ecological Economics 71 (2011) 80–88

Contents lists available at SciVerse ScienceDirect

Ecological Economics

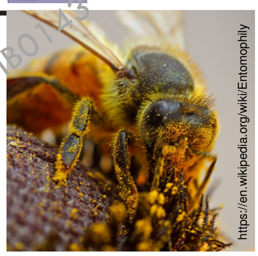
journal homepage: www.elsevier.com/locate/ecolecon

Analysis

Valuing pollination services to agriculture

Rachael Winfree [a,*,1], Brian J. Gross [b,1], Claire Kremen [c]

[a] Department of Entomology, 93 Lipman Dr., Rutgers University, New Brunswick, NJ 08901, USA
[b] Food and Resource Economics, University of British Columbia, Vancouver, Canada, BC V6T1Z4
[c] Department of Environmental Science, Policy and Management, University of California, Berkeley, Berkeley, CA 94720, USA



https://en.wikipedia.org/wiki/Entomophily

A polinização por animais em culturas é um importante **serviço ecossistêmico**!

✓ Cerca de 35% da produção global de alimento depende de agente polinizador

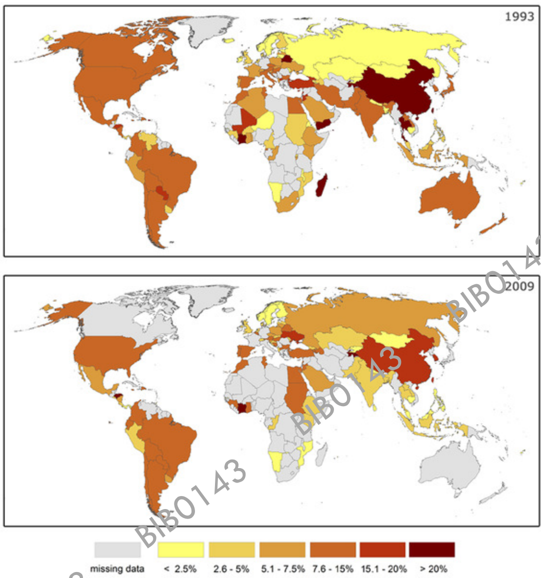


Figure 6. Spatial pattern of vulnerability.

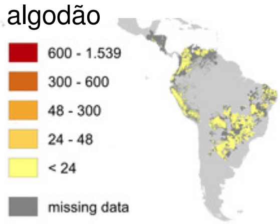
The maps show the national dependency of the agricultural GDP on pollination for the years 1993 and 2009 as an indicator of the vulnerability of agriculture in the different countries.

Identificação de *hot spots* beneficiados pela polinização

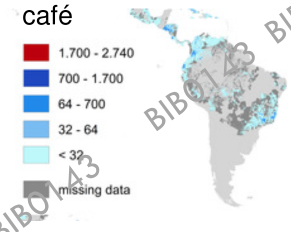
Lautenbach S, Seppelt R, Liebscher J, Dormann CF (2012) Spatial and Temporal Trends of Global Pollination Benefit. PLoS ONE 7(4): e35954. doi:10.1371/journal.pone.0035954. http://www.plosone.org/article/info:doi/10.1371/journal.pone.0035954

Benefícios da polinização (US$/hectare – 2000) em culturas importantes no Brasil

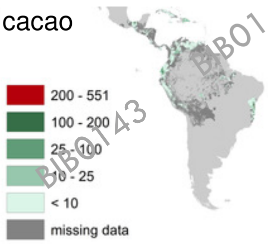
algodão



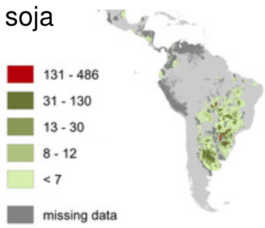
café



cacao



soja



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Analysis

Valuing pollination services to agriculture

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[c] Department of Environmental Science, Policy and Management, University of California, Berkeley, Berkeley, CA 94720, USA

A polinização por animais em culturas é um importante **serviço ecossistêmico**!

✓ Cerca de 35% da produção global de alimento depende de agente polinizador

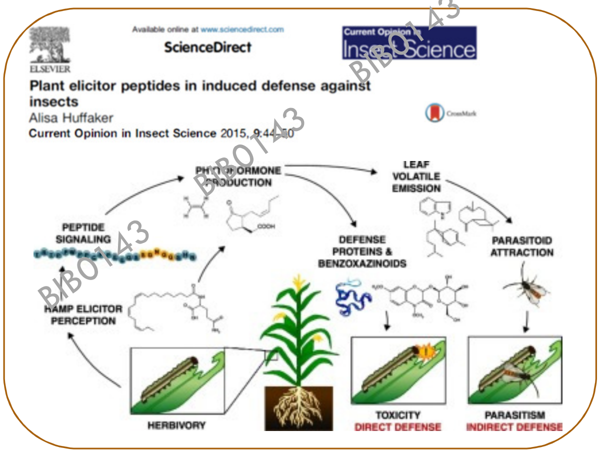
✓ Abelhas (Hymenoptera: Apiformes) - *Apis mellifera* ☠

✓ 17.000 espécies de abelhas nativas: café, melão, tomate, canola, girassol

- Protection against heat and oxidative stress
- Pollination
- Seed dispersal
- Anti-herbivore defense
- Anti-pathogen defense
- Anti-herbivore defense
- Anti-pathogen defense

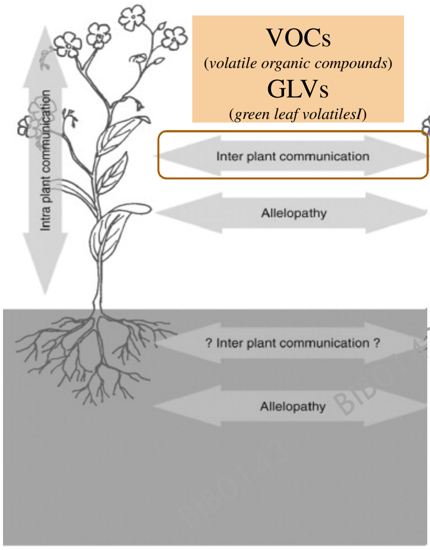
INTERAÇÕES COM FATORES BIÓTICOS

AÇÃO ANTI-HERBIVORIA



Sybille B Unsicker, Grit Kunert, Jonathan Gershenzon. 2009. Protective perfumes: the role of vegetative volatiles in plant defense against herbivores. **Current Opinion in Plant Biology** 12(4): 479 – 485.

INTERAÇÕES COM FATORES BIÓTICOS



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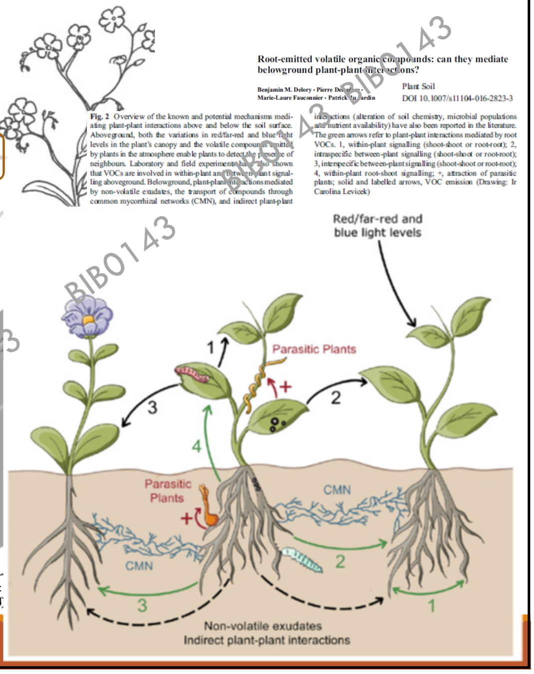
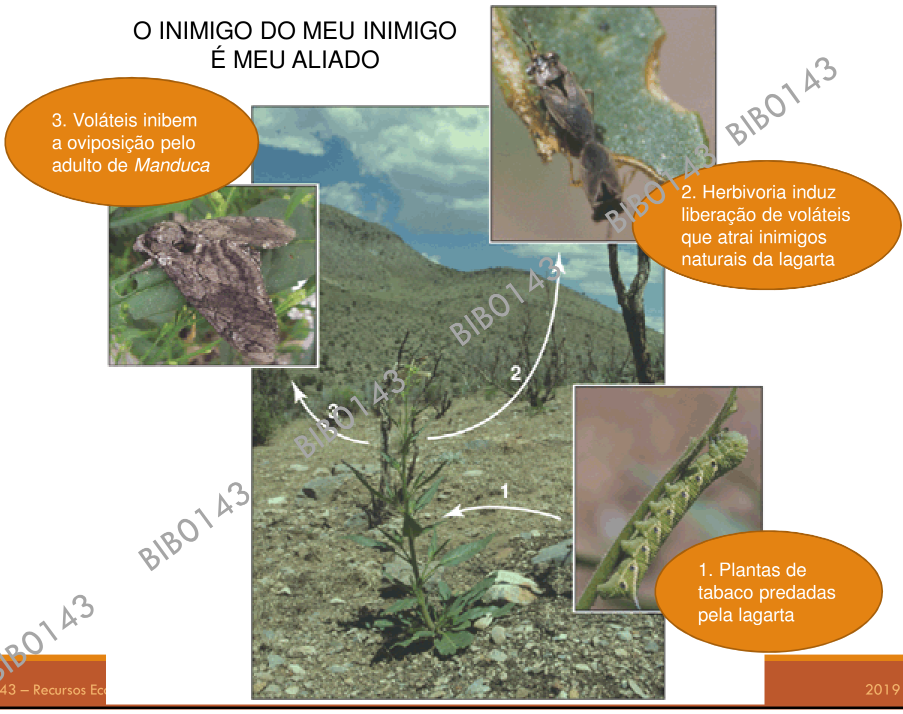


O INIMIGO DO MEU INIMIGO É MEU ALIADO

Sabelis et al. 2001. The enemy of my enemy is my ally. **Science** 291: 2104-5



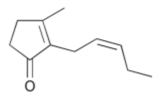
PLANT DEFENCES

Pesticide Outlook – June 2003

CIS-JASMONE SWITCHES ON PLANT DEFENCE AGAINST INSECTS

Toby Bruce, John Pickett and Lesley Smart from Rothamsted Research at Harpenden in the UK describe a volatile plant activator which could have an important part to play in plant defence mechanisms

cis-Jasmone



Substâncias voláteis induzidas em plantas injuriadas:

1. Repelente de insetos fitófagos.
2. Defesa indireta – atração de predador ou parasita do fitófago.
3. Sinais entre plantas – indução de mecanismos de defesa em plantas vizinhas antes do ataque dos herbívoros.

Trigo (*Triticum aestivum*) x afídeo (*Sitobion avenae*) x parasitoide (*Aphidius ervi*)

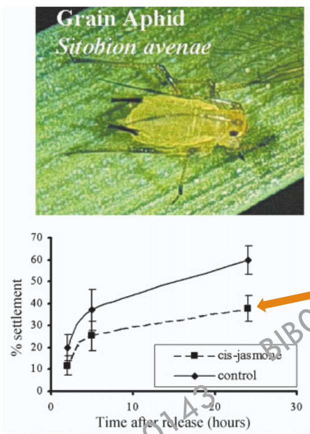


Figure 1 **Settlement of *S. avenae* in simulator bioassay**

Plantas tratadas com sinalizador são **menos** atrativas ao herbívoro e **mais** ao seu parasita

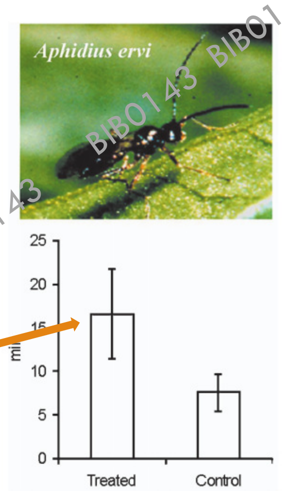
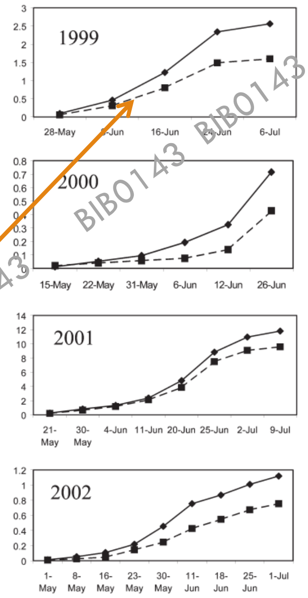


Figure 2 **Time spent foraging by *Aphidius ervi* on *cis*-jasmone and control wheat seedlings.**

Figure 3 **Field application of *cis*-jasmone**



Menor captura de afídeos em armadilhas de campo com plantas tratadas

Figure 4 **Cumulative Cereal Aphid Counts in Field Plot Trials with *cis*-jasmone treatment 1999–2002 (control: ——: *cis*-jasmone: - - -)**

Braz. J. Plant Physiol., 14(2):71-81, 2002

MINIREVIEW

Plant-insect interactions: an evolutionary arms race between two distinct defense mechanisms

Marcia O. Mello and Marcio C. Silva-Filho*

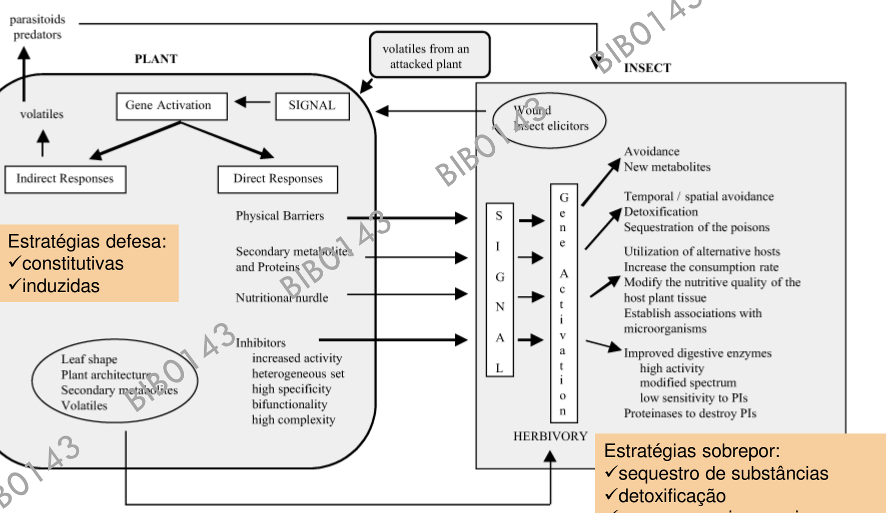
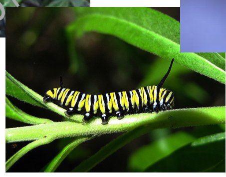
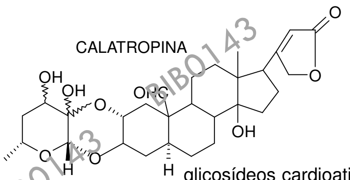


Figure 1. Interactions between plants and insects.

Estratégias defesa nos insetos: sequestro de substâncias

monarca x *Asclepias* x pássaro

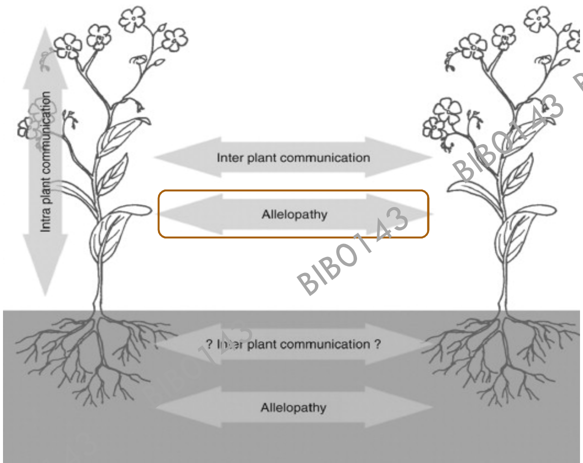




glicosídeos cardioativos

http://borboletasbr.blogspot.com.br/2016/02/lagartas-de-monarca-em-asclepias.html

INTERAÇÕES COM FATORES BIÓTICOS



Alelopatia é um fenômeno natural no qual diferentes organismos afetam o funcionamento de outros organismos nas suas imediações, negativa ou positivamente (Rice, 1984) pela liberação de metabólitos secundários (Farooq et al., 2011a).

Current Opini

Sybille B Unsicker, Grit Kunert, Jonathan Gershenzon. 2009. Protective perfumes: the role of vegetative volatiles in plant defense against herbivores. **Current Opinion in Plant Biology** 12(4): 479 – 485.

INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
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Int. J. Agric. Biol., Vol. 15, No. 6, 2013

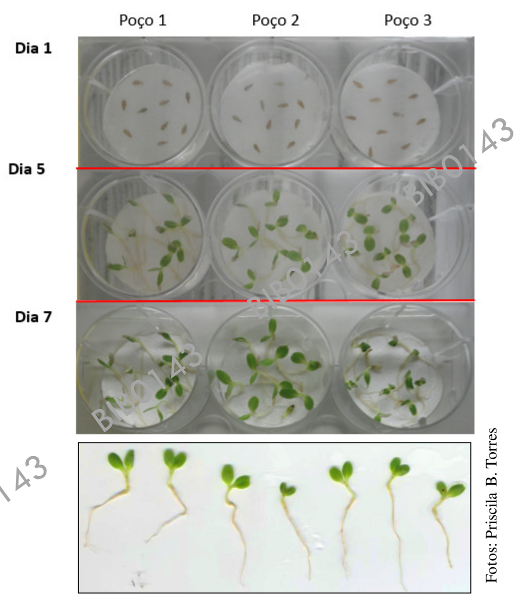
Review Article

Application of Allelopathy in Crop Production

Muhammad Farooq[1*], Ali Ahsan Bajwa[1], Sardar A. Cheema[1] and Zahid A. Cheema[1]
[1]*Allelopathy Laboratory, Department of Agronomy, University of Agriculture, Faisalabad-38040, Pakistan*
*For correspondence: farooqcp@gmail.com

Table 1: Weed control through allelopathic crop water extracts

Allelopathic extract	Crop	Weeds controlled	Weed control: Reduction in weed density (%)	Weed control: Reduction in dry weight (%)	Yield increase over control (%)	Reference
Sorghum	Wheat	*Fumaria indica, Phalaris minor, Rumex dentates, Chenopodium album*	21.6-44.2	35.4-49.0	11.0-20.0	Cheema and Khaliq (2000)
	Cotton	*Trianthema portulacastrum, Cynodon dactylon, Cyperus rotundus*	47.0	29.0-40.1	17.7-59.0	Cheema *et al.* (2002)
	Mungbean	*Cyperus rotundus, Chenopodium album, Convolvulus arvensis*	17.5-31.6	23.7-59.6	4.0-17.7	Cheema *et al.* (2001)
	Rice	*Echinocloa colonum, Cyperus rotundus, Cyperus iria*	-	40.4	12.5	Wazir *et al.* (2011)
Sunflower	Wheat	*Avena fatua, Melilotus officinalis, Phalaris minor, Rumex obtusifolius*	10.6-33.6	2.2-16.5	1.6-10.7	Cheema *et al.* (2003), Naseem *et al.* (2010)
Sorghum + Sunflower Sorghum + Brassica Sorghum + Tobacco Sorghum + Sesame		*Avena fatua, Phalaris minor*	-	10.0-62.0	18.55-62.0	Jamil *et al.* (2009)



COMPOSIÇÃO QUÍMICA E ATIVIDADE ALELOPÁTICA DO ÓLEO ESSENCIAL DE EUCALIPTO

CHEMICAL COMPOSITION AND ALLELOPATHIC ACTIVITY OF THE EUCALYPTUS ESSENTIAL OIL

Marcelo Antonio TOMAZ[1]; Adilson Vidal COSTA[2]; Wagner Nunes RODRIGUES[3]; Patrícia Fontes PINHEIRO[2]; Luciana Alves PARREIRA[4]; Daniel RINALDO[2]; Vagner Tebaldi de QUEIROZ[2]

1. Professor, Doutor, Departamento de Produção Vegetal, Centro de Ciências Agrárias - CCA, Universidade Federal do Espírito Santo - UFES, Alegre, Espírito Santo, tomaz@cca.ufes.br; 2. Professor, Doutor, Departamento de Química e Física, CCA - UFES, Alegre, Espírito Santo; 3. Mestre, Doutorando em Produção Vegetal, CCA - UFES, Alegre, Espírito Santo; 4. Professora, Mestre, Departamento de Química e Física, CCA - UFES, Alegre, Espírito Santo.

Biosci. J., Uberlandia, v. 30, supplement 2, p. 4[illegible]483, Oct./14

Componente	%
α-pineno	0,80
β-pineno	0,18
p-cimeno	0,44
1,8-cineol	1,75
γ-terpineno	0,27
linalol	0,35
iso-isopulegol	10,20
citronelal	**64,92**
neo-isopulegol	0,58
β-citronelol	8,25
Acetato de α-terpenila	6,74
Acetato de citronelila	3,21

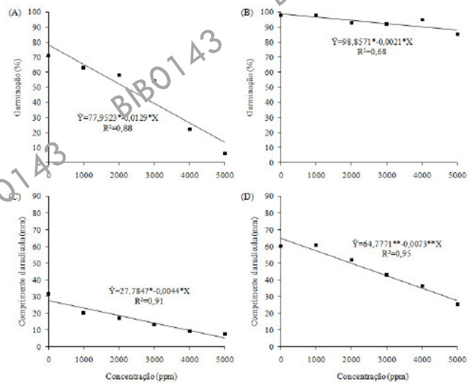


Figura 1. Germinação de sorgo (A) e pepino (B), e comprimento da radícula de sorgo (C) e pepino (D), em função do aumento da concentração do óleo essencial de *E. citriodora*.

Algal Research 32 (2018) 142–149
Contents lists available at ScienceDirect
Algal Research
journal homepage: www.elsevier.com/locate/algal

Effects of extracts and isolated molecules of two species of *Gracilaria* (Gracilariales, Rhodophyta) on early growth of lettuce

Priscila Torres[a,*], Paula Novaes[a], Luciana Garcia Ferreira[b], Janaína Pires Santos[c], Ester Mazepa[b], Maria Eugênia R. Duarte[b], Miguel D. Noseda[b], Fungyi Chow[c], Deborah Y.A.C. dos Santos[a]

alga
↓
extratos de diferentes polaridades
↓
bioensaios
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extrato aquoso
↓
polissacarídeos (ficocoloides)

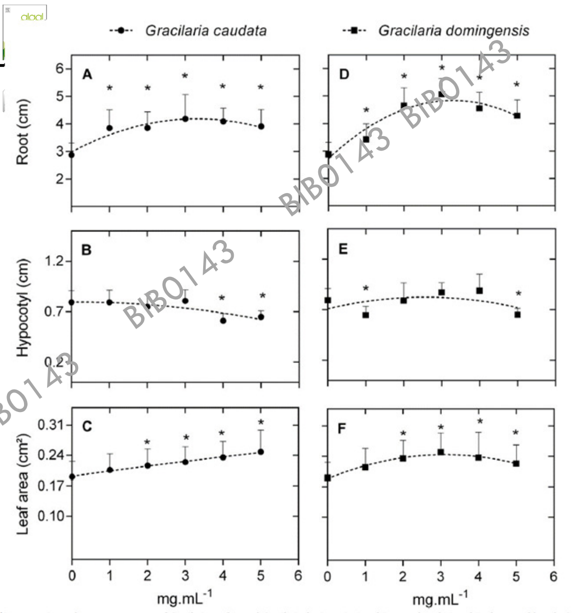
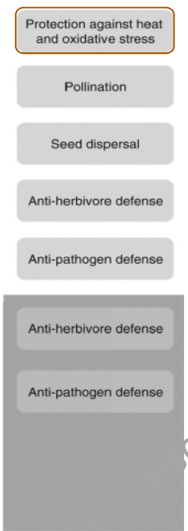
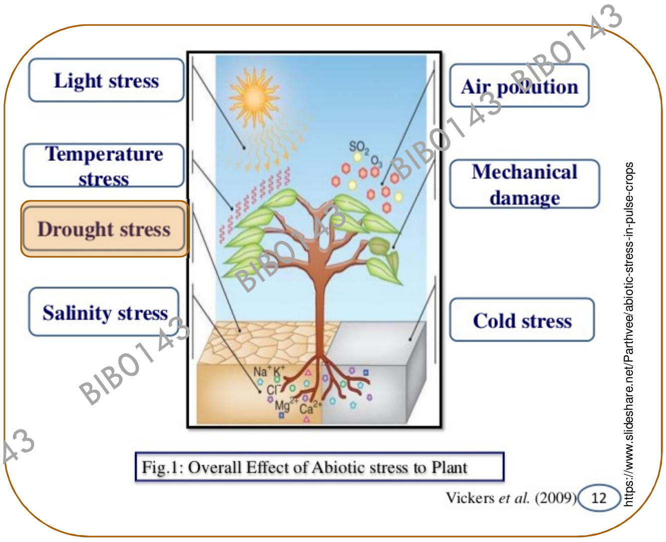


Fig. 2. Initial growth of *Lactuca sativa* under aqueous extracts of *Gracilaria caudata* and *Gracilaria domingensis*. A and D – root length, B and E – hypocotyl length, C and F – leaf area. Data correspond to means ± SD (n = 40). Asterisks (*) indicate significant difference from negative control (Kruskal-Wallis, Dunn; $p < 0.05$).

INTERAÇÕES COM FATORES ABIÓTICOS





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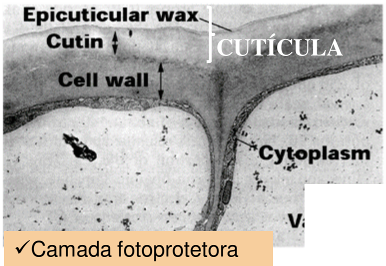


Ceras cuticulares

- ✓Camada fotoprotetora
- ✓ Minimizar a adesão de resíduos nas superfícies das plantas
- ✓Limitar perda de água não estomática
- ✓ Mediação da interação das plantas com ambiente e herbívoros/patógenos
- ✓ Manutenção do correto desenvolvimento de vários órgãos

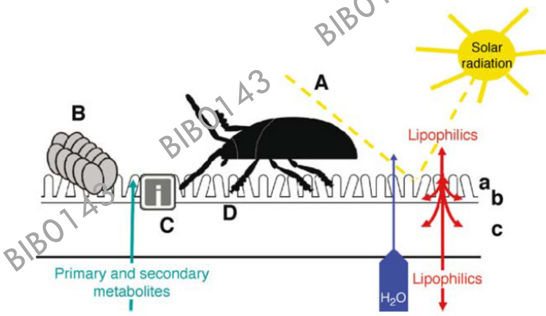
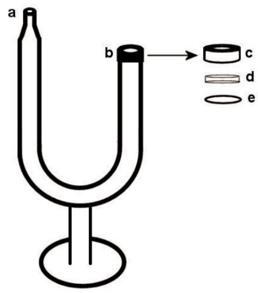


FIG. 4. Processes on the plant surface. (A) Reflectance, transmittance, and absorbance of solar radiation; (B) attachment of insect eggs (or spores of microorganisms, likewise); (C) physical and chemical cues used for host recognition by microorganisms and insects; (D) adhesion of insect legs and influences of surface characteristics on locomotion. Water and other metabolites diffuse in different degrees through the cuticular layer, formed by epicuticular wax crystals (a), the epicuticular wax film (b), and cutin and intracuticular waxes (c).

Müller, C. & Riederer, M. **J. Chemical Ecology** 31: 2621-51. (2005)

Hidrofobicidade da cutícula depende da composição relativa das frações de hidrocarbonetos, álcoois e aldeídos (mais relacionada com as ceras);



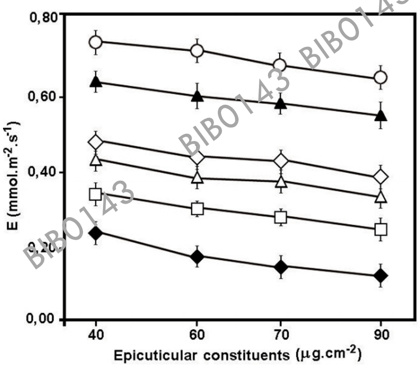


Fig. 3 – Evaporation rates (E) inWhatman paper discs impregnated with constituents separated fromfoliar epicuticularwaxes of species fromcaatinga and cerrado. Empty symbols correspond to triterpenoids. (○) ursolic acid, (▲) hentriacontan-16-one, (◇) lupeol, (△) lupeol + β-amyrin, (□) epifriedelinol, **(◆)n-alkanes**. Values correspond to means ± sd (n = 30), obtained at 25◦C and 65% relative humidity.

alcanos são mais eficientes que terpenoides como barreiras a perda de água

Oliveira & al. Epicuticular waxes from caatinga and cerrado species and their efficiency against water loss. Anais da Academia Brasileira de Ciências (2003) 75(4): 431-439

A composição de cada fração depende da espécie e afeta diretamente a condutância epidérmica e a estrutura da cera na superfície;

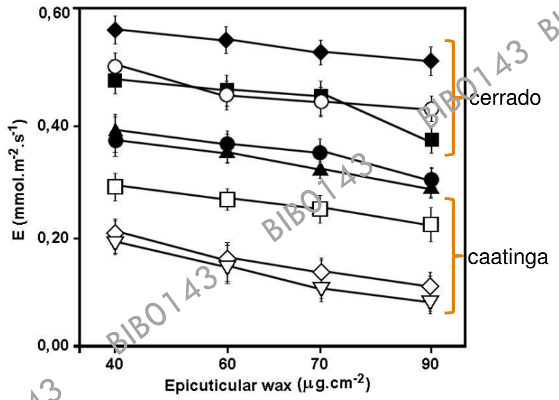


Fig. 2 – Evaporation rates (*E*) in Whatman paper discs impregnated with foliar epicuticular waxes of species from caatinga (empty symbols) and cerrado (full symbols). (○) *Aspidosperma pyrifolium*, (◇) *Capparis yco*, (□) *Maytenus rigida*, (▽) *Ziziphus joazeiro*, (■) *Aristolochia esperanzae*, (▲) *Didymopanax vinosum*, (●) *Strychnos pseudoquina*, (♦) *Tocoyena formosa*. Values correspond to means ± sd (n = 30), obtained at 25◦C and 65% relative humidity.

Increased Accumulation of Cuticular Wax and Expression of Lipid Transfer Protein in Response to Periodic Drying Events in Leaves of Tree Tobacco[1[W]]

Kimberly D. Cameron, Mark A. Teece, and Lawrence B. Smart*
Faculty of Environmental and Forest Biology (K.D.C., L.B.S.) and Faculty of Chemistry (M.A.T.), State University of New York, College of Environmental Science and Forestry, Syracuse, New York 13210

Plant Physiology, January 2006, Vol. 140, pp. 176–183

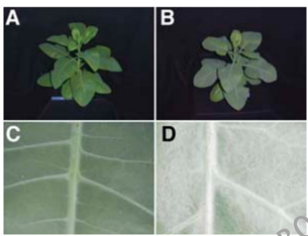


Figure 1. Tree tobacco plants exposed to periodic drying events. A, Well-watered plant. B, Plant exposed to three periodic drying events. C, Close-up of the adaxial surface of a fully expanded leaf from the plant in A. D, Close-up of the adaxial surface of a fully expanded leaf from the plant in B.

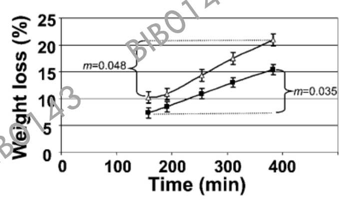


Figure 5. Rate of actual weight loss due to epidermal conductance from leaves excised from periodically dried (■) or well-watered (□) plants. Data represent one of three replicated experiments. Three leaves per plant from each of four well-watered and periodically dried plants were excised and immediately placed in a 30ºC incubator. Leaves were weighed after excision at approximately 150 min, 180 min, and at hourly increments thereafter. The percent of water loss was determined relative to the original leaf weight. Error bars indicate the mean SD across all time points. m 5 slope of the line.

Aumento na quantidade de cera nas plantas submetidas a seca

Aumento na tolerância a seca relacionado ao aumento de cera total

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COMPARISON OF DIFFERENT FRUIT COATINGS TO ENHANCE THE SHELFLIFE OF KINNOW MANDARIN

SakeenaTul-Ain Haider[1,*], Saeed Ahmad[1], Ahmad Sattar Khan[1] and Shahzad, M.A. Basra[2]
[1]Institute of Horticultural Sciences, University of Agriculture Faisalabad, Pakistan; [2]Department of Agronomy, University of Agriculture Faisalabad, Pakistan.
*Corresponding Author's e-mail: sandhu100hassan@yahoo.com

http://clausennursery.com/citrus-trees/tangerine-trees/item/kinnow-mandarin

Citrus notabilis Lour. X *Citrus deliciosa* Tenora

2014 – 2015:

Pakistão exportou > 350 ton (US$ 284 milhões)

Perdas pós-colheita – 23 – 38%

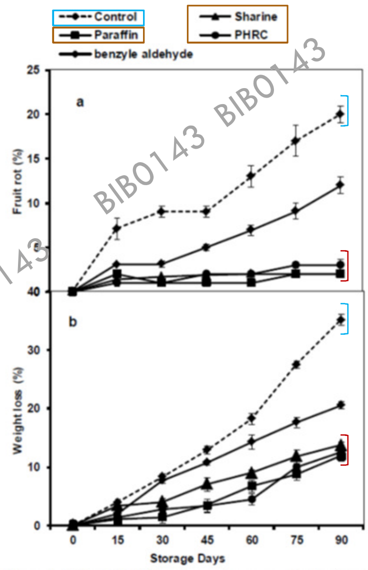


Figure 1. Effect of different wax types on fruit rot and weight loss (%) during storage.

Crop Protection 91 (2017) 57–65
Contents lists available at ScienceDirect
Crop Protection
journal homepage: www.elsevier.com/locate/cropro

The interactions between surfactants and the epicuticular wax on soybean or weed leaves: Maximal crop protection with minimal wax solubilization

Tatiana Cardoso Damato [a], Letícia D.M. Carrasco [b], Ana Maria Carmona-Ribeiro [b], Ricardo Vagner Luiz [c], Roberta Godoy [c], Denise F.S. Petri [a,*]

Componentes isolados da cera não tem efeito antifúngico. Porém, não há crescimento de fungo sobre a superfície com cera recristalizada. Logo, a ornamentação é a barreira!

água + surfactantes | herbicida

água | CTAB 0,04% | SDS 0,25% | ESM20 0,008% | CF 0,2%

θa

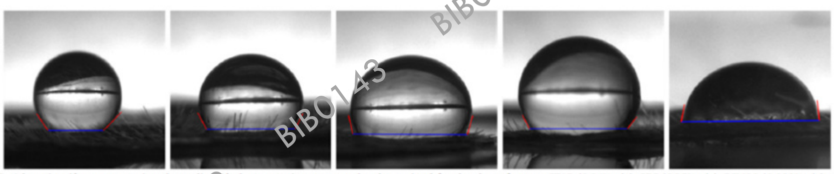


Fig. 5. Advancing (θa, upper row) and receding (θr, lower row) contact angles determined for droplets of water, CTAB (0.04% v/v), SDS (0.25% v/v), ESM20 (0.008% v/v), and CF (0.2% v/v) on freshly harvest soybean leaves.

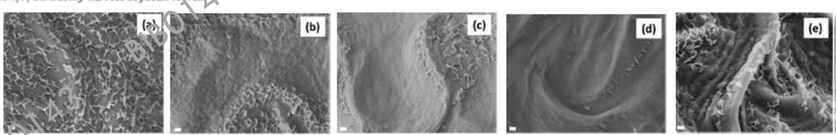
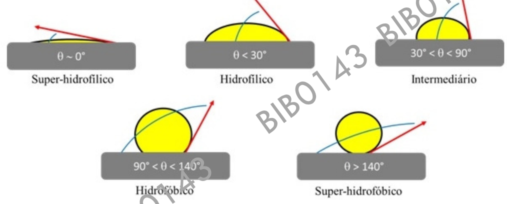


Fig. 3. SEM images obtained for freshly harvested soybean leaves (adaxial surfaces), which were in contact for 3 h with droplets of (a) MilliQ water, (b) CTAB (0.04% v/v), (c) SDS (0.25% v/v), (d) ESM20 (0.008% v/v), and (e) CF (0.2% v/v) until solvent evaporation, rinsed with water and allowed to dry in the air (see details in Fig. 4). The scale bar corresponds to 1 μm.

Efeito Lotus

Quanto menor o ângulo de contato da gota com a superfície, maior a possibilidade dessa superfície ficar molhada; relacionado com a impermeabilidade

http://www.olharnano.com/artigos/4001/63001/O-efeito-L%C3%B3tus-



https://www.youtube.com/watch?v=sCjmpyQlHYM

Chemosphere 76 (2009) 1445–1450
Contents lists available at ScienceDirect
Chemosphere
journal homepage: www.elsevier.com/locate/chemosphere

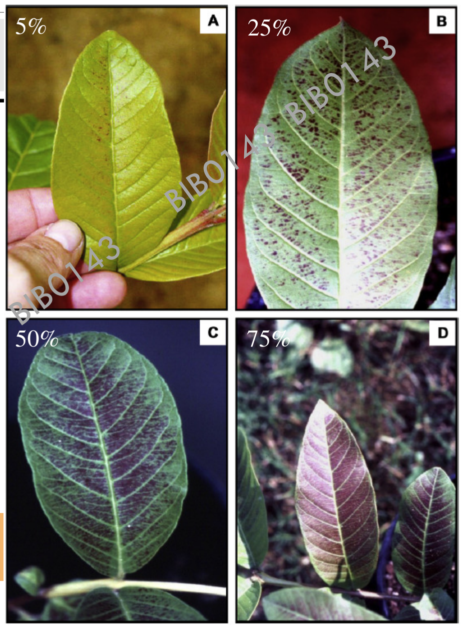
Anthocyanins and tannins in ozone-fumigated guava trees

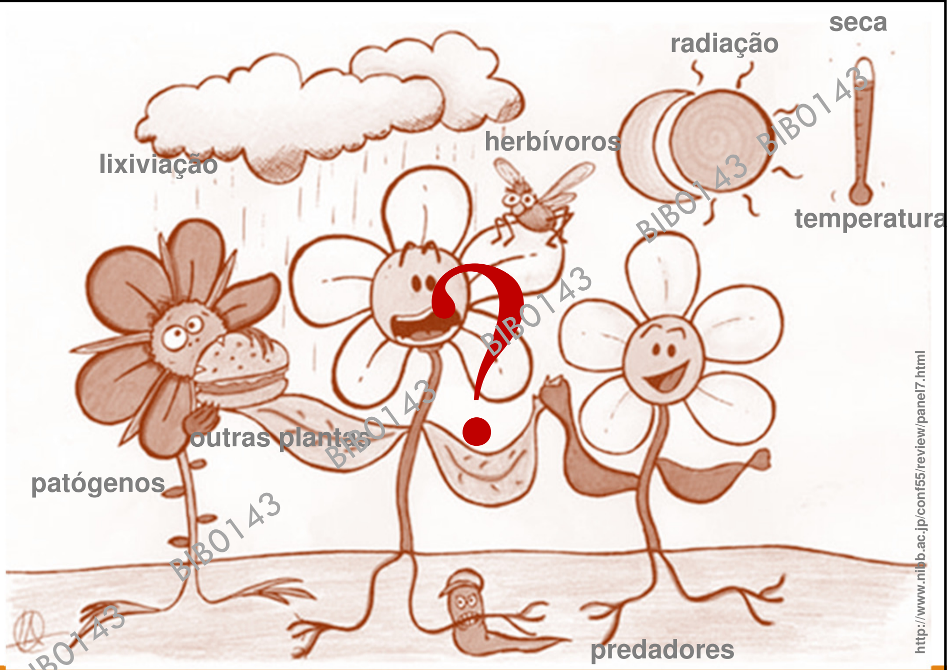
Fernanda Mendes de Rezende[a], Cláudia Maria Furlan[b,*]

Table 1
Mean percentages (±standard deviation) of anthocyanins and tannins on *Psidium guajava* 'Paluma' after 30 days of exposure to different fumigation treatments: CF – charcoal-filtered air; NF – ambient non-filtered air; NF + O_3 – ambient non-filtered air plus 40 ppb of O_3; $n = 10$; Values followed by # correspond to statistically different means when comparing to CF ($p < 0.05$).

Treatment	Anthocyanins	Tannins	
		Total	Condensed
CF	0.970 ± 0.4	0.136 ± 0.016	0.035 ± 0.006
NF	1.295 ± 0.7	0.160 ± 0.017#	0.051 ± 0.009#
NF + O_3	1.607 ± 0.6#	0.162 ± 0.014#	0.046 ± 0.006#

Correlação entre porcentagem de injúrias foliares e teor de antocianinas.





Modelo de desencadeamento de resposta em planta frente ao ataque de herbívoros e patógenos

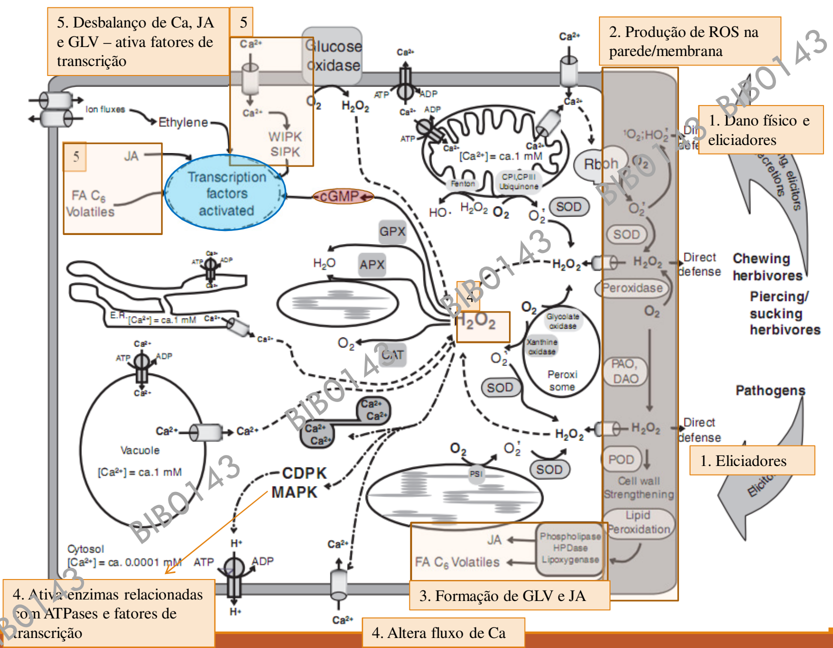
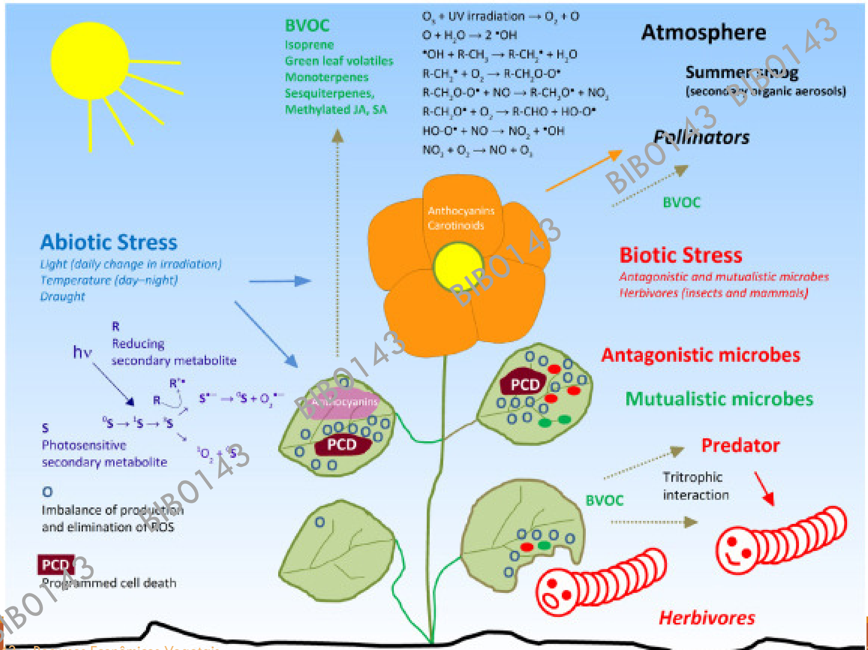


Figure 34 from David B Graves 2012 J. Phys. D: Appl. Phys. 45 263001



Environmental and Experimental Botany 114 (2015) 4–14
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journal homepage: www.elsevier.com/locate/envexpbot

Signaling events in plants: Stress factors in combination change the picture

Christian M. Prasch*, Uwe Sonnewald
Biochemistry Division, Department of Biology, Friedrich-Alexander-University Erlangen-Nuernberg, 91058 Erlangen, Germany

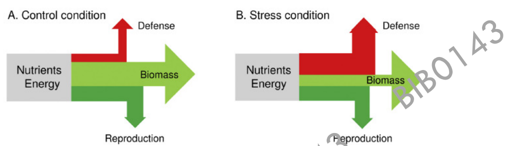

Fig. 1. Energy channeling is shifted from biomass production to defense programs. Under stress conditions nutrients and energy are redirected from biomass production towards defensive processes. Additionally reproduction is accelerated under adverse environmental conditions.

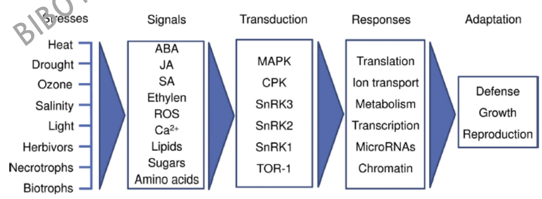

Fig. 2. Crucial events in the signal transduction pathway activated by several biotic and abiotic stress factors. The schematic diagram shows how different stress factors activate different signals, which themselves trigger signal transduction cascades. Different signaling events result in appropriate plant responses leading to adaption processes including defense, growth and reproduction. ABA (abscisic acid); ROS (reactive oxygen species); JA (jasmonic acid); SA (salicylic acid); Ca^{2+} (Calcium); MAPK (mitogen-activated protein kinase); CPK (Ca^{2+}-dependent protein kinases); SnRK (sucrose non-fermenting-1-related protein kinase); TOR-1 (target of rapamycin).

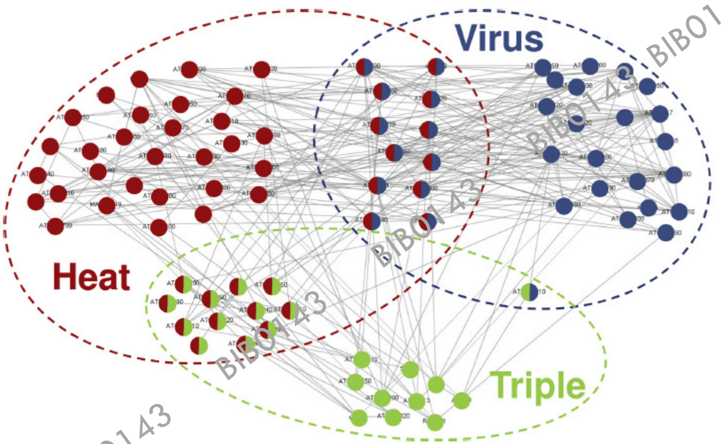

Fig. 3. Co-expression networks are changed under combination of stresses. A multifactorial test system, allowing simultaneous application of heat, drought, and virus stress revealed deactivation of defense responses under multifactorial stress, which in turn caused higher susceptibility to virus infection (Prasch and Sonnewald, 2013). As further transcriptome analysis showed clear changes in signaling genes, co-expression analysis of signaling genes under single and combined stress conditions have been conducted. The picture illustrates significantly regulated signaling genes within the heat, virus and triple stress network visualized by the ARANET Web tool (www.functionalnet.org/aranet/). These observations suggested that abiotic stress factors in combination with virus stress repress virus-specific networks. Gene identities are given in the supplemental Table S5 provided by Prasch and Sonnewald (2013).