

**Universidade de São Paulo
Escola Superior de Agricultura Luiz de Queiroz**

**Relação AtRALF1 - Etileno e a identificação de um promotor mínimo
em CML38, um gene induzido por AtRALF1 e componente da via de
resposta ao AtRALF1 independente de FERONIA**

Akemi Lueli Niitsu

Tese apresentada para obtenção do título de Doutora em
Ciências. Área de concentração: Fisiologia e Bioquímica de
Plantas

**Piracicaba
2020**

Akemi Lueli Niitsu
Bióloga

**Relação AtRALF1 - Etileno e a identificação de um promotor mínimo
em CML38, um gene induzido por AtRALF1 e componente da via de
resposta ao AtRALF1 independente de FERONIA**

Orientador:
Prof. Dr. **DANIEL SCHERER DE MOURA**

Tese apresentada para obtenção do título de Doutora em
Ciências. Área de concentração: Fisiologia e
Bioquímica de Plantas

**Piracicaba
2020**

RESUMO

Relação AtRALF1 - Etileno e a identificação de um promotor mínimo em CML38, um gene induzido por AtRALF1 e componente da via de resposta ao AtRALF1 independente de FERONIA

As plantas precisam de uma rede de sinalização química coordenada para regular o seu desenvolvimento, uma vez que não conseguem se esquivar das frequentes alterações do meio ambiente. Dentre estes sinais estão os peptídeos hormonais, pequenas proteínas que regulam processos como defesa, crescimento e reprodução. O qual também é regulado por hormônios vegetais como o etileno. A relação entre hormônios e peptídeos vem sendo elucidada nos últimos anos. Assim, o objetivo deste trabalho foi desvendar os componentes da via de sinalização de AtRALF1. O hormônio etileno foi induzido em raízes de plantas selvagens e tratadas com AtRALF1 e não foi induzido em plantas com perda de função para o receptor do peptídeo. Genes da via de sinalização de etileno são expressos no tratamento exógeno de plantas selvagens com AtRALF1. Da mesma maneira, genes da via de sinalização de etileno e calose são expressos e induzidos em plantas mutantes de *cml38* mostrando a importância das ligações de Ca^{2+} a elementos essenciais da parede celular durante a inibição do crescimento da raiz. Para entender a resposta de CML38 à AtRALF1, buscou-se os elementos regulatórios presentes na região promotora de CML38. Várias fragmentações do promotor de CML38 foram feitas até encontrar a região mínima responsável ao peptídeo. Através desta informação será possível a utilização destas regiões como ferramentas para isolamento de fatores transcripcionais envolvidos na resposta ao RALF.

Palavras-chave: RALF; Etileno, crescimento da raiz, CML38, Elementos regulatórios; Fatores transcripcionais.

ABSTRACT

AtRALF1 - Ethylene crosstalk and the identification of a minimal promoter in CML38, a gene induced by AtRALF1 and component of the FERONIA-independent response pathway to AtRALF1

Plants need a coordinated chemical signaling network to regulate their development, as they cannot avoid frequent changes in the environment. Among these signs are hormonal peptides, small proteins that regulate processes such as defense, growth and reproduction. Which is also regulated by plant hormones like ethylene. The relationship between hormones and peptides has been elucidated in the last years. Thus, the objective of this work was to unveil the components of the AtRALF1 signaling pathway. The ethylene hormone was induced in roots of wild plants and treated with AtRALF1 and was not induced in plants with loss of function for the peptide receptor. Genes of the ethylene signaling pathway are expressed in the exogenous treatment of wild plants with AtRALF1. Likewise, genes from the ethylene and callose signaling pathway are expressed and induced in *cml38* mutant plants showing the importance of Ca^{2+} bonds to essential elements of the cell wall during the inhibition of root growth. To understand CML38 responses to AtRALF1, the regulatory elements present in the CML38 promoting region were sought. Several fragmentations of the CML38 promoter were made until finding the minimal region responsible for the peptide. Through this information it will be possible to use these regions as tools to isolate transcription factors involved in the response to the RALF.

Keywords: RALF; Ethylene, root growth, CML38, Regulatory elements; Transcription factors

1 INTRODUÇÃO

O estudo da fisiologia e bioquímica de plantas busca entender os mecanismos responsáveis pela manifestação da vida onde, o sistema como um todo, é estruturado com células capazes de se regularem e regenerarem. As células são unidades microscópicas que, bioquimicamente, interagem entre si mantendo organização no nível molecular.

As plantas recebem estímulos endógenos e exógenos que regulam o seu crescimento e desenvolvimento. Algumas proteínas, como os peptídeos hormonais, funcionam como moléculas de sinalização celular em vários processos fisiológicos (MOURA; SILVA-FILHO, 2006; MATSUBAYASHI; SAKAGAMI, 2006; FUKUDA; HIGASHIYAMA, 2011; KATSIR et al., 2011; ALBERT, 2013). Uma família de peptídeos hormonais denominados por RALF (*Rapid Alkalization Factor*) afetam o crescimento da planta, resposta a patógenos e a geração do tubo polínico (PEARCE et al., 2001; GE et al., 2017; GE; STEGMANN et al., 2017; GONNEAU et al., 2018 CHEUNG; QU, 2019). O RALF originalmente isolado de tabaco possui 49 aminoácidos e é derivado de um precursor maior, uma pré-pro-proteína de 115 aminoácidos. Há duas características essenciais para a atividade de AtRALF1, o motivo - YISY - e quatro cisteínas que formam duas pontes dissulfetos. Outra característica da estrutura primária do precursor é a presença de um sítio dibásico, dupla arginina (Arg63, Arg64), necessário para o reconhecimento da enzima responsável pelo processamento do precursor (PEARCE et al., 2001; MATOS et al., 2008; SRISVASTAVA et al., 2009).

Sabe-se que AtRALF1 se liga à proteína de membrana FERONIA. Esta interação RALF1-FERONIA, leva a uma fosforilação da serina899 (Ser899) que resulta na regulação negativa da ATPase AHA2, alcalinizando assim o apoplasto (HARUTA et al., 2014). A via completa de sinalização do peptídeo ainda é pouco conhecida, entretanto é proposto que tenha mais do que um receptor para RALF (SCHEER; PEARCE; RYAN, 2005; DRESSANO et al., 2017). Recentemente, foi descoberto uma proteína que atua como co-receptor de AtRALF1, BAK1 (*BRASSINOSTEROID INSENSITIVE 1-associated receptor kinase 1*). BAK1 está relacionada com o controle da expansão celular, mas não envolve a alcalinização e a mobilização de Ca^{2+} que são algumas das funções do peptídeo (DRESSANO et al., 2017). A alcalinização do meio extracelular iniciada por AtRALF1 permite a dissociação do complexo proteico responsável pela resposta ao brassinolide (BL). Este complexo é formado pelo receptor dos brassinoesteróides, a proteína BRI1 (*BRASSINOSTEROID INSENSITIVE1*), BL e BAK1 e sua formação é dependente de um pH ácido (SUN et al., 2013). O envolvimento da proteína BAK1 na percepção de AtRALF1 sugere a existência de duas vias independentes

para a ativação dos genes que levam a inibição da expansão celular (DRESSANO et al., 2017). Uma proteína que detecta oscilações de Ca^{2+} , a CML38 (*Calmodulin-like 38*), no apoplasto, se liga à AtRALF1 e assim se ligam à BAK1, formando então, um novo complexo para a via de respostas à AtRALF1 (CAMPOS et al., 2017). Mutantes de *cml38* não inibem suas raízes através de AtRALF1, entretanto essas plantas exibem alcalinização normal em resposta ao peptídeo. Sugerindo também, a dissociação das respostas à AtRALF1 (CAMPOS et al., 2017).

Grandes avanços na interação de AtRALF1 e hormônios vegetais vêm sendo alcançados nos últimos anos. AtRALF1 altera os genes envolvidos na via desses hormônios, como o hormônio etileno, ajudando na compreensão do funcionamento da via de sinalização do peptídeo (AALEN et al., 2013; LIU et al., 2013; HARUTA et al., 2014). NIITSU (2016), analisou a interação entre o peptídeo AtRALF1 e o hormônio vegetal etileno. Onde foi observado a dependência do hormônio pelo peptídeo.

O objetivo desta pesquisa foi aprofundar o conhecimento da relação entre AtRALF1 e etileno assim como identificar um promotor mínimo no gene *CML38* capaz de responder a AtRALF1. Os resultados aqui descritos compõem um esforço maior para desvendar os componentes da via de sinalização envolvida na resposta ao AtRALF1 e suas funções na regulação da inibição da expansão celular.

6 CONCLUSÕES

-O peptídeo AtRALF1 induz a produção de etileno, da mesma maneira expressa genes da via de sinalização deste hormônio em plantas wt.

- No tratamento com AtRALF1 mutantes *fer4* não produzem etileno, assim não expressam genes da via de etileno e não induzem placas de calose.

-Mutantes de *cml-38*, não inibem o tamanho das raízes através de AtRALF1, entretanto expressam genes da via de etileno e induzem a formação de placas de calose na ponta de suas raízes.

-Embora as duas vias proponham sinalizações para a inibição do crescimento da raiz, há uma via que ocasiona à alcalinização e outra via que ocasiona a inibição da raiz, ambas por AtRALF1.

-A sequência que apresenta os elementos regulatórios, que respondem ao peptídeo AtRALF1 no promotor do gene CML38, está presente próximo ao início do gene, entre 59pb.

-Fatores transcripcionais que possivelmente podem ser induzidos pela sequência mínima do promotor de *cml38*, e respondem ao peptídeo, podem estar atuando em diversas áreas do desenvolvimento vegetal.

REFERÊNCIAS BIBLIOGRÁFICAS

- AALEN, R.B.; WILDHAGEN, M.; STO, I.M.; BUTENKO, M.A. IDA: a peptide ligand regulating cell separation processes in *Arabidopsis*, **Journal of Experimental Botany**, v. 64, p. 5253–5261, 2013.
- ABBE, E. C.; PHINNEY, B. O.; BAER, D. F. The growth of the shoot apex in maize: internal features. **American Journal of Botany**, v. 38, p. 744-751, 1951.
- ABELES, F.B.; MORGAN, P.W.; SALTVEIT, M.E. Jr. **Ethylene in plant biology**. 2nd ed. San Diego: Academic Press, 1992. 414 p.
- ADAMS, D.O.; YANG, S.F. Ethylene biosynthesis: identification of 1-aminocyclopropane-1-carboxylic acid as an intermediate in the conversion of methionine to ethylene. **PNAS**, v. 76, p. 170–174, 1979.
- ALBERT, M. Peptides as triggers of plant defense. **Journal of Experimental Botany**, v. 64, p. 5269-5279, 2013.
- ALDON, D.; MBENGUE, M.; MAZARS, C.; GALAUD, J.-P. Calcium signalling in plant biotic interactions. **International Journal of Molecular Science**, v. 19, p. 665; 2018.
- AN, S.H.; SOHN, K.H.; CHOI, H.W.; HWANG, I.S.; LEE, S.C.; HWANG, B.K. Pepper pectin methylesterase inhibitor protein CaPMEI1 is required for antifungal activity, basal disease resistance and abiotic stress tolerance. **Planta**, v. 228, p. 61–78, 2008.
- ATKINSON, N.J.; LILLEY, C.J.; URWIN, P.E. Identification of genes involved in the response of *Arabidopsis* to simultaneous biotic and abiotic stresses. **Plant Physiology**, v. 162, p. 2028-2041, 2013.
- BABU, Y.S.; SACK, J.S.; GREENHOUGH, T.J.; BUGG, C.E.; MEANS, A.R.; COOK, W.J. Three-dimensional structure of calmodulin. **Nature**, v. 315, p. 37–40, 1985.
- BAILEY, P.C.; MARTIN, C.; TOLEDO-ORTIZ, G.; QUAIL, P.H.; HUQ, E.; HEIM, MA, JAKOBY M, WERBER M, WEISCHAAR B: Update on the basic helixloop-helix transcription factor gene family in *Arabidopsis thaliana*. **Plant Cell**, v. 15, p. 2497-2502, 2003.
- BAKSHI, A.; SHEMANSKY, J. M.; CHANG, C.; BINDER, B. M. History of research on the plant hormone ethylene. **Journal of Plant Growth Regulation**, v. 34, p. 809–827, 2015.
- BENAVENTE, L.M.; ALONSO, J.M. Molecular mechanisms of ethylene signaling in *Arabidopsis*, **Molecular Biosystem**, v. 2, p. 165–173, 2006.
- BENN, G.; WANG, C-Q.; HICKS, D.R.; STEIN, J.; GUTHRIE, C.; DEHESH, K. A key general stress response motif is regulated non-uniformly by CAMTA transcription factors. **Plant Journal**, v. 80, p. 82–92, 2014.
- BERGEY, D. R.; RYAN, C. A. Wound- and systemin-inducible calmodulin gene expression in tomato leaves. **Plant Molecular Biology**, v. 40, p. 815–823, 1999.

BERGONCI, T.; SILVA-FILHO, M.C.; MOURA, D.S. Antagonistic relationship between AtRALF1 and brassinosteroid regulates cell-expansion-related genes. **Plant Signaling & Behavior**, Austin, v. 10, p. e976146, 2014a.

BERGONCI, T.; RIBEIRO, B.; CECILIATO, P.H.O.; GUERRERO-ABAD, J.C.; SILVA-FILHO, M.C.; MOURA, D.S. Arabidopsis thaliana RALF1 opposes brassinosteroid effects on root cell elongation and lateral root formation. **Journal of Experimental Botany**, Oxford, v. 65, p. 2219-2230, 2014b.

BHURIA, M., GOEL, P., KUMAR, S., SINGH, A.K. The Promoter of AtUSP Is Co-regulated by Phytohormones and Abiotic Stresses in Arabidopsis thaliana. **Frontiers in Plant Science**, v. 7, p. 1-13, 2016.

BIANCHI, ME. DAMPs, PAMPs and alarmins: all we need to know about danger. **Journal Leukocyte Biology**, v. 81, p. 1-5, 2007.

BLACKBURN, M. R.; HARUTA, M.; MOURA, D. S. RALF as a growth inhibitory fator. **Plant Physiology**, 2020.

BOLLER, T.; FELIX, G. A renaissance of elicitors: perception of microbe-associated molecular patterns and danger signals by pattern-recognition receptors. **Annuals Review Plant Biology**, v.60, p. 379–406, 2009.

BOLWELL, G.P.; BINDSCHEDLER, L.V.; BLEE, K.A.; BUTT, V.S.; DAVIES, D.R.; GARDNER, S.L.; GERRISH, C.; MINIBAYEVA, F. The apoplastic oxidative burst in response to biotic stress in plants: a three-component system. **Jounal Experimental Botany**, v. 53, p. 1367-1376, 2002.

BOUCHÉ, N.; YELLIN, A.; SNEDDEN, W.A; FROM, H. Plant-specific calmodulin binding proteins. **Annual Review of Plant Biology**, v. 56, p. 435-466, 2005.

BOUDSOCQ, M.; WILLMANN, M.R.; MCCORMACK, M.; LEE, H.; SHAN, L.; HE, P.; BUSH, J.; CHENG, S-H.; SHEEN, J. Differential innate immune signalling via Ca^{2+} sensor protein kinases. **Nature**, v. 464, p. 418-422, 2010.

BOWLER, C.; NEUHAUS, G.; YAMAGATA, H.; CHUA, N.H. Cyclic GMP and calcium mediate phytochrome phototransduction. **Cell**, v. 77, p. 73–81, 1994.

BURLEY, S.K.; ROEDER, R.G. Biochemistry and structural biology of transcription factor IID (TFIID). **Annual Review of Biochemistry**, v. 65, 769–799, 1996.

BUTLER, J.E.; KADONAGA, J.T. "The RNA polymerase II core promoter: a key component in the regulation of gene expression". **Genes & Development**, v. 16, p. 2583–2592, 2002.

CAI, X.; ZHANG, Y.; ZHANG, C.; ZHANG, T.; HU, T.; YE, J.; ZHANG, J.; WANG, T.; LI, H.; YE, Z. Genome-wide analysis of plant-specific Dof transcription factor family in tomato. **Journal Integrative Plant Biology**, v. 55, p. 552–566, 2013.

CAMPBELL, L.; TURNER, S. R. A comprehensive analysis of AtRALF proteins in green plants suggests there are two distinct functional groups. **Frontiers in Plant Science**, v. 8, p. 1-14, 2017.

CAMPOS, W. F.; DRESSANO, K.; CECILIATO, P. H.O.; GUERRERO-ABAD, J.C.; SILVA, A. P.; FIORI, C. S.; CANTO, A. M.; BERGONCI, T.; CLAUS, L. A. N.; SILVA-FILHO, M. C.; MOURA, S. D. *Arabidopsis thaliana* rapid alkalinization factor-mediated root growth inhibition is dependent on calmodulin-like protein38. **Journal of Biological Chemistry**, v. 293, p. 2159-2171, 2017.

CAO, J.; SHI, F. Evolution of the RALF gene family in plants: gene duplication and selection patterns. **Evolutionary Bioinformatics**, Auckland, v. 8, p. 271-292, 2012.

CHANG, K.N.; S. ZHONG, M.T.; WEIRAUCH, G.; HON, M.; PELIZZOLA, H.; LI, S.-S.C.; HUANG, R.J.; SCHMITZ, M.A.; URICHA, D.; KUO, J.R.; NERY, H.; QIAO, A.; YANG, A.; JAMALI, H.; CHEN, T.; IDEKER, B.; REN, Z.; BAR-JOSEPH, T.R.; ECKER, J.R. Temporal transcriptional response to ethylene gas drives growth hormone cross-regulation in *Arabidopsis*, **ELife**, v. 2, 2013.

CHEN, Y. F.; MATSUBAYASHI, Y.; SAKAGAMI, Y. Peptide growth factor phytosulfokinealpha contributes to the pollen population effect. **Planta**, v. 211, p.752–755, 2000.

CHEN, X.Y.; LIU, L.; LEE, E.; HAN, X.; RIM, Y.; CHU, H.; KIM, S.W.; SACK, F.; KIM, J.Y. The *Arabidopsis* callose synthase gene GSL8 is required for cytokinesis and cell patterning. **Plant Physiology**, v. 150, p. 105–113, 2009.

CHEN, J.; YU, F.; LIU, Y.; DU, C.; LI, X.; ZHU, S.; WANG, X.; LAN, W.; RODRIGUEZ, P. L.; LIU, X.; LI, D.; CHEN, L.; LUAN, S. FERONIA interacts with ABI2-type phosphatases to facilitate signaling cross-talk between abscisic acid and RALF peptide in *Arabidopsis*. **PNAS**, v. 113, p. 5519-5527, 2016.

CHEVALIER, E.; LOUBERT-HUDON, A.; MATTON, D.P.; ScRALF3, a secreted RALF-like peptide involved in cell-cell communication between the sporophyte and the female gametophyte in a solanaceous species. **The Plant Journal**, v. 73, p. 1019-1033, 2013.

CHILLEY, P.M.; CASSON, S.A.; TARKOWSKI, P.; HAWKINS, N.; WANG, K.L.; HUSSEY, P.J.; BEALE, M.; ECKER, J. R.; SANDBERG, G.K.; LINDSEY, K. The POLARIS peptide of *Arabidopsis* regulates auxin transport and root growth via effects on ethylene signaling. **The Plant cell**, v. 18, p. 3058–3072, 2006.

CHO, K.M.; NGUYEN, H.T.; KIM, S.Y.; SHIN, J.S.; CHO, D.H.; HONG, S.B.; OK, S.H. Cml10, a variant of calmodulin, modulates ascorbic acid synthesis. **New Phytologist**, v. 209, p. 664–678. 2016.

CHOI, W-G.; MILLER, G.; WALLACE, I.; HARPER, J.; MITTLER, R.; GILROY, S. Orchestrating rapid long-distance signaling in plants with Ca^{2+} , ROS and electrical signals. **Plant Journal**, v. 90, p. 698–707, 2017.

CHN D.; MEANS, A.R. Calmodulin: a prototypical calcium sensor. **Trends in Cell Biology**, v. 8, p. 322-328, 2000.

CIFTCI-YILMAZ, S.; MITTLER, R., The zinc finger network of plants, *Cellular and Molecular Life Science*, v. 65, p. 1150–1160, 2008.

CLAPHAM, D. E. Calcium signaling. **Cell**, v. 80, p. 1041-1058, 2007.

CLARK, S. E.; WILLIAMS, R. W.; MEYEROWITZ, E. M. The CLAVATA1 gene encodes a putative receptor kinase that controls shoot and floral meristem size in *Arabidopsis*. **Cell**, v. 89, p. 575-585, 1997.

CLARK, K.L.; LARSEN, P.B.; WANG, X.; CHANG, C. Association of the *Arabidopsis* CTR1 Raf-like kinase with the ETR1 and ERS ethylene receptors. **PNAS**, v. 95, 5401–5406, 1998.

CLOUGH S. J.; BENT A. F. Floral dip: a simplified method for Agrobacterium-mediated transformation of *Arabidopsis thaliana*. **Plant Journal**, v. 16, p. 735-743, 1998.

CNODEDER, T.; VISSENBERG, K.; VAN DERSTRAETEN, D.; VERBELEN, J.P. Regulation of cell length in the *Arabidopsis thaliana* root by ethylene precursor 1-aminocyclopropane-a-carboxylic acid: a matter of apoplastic reactions. **New Phytologist**, v. 169, p. 541-550, 2005.

CONSTABEL, C. P.; YIP, L.; RYAN, C. A. Prosystemin from potato, black nightshade, and bell pepper: primary structure and biological activity of predicted systemin polypeptides. **Plant Molecular Biology**, v. 36, p. 55-62, 1998.

COSGROVE, D.J. Relaxation in a high-stress environment: the molecular bases of extensible cell walls and cell enlargement. **Plant Cell**, v. 9, p. 1031–1041. 1997.

COSGROVE DJ. Plant cell wall extensibility: connecting plant cell growth with cell wall structure, mechanics, and the action of wall-modifying enzymes. **Journal Experimental Botany**, v. 67, p. 463-476, 2016.

COVEY, P.A.; SUBBAIAH, C.C.; PARSONS, R.L.; PEARCE, G; LAY, F.T.; ANDERSON, M.A.; RYAN, C.A.; BEDINGER, P.A. A pollen-specific RALF from tomato that regulates pellon tube elongation. **Plant Physiology**, v. 2, p. 703-715, 2010.

DAS, M.K.; DAI, HK. A survey of DNA motif finding algorithms. **BMC Bioinformatics**, v. 8, p. 1-13, 2007.

DAY, I.S.; REDDY, V.S.; SHAD ALI, G.; REDDY, A.S. Analysis of EF-hand-containing proteins in *Arabidopsis*. **Genome Biology**, v. 3, p. 2002.

DELK, N.A.; JOHNSON, K.A.; CHOWDHURY, N.I.; BRAAM, J. CML24, regulated in expression by diverse stimuli, encodes a potential Ca²⁺ sensor that functions in responses to abscisic acid, daylength, and ion stress. **Plant Physiology**, v. 139, p. 240–253, 2005.

DODD, A.N.; KUDLA, J.; SANDERS, D. The language of calcium signaling, **Annual Review Plant Biology**, v. 61, p. 593–620, 2010.

DOMBROWSKI, J. E.; PEARCE, G.; RYAN, C. A. Proteinase inhibitor-inducing activity of the prohormone prosystemin resides exclusively in the C-terminal systemin domain. **PNAS**, v. 96, p. 12947-12952, 1999.

DONG, J.G.; FERNANDEZ-MACULET, J.C.; YANG, S.F., Purification and characterization of laminocyclopropane-1-carboxylate oxidase from apple fruit. **PNAS**, v.89, p. 9789- 9793, 1992.

DOUDNA, J.A.; CHARPENTIER, E. Genome editing. The new frontier of genome engineering with CRISPR-Cas9. **Science**, v. 346, p. 1258096, 2014.

DRESSANO, K.; CECILIATO, P. H. O.; SILVA, A. L.; GUERRERO-ABAD, J. C.; BERGONCI, T.; ORTIZ-MOREA, F. A.; BÜRGER, M.; SILVA-FILHO, M.; MOURA, D. S. BAK1 is involved in AtRALF1-induced inhibition of root cell expansion. **PLOS Genetics** v. 13, p. 1-33, 2017.

DU, C.; LI, X.; CHEN, J.; CHEN, W.; LI, B.; LI, C.; WANG, L.; LI, J.; ZHAO, X.; LIN, J.; LIU, X.; LUAN, S.; YU, F. Receptor kinase complex transmits RALF peptide signal to inhibit root growth in Arabidopsis. **PNAS**, v. 113, p. 8326-8334, 2016.

ESCOBAR, N.M.; HAUPT, S.; THOW, G.; BOEVINK, P.; CHAPMAN, S.; OPARKA, K. High-throughput viral expression of cDNA-green fluorescent protein fusions reveals novel subcellular addresses and identifies unique proteins that interact with plasmodesmata. **The Plant Cell**, v. 15, p. 1507-1523, 2003.

ESCOBAR-RESTREPO, J.M.; HUCK, N.; KESSLER, S.; GAGLIARDINI, V.; GHEYSELINCK, J.; YANG, W.; GROSSNIKLAUS, U. The FERONIA receptor-like kinase mediates male-female interactions during pollen tube reception. **Science**, v. 317, p. 656-660, 2007.

EULGEM, T.; RUSHTON, P.J.; ROBATZEK, S.; SOMSSICH, I.E. The WRKY superfamily of plant transcription factors. **Trends Plant Science**, v. 5, p. 199-206, 2000.

EVANS, D. E.; BENGOCHEA, T.; CAIRNS, A. J.; DODDS, J. H.; HALL, M. A. Studies on ethylene binding by cell-free preparations from cotyledons of *Phaseolus vulgaris* L.: subcellular localization. **Plant Cell Environment**, v. 5, p. 101–107, 1982.

EVANS, D. E.; DODDS, J. H; LLOYD, P. C.; APGWYNN, I.; HALL, M. A. A study of the subcellular localisation of an ethylene binding site in developing cotyledons of *Phaseolus vulgaris* L. by high resolution autoradiography. **Planta**, v. 154, p. 48–52, 1982.

FENG, J.X.; LIU, D.; PAN, Y.; GONG, W.; MA, L.G.; LUO, J.C.; DENG, X.W.; ZHU, Y.X.; An annotation update via cDNA sequence analysis and comprehensive profiling of developmental, hormonal or environmental responsiveness of the *Arabidopsis* AP2/EREBP transcription factor gene family. **Plant Molecular Biology**, v. 59, p. 853-868, 2005.

FENG, B.H.; HAN, Y.C.; XIAO, Y.Y.; KUANG, J.F.; FAN, Z.Q.; CHEN, J.Y.; LU, W.J. The banana fruit Dof transcription factor MaDof23 acts as a repressor and interacts with MaERF9 in regulating ripening-related genes. **Journal of experimental botany**, v. 67, p. 2263–2275, 2016.

FELIX, G.; BOLLER, T. Systemin induces rapid ion fluxes and ethylene biosynthesis in *Lycopersicon peruvianum* cells. **The Plant Journal**, v. 7, p. 381–389, 1995.

FOREMAN, J.; DEMIDCHIK, V.; BOTHWELL, J.H.F.; MYLONA, P.; MIEDEMA, H.; TORRES, M.A.; LINSTEAD, P.; COSTA, S.; BROWNLEE, C.; JONES, J.D.G.; DAVIES, J.M. DOLAN, L. Reactive oxygen species produced by NADPH oxidase regulate plant cell growth. **Nature**, v. 422, p. 442-446, 2003.

FRANCK, C.M.; WESTERMANN1, J.; BÜRSSLER, S.; LENTZ1, R.; LITUIEV2, D.S.; BOISSON-DERNIER, A. The Protein Phosphatases ATUNIS1 and ATUNIS2 Regulate Cell Wall Integrity in Tip-growing Cells, **Plant Cell**, v. 30, p.1906 – 1923, 2018.

FROMMER, W.B.; LUDEWIG, U.; RENTSCH, D. Taking transgenic plants with a pinch of salt. **Science**, v. 285, p. 1222–1223, 1999.

FUJIMOTO, S.; MATSUNAGA, S.; YONEMURA, M.; UCHIYAMA, S.; AZUMA, T.; FUKUI, K. Identification of a novel plant MAR DNA binding protein localized on chromosomal surfaces. **Plant Molecular Biology**, v. 56, p. 225–239, 2004.

FUKUDA, H.; HIGASHIYAMA, T. Diverse functions of plant peptides: entering a new phase. **Plant cell Physiology**, v. 52, p. 1-4, 2011.

GAMBLE, R.L.; COONFIELD, M.L.; SCHALLER, G.E. Histidine kinase activity of the ETR1 ethylene receptor from *Arabidopsis*. **PNAS**, v, 95, p. 7825–7829, 1998.

GE, Z.; BERGONCI, T.; ZHAO, Y.; ZOU, Y.; DU, S.; LIU, M. C.; LUO, X.; RUAN, H.; GARCIA-VALENCIA, L. E.; ZHONG, S.; HOU, S.; HUANG, Q.; LAI, L.; MOURA, D.S.; GU H, DONG, J.; WU, H. M.; DRESSELHAUS, T.; XIAO, J.; CHEUNG, A.Y.; QU, L.J. *Arabidopsis* pollen tube integrity and sperm release are regulated by RALF mediated signaling. **Science**, v. 358, p. 1596–1600, 2017.

GE, Z.; CHEUNG, A. Y.; QU, L. J. Pollen tube integrity regulation in flowering plants: insights from molecular assemblies on the pollen tube surface. **New Phytologist**, v. 222, p. 6876–693, 2019.

GERMAIN, H.; CHEVALIER, E.; CARON, S.; MATTON, D.P. Characterization of five Ralf-like genes from *Solanum chacoense* provides support for a developmental role in plants. **Planta**, Berlin, v. 200, p. 447-454, 2005.

GHIM, C.M.; LEE, S.K.; TAKAYAMA, S.; MITCHELL, R.J. The art of reporter proteins in science: past, present and future applications. **BMB Reports**, v. 43, p. 451-60, 2010.

GJETTING, S.K.; MAHMOOD, K.; SHABALA, L.; KRISTENSEN, A.; SHABALA, S.; PALMGREN, M.; FUGLSANG, A.T. Evidence for multiple receptors mediating RALF-triggered Ca^{2+} signaling and proton pump inhibition. **Plant Journal**, 2020.

GOMEZ, B.; DAVIERO-GOMEZ, V.; COIFFARD, C.; MARTÍN-CLOSAS, C.; DILCHER, D. L. Montsechia, an ancient aquatic angiosperm **PNAS**, v. 112, p. 10985–10988, 2015.

GONG, W.; SHEN, Y.P.; MA, L.G.; PAN, Y.; DU, Y.L.; WANG, D.H.; YANG, J.Y.; HU, L.D.; LIU, X.F.; DONG, C.X.; MA, L.; CHEN, Y.H.; YANG, X.Y.; GAO, Y.; ZHU, D.; TAN, X.; MU, J.Y.; ZHANG, D.B.; LIU, Y.L.; DINESH-KUMAR, S.P.; LI, Y.; WANG, X.P.; GU, H.Y.; QU, L.J.; BAI, S.N.; LU, Y.T.; LI, J.Y.; ZHAO, J.D.; ZUO, J.; HUANG, H.; DENG, X.W.; ZHU, Y.X. Genome-wide ORFeome cloning and analysis of Arabidopsis transcription factor genes. **Plant Physiology**, v. 135, p. 773-82, 2004.

GONNEAU, M.; DESPREZ, T.; MARTIN, M.; DOBLAS, V. G.; BACETE, L.; MIART, F.; SORMANI, R.; HEMATY, K.; RENOU, J.; LANDREIN, B.; MURPHY, E.; VAN DE COTTE, B.; VERNHETTES, S.; DE SMET, I.; HOFTE, H. Receptor kinase THESEUS1 is a rapid alkalinization factor 34 receptor in Arabidopsis. **Current Biology**, v. 28, p. 2452–2458, 2018.

GRISAR, T.; LAKAYE, B.; DE NIJS, L.J.; LoTURCO, A.; DAGA, A.V.; DELGADO-ESCUETA. Myoclonin1/EFHC1 in cell division, neuroblast migration, synapse/dendrite formation in juvenile myoclonic epilepsy. In: NOEBELS; J.L.; AVOLI, M.; ROGAWSKI, M.A.; W.; OLSEN, A.V DELGADO-ESCUETA. BETHESDA (MD): National Center for Biotechnolog editors. **Jasper's Basic Mechanisms of the Epilepsies**. 4th edition. Bethesda (MD) National Center for Biotechnology Information, 2012.

GUTTERSON, N.; REUBER, T.L. Regulation of disease resistance pathways by AP2/ERF transcription factors. **Current Opinion Plant Biology**, v. 7, p. 465-471, 2004.

HALL, A. E.; CHEN, Q. G.; FINDELL, J. L.; SCHALLER, G. E.; BLEECKER, A. B. The relationship between ethylene binding and dominant insensitivity conferred by mutant forms of the ETR1 ethylene receptor. **Plant Physiology**, v. 121, p. 291–300, 1999.

HANAI, H.; MATSUNO, T.; YAMAMOTO, M.; MATSUBAYASHI, Y.; KOBAYASHI, T.; Kamada, H.; Sakagami, Y. A secreted peptide growth factor, phytosulfokine, acting as a stimulatory factor of carrot somatic embryo formation. **Plant Cell Physiology**, v. 41, p. 27–32, 2000.

HARUTA, M.; CONSTABEL, C. P. Rapid alkalinization factor in poplar cell cultures: peptide isolation, cDNA cloning, and differential expression in leaves and jasmonate-treated cells. **Plant Physiology**, v. 131, p. 814-823, 2003.

HARUTA, M.; MONSHAUSEN, G.; GILROY, S.; SUSSMAN, M. R. A cytoplasmic Ca^{2+} functional assay for identifying and purifying endogenous cell signaling peptides in Arabidopsis seedlings: identification of AtRALF1 peptide. **Biochemistry**, v. 47, p. 6311-6321, 2008.

HARUTA, M.; SABAT, G.; STECKER, K.; MINKOFF, B.B.; SUSSMAN, M.R. A peptide hormone and its receptor protein kinase regulate plant cell expansion. **Science**, v. 343, p. 408–411, 2014.

HEIM, M.A.; JAKOBY, M.; WERBER, M.; MARTIN, C.; WEISSCHAAR, B.; BAILEY, P.C. The basic helix-loop-helix transcription factor family in plants: a genome-wide study of

protein structure and functional diversity. **Molecular Biology Evolution**, v. 20, p. 735-747, 2003.

HEMM, M.R.; HERRMANN, K.M.; CHAPPLE, C. AtMYB4: a transcription factor general in the battle against UV. **Trends in Plant Science**, v. 6, p. 135-136, 2001.

HERATH, V. Small family, big impact: In silico analysis of DREB2 transcription factor family in rice. **Computational Biology and Chemistry**, v. 65, p. 128-139, 2016.

HILTON, I.B.; D'IPPOLITO, A.M.; VOCKLEY, C.M.; THAKORE, P.i.; CRAWFORD, G.E.; REDDY, T.E.; GERSBACH, C.A. Epigenome editing by a CRISPR-Cas9-based acetyltransferase activates genes from promoters and enhancers. **Nature biotechnology**, v. 33, p. 510–517, 2015.

HINDERHOFER, K.; ZENTGRAF, U. Identification of a transcription factor specifically expressed at the onset of leaf senescence. **Planta**, v. 52, p. 213:469-473, 2001.

HÖFTE, H. The Yin and Yang of Cell Wall Integrity Control: Brassinosteroid and FERONIA Signaling. **Plant Cell Physiology**, v. 56, p. 224-231, 2015.

HOLMES, P.; GOFFARD, N.; WEILLER, G. F.; ROLFE, B. G.; IMIN, N. Transcriptional profiling *Medicago truncatula* meristematic root cells. **BMC Plant Biology**, v.8, p. 11-22, 2008.

HOLTON, N.; CANO-DELGADO, A.; HARRISON, K.; MONTOYA, T.; CHORY, J.; BISHOP, G.J. Tomato BRASSINOSTEROID INSENSITIVE1 is required for systemin-induced root elongation in *Solanum pimpinellifolium* but is not essential for wound signaling. **Plant Cell**, v. 19, p. 1709-1717, 2007.

HOLZWART, E.; HUERTA, A.I.; GLÖCKNER, N.; GARNELO GÓMEZ, B.; WANKE, F.; AUGUSTIN, S.; ASKANI, J.C.; SCHÜRHOLZ, A-K.; HARTER, K.; WOLF, S. BRI1 controls vascular cell fate in the *Arabidopsis* root through RLP44 and phytosulfokine signaling. **PNAS**, v. 115, p. 11838–11843, 2018.

HOTHORN, M.; BELKHADIR, Y.; DREUX, M.; DABI, T.; NOEL, J.P.; WILSON, I.A.; CHORY, J. Structural basis of steroid hormone perception by the receptor kinase BRI1. **Nature**, v. 474, p. 467–471, 2011.

HUA, J.; CHANG, C.; SUN, Q.; MEYEROWITZ, E.M. Ethylene insensitivity conferred by *Arabidopsis* ERS gene. **Science**, v.269, p. 1712–1714, 1995.

HUA, J.; SAKAI, H.; NOURIZADEH, S.; CHEN, Q.G.; BLEECKER, A.B.; ECKER, J.R.; MEYEROWITZ, E.M. *EIN4* and *ERS2* are members of the putative ethylene receptor gene family in *Arabidopsis*. **Plant Cell**, v. 10, p. 1321–1332, 1998.

HUCK, N.; MOORE, J. M.; FEDERER, M.; GROSSNIKLAUS, U. The *Arabidopsis* mutant feronia disrupts the female gametophytic control of pollen tube reception. **Development**, v. 130, p. 2149–2159, 2003.

HUFFAKER, A.; PEARCE, G.; RYAN, C. A. An endogenous peptide signal in *Arabidopsis* activates components of the innate immune response. **PNAS**, v. 103, p. 10098–10103, 2006.

HUFFORD, M.B.; XU, X.; VAN-HEERWAARDEN, J.; PYHÄJÄRVI, T.; CHIA, J.M.; CARTWRIGHT, R.A.; ELSHIRE, R.J.; GLAUBITZ, J.C.; GUILL, K.E.; KAEPPLER, S.M.; LAI, J.; MORRELL, P.L.; SHANNON, L.M.; SONG, C.; SPRINGER, N.M.; SWANSON-WAGNER, R.A.; TIFFIN, P.; WANG, J.; ZHANG, G.; DOBLEY, J.; MCMULLEN, M.D.; WARE, D.; BUCKLER, E.S.; YANG, S. ROSS-IBARRA, J. Comparative population genomics of maize domestication and improvement. **Nature genetics**, v. 44, p. 808–811, 2012.

IGASAKI T, AKASHI N, UJINO-IHARA T, MATSUBAYASHI Y, SAKAGAMI Y, SHINOHARA K. Phytosulfokine stimulates somatic embryogenesis in *Cryptomeria japonica*. **Plant Cell Physiology**, v. 44, p. 1412–1416, 2003.

IGARASHI, D.; TSUDA, K.; KATAGIRI, F. The peptide growth factor, phytosulfokine, attenuates pattern-triggered immunity. **Plant Journal**, v. 71, p. 194–204, 2012.

JACINTO, T.; MCGURL, B.; FRANCESCHI, V.; DELANO-FREIER, J.; RYAN, C. A. Tomato prosystemin promoter confers wound-inducible, vascular bundle-specific expression of the β -glucuronidase gene in transgenic tomato plants. **Planta**, v. 203, p. 406–412, 1997.

JAFFE, L.F. Calcium explosions as triggers of development. **Annals of the New York Academy of Sciences**. v. 339, p. 86–101, 1980.

JIA, Q.S.; ZHU, J.; XU, X.F.; LOU, Y.; ZHANG, Z.L.; ZHANG, Z.P.; YANG, Z.N. *Arabidopsis* AT-hook protein TEK positively regulates the expression of arabinogalactan proteins for Nexine formation. **Molecular Plant Pathology**, v. 8, p. 251–260, 2015.

JIN, H.; MARTIN, C. Multifunctionality and diversity within the plant MYB-gene family. **Plant Molecular Biology**, v. 41, p. 577-585, 1999.

JU, C.; YOON, G.M.; SHEMANSKY, J.M.; LIN, D.Y.; YING, Z.I.; CHANG, J.; GARRETT, W.M.; KESSEN BROCK, M.; GROTH, G.; TUCKER, M.L.; COOPER, B.; KIEBER, J.J.; CHANG, C. CTR1 phosphorylates the central regulator EIN2 to control ethylene hormone signalling from the ER membrane to the nucleus in *Arabidopsis*. **PNAS**, v. 109, p. 19486–19491, 2012.

JUNG, H.; KIM, J-K.; HÁ, S-H. Use of animal viral internal ribosome entry site sequence makes multiple truncated transcripts without mediating polycistronic expression in rice. **Journal of the Korean Society Applied Biological Chemistry**, v. 54, p. 678–684, 2011.

JUVEN-GERSHON, T.; KADONAGA, J.T. Regulation of gene expression via the core promoter and the basal transcriptional machinery. **Developmental biology**, v. 339, p. 225–229, 2010.

KARIMI, M.; DEPICKER, A.; HILSON, P. Recombinational cloning with plant gateway vectors. **Plant Physiology**, v. 145, p. 1144-1154, 2007.

KANG, H. G.; SINGH, K. B. Characterization of salicylic acid-responsive, arabidopsis Dof domain proteins: overexpression of OBP3 leads to growth defects. **The Plant Journal: For Cell and Molecular Biology**, v. 21, p. 329–339, 2000.

KATO, M.; HATA, N.; BANERJEE, N.; FUTCHER, B.; ZHANG, M.Q. Identifying combinatorial regulation of transcription factors and binding motifs. **Genome Biology**, v. 5, p. R56, 2004.

KATSIR, L.; DAVIES, K.A.; BERGMANN, D.C.; LAUX, T. Peptide signaling in plant development. **Current Biology**, v. 21, p. 356-364, 2011.

KENDE, H.; ZEEVAART, J.A.D. The five “classical” plant hormones. **The Plant Cell**, v. 9, p. 1197-1210, 1997.

KIEBER, J.J.; ROTENBERG, M.; ROMAN, G.; FELDMANN, K.A.; ECKER, J.R. *CTR1*, a negative regulator of the ethylene response pathway in *Arabidopsis*, encodes a member of the raf family of protein kinases. **Cell**, v. 72, p. 427–441, 1993.

KIM, S.H.; HONG, J. K.; LEE, S.C., SOHN, K.H.; JUNG, H.W.; HWANG, B.K. CAZFP1, Cys2/His2-type zinc-finger transcription factor gene functions as a pathogen-induced early-defense gene in *Capsicum annuum*. **Plant molecular biology**, v. 55, p. 883–904, 2004.

KIM, T.H.; REN, B. Genome-wide analysis of protein-DNA interactions. **Annual Review Genomics Human Genetics**. 7, 81–102 (2006).

KINOSHITA, T.; CAÑO-DELGADO, A.; SETO, H.; HIRANUMA, S.; FUJIOKA, S.; YOSHIDA, S.; CHORY, J. Binding of brassinosteroids to the extracellular domain of plant receptor kinase BRI1. **Nature**, v. 433, p. 167–171, 2005.

KOENIG, D.; JIMÉNEZ-GÓMEZ, J.M.; KIMURA, S.; FULOP, D.; CHITWOOD, D.H.; HEADLAND, L.R.; KUMAR, R.; COVINGTON, M.F.; DEVISETTY, U.K.; TAT, A.V.; TOHGE, T.; BOLGER, A.; SCHNEEBERGER, K.; OSSOWSKI, S.; LANZ, C.; XIONG, G.; TAYLOR-TEEPLES, M.; BRADY, S.M.; PAULY, M.; WEIGEL, D.; USADEL, B.; FERNIE, A.R.; PENG, J.; SINHA, N.R.; MALOOF, J.N. Comparative transcriptomics reveals patterns of selection in domesticated and wild tomato. **PNAS**, v. 110, p. 2655–2662, 2013.

KROL, E.; MENTZEL, T.; CHINCHILLA, D.; OLLER, T.; FELIX, G.; KEMMERLING, B.; POSTEL, S.; ARENTS, M.; EWORUTZKI, E.; AL-RASHEID, K. A.; BECKER, D.; HEDRICH, R. Perception of the Arabidopsis danger signal peptide 1 involves the pattern recognition receptor AtPEPR1 and its close homologue AtPEPR2. **The Journal Biochemistry**, v. 285, p. 13471–13479, 2010.

KUBO, M.; UDAGAWA, M.; NISHIKUBO, N.; HORIGUCHI, G.; YAMAGUCHI, M.; ITO, J.; MIMURA, T.; FUKUDA, H.; DEMURA, T. Transcription switches for protoxylem and metaxylem vessel formation. **Genes & Development**, v. 15, p. 1855-1860, 2005.

KUDLA, J.; BATISTIC, O.; HASHIMOTO, K. Calcium Signals: The lead currency of plant information Processing. **Plant Cell**, v. 22, p. 541-563, 2010.

KUDLA, J.; BECKER, D.; GRILL, E.; HEDRICH, R.; HIPPLER, M.; KUMMER, U.; PARNISKE, M.; ROMEIS, T.; SCHUMACHER, K. Advances and current challenges in calcium signaling. **New Phytologist**, v. 218, p. 414–431, 2018.

KUMAR H, KAWAI T, AKIRA S. Pathogen recognition by the innate immune system. **International Reviews of Immunology**, v. 30, p. 16–34, 2011.

KUO, M.H.; ALLIS, C.D. In vivo cross-linking and immunoprecipitation for studying dynamic protein: DNA associations in a chromatin environment. **Methods**, v. 19, p. 425–433, 1999.

KUTSCHMAR, A.; RZEWUSKI, G.; STÜHRWOHLDT, N.; BEEMSTER, G.T.; INZÉ, D.; SAUTER, M. PSK- α promotes root growth in Arabidopsis. **New Phytologist**, v. 181, p. 820–831, 2009.

LADWIG, F.; DAHLKE, RI.; STÜHRWOHLDT, N.; HARTMANN, J.; HARTER, K.; SAUTER, M. Phytosulfokine Regulates Growth in Arabidopsis through a Response Module at the Plasma Membrane That Includes CYCLIC NUCLEOTIDE-GATED CHANNEL17, H⁺-ATPase, and BAK1. **Plant Cell**, v. 27, p. 1718-1729, 2015.

LAITY, J.H.; LEE, B.M.; WRIGHT, P.E. Zinc finger proteins: new insights into structural and functional diversity, **Current Opinion in Structural Biology**, v. 11, p. 39–46, 2001.

LAMPORT, D.T.A.; ANDVARNAI, P. Periplasmicarabinogalactan glycoproteins act as a calcium capacitor that regulates plant growth and development. **New Phytologist**, v. 197, p. 58–64, 2013.

LE, J.; VANDENBUSSCHE, F.; VAN DER STRAETEN, D.; VERBENEL, J. P. In the early response of Arabidopsis roots to ethylene, cell elongation is up-and down- regulated and uncoupled from differentiation. **Plant Physiology**, v. 125, p. 519-522, 2001.

LEE, K.; SEO, P.J. Coordination of matrix attachment and ATP-dependent chromatin remodeling regulate auxin biosynthesis and Arabidopsis hypocotyl elongation. **PLoS ONE**, v. 12, p. e0181804, 2017.

LEE, T.I.; YOUNG, R.A. Transcription of eukaryotic protein-coding genes, **AnnualReview of Genetics**, v. 34, p. 77–137, 2000.

LEUCCI, M.R.; LENUCCI, M.S.; PIRO, G.; DALESSANDRO, G. Water stress and cell wall polysaccharides in the apical root zone of wheat cultivars varying in drought tolerance. **Journal of Plant Physiology**, v. 165, p. 1168–1180, 2008.

LI, L.; LI, C.; LEE, G.I.; HOWE, G.A. Distinct roles for jasmonate synthesis and action in the systemic wound response of tomato. **PNAS**, v. 99, p. 6416–6421, 2002.

LI, J.; CHORY, J. A putative leucine-rich repeat receptor kinase involved in brassinosteroid signal transduction. **Cell**, v. 90, p. 929–938, 1997.

LI, J.; YUAN, J.; LI, M. Characterization of putative cis-regulatory elements in genes preferentially expressed in *Arabidopsis* male meiocytes. **BioMed Research International**, v. 2014, p. 1-10, 2014.

LI, X.Z.; ROY, C.K.; DONG, X.; BOLCUN-FILAS, E.; WANG, J.; HAN, B.W.; XU, J.; MOORE, M.J.; SCHIMENTI, J.C.; WENG, Z.; ZAMORE, P.D. An ancient transcription factor initiates the burst of piRNA production during early meiosis in mouse testes. **Molecular Cell**, v.11, p. 67-81, 2013.

LI, W.; HALLING, D.B.; HALL, A.W.; ALDRICH, R.W. EF hands at the N-lobe of calmodulin are required for both SK channel gating and stable SK–calmodulin interaction. **The Journal of general physiology**, v. 134, p. 281–293, 2009.

LI, C.; YEH, F. L.; CHEUNG, A. Y.; DUAN, Q.; KITA, D.; LIU, M. C.; MAMAN, J.; LUU, E.J.; WU, B. W.; GATES, L.; JALAL, M.; KWONG, A.; CARPENTER, H.; WU, H. M. Glycosylphosphatidylinositol-anchored proteins as chaperones and co-receptors for FERONIA receptor kinase signaling in *Arabidopsis*. **eLife**, v. 4, p. 06587, 2015.

LIANG, X.; ABEL, S.; KELLER, J.A.; SHEN, N.F.; THEOLOGIS, A. The 1-aminocyclopropane-1-carboxylate synthase gene family of *Arabidopsis thaliana*. **PNAS**, v. 89, p. 11046–11050, 1992.

LIANG, X.; OONO, Y.; SHEN, N.F.; KOHLER, C.; LI, K. Characterization of two members (ACS1 and ACS3) of the 1- aminocyclopropane-1-carboxylate synthase gene family of *Arabidopsis thaliana*. **Gene**, v. 167, p. 17–24, 1995.

LIN, Z.; ZHONG, S.; GRIERSON, D. Recent advances in ethylene research. **Journal Experimental Botany**, v. 60, p. 3311–3336, 2009.

LINDNER, H.; MÜLLER, L.M.; BOISSON-DERNIER, A.; GROSSNIKLAUS, U. CrRLK1L receptor-like kinases: not just another brick in the wall. **Current opinion plant biology**, v. 15, p. 659-669, 2012.

LIU, J.; MEHDY, S.; TOPPING, J.; FRIML, J.; LINDSEY, K. Interaction of PLS and PIN and hormonal crosstalk in *Arabidopsis* root development. **Frontiers in Plant Science**, v. 4, p. 1-8, 2013.

LIVAK, K.J.; SCHMITTGEN, T.D. Analysis of relative gene expression data using real-time quantitative PCR and the $2^{-\Delta\Delta CT}$ method. **Methods**, v. 25, p. 402-408, 2001.

LOKDARSHI, A.; CONNER, W. C.; MCCLINTOCK, C.; LI, T.; ROBERTS, D. M. *Arabidopsis* CML38, a Calcium Sensor That Localizes to Ribonucleoprotein Complexes under Hypoxia Stress. **Plant physiology**, v. 170, p. 1046–1059, 2016.

LORBIECKE, R.; SAUTER, M. Comparative analysis of PSK peptide growth factor precursor homologs. **Plant Science**, v. 163, p. 321-332, 2002.

LU, H.; ZOU, Y.; FENG, N. Overexpression of AHL20 negatively regulates defenses in *Arabidopsis*. **Journal of Integrative Plant Biology**, v. 52, p. 801–808, 2010.

LUO, X.; DEAN, D.C. Chromatin remodeling and transcriptional regulation. **Journal of the National Cancer Institute**, v. 91, p. 1288–1294, 1999.

LUO, X.; BAI, X.; ZHU, D.; LI, Y.; JI, W.; CAI, H.; WU, J.; LIU, B.; ZHU, Y. GsZFP1, a new Cys2/His2-type zinc-finger protein, is a positive regulator of plant tolerance to cold and drought stress. **Planta**, v. 235, p. 1141–1155, 2012.

LUSCOMBE, N.M.; AUSTIN, S.E.; BERMAN, H.M.; Thornton JM. An overview of the structures of protein-DNA complexes. **Genome Biology**, v. 1, 2000.

MA, J.; LI, M.Y.; WANG, F.; TANG, J.; XIONG, A.S. Genome-wide analysis of Dof family transcription factors and their responses to abiotic stresses in Chinese cabbage. **BMC Genomics**, v. 16, 2015.

MALINOWSKI, R.; HIGGINS, R.; LUO, Y.; PIPER, L.; NAZIR, A.; BAJWA, V.S.; CLOUSE, S.D.; THOMPSON, P.R.; STRATMANN, J.W. The tomato brassinosteroid receptor BRI1 increases binding of systemin to tobacco plasma membranes but is not involved in systemin signaling. **Plant Molecular Biology**, v. 70, p. 603–616, 2009.

MAO, D.; YU, F.; LI, J.; POEL, B.V.; TAN, D.; LI, J. ; LIU, Y.; LI, X.; DONG, M. ; CHEN, L.; LI, D. ; LUAN, S. FERONIA Receptor Kinase Interacts with S-adenosylmethionine Synthetase and Suppresses S-adenosylmethionine Production and Ethylene Biosynthesis in *Arabidopsis*. **Plant Cell Environment**, 10.1111/pce.12570, 2015.

MASACHIS, S.; SEGORBE, D.; TURRÀ, D.; LEON-RUIZ, M.; FÜRST, U.; EL GHALID, M.; LEONARD, G.; LÓPEZ-BERGES, M. S.; RICHARDS, T.A; FELIX, G.; DI PIETRO, A. A fungal pathogen secrets plant alkalinizing peptide to increase infection. **Nature Microbiology**, v. 1, p. 21-30, 2016.

MATOS, J.L.; FIORI, C.S.; SLVA-FILHO, M.C.; MOURA, D.S. A conserved dibasic site is essential for correct processing of the peptide hormone AtRALF1 in *Arabidopsis thaliana*. **FEBS Letters**, v. 582, p. 3343-3347, 2008.

MATSUBAYASHI, Y.; OGAWA, M.; MORITA, A.; SAKAGAMI, Y. An LRR receptor kinase involved in perception of a peptide plant hormone, phytosulfokine. **Science**, v. 296, p. 1470–1472, 2002.

MATSUBAYASHI, Y.; OGAWA, M.; KIHARA, H.; NIWA, M.; SAKAGAMI, Y. Disruption and overexpression of Arabidopsis phytosulfokine receptor gene affects cellular longevity and potential for growth. **Plant Physiology**, v. 142, p. 45–53, 2006.

MATSUBAYASHI, Y.; SAKAGAMI, Y. Phytosulfokine, sulfated peptides that induce the proliferation of single mesophyll cells of *Asparagus officinalis* L. **PNAS**, v. 93, p. 7623-7627, 1996.

MATSUBAYASHI, Y.; SAKAGAMI, Y. Peptide hormones in plants. **Annual Review of Plant Biology**, v. 57 p. 649-674, 2006.

MCAINSH, M.R.; PITTMAN, J.K. Shaping the calcium signature, **New Phytologist**, v. 181, p. 275–294, 2009.

McCORMACK, E.; BRAAM, J. Calmodulins and related potential calcium sensors of Arabidopsis. **New Phytologist**, v. 159, p. 275-294, 2003.

McCORMACK, E.; TSAI, Y. C.; BRAAM, J. Handling calcium signaling Arabidopsis CaMs and CMLs. **Trends Plant Science**, Kidlington, v. 10, p. 383-389, 2005.

MCGURL, B.; PEARCE, G.; OROZCO-CARDENAS, M.; RYAN, C. A. Structure, expression, and antisense inhibition of the systemin precursor gene. **Science**, v. 255, p. 1570-1573, 1992.

MCQUEEN-MASON, S.J.; COSGROVE, D.J. "Expansin mode of action on cell walls. Analysis of wall hydrolysis, stress relaxation, and binding". **Plant Physiology**, v. 107, p. 87-100, 1995.

MECCHIA, M.A.; SANTOS-FERNANDEZ, G.; DUSS, N.N.; SOMOZA, BOISSON-DERNIER, S.C.A.; GAGLIARDINI, V.; MARTÍNEZ-BERNARDINI, A.; FABRICE, T.N.; RINGLI, C.; MUSCHIETTI, J.P.; GROSSNIKLAUS, U. RALF4/19 peptides Interact with LRX proteins to control Pollen tube growth in arabidopsis. **Science**, v. 358, p. 1600 – 1603, 2017.

MEYER, R.S.; PURUGGANAN, M.D. Evolution of crop species: genetics of domestication and diversification. **Nature Reviews Genetics**, v. 14, p. 840–852, 2013.

MILLER, G.; SHULAEV, V.; MITTLER, R. Reactive oxygen signaling and abiotic stress. **Plant Physiology**, v. 133, p. 481–489, 2008.

MINGOSSI, F. B.; MATOS, J. L.; RIZZATO, A. P.; MEDEIROS, A. H.; FALCO, M. C.; SILVA-FILHO, M. C.; MOURA, D. S. SacRALF1 a peptide signal from the grass sugarcane (*Saccharum spp.*), is potentially involved in the regulation of tissue expansion. **Plant Molecular Biology**, v. 73, p. 271-281, 2010.

MIYAZAKI, J.H.; YANG, S.F. The methionine salvage pathway in relation to ethylene and polyamine biosynthesis. **Plant Physiology**, v. 69, p. 366–370, 1987.

MOHANTA, T.K.; KUMAR, P.; BAE, H. Genomics and evolutionary aspect of calcium signaling event in calmodulin and calmodulin-like proteins in plants. **BMC Plant Biology**, v. 17, p. 38, 2017.

MONSHAUSEN, G.B.; BIBIKOVA, T.N.; MESSERLI, M.A.; SHI, C.; GILROY, S. Oscillations in extracellular pH and reactive oxygen species modulate tip growth of Arabidopsis root hairs. **PNAS**, v. 104, p. 20996–21001, 2007.

MONTOYA, T.; NOMURA, T.; FARRAR, K.; KANETA, T.; YOKOTA, T.; BISHOP, G. J. Cloning the tomato curl3 gene highlights the putative dual role of the leucine-rich repeat receptor kinase tBRI1/SR160 in plant steroid hormone and peptide hormone signaling. **Plant Cell**, v. 14, p. 3163–3176, 2002.

MORATO DO CANTO, A. M.; CECILIATO, P. H. O.; RIBEIRO, B.; MOREA, F. A. O.; GARCIA, A. A. F.; SILVA-FILHO, M. C.; MOURA, D. S. Biological activity of nine

recombinant AtRALF peptides: implications for their perception and function in *Arabidopsis*. **Plant Physiology and Biochemistry**, v. 75, p. 45-54, 2014.

MOSHER, S.; KEMMERLING, B. PSKR1 and PSY1R-mediated regulation of plant defense responses. **Plant Signal Behavior**, v. 8, p. e24119, 2013.

MOURA, D.S.; SILVA-FILHO, M.C. Plant peptide hormone, from defense to pollen self-incompatibility, cell fate and development: small peptides as signaling molecules in plants. In: SILVA, J.A.T. **Floriculture, ornamental and plant biotechnology: advances and topical issues**. London: Global Science Book, 2006. p. 203-209.

MOUSSU, S.; BROYART, C.; SANTOS- FERNANDEZ, G.; AUGUSTIN, S.; WEHRLE, S.; GROSSNIKLAUS, U.; Santiago, J. Structural basis for recognition of RALF peptides by LRX proteins during pollen tube growth. **PNAS**, v. 117, p. 7494-7503, 2020.

MOYEN, C.; JOHANNES, E. Systemin transiently depolarizes the tomato mesophyll cell membrane and antagonizes fusicoccin-induced extracellular acidification of mesophyll tissue. **Plant, Cell and Environment**, v. 19, p. 464–470, 1996.

MOYEN, C.; HAMMOND-KOSACK, K. E.; JONES, J.; KNIGHT, M. R.; JOHANNES, E. Systemin triggers an increase of cytoplasmic calcium in tomato mesophyllo cells: Ca²⁺ mobilization from intra- and extracellular compartments. **Plant Cell and Environment**, v. 21, p. 1101-1111, 1998.

MURPHY, E.; SMITH, S.; DE SMET, I. Small signaling peptides in *Arabidopsis* development: how cells communicate over a short distance. **Plant Cell**, v. 24, p. 3198–3217, 2012.

NAGANO, Y., INABA, T., FURUHASHI, H. AND SASAKI, Y. Trihelix DNA-binding protein with specificities for two distinct cis-elements: both important for light downregulated and dark-inducible gene expression in higher plants, **Journal of Biological Chemistry**, v. 276, p. 22238–22243, 2001.

NARVÁEZ-VÁSQUEZ, J.; RYAN, C.A. The cellular localization of prosystemin: a functional role for phloem parenchyma in systemic wound signaling. **Planta**, v. 218, p. 360–369, 2004.

NEGRINI, F.; O'GRADY, K.; HYVÖNEN, M.; FOLTA, K.M.; BARALDI, E. Genomic structure and transcript analysis of the Rapid Alkalization Factor (RALF) gene family during host-pathogen crosstalk in *Fragaria vesca* and *Fragaria x ananassa* strawberry. **PloS one**, v. 15, p. e0226448, 2020.

NEURATH, H. Proteolytic processing and physiological regulation. **Trends Biochemistry. Science**, v.14, p. 268-271, 1989.

NI, M.; DEHESH, K.; TEPPERMAN, J.M.; QUAIL, P.H. GT-2: in vivo transcriptional activation activity and definition of novel twin DNA binding domains with reciprocal target sequence selectivity, **Plant Cell**, v. 8, p. 1041–1059, 1996.

NIITSU; A.L. A inibição da expansão celular causada pelo peptídeo AtRALF1 é dependente de etileno. 2016. 70f. Dissertação (Mestrado em Ciências) – USP, Esalq, Piracicaba, 2016.

NISSEN, K.S.; WILLATS, W.G.T.; MALINOVSKY F.G. Understanding CrRLK1L function: cell walls and growth control. **Trends Plant Science**, v. 21, p. 516-527, 2016.

NOGUERO, M.; ATIF, R.M.; OCHATT, S.; THOMPSON, R.D. The role of the DNA-binding One Zinc Finger (DOF) transcription factor family in plants. **Plant Science**, v. 209, p. 32–45, 2013.

OH, M.H.; KIM, H.S.; WU, X.; CLOUSE, S.D.; ZIELINSKI, R.E.; HUBER, S.C. Calcium/calmodulin inhibition of the arabidopsis brassinosteroid-insensitive 1 receptor kinase provides a possible link between calcium and brassinosteroid signalling. **Biochemistry Journal**, v. 443, p. 515–523, 2012.

OROZCO-CARDENAS, M.; RYAN, C. A. Hydrogen peroxide is generated systemically in plant leaves by wounding and systemin via the octadecanoid pathway. **PNAS**, v. 96, p. 6553-6557, 1999.

OSLEN, A. N.; MUNDY, J.; SKRIVER, K. Peptomics, identification of novel cationic Arabidopsis peptides with conserved sequence motif. **In silico Biology**, 4, p. 441-451, 2002.

PAIK, I.; KATHARE, P.K.; KIM, J.I.; AND HUQ, E. Expanding roles of PIFs in signal integration from multiple processes. **Molecular Plant Pathology**, v. 10, p. 1035– 1046, 2017.

PAPI, M.; SABATINI, S.; BOUCHEZ, D.; CAMILLERI, C.; COSTANTINO, P.; VITTORIOSO, P. Identification and disruption of an Arabidopsis zinc finger gene controlling seed germination. **Genes & development**, v. 14, p. 28–33, 2000.

PEARCE, G.; MOURA, D.S.; STRATMANN, J.; RYAN, C. A. Jr.; RALF, a 5-kDa ubiquitous polypeptide in plants, arrests root growth and development. **PNAS**, v. 98, p. 12843–12847, 2001.

PEARCE, G.; MOURA, D.S.; STRATMANN, J.; RYAN, C. A. Production of multiple plant hormones from a single polyprotein precursor. **Nature**, v. 411, p. 817-820, 2001.

PEARCE, G.; RYAN, C. A. Systemic signaling in tomato plants for defense against herbivores. **The Journal of Biological Chemistry**, v. 278, p. 30044-30050, 2003.

PEARCE, G.; STRYDOM, D.; JOHNSON, S.; RYAN, C. A. A polypeptide from tomato leaves induces wound-inducible inhibitor proteins. **Science**, v. 253, p. 895-898, 1991.

PEARCE, G.; YAMAGUCHI, Y.; MUNSKE, G.; RYAN, C. A. Structure-activity studies of RALF, rapid alkalization factor, reveals an essential – YISY – motif. **Peptides**, v. 31, p. 1973-1977, 2010.

PEARCE, G.; YAMAGUCHI, Y.; MUNSKE, G.; RYAN, C. A. Structure-activity studies of AtPep1, a plant peptide signal involved in the innate immune response. **Peptides**, v. 29, p. 2083-2089, 2008.

PEISER, G.D.; WANG, T.T.; HOFFMAN, N.E.; YANG, S.F.; LIU, H.W.; WALSH, C.T. Formation of cyanide from carbon 1 of 1-aminocyclopropane-1-carboxylic acid during its conversion to ethylene. **PNAS**, v. 81, p. 3059-3063, 1984.

PELLOUX, J.; RUSTÉRUCCI, C.; MELLEROWICZ, E.J. New insights into pectin methylesterase structure and function. **Trends in Plant Science**, v. 12, p. 267–277, 2007.

PEROCHON, A.; DIETERLE, S.; POUZET, C.; ALDON, D.; GALAUD, J.P.; RANTY, B. Interaction of a plant pseudo-response regulator with a calmodulin-like protein. **Biochemical and Biophysical Research Communications**, v. 398, p. 747–751, 2010.

PEROCHON, A.; ALDON, D.; GALAUD, J.P.; RANTY, B. Calmodulin and calmodulin-like proteins in plant calcium signaling. **Biochimie**, v. 93, p. 2048–2053, 2011.

PHILLIPS, T.; HOOPES, L. Transcription factors and transcriptional control in eukaryotic cells. **Nature Educational**, v. 1, p.119, 2008.

PIERIK, R.; THOLEN, D.; POORTER, H.; VISSER, E. J.; VOESENEK, L. A. The Janus face of ethylene: growth inhibition and stimulation. **Trends Plant Science**, v. 11, p. 176–183, 2006.

PIRO, G.; LEUCCI, M.R.; WALDRON, K.; DALESSANDRO, G. Exposure to water stress causes changes in the biosynthesis of cell wall polysaccharides in roots of wheat cultivars varying in drought tolerance. **Plant Science**, v. 165, p. 559–569, 2003.

QI, Z.; VERMA, R.; GEHRING, C.; YAMAGUCHI, Y.; ZHAO, Y.; RYAN, C. A.; BERKOWITZ, G. A. Ca^{2+} signaling by plant *Arabidopsis thaliana* Pep peptides depends on AtPepR1, a receptor with guanylyl cyclase activity, and cGMP-activated Ca^{2+} channels. **PNAS**, v. 107, p. 21193-21198, 2010.

QIAO, H.; SHEN, Z.S.; HUANG, C.; SCHMITZ, R.J.; URICH, M.A.; BRIGGS, S.P.; ECKER, J.R. Processing and subcellular trafficking of ER-tethered EIN2 control response to ethylene gas. **Science**, v. 338, p. 390–393, 2012

RAYLE, D.L.; CLELAND, R.E. The acid growth theory of auxin-induced cell elongation is alive and well. **Plant Physiology**, v. 99, p. 1271–1274, 1992.

REDDY, V.S; ALI, S.G.; REDDY, A.S.N. Genes encoding calmodulin-binding proteins in the *Arabidopsis* genome. **Journal of Biology and Chemistry**, v. 277, p. 9840-9852, 2002.

RIECHMANN, J. L.; HEARD, J; MARTIN G.; REUBER, L.; JIANG, C.-Z; KEDDIE, J.; ADAM, L.; PINEDA, O.; RATCLIFFE, O. J.; SAMAHA, R. R.; CREELMAN, R.; PILGRIM, M.; BROUN, P.; ZHANG, J. Z.; GHANDEHARI, D.; SHERMAN, B. K.; YU, G-L. *Arabidopsis* Transcription Factors: Genome-Wide Comparative Analysis Among Eukaryotes. **Science**, v. 290, p. 2105-2110, 2000.

ROBATZEK, S.; SOMSSICH, I.E. A new member of the *Arabidopsis* WRKY transcription factor family, AtWRKY6, is associated with both senescence- and defence-related processes. **Plant Journal**, v. 28, p. 123-133, 2001.

RODIUC, N.; BARLET, X.; HOK, S.; PERFUS-BARBECH, L.; ALLASIA, V.; ENGLER, G.; SÉASSAU, A.; MARTEU, N.; ALMEIDA-ENGLER, J.; PANABIÈRES, F.; ABAD, P.; KEMMERLING, B.; MARCO, Y.; FAVERY, B.; KELLER, H. Evolutionarily distant pathogens require the *Arabidopsis* phytosulfokine signaling pathway to establish disease. **Plant Cell Environment**, v. 39, p. 1396–1407, 2016.

ROJO, E., SHARMA, V. K., KOVALEVA, V., RAIKHEL, N. V.; FLETCHER, J. C. CLV3 is localized to the extracellular space, where it activates the *Arabidopsis* CLAVATA stem cell signaling pathway. **Plant Cell**, v. 14, p. 969-977, 2002).

ROTMAN, N.; ROZIER, F.; BOAVIDA, L.; DUMAS, C.; BERGER, F.; FAURE, J. E. Female control of male gamete delivery during fertilization in *Arabidopsis thaliana*. **Current Biology**, v. 13, p. 432–436, 2003.

RUSHTON, P.J.; SOMSSICH, I.E. Transcriptional control of plant genes responsive to pathogens. **Current Opinion Plant Biology**, v. 1, p. 311-315, 1998.

RYAN, C. A. Protease Inhibitors in Plants: Genes for Improving Defenses Against Insects and Pathogens. **Annual Review of Phytopathology**, v. 28, p. 425-449, 1990.

RYAN, C. A. THE DISCOVERY OF SYSTEMIN. In: KUNG, D.; YANG, S-F. **Discoveries in Plant Biology**, World Scientific Press, p. 175-188, 1998.

RYAN, C. A. The systemin signaling pathway: differential activation of plant defensive genes. **Biochimica et Biophysica Acta**, v. 1477, p. 112-121, 2000.

RYAN, C. A.; HUFFAKER, A.; YAMAGUCHI, Y. New insights into innate immunity in *Arabidopsis*. **Cell Microbiology**, v. 9, p. 1902-1908, 2007.

RYAN, C. A.; MOURA, D. S. Systemic wound signaling in plants: A new perception **PNAS**, v. 99, p. 6519-6520, 2002.

RYAN, C. A.; NARVÁEZ-VÁSQUEZ, J. The cellular localization of prosystemin: a functional role for phloem parenchyma in systemic wound signaling. **Planta**, v. 218, p. 360–369, 2004

RYAN, C. A.; PEARCE, G.; MOURA, D. S.; SCHEER, J. Polypeptide hormones. **Plant Cell**, v. 14, p. 251–264, 2002.

SAKAI, H.; HUA, J.; CHEN, Q.G.; CHANG, C.; MEDRANO, L.J.; BLEECKER, A.B.; MEYEROWITZ, E.M. *ETR2* is an *ETR1*-like gene involved in ethylene signaling in *Arabidopsis*. **PNAS**, v. 95, p. 5812–5817, 1998.

SANDERS, D.; BROWNLEE, C.; HARPER, J.F. Communicating with Calcium. **Plant Cell**, v. 11, p. 691-706, 1999.

SAUTER, M. Phytosulfokine peptide signalling. **Journal Experimental Botany**, v. 66, p. 5161-5169, 2015.

SCHALLER, G. E. Ethylene and the regulation of plant development. **BMC Biology**, v. 10, 2012.

SCHMID, M.; DAVISON, T.S.; HENZ, S.R.; PAPE, U.J.; DEMAR, M.; VINGRON, M.; SCHOLKOPF, B.; WEIGEL, D.; LOHMANN, J.U. A gene expression map of *Arabidopsis thaliana* development. **Nature Genetics**, v. 37, p. 501-506, 2005.

SCHEER, J.M.; PEARCE. G.; RYAN, C.A. LeRALF, a plant peptide that regulates root growth and development, specifically binds to 25 and 120kDa cells surface membrane proteins of *Lycopersicon peruvianum*. **Planta**, v. 221, p. 667-674, 2005.

SCHEER, J. M.; RYAN, C. A. The systemin receptor SR160 from *Lycopersicon peruvianum* is a member of the LRR receptor kinase family. **PNAS**, v. 99, p. 9585–9590, 2002.

SCHILMILLER, A. L.; HOWE, G. A. Systemic signaling in the wound response. **Current Opinion in Plant Biology**, v. 8, p. 369-377, 2005.

SCOTT, M.P. Cell, Development: The Natural History of Genes. **Cell Press**, V. 100, p. 27–40, 2000.

SHARMA, A.; HUSSAIN, A.; MUN, B-G.; IMRAN, Q.M.; FALAK, N.; LEE, S-U.; KIM, J.Y.; HONG, J.K.; LOAKE, G.J.; ALI, A.; YUN, B-W. Comprehensive analysis of plant rapid alkalinization factor (RALF) genes. **Plant Physiology and Biochemistry**, v. 106, p. 82-90, 2016.

SHIN, J.; KIM, K.; KANG, H.; ZULFUGAROV, I.S.; BAE, G.; LEE, C.H.; LEE, D.; CHOI, G. Phytochromes promote seedling light responses by inhibiting four negatively-acting phytochrome-interacting factors. **PNAS**, v. 106, p. 7660–7665, 2009.

SHIGYO, M.; MITSUYASU, H.; ITO, M. Molecular evolution of the AP2 subfamily. **Gene**, v. 366, p. 256-265, 2006.

SHIU, S. H.; BLEECKER, A. B. Receptor-like kinases from *Arabidopsis* form a monophyletic gene family related to animal receptor kinases. **PNAS**, v. 98, p. 10763–10768, 2001.

SHIU, S-H.; SHIH, M-C.; LI, W-H. Transcription Factor Families Have Much Higher Expansion Rates in Plants than in Animals. **Plant Physiology**, v. 139, p. 18-26, 2005.

SISTRUNK, M. ANTOSIEWICZ, D.M.; PURUGGANAN, M.M.; BRAAM, J. *Arabidopsis* TCH3 encodes a novel Ca^{2+} binding protein and shows environmentally induced and tissue specific regulation. **Plant Cell**, v. 6, p. 1553–1565, 1994.

SMALE, S.T.; KADONAGA, J.T. The RNA polymerase II core promoter. **Annual review of biochemistry**, v. 72, p. 449–479, 2003.

SNEDDEN, W.A.; FROMM, H. Calmodulin as a versatile calcium signal transducer in plants. **New Phytologist**, v. 151, p. 35–66, 2001.

SOLANO, R.; STEPANOVA, A.; CHAO, Q.; ECKER, J.R. Nuclear events in ethylene signaling: a transcriptional cascade mediated by ethylene-insensitive3 and ethylene-response-factor1. **Genes and Development**, v. 12, p. 3703-3714, 1998.

SRIVASTAVA, R.; LIU, J.; GUO, H.; YIN, Y.; HOWELL, S.H. Regulation and processing of a plant peptide hormone AtRALF23, in Arabidopsis. **The Plant Journal**, v. 59, p. 930-939, 2009.

STEFFENSEN, D. M. A reconstruction of cell development in shoot apex of maize. **American Journal of Botany**, v. 55, p. 354-369, 1968.

STEGMANN, M.; MONAGHAN, J.; SMAKOWSKA-LUZAN, E.; ROVENICH, H.; LEHNER, A.; HOLTON, N.; BELKHADIR, Y.; ZIPFEL, C. The receptor kinase FER is a RALF-regulated scaffold controlling plant immune signaling. **Science**, v. 355, p. 287–289, 2017.

STONE, B.A.; CLARKE, A.E. Chemistry and Biology of (1-3)- β -D-Glucans. Victoria, Australia: **La Trobe University Press**, 1992.

STRATMANN, J.; RYAN, C. A. Myelin basic protein kinase activity in tomato leaves is induced systemically by wounding and increases in response to systemin and oligosaccharide elicitors. **PNAS**, v. 94, p. 11085-11089, 1997.

STÜHRWOHLDT, N.; DAHLKE, R.I.; STEFENS, B.; JOHNSON, A.; SAUTER, M. Phytosulfokine- α controls hypocotyl length and cell expansion in *Arabidopsis thaliana* through phytosulfokine receptor 1. **PLoS One**, v. 6, p. 21054, 2011.

SUN, Y.; HAN, Z.; TANG, J.; HU, Z.; CHAI, C.; ZHOU, B.; CHAI, J. Structure reveals that BAK1 as a co-receptor recognizes the BRI1-bound brassinolide. **Cell Research**, v. 23, p. 1326-1329, 2013.

SUN, J.; MA, Q.; MAO, T. Ethylene regulates the *Arabidopsis* microtubule-associated protein wave-dampened2-like5 in etiolated hypocotyls elongation. **Plant Physiology**, v. 169, p. 325-337, 2015.

SUSSMAN, H. Choosing the best reporter's assay. **The scientist**, v. 15, p. 25-32, 2001.
TANG, D.; KANG, R.; COYNE, C.B.; ZEH, H.J.; LOTZE, M.T. PAMPs and DAMPs: signal 0 s that spur autophagy and immunity. **Immunol Review**, v. 249, p. 158–75, 2012.

TANG, D.; KANG, R.; COYNE, C.B.; ZEH, H.J.; LOTZE, M.T. PAMPs and DAMPs: signal 0 s that spur autophagy and immunity. **Immunol Review**, v. 249, p. 158–75, 2012.

TANG, J.; HAN, Z.; SUN, Y.; ZHANG, H.; GONG, X.; CHAI, J. Structural basis for recognition of an endogenous peptide by the plant receptor kinase PEPR1. **Cell Research**, v. 25, p. 110–120, 2015.

THAKORE, P.I.; D'IPPOLITO, A.M.; SONG, L.; SAFI, A.; SHIVAKUMAR, N.K.; KABADI, A.M.; REDDY, T.E.; CRAWFORD, G.E.; GERSBACH, C.A. Highly specific epigenome editing by CRISPR-Cas9 repressors for silencing of distal regulatory elements. **Nature methods**, v. 12, p. 1143–1149, 2015.

THIELE, K.; WANNER, G.; KINDZIERSKI, V.; JÜRGENS, G.; MAYER, U.; PACHL, F.; ASSAAD, F.F. The timely deposition of callose is essential for cytokinesis in Arabidopsis. **The Plant Journal**, v. 58, p. 13–26, 2009.

THIRUGNANASAMBANTHAM, K.; DURAIRAJ, S.; SARAVANAN, S.; KARIKALAN, K.; MURALIDARAN, S.; ISLAM, V.I.H. Role of Ethylene Response Transcription Factor (ERF) and Its Regulation in Response to Stress Encountered by Plants. **Plant Molecular Biology**, v. 33, p. 347–357, 2015.

THYNNE, E., SAUR, I., SIMBAQUEBA, J., OGILVIE, H. A., GONZALEZ-CENDALES, Y., MEAD, O., TARANTO, A., CATANZARITI, A. M., MCDONALD, M. C., SCHWESSINGER, B., JONES, D. A., RATHJEN, J. P., & SOLOMON, P. S. Fungal phytopathogens encode functional homologues of plant rapid alkalinization factor (RALF) peptides. **Molecular Plant Pathology**, v. 18, p. 811–824, 2017.

TOLEDO-ORTIZ, G.; HUQ, E.; QUAIL, P.H. The Arabidopsis basic/helixloop-helix transcription factor family. **Plant Cell**, v. 15, p. 1749-1770, 2003.

VANDERBELD, B.; SNEDDEN, W.A. Developmental and stimulus-induced expression patterns of Arabidopsis calmodulin-like genes *CML37*, *CML38* and *CML39*. **Plant Molecular Biology**, v. 64, p. 683-697, 2007.

VENTER, M.; BOTHA, F.C. Synthetic promoter engineering. In: PUA, E.C.; DAVEY, M.R. Plant developmental biology-biotechnological perspectives. **Springer**, p. 393–414, 2010.

VOGEL, H.J. Calmodulin: A versatile calcium mediator protein. **Biochemistry Cell Biology**, v. 72, p. 357–376, 1994.

XIAO, Y.; STEGMANN, M.; HAN, Z.; DEFALCO, T. A.; PARYS, K.; XU, L.; BELKHADIR, Y.; ZIPFEL, C.; CHAI, J. Mechanisms of AtRALF peptide perception by a heterotypic receptor complex. **Nature**, v. 572, p. 270-274, 2019.

XIONG, Y.; LIU, T.; TIAN, C.; SUN, S.; LI, J.; CHEN, M. Transcription factors in rice: a genome-wide comparative analysis between monocots and eudicots. **Plant Molecular Biology**, v. 59, p. 191-203, 2005.

XU, Y.; GAN, E.S.; ITO, T. The AT-hook/PPC domain protein TEK negatively regulates floral repressors including MAF4 and MAF5. **Plant Signaling and Behavior**, v. 8, p. e25006, 2013.

XU, Z.; MA, J.; QU, C.; YANBO, HU.; HAO, B.; SUN, Y.; LIU, Z.; YANG, H.; YANG, C.; WANG, H.; LI, Y.; GUANJUN, L. Identification and expression analyses of the alanine aminotransferase (AlaAT) gene family in poplar seedlings. **Scientific Reports**, v. 7, p. 45933, 2017.

XU, G.; CHEN, W.; SONG, L.; CHEN, Q.; ZHANG, H.; LIAO, H.; ZHAO, G.; LIN, F.; ZHOU, H.; YU, F. FERONIA phosphorylates E3 ubiquitin ligase ATL6 to modulate the stability of 14-3-3 proteins in plant C/N responses. **Journal Experimental Botany**, v. 70, p. 6375–6388, 2019.

ZHANG, G.Y.; WU, J.; WANG, X.W. Cloning and expression analysis of a pollen preferential rapid alkalinization factor gene, BoRALF, from broccoli flower. **Molecular Biology Reports**, v. 37, p. 3273-3281, 2010.

ZHANG, H.; HU, Z.; LEI, C.; ZHENG, C.; WANG, J.; SHAO, S.; LI, X.; XIA, X.; CAI, X.; ZHOU, J.; ZHOU, Y.; YU, J.; FOYER, C.H.; SHI, K. A plant phytosulfokine peptide initiates auxin-dependent immunity through cytosolic Ca²⁺ signaling in tomato. **Plant Cell**, v. 30, p. 652–667, 2018.

ZHANG, H.; JING, X.; CHEN, Y.; LIU, Z.; XIN, Y.; QIAO, Y. The Genome-Wide Analysis of RALF-Like Genes in Strawberry (Wild and Cultivated) and Five Other Plant Species (Rosaceae). **Genes**, v. 11, p. 174, 2020.

ZHAO, J.; FAVERO, D.S.; PENG, H.; NEFF, M.M. *Arabidopsis thaliana* AHL family modulates hypocotyl growth redundantly by interacting with each other via the PPC/DUF296 domain. **PNAS**, v. 110, p. E4688–E4697, 2013.

ZHOU, J.; WANG, X.; LEE, J.Y.; LEE, J.Y. Cell-to-cell movement of two interacting AT-hook factors in *Arabidopsis* root vascular tissue patterning. **Plant Cell**, v. 25, p. 187–201, 2013.

ZENG, H.; XU, L.; SINGH, A.; WANG, H.; DU, L.; POOVAIAH, B.W. Involvement of calmodulin and calmodulin-like proteins in plant responses to abiotic stresses. **Frontiers in Plant Science**, v. 6, p.600; 2015.

ZIELINSKI, R.E. Calmodulin and calmodulin-binding proteins in plants. **Annuals Review of Plant Physiology and Plant Molecular Biology**, v. 49, p. 697-725, 1998.

ZOU, C.; SUN, K.; MACKALUSO, J.D.; SEDDON, A.E.; JIN, R.; THOMASHOW, M.F.; SHIU, S.H. Cis-regulatory code of stress-responsive transcription in *Arabidopsis thaliana*. **PNAS**, v. 108, p. 14992–14997, 2011.

WAЛЕЕВ, Т.; СHTOKАЛО, Д.; КОНОВАЛОВА, Т.; VOSS, N.; CHEREMUSHKIN, E.; STEGMAIER, P.; KEL-MARGOULIS, O.; WINGENDER, E.; KEL, A. Composite Module Analyst: identification of transcription factor binding site combinations using genetic algorithm. **Nucleic Acids Research**, v. 34, p. W541–W545, 2006.

WANG, J.; LI, H.; HAN, Z.; ZHANG, H.; WANG, T.; LIN, G.; CHANG, J.; YANG, W.; CHAI, J. Allosteric receptor activation by the plant peptide hormone phytosulfokine. **Nature**, v. 525, p. 265-268, 2015.

WANG, L.; EINIG, E.; ALMEIDA-TRAPP, M.; ALBERT, M.; FLIEGMANN, J.; MITHÖFER, A.; KALBACHER, H.; FELIX, G. The systemin receptor SYR1 enhances resistance of tomato against herbivorous insects. **Nature Plants**, v. 4, p. 152-156, 2018.

WEI, Z.; YUAN, T.; TARKOWSKÁ, D.; KIM, J.; NAM, H.G.; NOVÁK, O.; HE, K.; GOU, X.; LI, J. Brassinosteroid biosynthesis is modulated via a transcription factor cascade of COG1, PIF4, and PIF5. **Plant Physiology**, v. 174, p. 1260–1273, 2017.

WEN, X.; ZHANG, C.; JI, Y.; ZHAO, Q.; HE, W.; AN, F.; JIANG, L.; GUO, H. Activation of ethylene signaling is mediated by nuclear translocation of the cleaved EIN2 carboxyl terminus. **Cell Research**, v. 22, p. 1613–1616, 2012.

WRAY, G.A.; HAHN, M.W.; ABOUHEIF, E.; BALHOFF, J.P.; PIZER, M.; ROCKMAN, M.V.; ROMANO, L.A. The evolution of transcriptional regulation in eukaryotes. **Molecular Biology Evolution**, v. 20, p. 1377–1419, 2003.

WRIGGERS, W.; MEHLER, E.; PITICI, F.; WEINSTEIN, H.; SCHULTEN, K. Structure and dynamics of calmodulin in solution. **Biophysics Journal**, v. 74, p. 1622–1639, 1998.

WHITE, P.J. BROADLEY, M.R. Calcium in plants. **Annals of Botany**, v. 92, p. 487- 511, 2003.

WHITFORD, R.; FERNANDEZ, A.; TEJOS, R., PÉREZ, A.C.; KLEINE-VEHN, J.; VANNESTE, S.; DROZDZECKI, A.; LEITNER, J.; ABAS, L.; AERTS, M.; HOOGEWIJS, K.; BASTER, P.; DE GROOT, R.; LIN, Y.C.; STORME, V.; VAN DE PEER, Y.; BEECKMAN, T.; MADDER, A.; DEVREESE, B.; LUSCHNIG, C.; HILSON, P. Golven secretory peptides regulate auxin carrier turnover during plant gravitropic responses. **Developmental cell**, v. 22, p. 678–685, 2012.

WOLF, S.; VAN DER DOES, D.; LADWIG, F.; STICHT, C.; KOLBECK, A.; SCHÜRHOLZ, A.K.; AUGUSTIN, S.; KEINATH, N.; RAUSCH, T.; GREINER, S.; SCHUMACHER, K.; HARTER, K.; ZIPFEL, C.; HÖFTE, H. A receptor-like protein mediates the response to pectin modification by activating brassinosteroid signaling. **PNAS**, v. 111, p. 15261-15266, 2014.

WU, J.; KURTEN, E.L.; MONSHAUSEN, G.; HUMMEL, G.M.; GILROY, S.; BALDWIN, I.T. NaRALF, a peptide signal essential for the regulation of root hair tip apoplastic pH in *Nicotiana attenuata*, is required for root hair development and plant growth in native soils. **The Plant Journal**, Oxford, v. 52, p. 877-890, 2007.

WYMER, C.L.; BIBIKOVA, T.N.; GILROY, S. Cytoplasmic free calcium distributions during the development of root hairs of *Arabidopsis thaliana*. **Plant Journal**, v. 12, p. 427–439, 1997.

YAMAGAMI, T.; TSUCHISAKA, A.; YAMADA, K.; HADDON, W.F.; HARDEN, L.A.; Biochemical diversity among the 1-aminocyclopropane- 1-carboxylate synthase isozymes encoded by the *Arabidopsis* gene family. **The Journal of Biological Chemistry**, v. 278, p. 49102–49112, 2003.

YAMAGUCHI, Y.; PEARCE, G.; RYAN, C. A. The cell surface leucine-rich repeat receptor for AtPep1, an endogenous peptide elicitor in *Arabidopsis*, is functional in transgenic tobacco cells. **PNAS**, v. 103, p. 10104– 10109, 2006.

YANAGISAWA, S.; IZUI, K. Molecular cloning of two DNA-binding proteins of maize that are structurally different but interact with the same sequence motif. **Journal of Biological Chemistry**, v.268, p. 16028–16036, 1993.

YANAGISAWA, S. The dof family of plant transcription factors. **Trends plant science**, v. 7, p. 555–560, 2002.

YANAGISAWA, S. Dof domain proteins: plant-specific transcription factors associated with diverse phenomena unique to plants. **Plant cell physiology**, v. 45, p. 386–391, 2004.

YANG, T.; SEGAL, G.; ABBO, S.; FELDMAN, M.; FROMM, H. Characterization of the calmodulin gene family in wheat: structure, chromosomal location, and evolutionary aspects. **Molecular and General Genetics**, v. 252, p. 684–694, 1996.

YANG, H.; MATSUBAYASHI, Y.; NAKAMURA, K.; SAKAGAMI, Y. *Oryza sativa* PSK gene encodes a precursor of phytosulfokine- α , a sulfated peptide growth factor found in plants. **PNAS**, v. 96, p. 13560–13565, 1999.

YANG, T.; POOVAIAH, B.W. Calcium/calmodulin mediated-signal network in plants. **Trends in Plant Science**, v. 8, p. 505–512, 2003.

YANG, L.; LIU, Z.; LU, F.; DONG, A.; HUANG, H. SERRATE is a novel nuclear regulator in primary microRNA processing in Arabidopsis. **The Plant Journal**, v. 47, p. 841–850, 2006.

YAMAKAWA, S.; SAKURAI, C.; MATSUBAYASHI, Y.; SAKAGAMI, Y.; KAMADA, H.; SATOH, S. The promotive effects of a peptidyl plant growth factor, phytosulfokine, on the formation of adventitious roots and expression of a gene for a root-specific cystatin in cucumber hypocotyls. **Journal of Plant Research**, v. 111, p. 453–458, 1998.

YENNAWAR, N.H.; LI, L.C.; DUDZINSKI, D.M.; TABUCHI, A.; COSGROVE, D.J. "Crystal structure and activities of EXPB1 (*Zea m. 1*), a β -expansin and group-1 pollen allergen from maize". **PNAS**, v. 103, p. 14664–14671, 2006.

YU, Y.; ASSMANN, S.M. Inter-relationships between the heterotrimeric G β subunit AGB1, the receptor-like kinase FERONIA, and AtRALF1 in salinity response. **Plant Cell Environment**, v. 41, p. 2475–2489, 2018.