WHITE PAPER

Reducing Fungicide Rates Without Sacrificing Control: Mancozeb as a Case Study

Author: Jeff Barnes
Vice President of Research & Development, Ichor Agriculture
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Problem Statement

Global agriculture is facing a paradox. Disease pressure and fungicide resistance are increasing across all major crops. Regulatory scrutiny and active-ingredient attrition are accelerating. And growers are being forced to apply more product, more often, to maintain the same level of control they achieved a decade ago.

Multi-site fungicides like mancozeb have historically played a foundational role in resistance management and food security. Their broad-spectrum activity and multi-site mode of action made them cornerstones of integrated disease management programs worldwide. However, regulatory pressure and public perception are increasingly challenging the long-term viability of these chemistries, despite decades of safe and effective use.

At the same time, the alternatives available to growers often come with trade-offs: higher use rates, increased application frequency, and greater selection pressure on single-site chemistries whose efficacy is already eroding. The result is a compounding problem in which the tools most needed for resistance management are the ones being removed from the market.

The industry lacks scalable solutions that preserve the agronomic value of proven chemistries while meaningfully reducing total chemical load per hectare. This white paper examines how a new photodynamic fungicide platform developed by Ichor Agriculture offers a practical path forward, using mancozeb as the primary case study, and extending the evidence to strobilurins, triazoles, and SDHIs.

The Mancozeb Dilemma

Mancozeb is one of the most widely used fungicides in the world, with applications spanning soybeans, corn, wheat, rice, potatoes, grapes, and dozens of specialty crops. Its multi-site mode of action – disrupting multiple metabolic pathways simultaneously – makes it one of the most resistance-resilient tools in the grower’s toolbox. In markets like Brazil, where Asian soybean rust threatens billions of dollars in production annually, mancozeb remains a critical component of spray programs.

Yet mancozeb faces an uncertain regulatory future. The European Union revoked its approval in 2021 on the basis of endocrine-disruption concerns, and similar scrutiny is emerging in other jurisdictions. Even where registrations remain intact, environmental and public perception pressures are driving a narrative that legacy chemistries should be phased out.

The agronomic consequence of removing mancozeb – or restricting it to the point of impracticality – is not trivial. When a multi-site protectant is lost, growers must compensate with increased applications of single-site fungicides such as strobilurins, triazoles, and SDHIs. These chemistries, while effective, exert strong selection pressure on fungal populations and are already showing resistance in key pathogens globally. The loss of multi-site protectants therefore accelerates the very resistance crisis the industry is trying to manage.

The question is not whether mancozeb should be used. It is whether we can find a way to preserve its agronomic benefits while reducing the total amount of active ingredient applied per hectare.

A New Approach: Photodynamic Chemistry as a Rate-Reduction Enabler

Ichor Agriculture has developed a novel class of fungicides based on photodynamically active xanthene chemistry. The company's lead active, ICH 700F, is a formulation of Phloxine B – a compound already regulated by the FDA for use in cosmetics. When applied to crop surfaces, ICH 700F absorbs visible light and generates reactive oxygen species (ROS) including singlet oxygen, hydrogen peroxide, and hydroxyl radicals. These ROS rapidly oxidize fungal cell membranes, proteins, and lipids, leading to pathogen death within hours of exposure. Interestingly, its observed efficacious use rate is just 50 grams of active ingredient per hectare.

Critically, this mechanism is multi-site and non-target-specific. Because the oxidative damage is broad and non-enzymatic, fungal populations cannot readily develop resistance through single-gene mutations – the same fundamental advantage that has sustained mancozeb's utility for decades. Ichor's research has also demonstrated that the actives retain measurable efficacy under low-light and dark conditions through alternative oxidative pathways, extending the platform's applicability to canopy-shaded environments, seed treatments, and soil applications.

The safety profile of ICH 700F is notable. Phloxine B has an LD50 of 8,400 mg/kg (rat), classifying it as practically non-toxic. Completed GLP regulatory studies have also shown ICH 700F to be practically non-toxic to fish, aquatic invertebrates, and honeybees, and non-mutagenic in both Ames and chromosomal aberration assays.

Greenhouse Evidence: Mancozeb Rate Reduction in Soybean

Greenhouse studies conducted under controlled conditions provide early validation of the rate-reduction strategy in field environments. In a replicated study targeting Asian soybean rust, ICH 700F was evaluated alone and in combination with mancozeb across a matrix of 0.5× and 1× rates. Treatments were applied preventatively in two applications at 14-day intervals, with disease severity assessed at 7, 14, and 21 days after the first application across middle, and upper canopy positions.

Asian Soybean Rust (Phakopsora pachyrhizi)

ICH 700F and mancozeb both provided moderate, rate-responsive control when applied alone. ICH 700F at the 1× rate achieved approximately 74% control in the upper canopy 21 days after first application, demonstrating strong standalone activity. Mancozeb at the 0.5× rate provided 42% control, consistent with expected performance for a reduced-rate multi-site protectant.

Combination Performance: The Rate-Reduction Evidence

The most compelling results were observed in the combination treatments. When ICH 700F was paired with reduced rates of mancozeb, the combinations significantly outperformed either component alone and exceeded expected additive effects:

Treatment (g ai/ha)	Mancozeb Rate (g ai/ha)	Mid-Canopy Severity (%) 21/7 DAA/B	Upper-Canopy Severity (%) 21/7 DAA/B
Untreated Control	—	56	35
ICH 700F alone (50g)	—	28	9
Mancozeb alone (1×)	1680	16	7
Mancozeb alone (0.5×)	840	36	20
ICH 700F (25g) + Mancozeb (0.5×)	840	10	1
ICH 700F (50g) + Mancozeb (0.5x)	840	1	1
ICH 700F (25g) + Mancozeb (1×)	1680	5	0
ICH 700F (50g) + Mancozeb (1×)	1680	1	0
Proline 480 SC (industry standard)	—	0	2

Table 1. Mid-canopy and upper-canopy ASR severity in soybean at 21 days after first application, 7 days after second application. Quitman, GA. Statistical analyses (AOV + SNK) conducted within ARM. LSD 2.
0.5x and 1x rates based on US greenhouse label rate.

The critical finding: combining ICH 700F at a rate of 50g ai/ha with a 50% reduced rate of mancozeb (rate of 840g ai/ha) delivered 98.2% disease control, far exceeding either standalone treatment. This confirms a strong combinatorial interaction between the two actives.

This demonstrates that growers can significantly reduce mancozeb use rates without sacrificing performance by incorporating ICH 700F. The same pattern was observed across multiple rate combinations, with best performance generally achieved using 1× rates of ICH 700F paired with 0.5× to 1× rates of mancozeb. No phytotoxicity was observed from any treatment, and all combinations were operationally compatible.

Field Evidence: Mancozeb Rate Reduction in Soybean

Independent field trials conducted in Quitman, Georgia under natural disease pressure provide further compelling evidence for this rate-reduction strategy. In a replicated study targeting *Corynespora cassiicola* (target spot) in soybean, ICH 700F was evaluated alone and in combination with mancozeb at multiple rate combinations across a full matrix design. Treatments were assessed at 14 and 35 days after application across lower and mid-canopy positions.

Target Spot in Soybean (*Corynespora cassiicola*)

Mancozeb alone provided moderate control that improved with rate. At the standard commercial rate of 1,200g ai/ha, mancozeb reduced mid-canopy target spot severity to 6.5% at 35 days after first application, and 14 days after second application compared to 70% in the untreated control. However, at the reduced rate of 900g ai/ha, mid-canopy severity remained at 9%.

ICH 700F alone at 50g ai/ha reduced mid-canopy severity to just 3.3%, outperforming even the highest mancozeb rate as a standalone treatment.

Combination Performance: The Rate-Reduction Evidence

The most striking results came from the combination treatments. When ICH 700F was paired with reduced rates of mancozeb, the combinations consistently outperformed either component alone and exceeded the industry standard comparator (Priaxor):

Treatment (g ai/ha)	Mancozeb Rate (g ai/ha)	Mid-Canopy Severity (%) 35/14 DAA/B	% Reduction vs. Untreated
Untreated Control	—	70	—
ICH 700F alone (50g)	—	3.3	95.3%
Mancozeb alone (1×)	1,200	6.5	90.7%
Mancozeb alone (0.75×)	900	9.0	87.1%
ICH 700F (37.5g) + Mancozeb (0.75×)	900	1.8	97.4%
ICH 700F (50g) + Mancozeb (0.75×)	900	2.5	96.4%
ICH 700F (50g) + Mancozeb (1×)	1,200	0.0	100%
Priaxor (industry standard)	—	20.8	70.3%

Table 2. Mid-canopy target spot severity in soybean at 35 days after first application, 14 days after second application. Quitman, GA. Statistical analyses (AOV + SNK) conducted within ARM. LSD 1.5.
0.75x and 1x rates based on common Brazil field label rate.

The critical finding: adding just 37.5g ai/ha of ICH 700F to a 25% reduced-rate of mancozeb (900g ai/ha) delivered 97.4% disease reduction, exceeding the full-rate mancozeb and ICH 700F, and the industry comparator Priaxor.

This means growers can reduce their mancozeb load by 25% without any loss of disease control, simply by incorporating a low dose of ICH 700F into the tank mix. The same pattern held across multiple rate combinations and was confirmed in both target spot and Asian soybean rust trials, where 50g ai/ha of ICH 700F enabled a 25% reduction in mancozeb rate while improving middle-canopy control from 87% to 96.4%.

Beyond Mancozeb: Rate Reduction Across Strobilurins, Triazoles, and SDHIs

While the mancozeb data make a compelling case on their own, the rate-reduction effect is not unique to dithiocarbamate chemistry. Additional field trials conducted in Quitman, Georgia evaluated ICH 700F in combination with reduced rates of major branded fungicides spanning all three dominant single-site classes: strobilurins, triazoles, and SDHIs. The results demonstrate that the same combinatorial enhancement observed with mancozeb extends across the full spectrum of conventional fungicide chemistry.

In each trial, commercial products from BASF, Bayer, Corteva, Syngenta, FMC, and Adama were applied at their full labeled rate (1.0×) as standalone treatments, and then at a reduced rate (0.75×) in combination with 50g ai/ha of ICH 700F. The combination treatments consistently matched or exceeded the full-rate standalone performance – and in many cases, dramatically outperformed it.

Frogeye Leaf Spot in Soybean (*Cercospora sojina*)

Frogeye leaf spot is one of the most significant examples of single-site resistance in U.S. row crops. QoI (strobilurin) resistance in *Cercospora sojina* is now widespread, and triazole sensitivity is declining in some populations. This makes frogeye an especially relevant test case for evaluating whether ICH 700F can restore efficacy to chemistries under resistance pressure.

In the Quitman field trial, untreated severity reached 50%. Several leading branded products showed the hallmarks of emerging resistance, with frogeye severity remaining above 30% even at full labeled rates:

Treatment	Fungicide Class	1.0× Rate Alone (%)	0.75× Rate + ICH 700F (%)	Improvement
Untreated Control	—	50	—	—
ICH 700F	—	10	—	—
Headline SC (Pyraclostrobin)	Strobilurin	34	12.5	63%
Miravis (Pydiflumetofen)	SDHI	2	0.8	60%
Bravo WS (Chlorothalonil)	Chloronitrile	33	13.0	61%
Koverall (Mancozeb)	Dithiocarbamate	30	12.8	57%
Proline (Prothioconazole)	Triazole	4	0.8	80%
Onset (Tebuconazole)	Triazole	31	11.3	64%

Table 3. Frogeye leaf spot severity in soybean (% disease). 35 days after first application and 14 days after second application. LSD 4.8. Quitman, GA. 1x rate of ICH 700F = 50 g ai/ha.

The frogeye data reveal two important findings. First, products showing signs of resistance erosion or weak control under normal conditions – Headline SC (34%), Bravo WS (33%), Koverall (30%), and Onset (31%) – all improved dramatically when combined with ICH 700F at reduced rates, dropping to the 11–13% range. Second, the already-strong performers got even better: Proline fell from 4% to 0.8%, and Miravis from 2% to 0.8%.

This is not simply additive performance. The magnitude of improvement—particularly in chemistries experiencing resistance pressure—suggests a true combinatorial effect in which ICH 700F's oxidative mechanism sensitizes pathogens to the conventional active ingredient, restoring efficacy that resistance had eroded.

A Platform Effect, Not a Single-Product Story

The showed frogeye leaf spot data – combined with the mancozeb target spot results, and not displayed Southern Rust, Asian Soybean Rust, and Tar Spot data – establish a clear pattern: ICH 700F enables meaningful rate reduction across every major class of conventional fungicide chemistry. Whether the partner is a multi-site protectant, a strobilurin, a triazole, an SDHI, or a chloronitrile, the addition of 50 g/ha of ICH 700F at the partner's 0.75× rate consistently delivers performance equal to or better than the full-rate standalone.

This cross-class compatibility is a direct consequence of ICH 700F's oxidative mode of action. Because it damages fungal cells through reactive oxygen species rather than by targeting a specific enzyme or pathway, it complements – rather than competes with – the mechanism of any conventional partner. The photodynamic disruption of cell membranes may also enhance the uptake and activity of co-applied fungicides, which would explain the combinatorial effects observed even with products that already perform well on their own.

Implications for Resistance Management

The combination of ICH 700F with conventional fungicides does not merely reduce chemical load – it strengthens the resistance management profile of the spray program. ICH 700F operates through a multi-site, non-target-specific oxidative mechanism, meaning it does not exert the kind of single-site selection pressure that drives resistance evolution. When combined with strobilurins, triazoles, or SDHIs, it provides an overlapping but mechanistically distinct source of pathogen mortality that reduces the selective advantage of resistant genotypes.

This is important context for the broader industry trend. As strobilurin, SDHI and triazole resistance continues to expand in key pathogens – including *Cercospora sojina*, *Puccinia polysora*, and *Phyllachora maydis* – the value of introducing a genuinely new mode of action into spray programs has never been higher. The frogeye leaf spot data are particularly instructive: products showing clear signs of resistance erosion recovered much of their efficacy when partnered with ICH 700F, suggesting the photodynamic mechanism may directly counteract the biochemical advantages that resistant populations have evolved.

Rather than replacing existing tools, the approach described here preserves their place in integrated programs while reducing the volume applied per hectare – a strategy that simultaneously addresses resistance, regulatory, and sustainability concerns.

Conclusion

The data presented here demonstrate a clear and practical path to reducing fungicide application rates without compromising disease control. By combining Ichor Agriculture's photodynamic fungicide platform with reduced rates of mancozeb, growers can achieve 99% disease control at half the mancozeb load. By combining it with strobilurins, triazoles, and SDHIs at 0.75× rates, they can match or exceed full-rate performance – and in the case of resistance-compromised products, dramatically restore efficacy.

This approach addresses multiple challenges simultaneously, including preserving agronomic value of proven fungicides strengthening resistance management programs, while also offering opportunities for reductions in chemical load and cost of goods. The combination of a novel photodynamic mode of action with established chemistries across every major fungicide class represents a new paradigm in fungicide stewardship – one built on adding efficacy, value, and sustainable solutions.

About the Author: Jeff Barnes is Vice President of Research & Development at Ichor Agriculture. He brings over thirty years of experience in the global fungicide industry, including leadership of flagship brands at BASF such as Headline®, Priaxor®, and Revysol®.

About Ichor Agriculture: Ichor Agriculture is developing the first new class of fungicides in decades, built on photodynamically active xanthene chemistry. The platform delivers broad-spectrum, resistance-resilient disease control using FDA-regulated compounds with established safety profiles.

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