DOTTORATO DI RICERCA IN BIOLOGIA CELLULARE E DELLO SVILUPPO

40th CYCLE
Project proposal for a Sapienza PhD scholarship

Main research line

Title: Exploring Plant Cell Wall potential to Boost Crop protection Against Pests and Upcycle Agro-Industrial Waste into Immunostimulants

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Summary (max 500 words)

The plant cell wall (CW) consists primarily of a complex arrangement of cellulose, pectins, hemicelluloses, proteins, and lignin. The CW serves as a critical interface between plants and microbes. Plants can utilize sophisticated apoplast mechanisms to detect a wide range of microbial molecules, termed Microbial/Pathogen Associated Molecular Patterns (MAMPs/PAMPs), via Pattern Recognition Receptors (PRRs), which trigger Pattern Triggered Immunity (PTI). Moreover, the CW serves as a reservoir of endogenous danger molecules released during microbial attack. Notable examples include CW oligosaccharides such as oligogalacturonides, derived from Homogalacturonan, a major constituent of pectin in the CW.
This project will adopt a multidisciplinary approach encompassing molecular biology, green chemistry, glycobiology, plant pathology, industrial process engineering and computer science. One of the key objectives of the research will be to obtain insights into the functions of CWs and associated enzymes in critical interactions between crops and microbes. Beginning with the model pathosystem Arabidopsis-Botrytis, the study will advance towards an economically significant pathosystem. A specific objective is to identify potential correlations between cell wall traits and resistance/susceptibility in olive trees to Xylella and in grapevines to Botrytis, both pathogens exerting destructive effects on a global scale. The investigation will yield novel biochemical and genetic tools, thereby aiding efforts in plant breeding and engineering aimed at bolstering crop resistance against phytopathogens.
Furthermore, the project aligns with the principles of the circular economy and green chemistry by striving to optimize the upcycling of by-products from agro-industrial processes like olive oil and biogas production into plant biostimulants and bioprotectants. The potential of olive pomace and digestate as sources of oligosaccharides, phenols, and other bioactive compounds will be explored. A green mixture enriched with bioactive molecules will be formulated and evaluated for its effectiveness against various plant pathogens. The partnership with biorefineries, the exploitation of Artificial Intelligence (AI) and the integration of nanomaterials will give a multidisciplinary and industrial dimension to the project, driving the progress of eco-innovative sectors alternative to chemical pesticides to improve environmental sustainability.

Pertinent Publications of the proponent

1. Coculo D, Del Corpo D, Ozáez Martínez M., Vera P., Piro G, De Caroli M, Lionetti V. Arabidopsis subtilases promote defense-related pectin methylesterase activity and robust immune responses to botrytis infection. Plant Physiology and Biochemistry. 2023, Volume 201, 107865
2. Vicré M, Lionetti V. Editorial: Plant cell wall in pathogenesis, parasitism and symbiosis, Volume II. Front Plant Sci. 2023 Jun 20; 14:1230438.
3. Swaminathan S, Lionetti V, Zabotina OA. Plant Cell Wall Integrity Perturbations and Priming for Defense. Plants. 2022 Dec 15;11(24):3539.
4. Coculo D., Lionetti V. The Plant Invertase/Pectin Methylesterase Inhibitor Superfamily. Front Plant Sci. 2022 25; 13:863892.
5. Swaminathan, S.; Reem, N.T.; Lionetti, V.; Zabotina, O.A. Coexpression of Fungal Cell Wall-Modifying Enzymes Reveals Their Additive Impact on Arabidopsis Resistance to the Fungal Pathogen, Botrytis cinerea. Biology. 2021, 10, 1070.
6. Sciubba F, Chronopoulou L, Pizzichini D, Lionetti V, Fontana C, Aromolo R, Socciarelli S, Gambelli L, Bartolacci B, Finotti E Olive mill wastes: a source of bioactive molecules for plant growth and protection against pathogens. Biology. 2020, 9: 450
7. Del Corpo D, Fullone MR, Miele R, Lafond M, Pontiggia D, Grisel S, Kieffer-Jaquinod S, Giardina T, Bellincampi D, Lionetti V. AtPME17 is a functional Arabidopsis thaliana pectin methylesterase regulated by its PRO region that triggers PME activity in the resistance to Botrytis cinerea. Molecular Plant Pathology. 2020, 21, 1620–1633

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5. Lionetti, V., Cervone, F. and Bellincampi, D. (2012) Methyl esterification of pectin plays a role during plant-pathogen interactions and affects plant resistance to diseases. J. Plant Physiol., 169, 1623–1630.
6. Lionetti, V., Fabri, E., De Caroli, M., Hansen, A.R., Willats, W.G., Piro, G. and Bellincampi, D. (2017) Three pectin methyl esterase inhibitors protect cell wall integrity for immunity to Botrytis. Plant Physiol., Jan 12., pii: pp.01185.2016.
7. Lionetti, V., Francocci, F., Ferrari, S., Volpi, C., Bellincampi, D., Galletti, R., D'Ovidio, R., De Lorenzo, G. and Cervone, F. (2010) Engineering the cell wall by reducing de-

methyl-esterified homogalacturonan improves saccharification of plant tissues for bioconversion. Proc. Natl. Acad. Sci. U. S. A., 107, 616–621.

8. Lionetti, V., Giancaspro, A., Fabri, E., Giove, S., Reem, N., Zabotina, O.A., Blanco, A., Gadaleta, A. and Bellincampi, D. (2015) Cell wall traits as potential resources to improve resistance of durum wheat against Fusarium graminearum. Bmc Plant Biol., 15, 6.
9. Lionetti, V. and Metraux, J.P. (2014) Plant cell wall in pathogenesis, parasitism and symbiosis. Front. Plant Sci., 5, 612. doi:10.3389/fpls.2014.00612.
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13. Swaminathan, S., Lionetti, V. and Zabotina, O.A. (2022) Plant Cell Wall Integrity Perturbations and Priming for Defense. Plants, 11, 3539.
14. Uddin, M.A., Siddiki, S.Y.A., Ahmed, S.F., Rony, Z.I., Chowdhury, M. a. K. and Mofijur, M. (2021) Estimation of Sustainable Bioenergy Production from Olive Mill Solid Waste. Energies, 14, 7654.