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THE INNOVATIVE APPROACH OF CIHEAM BARI IN EARLY PEST DETECTION BY REMOTE SENSING

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Early detection of pests, before symptoms develop, is a major challenge that research has to face. The integration of digital and geomatics methods and tools are essential for supporting NPPOs in the early identification of large and small scale pest-infected areas, even in inaccessible sites, thereby guiding timely ground inspections for the application of phytosanitary measures and sound pest management. It is important to enhance accuracy and robustness in discriminating not only biotic and abiotic stresses, but also in identifying specific infections. Globally, satellite data are used extensively for species classification and the study of plant health. Due to some constraints, including the cost of data, much work has focused on freely available satellite data (e.g., LANDSAT, EU Copernicus program), which, however, have low spatial resolution. In contrast, non-free satellite programs (e.g., WORDVIEW 2, GEOEYE 2,3,4) provide high-resolution hyperspectral data that are more accurate for pest identification. However, costs are still high for image acquisition by aircraft, and require high skills for data interpretation, the information extraction processes being labor-intensive and complex. For this reason, they are less applied in plant health because they are not sustainable for use in official surveillance programs by NPPOs.

Within this context, CIHEAM Bari has developed the innovative 'spectra-metabolomic approach' which provides a new horizon of knowledge through which specific sensors can be tailored for early pest detection at the first stage of infection. This approach is based on the use of spectroscopy combined with the chemical diversity found in thousands of primary and secondary metabolites stimulated by pest attack in a specific host plant species. However, the phenotypic and metabolic changes that occur during the period from plant infection to symptoms development also depend on the different susceptibility of the cultivar to infection.

This research led to the development of an analytical method able to detect variations in the metabolome of olive and pear leaves at the early stage of infection by *Xylella fastidiosa* (Gualano *et al*., 2019; Jlilat *et al*., 2021; Elhussein *et al*., 2021) and *Erwinia amylovora* (Rizzuti *et al*., 2018), respectively. Inoculated host plants were submitted simultaneously to non-targeted metabolomics (NMR and HRMS) and hyperspectral reflectance (HSR) analyses, the data of which were further analysed by chemometrics. As a result, covariance matrices were obtained providing useful insights into the optimal associations between the HSR spectral features and the diagnostic NMR and HRMS signals. These results provide technical specifications on the package of wavelengths, which are pest-specific and lead to the development of new sensors for the early detection of infections by *X. fastidiosa* in olive plants and *E. amylovora* in pear plants.

The future of pest monitoring, from drones but also from aerial platforms, should therefore include an integrated and specific set of sensors that can detect infections in appropriate windows of the electromagnetic spectrum, suitable for maximizing and capturing differences in the specific biotic

stress under monitoring. This innovative approach using pest-specific sensors must also be based on lightweight and low-cost sensors to be user-friendly for remote sensing application by NPPOs.