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The Invisible Invader: How A Changing Climate Is Helping White Rust Creep into Our Crops

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Picture a healthy mustard field in early February. Tall, green plants stretching to the horizon, dotted with bright yellow flowers. Now look closer. On the underside of a leaf, tiny white blisters are beginning to form no bigger than a pinhead. Within days those blisters burst open and the whole plant is coated in a white powdery mess. The flowers warp and twist. The seeds never fully form. The farmer loses a third of the crop. This is white rust. And it is becoming more common, more widespread and more difficult to control thanks largely to a warming, increasingly unpredictable climate. White rust has always been a problem for mustard and other vegetable farmers, especially in South Asia. But something has changed in recent decades. The disease is turning up in places it was rarely seen before, attacking crops it used to leave alone and arriving earlier in the season than farmers expect. Scientists are now putting together a clear picture of why, and the answer points squarely at climate change.

Introduction

Quick Facts: White Rust at a Glance	
What causes it?	A water-mould (Albugo candida) not a true fungus
Crops affected	Mustard, cabbage, cauliflower, broccoli, radish
Where is it worst?	South Asia; now spreading into temperate Europe
Typical yield loss	15 to 40 per cent in badly hit fields
Climate connection	Warmer temperatures and wetter conditions favour the pathogen
Can we control it?	Yes — through resistant varieties, rotation, and careful spraying

Key facts about white rust disease and its connection to climate change.

So, what exactly is white rust?

First, a small but important correction to the name. White rust is not actually caused by a fungus. It is caused by something called a water mould or oomycete, which belongs to a completely different branch of life more closely related to seaweed than to the mushrooms in your kitchen (Saharan *et al*., 2014). This matters because ordinary antifungal sprays simply do not work against it, in the same way that an antibiotic designed for bacteria does nothing against a viral infection.

The culprit is a microscopic organism called *Albugo candida*. It is an obligate parasite, meaning it can only survive by living inside a living plant. It cannot grow in the soil, it cannot survive in dead plant matter, and it cannot exist on its own. It needs a living host and its favourite hosts are plants in the mustard family: mustard, cabbage, cauliflower, broccoli, radish and their close relatives.

What makes Albugo particularly troublesome is how quickly it reproduces. It produces thousands of tiny spores called zoospores that literally swim. These spores are released only when there is a film of water on the leaf surface, and once released they actively swim toward the plant's natural openings, find their way in, and begin feeding. Under warm, moist conditions, the whole process from spore landing on a leaf to a new batch of spores being released can happen in as little as seven to ten days. In a single growing season, dozens of these cycles can stack on top of each other, turning a minor infection into a full-blown epidemic (Saharan *et al*., 2014).

"In a single growing season, dozens of infection cycles can stack on top of each other — turning a minor outbreak into a full-blown epidemic."

What does climate change have to do with it?

To understand the climate connection, we need to think about what white rust needs to thrive. Like most living things, it has a sweet spot: a range of temperature and moisture conditions within which it grows fastest and causes the most damage. Too cold and the spores barely move. Too hot and the organism shut down. But in the middle roughly between 18 and 26^{0}C with regular moisture on the leaves white rust spreads explosively.

Here is where climate change enters the picture. Over the past few decades, average temperatures across South Asia and temperate Europe have risen by roughly one to two degrees Celsius. That may sound small, but for a pathogen with such a precise temperature sweet spot, even a one-degree shift can mean the difference between an infection that fizzles out and one that takes off. Warmer nights, in particular, prevent the cool-temperature dips that used to keep the disease in check (Velasquez *et al*., 2018).

Rainfall patterns have also changed. Many brassica-growing regions now experience more intense rain events followed by longer dry spells. This feast-and-famine pattern happens to be almost ideal for white rust. Heavy rain creates the wet leaf surfaces that zoospores need in order to swim and infect. The dry spells that follow allow the spores to mature and spread through the air. It is as though the climate has accidentally been re-engineered to favour the pathogen.

There is a third, more surprising factor: rising levels of carbon dioxide in the atmosphere. Plants absorb carbon dioxide and use it to make sugar through photosynthesis. When carbon dioxide levels are higher, plants produce more sugar. This sounds like good news for crops. But Albugo feeds directly on that plant sugar through tiny feeding structures it pushes into plant cells. More sugar in the plant means more food for the parasite, allowing it to grow faster and produce more spores (Vary *et al*., 2015). Climate change, in effect, accidentally places a larger meal on the table for the pathogen.

When these three factors warmer temperatures, more favourable rain patterns and higher carbon dioxide act together, their combined effect is not simply additive. They amplify each other. Scientists have found that these interacting changes can push disease intensity far beyond what any single factor would predict on its own (Garrett *et al*., 2006).

A disease on the move

The numbers tell a striking story. For most of the twentieth century, white rust was predominantly a South Asian problem. Farmers in India, Bangladesh and Pakistan knew it well and managed it season after season. European brassica growers, by contrast, rarely gave it a second thought.

That has changed dramatically. Since the early 2010s, white rust has been detected across eight European countries, including the United Kingdom, Germany, France and the Netherlands. Surveys in some regions have found it in roughly one in four fields a frequency that would have been almost unthinkable twenty years ago (Singh *et al*., 2019). The pathogen appears to be spreading northward at a rate of fifty to eighty kilometres per year, a speed that cannot be explained by spores simply drifting on the wind.

So how is it travelling so fast? The most likely answer is seeds. Albugo produces thick-walled, long-lived resting spores that can hide inside or on the surface of brassica seeds. When contaminated seeds are traded globally and global brassica seed trade is enormous the pathogen gets a free ride. A bag of mustard seed exported from India to the Netherlands can carry the disease thousands of kilometres in a matter of days. Once the seed is planted, and if the local climate has become just warm and wet enough, the pathogen establishes itself and begins spreading (Kaur *et al*., 2011).

This is also why seed crops face special risk. Crops grown to produce seeds must stay in the field much longer than vegetables harvested for eating, giving the disease far more time to attack. Infected seeds sell for less, germinate poorly, and carry the pathogen forward into the next season. For seed-producing regions, white rust is not just a yield problem but a supply-chain problem that ripples through the entire food system.

"A bag of contaminated seed exported from India to the Netherlands can carry the disease thousands of kilometres in just days."

Why is this a food security concern?

Brassica crops feed billions of people. Mustard oil is a dietary staple across South Asia. Cabbage, broccoli, and cauliflower are major vegetables worldwide. Rapeseed, also known as canola, is one of the world's most important sources of cooking oil and a key ingredient in biofuels. Any pathogen capable of cutting yields by fifteen to forty per cent across large areas of cultivation is a genuine food security threat (Savary *et al*., 2019).

The picture is especially worrying in India, where brassica oilseeds are grown on millions of hectares and white rust is already endemic. Farmers here often have limited access to expensive inputs or specialist advice. When disease strikes early, before flowering, it can destroy the entire inflorescence the part of the plant that would have become seeds leaving the farmer with almost nothing to harvest.

There is an additional complication. Many farmers respond to disease pressure by applying more fungicide. But the chemicals available for white rust are quite limited, and Albugo can evolve resistance to them with repeated exposure. Spray programmes that fail to control the disease still cost money the farmer may not have. It becomes a trap: the worse the disease gets, the more inputs are used; the more inputs are used, the faster resistance develops, making the chemicals progressively less effective.

At the international level, concerns about white rust contamination in seeds have led to tighter regulations in some importing countries. This can effectively shut South Asian seed producers out of export markets, disrupting livelihoods and reducing the variety of cultivars available to growers globally.

What can we do about it?

The good news is that white rust is not unstoppable. Farmers, breeders and scientists have genuine tools to fight back. The challenge is that many of these tools were designed for a stable climate and need to be updated for a world that is changing fast.

The most sustainable long-term solution is plant breeding: developing brassica varieties that carry strong, durable resistance to white rust. Some resistance already exists in wild relatives of our crop plants, but breeding it into productive varieties takes years of careful work. Scientists are now using genomic tools essentially reading the DNA of thousands of plants to speed this process up considerably. The goal is varieties that resist not just today's strains of the pathogen, but that remain resistant even as the pathogen evolves and the climate shifts further.

Good farm management also makes a significant difference. Rotating crops so that brassicas are not grown in the same field year after year starves the pathogen of its host and breaks the inoculum cycle. Spacing plants further apart allows air to circulate and leaves to dry faster after rain, shortening the wet periods that zoospores need. Treating seed with hot water before planting kills resting spores and reduces the risk of introducing the disease to a clean field.

Researchers are building disease forecasting systems that combine weather data, pathogen detection, and computer models to predict when and where white rust outbreaks are likely. In pilot programmes in parts of South Asia, farmers have received weekly risk alerts on their mobile phones, allowing them to time fungicide applications much more precisely using less chemical while achieving better control. This kind of precision, intelligence-led approach is likely to become essential as climate variability makes traditional, calendar-based spray schedules less reliable (Singh *et al*., 2019).

"Farmers in pilot programmes receiving weekly outbreak alerts were able to use less fungicide while achieving better disease control."

Conclusion

White rust is just one example of a pattern playing out across agriculture globally. Pathogens that were once confined to warm tropical regions are finding the doors to temperate regions opened by a warming climate. Diseases that used to arrive in a field two weeks into the season now turn up from the first week. Outbreaks that once happened once a decade are arriving every other year.

This is not a reason for despair. Farmers are adaptable, scientists are innovative, and real solutions are on the table. But it does mean that the agricultural research, extension, and policy systems the networks that connect scientific knowledge to the farmer's field need to move faster and think more carefully about a future where the climate conditions they were designed for are no longer the conditions they will face.

It also underlines the importance of global cooperation. A disease that begins in one country's seed supply can end up in another country's fields within a single growing season. Sharing information, harmonising the rules around what seeds can and cannot be traded, and investing in pathogen surveillance networks that span borders are not abstract policy goals. They are practical tools for protecting food supplies in a climate-disrupted world.

White rust is small. Invisible to the naked eye until it is far too late. But it is a sharp reminder that in the linked systems of climate and agriculture, what seems tiny can have very large consequences indeed.

References

1. Kaur, P., Sharma, M., & Singh, D. (2011). Epidemiology and management of white rust of rapeseed-mustard: Current status and future prospects. Plant Pathology Journal, 10(4), 137-147. https://doi.org/10.3923/ppj.2011.137.147
2. Saharan, G. S., Verma, P. R., Meena, P. D., & Kumar, A. (2014). White Rust of Crucifers: Biology, Ecology and Management. Springer India. https://doi.org/10.1007/978-81-322-1792-3
3. Savary, S., Willocquet, L., Pethybridge, S. J., Esker, P., McRoberts, N., & Nelson, A. (2019). The global burden of pathogens and pests on major food crops. Nature Ecology & Evolution, 3(3), 430-439. https://doi.org/10.1038/s41559-018-0793-y
4. Singh, U. B., Malviya, D., Singh, S., Imran, M., Pathak, N., Alam, M., & Sarma, B. K. (2019). Induced systemic responses against white rust in brassica. Scientific Reports, 9, 4054. https://doi.org/10.1038/s41598-019-39806-1
5. Velasquez, A. C., Castroverde, C. D. M., & He, S. Y. (2018). Plant-pathogen warfare under changing climate conditions. Current Biology, 28(10), R619-R634. https://doi.org/10.1016/j.cub.2018.03.054
6. Vary, Z., Mullins, E., McElwain, J. C., & Doohan, F. M. (2015). The severity of wheat diseases increases when plants and pathogens are acclimatized to elevated carbon dioxide. Global Change Biology, 21(7), 2661-2669. https://doi.org/10.1111/gcb.12899