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Oxathiapiprolin: A Novel Fungicide for Oomycete Disease Management

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Oxathiapiprolin is a first-in-class fungicide developed by DuPont (now Corteva) that belongs to the piperidinyl thiazole isoxazoline chemical group. It represents a major breakthrough in the control of oomycete pathogens, such as Phytophthora spp. and Pythium spp., which cause significant yield losses globally. Oxathiapiprolin exhibits preventive, curative, and anti-sporulant activity, targeting a novel site of action—oxysterol-binding protein (OSBP)—classified under FRAC Group 49. Its low use rate, excellent rainfastness, systemic properties, and unique mode of action make it an essential tool for sustainable agriculture and resistance management in high-value crops like vegetables, grapes, and potatoes.

Introduction

Oxathiapiprolin was introduced as a new-generation oomycete-specific fungicide around 2016 by DuPont (Pasteris *et al.*, 2016). It is marketed globally under several brand names, including Zorvec Enicade, Zorvec Vinabel, and Orondis (FRAC, 2024). Its development marked a significant milestone due to its novel mode of action, targeting lipid transfer proteins essential for the development and pathogenicity of oomycetes.

Oomycetes represent a varied collection of several hundred species, many of which rank among the most destructive plant pathogens in the world (Fawke *et al.*, 2015). These "Oomycete" possess traits that render them especially aggressive. They develop as filamentous forms, extract nutrients directly from their hosts, and reproduce rapidly through spores, including motile zoospores that are capable of swimming in water films on plant surfaces or in soil moisture. This distinct biology enhances their notorious ability for rapid growth under suitable environmental conditions. Such quick proliferation means that an infection can spread at an alarming rate, leading to widespread damage in a brief time frame. This innate ability for swift and severe destruction directly necessitates highly effective, quick-acting measures that can either prevent the onset of disease or swiftly halt its spread once it is identified. As traditional fungicides face increasing resistance problems, particularly among *Phytophthora infestans* and *Pythium ultimum*, Oxathiapiprolin's entry provided a unique and highly effective solution. Its superior efficacy at low doses, high specificity, and multiple stage activity make it a key innovation in modern crop protection (Reuveni, 2017).

Characteristics of Oxathiapiprolin Fungicide

1. Active against oomycetes only (e.g., *Phytophthora, Pythium, Peronospora*)
2. Novel MoA: OSBP inhibition (FRAC 49)
3. Preventive, curative, and antisporulant activity
4. Systemic and translaminar movement

5. Low resistance risk (no cross-resistance with other fungicides)
6. Very low application rates (as low as 10–50 g a.i./ha)
7. High rainfastness and persistence on foliage
8. Compatible with IPM and tank mixes

Mode of Action

Oxathiapiprolin functions by inhibiting oxysterol-binding proteins (OSBPs), which are essential for intracellular sterol transport and membrane function in oomycetes. These proteins are involved in maintaining sterol balance in membranes and vesicular trafficking. Disruption of this process inhibits germination, mycelial growth, and sporulation (Bains *et al.,* 2020). This unique target site—unshared by any other commercial fungicide—places Oxathiapiprolin in FRAC Group 49, making it a valuable resistance management tool (FRAC, 2024). Residual efficacy indicates that it provides long-lasting protection, remaining active on the plant for a significant period after application. This unique mode of action also provides a strategic advantage in resistance management, as it is effective against oomycete strains that have developed insensitivity to older fungicides with different mechanisms, demonstrating no evidence of cross-resistance with compounds like mefenoxam. Oxathiapiprolin exhibits remarkably high activity against a broad spectrum of devastating oomycete pathogens. This includes various *Phytophthora* species, such as *P. infestans* (late blight), *P. capsici*, *P. nicotianae* (black shank), *P. sojae*, *P. parasitica*, *P. ramorum*, *P. agathidicida*, and *P. citrophthora*. It is also highly effective against *Pseudoperonospora cubensis* (cucumber downy mildew), *Peronospora belbahrii* (basil downy mildew), and *Pythium ultimum*, although its efficacy against some other *Pythium* species may be less pronounced. notably, oxathiapiprolin is not active against all oomycetes; it displays little to no efficacy on Pythium species, likely due to differences in the OSBP target across species (Cohen *et al.*, 2018)

Molecular and Chemical Properties

IUPAC Name: 1-[4-[4-[5-(2,6-difluorophenyl)-4,5-dihydro-1,2-oxazol-3-yl]-1,3-thiazol-2-yl]-1-piperidyl]-2-[5-methyl-3-(trifluoromethyl)-1H-pyrazol-1-yl] ethenone.

Its high molecular affinity for OSBP receptors in oomycetes gives Oxathiapiprolin exceptional biological activity—even at nanomolar concentrations (Zhou *et al.*, 2019).

Mode of Application

Oxathiapiprolin is applied as a foliar spray, soil treatment, or seed treatment, depending on the crop and formulation. Once absorbed, it translocate acropetally, providing protection even in untreated leaf tissues. Some formulations, like Zorvec Enicade, include co-formulants that enhance adhesion and persistence. It can be used both preventively and curatively, but early application (before symptom development) maximizes efficacy (Zhou *et al.,* 2019). The fungicide is often used in pre-mix combinations with products like benthiavalicarb, chlorothalonil, or mandipropamid to broaden the spectrum and delay resistance. Maximum efficacy is achieved at very low application rates, sometimes in the parts-per-billion range for certain pathogens (Cohen *et al.,* 2018).

Target Pathogens and Crops

Oxathiapiprolin is highly effective against oomycete diseases in the following crops:

Target Diseases	Crops
Late blight (*Phytophthora infestans*)	Tomato, potato
Downy mildew (*Peronospora spp.*)	Grapes, cucurbits, onion
Root rot (*Pythium spp.*)	Soybean, vegetables, turf
Damping-off	Tobacco, ornamentals, vegetables
White rust (*Albugo spp.*)	Brassicas
Black shank (*Phytophthora nicotianae*)	Tobacco
Root and crown rot (*Phytophthora* spp.)	Pepper, vegetables

Its primary use lies in vegetables, grapes, potatoes, cucurbits, and turf, where oomycete pressure is high and crop value demands premium protection.

Formulations and Resistance Management

Oxathiapiprolin is available as both solo and mixture formulations:

1. Zorvec Enicade® – Solo formulation
2. Zorvec Epical® – With benthiavalicarb
3. Orondis Opti® – With chlorothalonil
4. Zorvec Active® – Seed treatment

To manage resistance, it is recommended to:

1. Use alternating or mixing with different FRAC groups (e.g., Group 40, Group M)
2. Apply no more than 2 sequential sprays
3. Follow label rates and application intervals strictly (FRAC, 2024)

Due to its novel mode of action and high efficacy, resistance risk is currently low, but vigilance is essential.

Environmental and Toxicological Profile

1. Oxathiapiprolin shows very low toxicity to mammals, birds, bees, and aquatic organisms at recommended doses. It has:
2. Low mammalian Toxicity
3. No mutagenic or carcinogenic effects
4. Minimal residue levels in food crops (when applied per label)
5. Rapid photodegradation on leaf surfaces
6. These properties make it ideal for use in Good Agricultural Practice (GAP) and residue-safe programs (EFSA, 2016).
7. Recent research indicates oxathiapiprolin can temporarily alter soil and rhizosphere microbial communities, but effects are generally minor and recoverable within a short period (Chen *et al.*, 2022).

Oxathiapiprolin's Role in Sustainable Agriculture

Oxathiapiprolin, which is essential for maintaining crop health and, consequently, for ensuring global food security, is a monument to the continuous advancement in agricultural science. Farmers are able to sustain high yields and produce high-quality crops as a direct result of its remarkable effectiveness against severe oomycete infections. In a world where environmental challenges and food demands are rising, this contribution is essential. There are several ways in which the fungicide is compatible with sustainable farming methods. It is essential to incorporate it into Integrated Pest Management (IPM) techniques because IPM encourages the prudent and focused application of pesticides, reducing the overall chemical load while optimizing efficacy. Additionally, developments in oxathiapiprolin fungicide formulation, such as innovative controlled-release and nanotechnology-based delivery methods, are consistently enhancing product efficacy while lowering the necessary application rates. These formulation innovations directly result in more accurate dosage and reduced environmental impact, improving farmers' cost-effectiveness and making a substantial contribution to the financial and ecological sustainability of farming operations. They are not only about making products more convenient. Its positive environmental profile, especially its subtle and generally positive effects on soil fungus populations, further supports its compatibility with environmental preservation objectives.

The market for oxathiapiprolin is expected to expand at a compound annual growth rate (CAGR) of 6% between 2025 and 2033, reaching $1.2 billion (Dimarket, 2025). This is a clear indication of the drug's acknowledged value and growing use in the agricultural industry. The increasing desire for greater crop yields and the ongoing prevalence of fungal infections in important agricultural regions are the main drivers of this growth. Leading businesses like Syngenta and Corteva keep pushing the boundaries of innovation by creating novel formulations and application techniques that improve effectiveness and lessen their

negative effects on the environment. This discovery raises the possibility that the fungicide may both directly suppress oomycetes and activate the plant's natural defenses against a wider range of dangers. This goes beyond straightforward chemical management to a more comprehensive approach to plant health, which could eventually lessen the need for further pesticides and improve its sustainability credentials.

Conclusion

Oxathiapiprolin stands as a revolutionary addition to modern fungicide portfolios. By targeting a unique mode of action specific to oomycetes, it has transformed disease management in high-value crops. Its strong preventive and antisporulant activity, systemic behavior, and compatibility with IPM strategies make it a sustainable, efficient, and reliable solution. As resistance management becomes ever more critical, fungicides like Oxathiapiprolin—with novel MoA and high efficacy at low rates—will continue to be indispensable for global agriculture.

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