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Why crop breeding is moving from resistance to immune restoration

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Dr. Cian Duggan discusses how AI-assisted trait discovery, molecular understanding and precision breeding could reshape the economics of crop diseaseâ??and redefine the relationship between genetics and chemical crop protection

Disease resistance in agriculture has long been defined by an evolutionary arms race as breeders introduce resistance, pathogens adapt, and the cycle begins again. **In this exclusive AgroSpectrum interview, Dr. Cian Duggan, Co-founder of Resurrect Bio, argues that the next breakthrough may come from understanding and restoring the plant immune mechanisms that pathogens have already learned to overcome.** He explains how Resurrect Bio's combination of computational discovery, AI-assisted prioritisation and wet-lab validation seeks to move disease resistance beyond broad screening towards the identification of causal, actionable traits. With spinach downy mildew as the immediate focus of its collaboration with Bejo, the approach offers a test case for whether mechanism-led trait discovery can produce resistance that is more durable and commercially relevant. Duggan also examines how climate-driven disease pressure could elevate crop immunity from a specialised breeding objective to a strategic pillar of global food security. Looking ahead, he envisions a more integrated crop-protection model in which genetics, biology, chemistry, digital tools and precision breeding converge to build resilience into crops rather than continually reacting to disease after it emerges.

For decades, the industry has been engaged in an arms race with pathogens, with resistance genes emerging and then quickly becoming obsolete. What convinces you that this partnership can alter that cycle rather than merely delay it?

The simple fact is that pathogens will continue to evolve to counter resistance genes. What makes this partnership with Bejo different is that it brings Resurrect Bio's immune-restoration approach into a breeding context shaped by Bejo's crop expertise and real-world understanding of disease pressure. Instead of simply introducing or selecting another resistance gene and

waiting for it to be overcome by the pathogens, Resurrect Bio identifies where plant immune systems have already been defeated by pathogens and looks for ways to restore or strengthen those immune functions. In spinach, the collaboration with Bejo will apply this targeted trait discovery approach to identify disease resistance mechanisms that could support more resilient varieties.

Resurrect Bio's platform combines computational discovery, AI-assisted prioritisation and wet-lab validation to identify causal resistance targets rather than relying only on broad screening. This gives the teams developing new varieties of spinach a clearer view of how the crop and the pathogen interact with each other, how resistance breaks down crops' immune systems and how immune systems can fight back against the pathogens.

As climate change accelerates the evolution and spread of crop diseases, do you foresee disease resistance becoming as strategically important to food security as yield enhancement once was?

Absolutely. As climate change accelerates the spread and evolution of crop diseases, disease resistance will become just as strategically important to food security as yield enhancement has been historically. Yield potential only matters if crops can withstand the disease pressures they face in the field. As pathogens move into new regions and place greater pressure on existing resistance traits, varieties that perform well today may become vulnerable faster than expected.

This is especially relevant in crops like spinach, where multiple growing cycles each year increase pressure on resistance durability. For seed companies, the challenge is to develop higher-performing varieties, whilst also ensuring reliable production in the face of evolving disease. The next phase of crop improvement needs to bring yield, quality and resilience closer together, with stronger and more durable disease resistance at its core.

The seed industry has traditionally relied on incremental breeding gains. Does targeted trait discovery represent a paradigm shift in how crop innovation will be conducted over the next decade?

We think targeted trait discovery has the potential to change how crop innovation is conducted, particularly for disease resistance. Traditional breeding will always be essential, but it relies on screening large populations and selecting for incremental gains. That approach can work well, but it's not always fast enough when pathogens are evolving quickly, accelerated for example by climate change, or when the causal resistance mechanism is not well understood.

Targeted trait discovery approaches the problem from the opposite direction. Instead of asking only which plants perform best, it asks why disease resistance works, why disease resistance fails or breaks down and which specific mechanisms can be strengthened or restored. This gives breeders more actionable targets and shortens the path from discovery to implementation.

We see this as complementary to seed companies' existing breeding expertise. The paradigm shift is not that breeding goes away, but that it becomes more informed by molecular understanding of interactions between plants and pathogens. Over the next few years, we expect crop innovation to become more targeted, more mechanistic and more closely integrated with precision breeding approaches. This is especially important for developing disease resistance, where durability, speed and biological understanding are becoming critical.

The world loses a significant portion of its agricultural output to pests and diseases each year, yet crop immunity rarely commands the same attention as productivity or sustainability. Why has the economic cost of plant disease remained so underappreciated?

The economic cost of plant disease is fragmented, variable and difficult to see in one place. Crop yield is easy to communicate and measure. Sustainability has become a clear strategic and regulatory priority. Disease, by contrast, is often treated as a technical problem within individual crops, regions or growing seasons. Losses may appear as lower yields, reduced quality, increased necessity of chemical usage, shorter variety lifetimes or disruptive supply rather than a single visible cost.

There is also a tendency to focus on disease only once resistance breaks down or an outbreak becomes severe. By that point, the economic impact has already been felt by growers, breeders and supply chains. The preventative value of strong crop immunity is harder to capture because success often means that the loss never happens.

As pathogens evolve and spread, disease resistance is becoming a core part of productivity and sustainability, not a separate issue. Stronger crop immunity protects yield, reduces reliance on chemical inputs and supports more stable production. In that sense, the cost of plant disease is not only what is lost today, but also the resilience the industry needs to build for the future.

If successful, could technologies that strengthen innate plant immunity fundamentally reduce agriculture's dependence on chemical crop protection products and what would that mean for the future of the agrochemical industry?

Where disease resistance can be made stronger, more durable and easier to integrate into breeding pipelines, strengthening plant immunity could reduce agriculture's reliance on chemical crop protection. However, we do not see technologies like ours as replacing crop protection products entirely. Continued evolution of pathogens and increasing unpredictability of growing conditions means that agricultural producers will need a multi-layered approach to fighting pathogens The opportunity is to shift more of the burden from chemical intervention towards built-in crop resilience.

For the agrochemical industry, that could mean a changing role rather than a disappearing one. Future crop protection strategies are likely to be more integrated, combining genetics, breeding, biology, chemistry and digital decision-making. Companies that successfully adapt to this shift will play a central role in helping growers protect crops with fewer inputs that are used more precisely and more sustainably.

Spinach downy mildew is the immediate target, but is the larger ambition to build a platform that can deliver durable disease resistance across multiple crops and geographies? What are the biggest scientific hurdles to achieving that vision?

Our platform is designed to be broadly applicable because many of the principles of plant immunity apply to all crops. The aim is to identify where resistance has been defeated, understand the crop-pathogen interaction at a molecular level and design ways to restore or strengthen immune functions. The biggest scientific hurdles are biological complexity and validation. Every crop-pathogen system is different and resistance can break down through different mechanisms. In each case, we must identify the right causal targets, understand how the pathogen is suppressing or evading plant immune systems and validate that the traits are strong, durable and relevant to commercial needs.

Spinach downy mildew is the immediate focus of this partnership with Bejo, but the broader ambition for Resurrect Bio is to develop disease resistance traits across multiple crops, pathogens and markets.

Investors are increasingly backing agricultural biotechnology, as evidenced by your recent Series A raise. What metrics should the market use to distinguish genuinely transformative ag-biotech platforms from technologies that are merely incremental?

The market should look beyond whether a platform sounds novel and ask whether it can actually create traits that seed companies can use and benefit from. Key metrics include speed, validation, applicability and commercial relevance.Can the platform identify causal targets rather than broad associations? Can it move from prediction to functional wet lab validation? Can it deliver actionable traits and timelines that match breeding programmes? Can those traits be implemented through existing seed company pipelines? Durability should also be central. In disease resistance, an incremental improvement may help for a season. A transformative platform should understand why resistance breaks down and use that knowledge to design much longer-lasting solutions.

Looking ten years ahead, do you envision a future in which seed companies compete not just on genetics and yield, but on their ability to engineer resilient crop immune systems capable of adapting to an increasingly volatile climate?

Yes, over the next decade, we expect resilience to become a major basis for competition in the seed industry. Yield will remain critical, but only if crops can withstand disease pressure in the field. The strongest companies will be those able to understand plant-pathogen interactions and develop more durable immune systems for increasingly volatile growing conditions.

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