How can control of invading plant pathogens increase their rate of spread? How can we prevent it?

Ryan Sharp and colleagues investigate the answers to both of these questions and discuss their recent work, The effect of competition on the control of invading plant pathogens, published in *Journal of Applied Ecology*.

When pathogens invade into an area, they may find themselves in competition with already endemic pathogen strains. This competition can severely limit the spread of the invader. Control methods generally do not distinguish between pathogen strains. Therefore, when control is applied, both invasive and endemic strains are affected. The loss of the endemic strain then creates an opening to allow the invasive strain to spread. This process is known as competitive release.

Studies investigating this effect have so far only considered control methods that discriminate against the endemic/resident species. Examples include: the effect of treating malaria in hosts infected by both drug-sensitive and drug-resistant malaria; how parapoxvirus aided the spread of grey squirrels in the UK; and, how the spread of beech in North America may have been facilitated by host-specific pathogens.

It remained to be seen what the effect of an indiscriminate control that affects both strains equally would be and ways to combat this effect were so far lacking.

A case study: cassava mosaic virus

We investigated this effect in the context of the East African cassava mosaic virus-Ugandan variant (EACMV-UG) pandemic from 1997 that spread across central Africa where the endemic African cassava mosaic virus (ACMV) was also present. This disease is spread in one of two ways: by a whitefly vector, *Bemisia Tabaci*; and, through the trade of infected planting material. A whole array of methods to control this disease exist, such as: resistant cultivars, insecticides, roguing, removal of infected planting material and clean cutting initiatives.

The adverse effect of control

We developed a model of the spread of EACMV-UG and tested two scenarios: one where it spreads into a region that is also infected by the endemic ACMV; and another in which it spreads into a region with no competitive endemic strains. We then intensified the business-as-usual control levels to investigate what the effect of control is under these two scenarios.

We found that, while all forms of control slowed the spread of disease when there were no competing endemic strains, many increased the rate of spread when ACMV was present. The only form of control we found that reduced the rate of spread was by restricting the trade of infected planting material.

How to control both incidence and spread?

While restricting trade can slow the spread of the disease, it is of limited use to regions that have already obtained the disease. We have so far applied control to the entire region, both where the epidemic has already hit and also ahead of the epidemic's 'wave' of advance. We next investigated the case where control is applied only when it reaches a certain level in a given region. This is the more likely

scenario in practice as control would only usually be intensified once the disease has reached detectable levels. When control was applied in this way, we no longer observed the increase in the rate of spread of the epidemic.

Putting all this together we arrive at a set of recommendations to optimally control invasive pathogens. If it is known that the invasive strain is not in competition with competing endemic strains, then intensifying control ahead of the wave of advance slows the spread of the invader. If, however, the invasive strain is in competition with competing endemic strains, we recommend that the only control measure that should be applied ahead of the wave are trade restrictions and to only intensify other forms of control once the wave front has passed. Applying control in this way is a win-win scenario, as trade restrictions only need to be applied ahead of the wave when disease levels are low, and once the disease begins to become problematic other forms of control that better manage the incidence of the disease can be intensified. When the presence of an endemic strain is unknown the safest course of action is to act as if the invader is in competition with competing endemic strains to prevent the possibility of increasing the invader's rate of spread.

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