European Plant Science Organisation
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Draft Statement

Plant Health Working Group
Healthy plants for a sustainable production

Brussels, 05.04.2022

Plants comprise the key component for -direct or indirect- human nutrition. Agriculture must be highly productive in order to meet the increasing demand for food, feed, fuel and fibre to support a rapidly growing global human population, as well as reach higher quality providing health benefits. Because of the large areas devoted to agriculture and the large demand of resources, the technologies used in the production and protection of plants are highly relevant for the global environment. Pathogens and pests compete with humans for plant-based food. **The impact of these biota onto plants and plant protection in agriculture, forestry and the natural (non-human made) environment is the main area for the Plant Health (PH) working group (WG) of EPSO.** Pathogens and pests cause disease or damage to their hosts that accounts for up to 25% of global crop losses in the five major crops (Savary et al., 2019). Crop losses need to be significantly reduced both in the field as well as during the post-harvest storage and processing for human and animal consumption.

When disease epidemics occur, the impacts can be devastating. The best example is the Irish potato famine (in the 1840s), caused by the late blight **oomycete** *Phytophthora infestans*, that killed around one million people and caused another million to emigrate to the USA. More recently, the wheat rust **fungus** *Puccinia graminis* f. sp. *tritici* isolate Ug99 alarmed the scientific community including the Nobel laureate Norman Borlaug because it had adapted to some major resistance genes globally used in wheat resistance breeding. Lately, the *Xylella fastidiosa* **bacterial** pathogen, having a wide host range, is threatening several crop industries in particular the olive tree cultivation and the oil industry in some areas of the Mediterranean basin. *Citrus tristeza virus* (CTV) has seriously threatened the citrus industry in south America till researchers developed the cross-protection method employing less severe CTV strains (a sort of vaccination) to control the tristeza disease. New **virus** diseases emerge or re-emerge constantly, sometimes establishing in new hosts: a recent example is *Tomato leaf curl New Delhi virus*, originally described in tomato in the late 90', that has been devastating cucurbit crops in Southern Europe since 2013. This can be regarded as a spillover event between hosts of unrelated families. *Tuta absoluta*, a devastating tomato leafminer **insect** arrived from South America to the Mediterranean area in 2006, still remains the most important biotic constraint to tomato production in Europe and Africa; there are still no treatments that guarantee success in its control. Root-knot **nematodes** (*Meloidogyne* spp.) are found worldwide and they infect almost every plant species. **Parasitic weeds** (e.g. *Striga* sp. in Africa) can lead to severe yield losses, making them an important constraint to food security in many areas worldwide. **Post-harvest diseases** leading to the production of toxins (e.g. aflatoxins) and reduction of produce quality cause huge economic losses. Several International plant protection organisations (e.g. EPPO) have created lists of pathogens of significant importance and/or quarantine for various regions of the world. Thus pathogen & pest monitoring, employing rapid and reliable diagnosis methods, and integrated pest and disease management are instrumental for successfully protecting plant health.

The environment plays a crucial role in plant disease development. Changing climatic conditions with respect to temperature, precipitation, or CO_2 concentrations can favor the emergence of pathogens and pests in both existing and newly established agriculture environments. For example, higher temperatures can reduce the activity of resistance genes against some pathogens (e.g. wheat and oats, which become more susceptible to rust diseases with increased temperature) or cause the host to have higher resistance to pathogenic infections (e.g. some forage species become more resistant) (Chaloner et al., 2021; Velásquez et al., 2018). Rising carbon dioxide (CO_2) levels could lead to changes in the crop's metabolism and architecture, and thus modify the plant defenses to pathogens and pests with still unpredictable outputs. Furthermore, temperature and precipitation increases may favor the growth and distribution of most pest species, reducing their generation time and allowing the pest to overcome host resistance (https://www.cimmyt.org/news/pests-and-diseases-and-climate-change-is-there-a-connection). Climate change may also affect the efficacy of pesticides. For example, frequent rainfalls could wash off chemicals from plant surfaces, especially in species that do not exhibit high metabolic rates known to result in an increased uptake of chemicals.

The means to sustain plant health include the use of existing natural genetic diversity and information, as well as novel environmentally friendly chemicals and biocontrol agents. The EU has put forward a policy initiative entitled the 'European Green Deal' (European Commission, 2019) aiming at 50% reduction of agrochemicals use in EU by 2030. This target to be met requires a concentrated and rapid research effort, at a large scale, towards the development of novel, innovative technologies for plant health.

A resolution adopted by the general assembly of the UN declared 2020 as "The International Year of Plant Health (extended till 1 July 2021 due to the COVID-19 pandemic) aimed at raising awareness in society regarding plant health, and helping governments as well as the international research societies to address plant health challenges that are expected to appear due to climate crisis and affect natural ecosystems and agricultural production worldwide (IPCC, 2021).

To sustainably improve plant health specifically in European agriculture, the Plant Health WG proposes to focus on three tasks:

First task*: *To <u>develop</u> novel, sustainable pathogen & pest control <u>methods</u> for plant health protection

All the technologies leading to control of pathogens and pests should be safe for human health, have no or reduced impact /risk to the environment and must be economically sustainable. Agronomic practices should be revisited in order to identify how they could better contribute to reduced crop damage. Furthermore, the pre- and post-harvest management should mitigate toxin contamination in the produce consumed, protecting -as a result- human health.

The most important (durable) means to reduce crop yield losses is by exploiting genetic resistance wherever the latter is available. **Breeding for pest- and disease-resistance** is an environmentally-friendly solution, since it reduces the need for pesticide usage. This approach is of outmost importance for key staple crops such as cereals, potato, cassava as well as fruits and vegetables. Expression of resistance genes and reduction in expression of susceptibility genes would allow crop plants to defend themselves against attacking pathogens & pests. The phenotypic and genotypic characterization of the large genetic diversity in gene banks needs to be comprehensively characterized for genetic resources useful for resistance breeding. The recent advances in crop genomics as well as the understanding of the complex networks regulating plant-pathogen interactions at protein, hormone, miRNA levels provide an excellent basis for an accelerated improvement of resistance by breeding. Furthermore, new breeding technologies such as **gene editing**, that have evolved rapidly in the recent years, could improve crop production and reduce agrochemical inputs. The new breeding technologies (NBTs) are resulting in final products that, according to the Court of Justice of the EU (EU parliament, 2020), should be treated as GMO, but will probably be partially deregulated in the coming years. This state of uncertainty slows down research and development.

RNAi (RNA interference) is a key cellular mechanism, conserved in almost all eukaryotes, that controls gene expression in a highly specific manner and is triggered by double-stranded RNA (dsRNA). RNAi-based pathogen & pest management such as the non-transgenic (exogenous) application of dsRNA molecules has been demonstrated against viruses and viroids, fungi, insects and nematodes (San Miguel and Scott, 2015; Fletcher et al., 2020). Such RNAi approaches could join the armoire in the future integrated pest management (IPM) and contribute to replacing the conventional chemical compounds used nowadays.

Biological control (or biocontrol) is an alternative to the synthetic chemicals method for controlling pathogens and pests (Pal and Gardener, 2011). Such biocontrol agents, exhibiting different types of interspecies antagonism, are important components of IPM strategies. Soil-borne and post-harvest pathogens as well as insects and nematodes are frequently targeted by biocontrol. Biocontrol agents would be also affected by the changes in climatic conditions rendering their control efficiency questionable.

Besides direct control of the damaging organisms, an important strategy is the **induction of plant resistance**. Several chemicals and microorganisms can stimulate/prime the plant immune system for a better activation of defences (Pieterse et al., 2014; Mauch-Mani et al., 2017). There is intense scientific interest in the contribution of the **plant microbiome** to plant health and the opportunities of its management for plant protection (Trivedi et al., 2020).

Second task: To <u>detect</u> pathogens & pests that affect plant health and reduce crop yields

Predicting when and where diseases and pests will spread is not an easy task. Surveillance systems need to be developed that should reach the farmers (mobile phone applications). An example of such a **global surveillance system** is the suitcase-sized mobile lab MARPLE [https://www.cimmyt.org/multimedia/using-the-marple-kit-to-diagnose-wheat-rust-in-ethiopia/]), which tests pathogens such as wheat rust in near real-time and gives results within 48 hours (Carvajal-Yepes et al., 2020). Similar attempts for an epidemiological monitoring system have been made for potato late blight. Imaging analysis tools are becoming more frequently integrated into smart systems for plant disease detection. Plant pathogen quarantine (e.g. regulations in transport of propagative material) should be a pillar for reducing the spread of pathogens and pests in the EU where there are usually not controls at country borders.

Molecular **diagnosis** has advanced in the recent years. For example, in an untargeted approach, the next generation sequencing and the subsequent bioinformatics analysis provide the means of a sensitive and accurate pathogen detection (e.g. seed-borne pathogens, *in field* pathogen detection, asymptomatic microorganism detection etc). On the other hand, if a targeted approach is necessary, a fast and reliable technique called LAMP can be the choice, since it can be performed on samples using a simple and accessible point-of-care (POC) instrument. Furthermore, spectral and hyperspectral methods as well as remote sensing are promising approaches for future improvement of diagnosis.

Furthermore, pathogen evolution and adaptation have to be monitored. For example, novel pathogens can evolve through hybridization, resulting in host expansion. Climate change can result in geographical expansion of specific pathogens. Finally, pathogens can adapt to host resistance mechanisms. Thus, pathogens and pests must be monitored for different genetic and phenotypic properties, and prediction models and network analyses (Savary and Willocquet, 2020; Garrett et al., 2018) are required. Surveillance systems should specifically target the identification of diversity, evolution and adaptation of all organisms that can impact plant health. Any future surveillance system will necessarily require improvements of the current interactions among regional, national, European and international phytosanitary services.

***Third task: To <u>develop</u> ready-to-apply pathogen & pest management <u>technologies</u> and disseminate them to end users*.**

Novel management technologies which integrate and adapt the control of pathogen & pests on host plants under variable changing climate conditions, and which at the same time aim for a reduced impact on the environment will be developed, starting in basic research and advancing in applied research. These technologies need subsequently to be delivered to the end users and get incorporated in an IPM strategy. Agricultural extension services and farmers education play a crucial role for adoption of such technologies. The phytosanitary services need to harmonize the regulations for protection actions. For example, there are several ring tests, performed by different laboratories in the EU that validate novel protocols for efficient and rapid pathogen and pest identification. Most important is to develop a pan-European strategy against the introduction and spread of pathogen and pests that have the ability to damage natural and cultivated ecosystems.

Members of the PH WG interact with international agencies/organizations/institutions for knowledge/ideas acquisition. This WG aims at linking the academia, industry and farming communities in order to contribute to a sustainable agriculture in the EU. EPSO with its Agricultural Technologies and PH Working Groups is discussing with the European Commission (EC), the EU Member States and Members o f the European Parliament (MEPs) the importance of the new breeding technologies as key contributors to the development of resilient crops in the EU. Public-private partnerships will be instrumental to bring these technologies/products to the market.

In conclusion, raising the societal awareness on how plant health protection could contribute to food security, sustain farmers' income, protect biodiversity and reduce impacts on the environment, ensuring a high-quality product and boosting economic development is a major challenge. This requires a joint effort and engagement of academia with industry, farmers, citizens and policy makers.

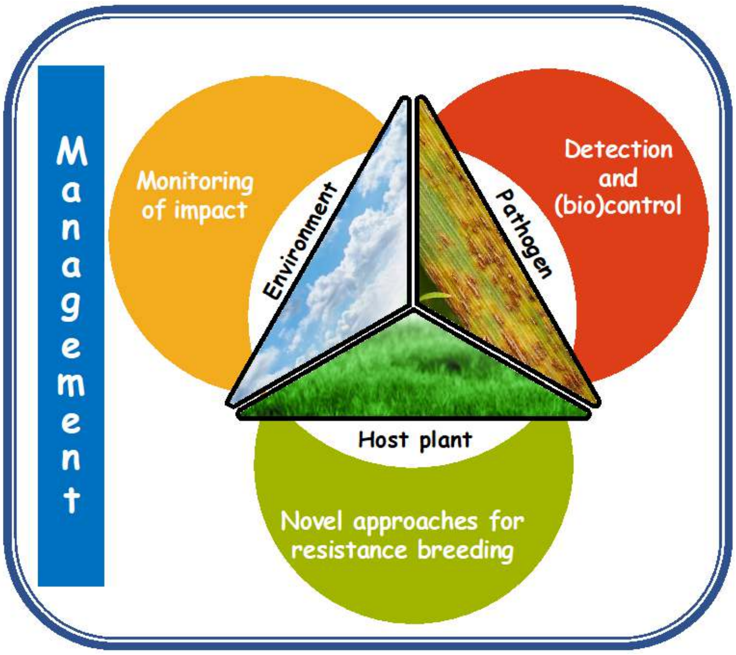

***Figure 1.** Disease triangle and the EPSO's Plant Health WG's tasks.*

Plant Health WG of EPSO is a group of experts spanning all the basic and applied research areas of plant health. It will link to the other EPSO WGs. This draft statement was developed by the PH WG chairs Gian Paolo Accotto, Beat Keller, Maria Pozo, Tina Romeis and Andreas Voloudakis together with Karin Metzlaff, following the discussions at the 2021 EPSO General Meeting. It will be further discussed at the 1st EPSO Plant Health Workshop 5th July and then finalised. Contact sofia.ciravegna@epsomail.org before end April to register for this workshop to be held online.

Contacts

Gian Paolo Accotto, IPSP, CNR, IT & EPSO PH WG Chair, Gianpaolo.Accotto@ipsp.cnr.it, +39-0113977916
Beat Keller, UZH, CH & EPSO PH WG Chair, bkeller@botinst.uzh.ch, +41 (0)44 63 48230
Maria Jose Pozo, CSIC, ES & EPSO PH WG Chair, mjpozo@eez.csic.es, +34 958181600
Tina Romeis, IPB-Halle, DE, & EPSO PH WG Chair; Tina.Romeis@ipb-halle.de, +49 (0) 345 5582 1400
Andreas Voloudakis, AUA, GR & EPSO PH WG Chair; avoloud@aua.gr, +30-2105294213
Karin Metzlaff, EPSO, Karin.Metzlaff@epsomail.org, +32-2-213-6260

Useful links

- EPSO http://www.epsoweb.org/
- EPSO: Statement on the Draft Strategic Research and Innovation Strategy by the Biodiversity Partnership Consortium, 29.1.2021
- EPSO: Statement on the Farm to Fork Strategy by the European Commission, 2.6.2020
- EPSO: Report and recommendations from the online Workshop 'Implementing a Plants and Microbiomes Strategy in Europe', 1.9.2021
- EPSO Implementing a Plants and Microbiomes Strategy in Europe – Report and recommendations from 2nd EPSO workshop, 18.10.2019
- EPSO Submission to the EC consultation on EU research and innovation missions (FP9), 30/03/2018, EPSO suggest three mission ideas: e.g. 1001 Crops – diverse crops for diverse diets and human health and sustainable production.

About EPSO

EPSO, the European Plant Science Organisation, is an independent academic organisation that represents around 200 research institutes, departments and universities from 32 countries, mainly from Europe, and 2.600 individuals Personal Members, representing over 26 000 people working in plant science. EPSO's mission is to improve the impact and visibility of plant science in Europe, to provide authoritative source of independent information on plant science including science advice to policy, and to promote training of plant scientists to meet the 21st century challenges in breeding, agriculture, horticulture, forestry, plant ecology and sectors related to plant science. https://epsoweb.org | EU Transparency Register Number 38511867304-09

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