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Plant pests and diseases in the context of climate change and climate variability, food security and biodiversity risks

Executive summary

- The purpose of this document is to outline key elements relevant for determining the consequences of climate change for plant health, with concomitant impacts on biodiversity and food security. It includes a number of considerations on linkages between the changing climate and plant pest threats in agriculture and natural environments and presents a set of available data relevant for the topic. The perspective is global throughout, but with specific examples given for the Europe and Central Asia region.
- Climate change affects both biotic and abiotic factors in crop systems, changing their production capacity. Climate change is scientifically recognized as one of the key triggers of changes in the dynamics and spatial distribution of pests and their interaction with plants. However, the complexity of the relationships among climate change, cropping systems and pests makes the assessment of their future effects on pest-related losses difficult, as climate change impacts vary significantly. Computer modelling of changing pest distributions under climate change scenarios gives valuable insights but needs to be better linked to process-based models of host performance and productivity if impacts on yield are to be better realized.
- Additionally, current agricultural practices are suggested to be revisited, for instance, by promoting climate-smart pest management (CSPM), which is an updated version of integrated pest management (IPM) that more effectively manages climate change-induced pest threats and invasions.
- In light of this, it is necessary to promote anticipatory strategies, enhanced adaptation capacity, and the development of more resilient cropping systems, with new insights based on research with a broader collaborative approach. Moreover, policies need to be developed or updated, considering a wide range of possible scenarios.

- FAO has valuable experience and technical expertise on issues relating to food security in the region – as well as on phytosanitary issues and associated risks to biodiversity – from working in close collaboration with many partners in Europe and Central Asia.

Guidance sought

The ECA is invited to:

- Endorse the recommendation for Members as outlined in paragraph 26.
- Endorse the recommendations to FAO as outlined in paragraph 27.

I. Introduction

1. Plants in agriculture and natural environments are of high importance for countries across Europe and Central Asia. The protection of plants from plant pests poses a constant challenge to experts and national authorities, especially as global drivers facilitate movements of pests between countries and regions. A general introduction to the relevance and importance of plant health in Europe and Central Asia has been provided in document ECA/41/19/3.

2. Climate change is considered one of the main factors that may facilitate the introduction and spread of plant pests to new areas. The effects of climate change on pests and diseases cover a broad spectrum of consequences for plants, including the increase of yield losses due to the increased metabolic activity and reproduction of insects, as well as insects' increased survival due to rising temperatures. Extreme climatic events (e.g. floods or hurricanes) may move pests to new areas, where they may find favourable conditions for establishment. Changing climatic conditions may also modify the level of susceptibility of plants to infestations. Although the impacts of climate change on plant health are difficult to anticipate, national plant protection authorities should be aware of them and prepare for pest incursions in new areas, taking those impacts into account. They are encouraged to work closely with research institutions in order to find more information on the potential impacts of changing climatic conditions on the development and establishment of pests.

3. The purpose of this document is to outline key elements relevant for determining the consequences of climate change for plant health, with concomitant impacts on biodiversity and food security. It includes a number of considerations on linkages between the changing climate and plant pest threats in agriculture and natural environments and presents a set of available data relevant for the topic. The perspective is global throughout, but with specific examples given for the Europe and Central Asia region.

4. The document has three sections. The first section outlines the main issues related to interactions between the changing climate and plant health. The second section highlights activities taken by FAO and other international organizations in relation to plant health and climate change. The paper concludes with recommendations for the Members and for FAO.

II. Impacts of plant pests and diseases on food security and biodiversity in the context of climate change

5. Increased average global temperatures and changing patterns of precipitation foster extreme natural events that affect whole landscapes and represent a major challenge to agriculture, food security and natural environments.[1] There can be considerable regional variability in the frequency, intensity and local occurrence of events associated with climate change, which leads to high levels of uncertainty in predictions, both in the short term and long term. Moreover, ecosystems worldwide, including agroecosystems, must simultaneously cope with several global change drivers, which might interact in unexpected ways and have potentially strong effects on ecosystem functioning. Although there are many scenarios of climate change effects on agriculture and agricultural trade (FAO, 2008, 2016, 2017, 2018b), it is difficult to predict precisely the impact of climate change on pests' behaviour.

6. The Europe and Central Asia region spans an extremely large diversity of agroecological environments. This diversity facilitates the production of diverse crops and is accompanied by a variety of plant health challenges. With climate change, the possibilities exist of shifts in the composition of threats and of increased risks of the spread of pests across the region and beyond.

7. It is important to understand the differences at the policy levels in Europe and in Central Asia in the potential adaptation and development strategies. In the European Union, within the framework of the European Commission's White Paper "Adapting to climate change: towards a European framework for action (COM(2009)147/4)"[2] and the report "Identification and Response to New Plant Health Risks",[3] there is emphasis on sustainability with regard to potentially increased pressures on cropping systems and overall food security. In Central Asia, the recognition of climate change impacts on pests at the policy level is still subject to further policy integration and elaboration.

8. Climate change and variability is considered likely to be an important factor contributing to impacts of plant pests and their spread to new areas.[4] This is relevant both in the case of pest species already present and those expanding their geographic ranges, depending on the shifting patterns of host cultivation and crop management, which are also driven by climate change.

9. Expansion of geographical ranges of pests can occur by natural means or be human-mediated through trade, human mobility or other factors not directly associated with plants. Once a pest is moved, the likelihood of its establishment and persistence in the new area depends on a range of biological and environmental factors. Warmer temperatures may allow pests to survive the colder months of the year or increase the number of generations. Furthermore, climate change may reduce plants' resistance to pest infestations. The potential for pest

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[1] https://www.ipcc.ch/site/assets/uploads/2019/08/Fullreport.pdf
[2] https://ec.europa.eu/health/ph_threats/climate/docs/com_2009_147_en.pdf
[3] http://ec.europa.eu/food/audits-analysis/overview_reports/act_getPDF.cfm?PDF_ID=1069
[4] https://www.ippc.int/en/news/the-ippc-climate-change-and-food-security/, https://www.ippc.int/en/news/the-ippc-seminar-on-plant-health-climate-change-and-environmental-protection/

adaptation and the scale of time over which it can occur are largely unexplored; this makes prediction of the impacts of plant pests introduced into new areas problematic if they are based only on impacts in their current geographic distribution. These features of pest introductions may lead to a lag period between the time of introduction and the time of detection, which can make early detection, prevention of spread, and subsequent efforts to control or eradicate pests very challenging, especially where human and logistical resources are limited. Thus, national institutions dealing with plant protection practices need to be vigilant about increasing climate change and variability. Appropriate capacities of national plant protection organizations (NPPOs) are indispensable to address such emerging challenges.

10. In some cases, the direct impacts of climate change can be confounded with indirect effects and interactions with other drivers, such as global trade.[5] As noted above, these interactions are often unexplored. Uncertainties over predictions of the spread of plant diseases under climate change scenarios call for the integration of pest management in a systems approach that is both anticipatory and that provides resilience. In particular, this would involve an approach stressing adaptive ecosystem management and a plant health perspective set at the landscape level, as proposed earlier by Pautasso *et al.* (2010). As noted by Pautasso *et al.* (2012), synthesis of all available information on spatial and temporal pest distributions across as wide a range of pest taxa as possible is a critical element in dissecting trends and predicting future developments. Bebber *et al.* (2015) (following an earlier review, Bebber, 2014), showed in an analysis of changing crop pest and pathogen distributions over the twentieth century that there was a possible latitudinal bias with pests moving "polewards." The observed range shifts could indicate a global-warming signal, although much of the interpretation of the empirical evidence remains speculative for some taxa and needs further confirmation.

11. Simulation models would be necessary to make predictions on the impacts of climate change on the development of plant pest populations. Mechanistic crop simulation models have been available for more than 40 years and more recently have been used to predict impacts on crop yields under different climate change scenarios. These are normally physiologically based and difficult to scale up to the crop population or cropping system level. Models for predicting epidemics and pest population dynamics have been available for the same period of time, but it has proved difficult to integrate the two approaches. Equally, models simulating the impacts of specific plant pests and diseases under different climate change scenarios have been available for a lesser period of time. Again, it has proved difficult to incorporate the essential dynamic aspects of disease epidemics or pest outbreaks into the mechanistic crop simulation models. In Bregaglio *et al.* (2013), the potential for infection events in Europe in wheat, rice and grapes over an extended time horizon was modelled based on climatic variables only. The aim was to combine this infection events approach with cropping system models. The outputs of this simulation show increases in infection events for most of the (currently) important pathogens on the three crops, in some cases up to 100 percent, but with marked regional differences. The predictions for two cereal rust diseases can differ widely, as shown in Fig. 1.

[5] See also ECA/41/19/5.

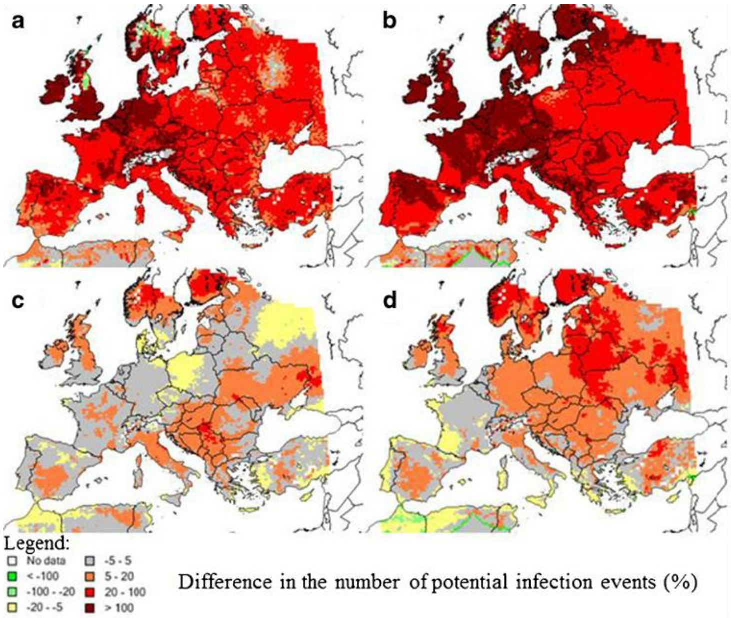

Fig. 1. Differences in the number of potential infection events simulated in the A1B climate scenario compared to the 1993–2007 reference scenario (%) (Bregaglio *et al.*, 2013): *Puccinia recondita* in the (a) 2030 and (b) 2050 time frames shows a general increase in the number of infections; *P. striiformis* in the (c) 2030 and (d) 2050 time frames maintains the current infection levels.

12. Many review articles are concerned with specific pests (arthropods, pathogens or weeds). Lamichhane *et al.* (2015) provide one of the few reviews that cover the effects of climate change on the distribution and impact of all injurious agents affecting plants. Although the scope of the review is global, many examples are given of high relevance for Europe, including the South American tomato moth *Tuta absoluta*, new strains of *Puccinia striiformis*, *Pseudomonas syringae* (first noted in 2002), and the northern shift in populations of black grass *Alopecurus myosuroides*. The review emphasizes the essential unpredictability of spatial and temporal interactions among weather, crops and crop pests and that adaptation of pests to a changing climate does not always lead to negative outcomes in plant health. Some reviews go even further in the generality of their approach but also show the existing commonalities. For example, a comprehensive review of the evidence that climate change shapes the introduction and establishment of alien species – as well as their geographic range, environmental impacts and the economic costs of their management – was made by Hulme *et al.* (2017). The concept of casual alien species, or "sleepers," whose persistence in the environment is constrained by current conditions but with greater likelihood of establishment under climate change, is introduced. This is particularly insightful and necessitates greater surveillance and management of sleeper pests if their impact under climate change is to be minimized.

13. Following on from Hulme *et al.* (2017), it is clear that there are many parallels in the ways introduced plant pests and invasive alien species can be viewed, even though regulation in these areas is the responsibility of different international treaties and agencies. Renault *et al.* (2018) take an invasion biology approach to the establishment and spread of non-native insects into new regions. Although not all non-native insects are invasive, they include plant pests along with species with animal, human and environmental impacts, so the implications go beyond plant health. The important distinction is made that whereas global trade may increase the rate

of introduction, climate change may facilitate successful establishment and subsequent spread in the new environment.

14. Threats to plant biodiversity include a reduction in species richness, impacts on ecosystem services, and *in situ* conservation of plant genetic resources. There is some scientific evidence indicating that the distribution, incidence and densities of pest populations are altering with the changing climate. However, there are certain difficulties in accurately quantifying the potential impacts of climate change on plant pests and crop production, as well as on food security and the risks to natural biodiversity. Difficulties arise mostly because of:

- The dynamic nature and different time horizons of pest epidemiology, changes in crops and cropping systems, and underlying ecological process compared with the rate of climate change.
- The lack of understanding of the interactions among climate change, agricultural trade and the biological components of agroecosystems.
- Limits to the predictability of emerging pest problems due to current uncertainties that are easy to state but difficult to quantify.
- Adaptation in pests or pathogens, which may be accompanied by similar adaptions in crops and cropping systems, but probably at a much slower pace. Such adaptation has genetic, ecological and social dimensions, which leads to high uncertainties in predicted outcomes and mitigation efforts.

15. The Europe and Central Asia region is diverse regarding the intensity of actions taken in order to improve capacities to tackle the consequences of climate change and plant pests and diseases. There are different components in the development of resilience that countries should address: at the institutional level (policies, strategies, investments and farmer networking), at the research level (forecasting, assessment, pest diagnosis and surveillance) and, finally, at the production level (risk analysis, plant health and other controls).

16. Current EU regulations in force, often referred to as the European Community Plant Health Regime, have formed a solid base for strengthening the plant health regulatory system. Furthermore, in order to further improve the collection and sharing of knowledge (e.g. the collection of comprehensive data on pest presence or establishment of early warning systems), the media monitoring system (MediSys[6]) was created in 2016 in a collaboration of the European Food Safety Authority (EFSA) and the European Commission Joint Research Centre (JRC) to share knowledge related to i.a. plant health threats through the collection of news and articles. This platform could present a useful model for other parts of the region.

17. Regarding countries in Central Asia and Southeastern Europe, it should be noted that an undeveloped legislative base, together with insufficient collaboration with the research community and low awareness of the existing new resilient practices, may create threats for food security in the future.

18. The European Union has advanced research results on scenarios of the impact of climate change on plant pests and diseases, supported by EU Directives and other policies,[7] while

[6] https://medisys.newsbrief.eu

[7] Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for community action to achieve the sustainable use of pesticides (OJ L 309 24/11/2009, p. 71); Communication from the

countries in Southeastern Europe, the Caucasus and Central Asia lack assessments of climate change's possible consequences and lack the scientific infrastructure and networks necessary to support surveillance, regulation and innovation.

19. Last but not least, at the production level the European Innovation Partnership "Agricultural Productivity and Sustainability" (EIP-AGRI), which was launched in 2012 to contribute to the European Union's "Europe 2020" strategy for smart, sustainable and inclusive growth, has implemented different projects focused on integrated pest management (IPM) practices. However, it has not fully taken into account the principles of climate-smart pest management (CSPM), which is an interdisciplinary approach aiming to increase rural resilience to pest threats, mitigate greenhouse gas emissions and contribute to food security, so further collaboration on the issue may be needed.

20. Taking into account that some strategies (e.g. the EU's "Europe 2020") will end in 2020, there is a good opportunity for FAO to collaborate with the governments in the region in terms of technical support for the development of further programmes and strategies.

III. The role and activities of FAO

21. Climate change belongs to the top challenges for the world community, as set out by the United Nations Framework Convention on Climate Change (UNFCCC). One of the areas closely linked with climate change, from both the adaptation and mitigation perspectives, is agriculture and natural resources. Thus, FAO has been contributing to global efforts and providing support to Member States in promoting and supporting actions that facilitate climate change adaptation and mitigation in the areas falling under its mandate. The Organization has been playing the leading role in bringing the dimensions of climate change related to agriculture and food security to the attention of the international community and governments, advocating for the inclusion of agriculture in the climate change agenda, particularly through contributing to the Conferences of the Parties (COP) of the UNFCCC. More specifically, it has been working with the Member States through its governing body discussions, the latest review being at the twenty-sixth session of the Committee on Agriculture (COAG)[8] in 2018. In parallel, climate change issues have also been in the focus of the work of the International Plant Protection Convention (IPPC) Secretariat, particularly from the point of view of awareness raising about the impacts of climate change on plant health challenges.[9]

22. Various units of FAO work in an integrated manner on different aspects of the interactions between climate change and plant health. The Climate, Biodiversity, Land and Water Department coordinates the overall work of the Organization on climate change, biodiversity and natural resources management. In this respect, FAO promotes and supports international collaborations and local actions for addressing climate change challenges through

Commission to the European Parliament and the Council "Action Plan against Threats from Antimicrobial Resistance" (COM(2011) 748)

[8] http://www.fao.org/fileadmin/user_upload/bodies/COAG_Sessions/COAG_26/MX511_8/MX511_COAG_2018_8_en.pdf

[9] https://www.ippc.int/en/news/the-ippc-climate-change-and-food-security/, https://www.ippc.int/en/news/the-ippc-seminar-on-plant-health-climate-change-and-environmental-protection/

its Strategy on Climate Change.[10] The FAO Plant Production and Protection Division, the FAO Forestry Department and other units concerned with water and land use promote the sustainable intensification of plant production and hence food security in the context of climate change. Actions include the strengthening of national capacities to monitor and control pests and the provision of technical support through the Emergency Prevention System (EMPRES).[11]

23. The FAO Climate-Smart Agriculture Sourcebook (2013) emphasizes that addressing climate change challenges has to be done in an integrated manner. Food production and other land-use systems have to be more resilient and efficient in the use of resources if they are to contribute to mitigating and adapting to climate change. In this respect, particular attention would need to be given to the principles of the "Save and Grow" concept and agroecology, developed and promoted by FAO and other partners. Finally, through the Food Chain Crisis Management Framework and the Emergency Prevention System, FAO addresses transboundary pests to enhance prevention by strengthening monitoring, early warning, early reaction, coordination, communication and capacity development.

24. At the regional level, the FAO Regional Office for Europe and Central Asia has taken climate change as a main challenge for the region. It has provided technical assistance to many countries, especially in Central Asia and Eastern Europe, in their efforts to develop and implement policies and strategies addressing challenges related to climate change adaptation and mitigation, pests, and the management of natural resources. In this respect, the Regional Initiative "Sustainable natural resource management under a changing climate" (RI-3) – and particularly its component on the effective provision and collection of data, tools and services for effective decision-making on addressing natural resource management, climate change and disaster risk reduction – has been developed to deliver the projected services and support to the countries of the region through the 2020–21 biennium. Substantial support has already been provided to the countries in this regard through international partnerships such as those with the European Union and the Global Environment Facility.

Conclusions and Recommendations

25. Considering the importance of plant resources in the region, the role of the climate in the ability of pests to survive and establish in new areas, the combined impact of pests and climate change on plants both in agriculture and in natural environments, and the lack of complete data on the impacts of a changing climate on issues related to plant health, a series of recommendations can be made aiming at bridging the gaps in knowledge – but also developing relevant policies based on facts already known – in order to increase the resilience to pests of plant resources in the region.

[10] http://www.fao.org/climate-change/our-work/what-we-do/climate-change-strategy/en/

[11] http://www.fao.org/food-chain-crisis/how-we-work/plant-protection/en/

Recommendations for Members

26. The European Commission on Agriculture may wish to recommend that Members undertake the following:

1) **Support** national or international research programmes aiming to gather more information on the impacts of climate change on issues related to plant health, such as the distribution or behaviour of pests or the resilience of plants to pest infestations.
2) In confronting the challenge of climate change and variability, **develop** strategic plans to include a landscape perspective and develop cropping systems that have greater resilience at the national level.
3) **Develop** strategies – especially in the areas of surveillance, monitoring, preparedness, prevention and pest management – to deal with more frequent geographical range expansions of pests and diseases.
4) **Ensure** that national plant protection organizations take into account the aspects of plant health related to climate change in their activities, and ensure that their capacities are adequate to address those challenges.
5) **Integrate** elements related to plant health into national strategies, with regard to climate change, invasive alien species, biodiversity and the environment.
6) **Support** and take part in international collaboration at subregional, regional or global levels and in the sharing of information and experiences on the impacts of climate change on plant pests and diseases.

Recommendations for FAO

27. The ECA is invited to recommend that FAO:

1) **Support** regional efforts to determine the trends of climate change effects on pest epidemiology and ecology, host distribution, and pest impacts.
2) Through Regional Initiative 3 in Europe and Central Asia, **strengthen** mechanisms for regional data collection and evidence building and develop plans and build capacities in addressing climate change issues, where relevant for plant health.
3) **Promote** efforts to increase knowledge and enhance understanding of the effects of climate change on interactions in agroecosystems.
4) **Support** the international collaboration and development of capacities, resources and expertise to track emerging pests and their new aggressive strains under climate change and to respond accordingly with improved pest management practices.

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