

# Changing perceptions of tree resistance research

If scientific research is “the art of the soluble” (Medawar, 1967), then a major hindrance to tree resistance research is a perception that its problems are insoluble. This perception has led to the problems of chronic underfunding, lack of interest from universities, and a paucity of publications about ongoing research in scientific journals. We seek to address the latter problem in this special issue of *Plants, People, Planet*, for 2020, the International Year of Plant Health (<https://www.ipcc.int/en/iyp/h/>). We hope that this special issue may help to shift perceptions about research into tree resistance to pests and pathogens.

Tree resistance research is needed now more than ever before. Globalization of trade has led to the transportation of pests and pathogens between continents, causing new epidemics in native host populations. Climate change may also be accelerating the growth and spread of native pests and pathogens. At the moment when more trees are needed to capture atmospheric carbon, huge numbers of trees are succumbing to pests and pathogens.

Despite the pressing need for trees resistant to pests and pathogens, research in this area is in the doldrums. In talking with scientists and stakeholders, especially in preparing for this special issue, several reasons for the perceived insolubility of challenges in tree resistance research have become evident. Some of these are biological and some are social. I outline six major ones below.

*First*, is the obvious fact that trees have long generation times and can grow to large sizes. They cannot be put through multiple rounds of experimental crossing in the lifetime of a typical research grant, or even the lifetime of a typical researcher. They cannot be grown for long in a growth cabinet or a glasshouse. The rate of research on them is of necessarily slow. It is hard to formulate research proposals that would fit within the funding cycles of most grant-awarding bodies, and even when this is possible, it is hard to compete with the rapid rate of knowledge acquisition offered by researchers working on more tractable species. Research therefore largely depends on long-term institutional commitment from well-funded organisations, and these are rare.

*Second*, reliance on long-term institutional funding (when available) means that experimental programs on tree resistance tend not to be exposed to the rigors of multidisciplinary peer-review from funding agencies every 3 or 4 years. Their scrutiny tends to be in terms of an institution deciding whether a programme should continue or be terminated, rather than gaining external input on how the latest developments in technology or methods could improve the outputs. This can lead to a perception

among other scientists that tree resistance research is a scientific backwater.

*Third*, because tree resistance research programs are long-term studies, publications tend to be of interim results and contain limited new biological knowledge. This can make them hard to publish in research journals. Publication therefore tends to be in institutional reports or conference proceedings, which can be hard to find and may not always be externally peer reviewed. When manuscripts are submitted to multidisciplinary journals, they may be rejected because reviewers and editors do not sufficiently account for the difficulties of the study systems, or because the researchers are unfamiliar with the standards that they are expected to meet.

*Fourth*, wider perceptions of the likelihood of success in tree resistance research have largely been set by experiences of Dutch elm disease and chestnut blight. For decades elms in Europe (Figure 1) and chestnuts in North America have lain waste, and scientific research has not led to their recovery. Both are particularly difficult problems to solve because very little heritable resistance occurs in European elms to Dutch elm disease or in American chestnut to chestnut blight. Not all tree resistance problems are as difficult as this: many programs can start with more heritable resistance in surviving populations.

*Fifth*, unrealistic goals have been set by the view that the only acceptable level of resistance to a newly emerged tree pest or pathogen would be complete resistance. In many cases, we must lower expectations and be satisfied with self-sustaining populations containing considerable variation in resistance level among individuals. In some cases, a breeding program for resistance may simply aim to generate individuals that can survive to produce seed, providing the raw materials for natural selection to take over.

*Sixth*, contradictory views about the desirability of resistant trees exist among stakeholders. Unlike wheat or barley, where almost everyone would agree that breeding for pest and pathogen resistance and high yields is a worthwhile endeavor, support for tree breeding is not universal. Some stakeholders see woodlands as natural wilderness areas in which any human intervention is unwanted. Among those who do want pathogen-resistant trees, some will want a tree that resembles pre-epidemic trees, whereas others will want a tree that produces more timber. Tree breeding programmes struggle to please everyone.

The combination of these six factors, together with the inevitable difficulties attached to every applied biological research program, mean that tree resistance research has not received the

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**FIGURE 1** Loss of elms in Kent, UK, showing photographs of the same scenes taken in the 1930s and in 2019. Capel Church before (a) and after (b) the loss of elms; and a close-up of Church Lane, Capel before (c) and after (d) the loss of elms

emphasis that it should. However, there are encouraging signs that perceptions could be changing. There is a new public awareness of the value of trees for climate change mitigation and the devastation that can be caused by tree pests and pathogens. This awareness can feed into citizen science, with the potential to allow researchers to work at scale with low expense. At the same time, advances in genomic research can dramatically shorten the length of time needed to generate meaningful biological results in tree resistance research.

These are the positive themes that motivate this special issue of *Plants, People, Planet* and we are delighted to include the following articles in this collection. Graziosi et al. raise awareness of the startling problems posed by pests and diseases of trees in Africa. We hope this will stimulate new grant proposals, perhaps for official development assistance funding. Federman and Zankowski underline the commitment of the U. S. Department for Agriculture to new approaches in tree resistance research and Spence et al. show the innovative approaches being taken by UK's Department for Environment, Food and Rural Affairs. TreeSnap, an app to harness the power of citizen science for tree resistance studies is presented by Crocker et al. Plans to use citizen science for the large scale diversification of American chestnuts resistant to chestnut blight, allowing local adaptation and preserving genetic diversity are described by Westbrook et al. Success here would be a huge boost for the reputation of tree resistance work in the public eye. Snieszko et al. describe encouraging levels of partial resistance to white pine blister rust in *Pinus monticola* and *P. lambertiana*. While at this stage, they know little about the

genetic basis for this, their 15- to 20-year old trials are surely ripe for genomic analyses. Snieszko et al. also give evidence for both qualitative and quantitative resistance to *Phytophthora lateralis* in Port Orford Cedar. Showalter et al. report encouraging levels of partial resistance to emerald ash borer in European ash, suggesting that breeding may be a viable solution to the much anticipated invasion of Europe by this pest. Also on European ash, Plumb et al. review evidence relating to its resistance to the fungus causing ash dieback, concluding that a breeding program may be a viable solution to this pest also.

This issue provides a small snapshot of current tree resistance research. It shows encouraging trends and innovations, but is notably lacking in primary papers reporting and applying genomic data. Well-designed genomic studies are urgently needed to turn the tide in tree resistance research. Once we have good case studies of rapid progress in breeding programs informed by genomic data, public perception of this field will change for good.

## KEYWORDS

globalisation, plant health, tree diseases, tree pathogens, tree pests, tree resistance

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