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Indiflin: The New-Gen Fungicide Farmers Can Count On

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Fungal diseases have long posed a formidable threat to global agriculture. Affecting major crops across continents, fungal pathogens are responsible for an estimated 10–20% of annual crop losses, amounting to billions of dollars in economic impact. The challenge is more pressing in the context of climate change, global trade, and the demand to feed an ever-growing population. Innovations in fungicide development have thus played a pivotal role in the evolution of modern agriculture.

Historically, fungicide use began with basic inorganic compounds like sulfur and copper-based formulations such as the Bordeaux mixture. By the mid-20th century, synthetic fungicides like dithiocarbamates, phthalimides, and benzimidazoles revolutionized crop protection with systemic and broader-spectrum capabilities. However, these molecules were eventually met with resistance issues as pathogens adapted through genetic mutations. The emergence of site-specific fungicides, including demethylation inhibitors (DMIs), quinone outside inhibitors (QoIs), and succinate dehydrogenase inhibitors (SDHIs), marked a new era of targeted and efficient fungal control. Yet, this too brought challenges, as resistance developed due to overuse and poor resistance management strategies.

As conventional tools lost the momentum, an urgent demand for novel fungicides that offer potent disease control with sustainable use raised. Indiflin, a next-generation SDHI developed by Sumitomo Chemical. Commercially launched in Japan in 2020 under the brand name Excalia, Indiflin showcases remarkable innovations in chemistry, activity, and environmental compatibility.

Scientific Profile of Indiflin

Indiflin, chemically classified as Inpyrfluxam, belongs to the SDHI class of fungicides. These fungicides function by inhibiting succinate dehydrogenase (SDH), also known as mitochondrial complex II, which is crucial for fungal cellular respiration. Specifically, SDH plays a dual role by linking the tricarboxylic acid (TCA) cycle and the electron transport chain in mitochondria. Indiflin's inhibition of SDH disrupts ATP production and energy metabolism, resulting in the suppression of spore germination and fungal growth.

Inpyrfluxam has been shown to strongly inhibit succinate-cytochrome c reductase (SCR) activity in phytopathogenic fungi such as *Phakopsora pachyrhizi* (soybean rust pathogen), confirming its SDH-targeting capability. Further metabolomic studies have revealed that treatment with Indiflin leads to a buildup of succinic acid and a reduction in malic acid, fumaric acid, and glucose-6-phosphate clear indicators of a metabolic shutdown.

The unique structural design of Indiflin includes a trifluoromethyl-pyridyl group and fluoromethyl side chains, which contribute to superior binding to the target site, better systemic movement within the plant, and enhanced persistence. This chemical innovation positions Indiflin apart from earlier SDHIs in terms of spectrum and longevity.

Mode of Action

Primarily Preventive with Early Therapeutic Capabilities: Indiflin's fungicidal activity is mainly preventive. When applied before infection, it interferes with the germination of fungal spores and the early colonization of host tissues. This action prevents disease establishment, making it an essential tool for proactive disease management. Moreover, Indiflin also exhibits early post-infection or therapeutic activity when applied shortly after pathogen invasion. It has demonstrated excellent curative control against soybean rust and apple scab in post-infection trials. While Indiflin is not curative in advanced infections, its early curative window significantly strengthens integrated disease management (IDM) protocols. It complements protective fungicides and allows growers to manage unpredictable disease pressure more effectively.

Biological Efficacy and Field Performance: Indiflin exhibits broad-spectrum activity against key plant-pathogenic fungi, especially those belonging to the divisions Basidiomycota (e.g., rusts, smuts) and Ascomycota (e.g., Dothideomycetes like Septoria and Leotiomycetes like Botrytis). Field trials across various crops and regions have consistently shown its robust performance:

- In soybeans, Indiflin provided 100% control of rust at 0.16 ppm in preventive applications and maintained similar control in early post-infection scenarios.
- In apple orchards, it achieved complete control of scab at the standard fruit tree dose (100 ppm).
- In peanut crops, Indiflin maintained 100% residual efficacy against white mold for over 42 days.

Indiflin also excels in rainfastness. Tests demonstrated 99% control of apple scab even after simulated rainfall (30 mm/hour for 60 minutes) just two hours post-application. Additionally, it exhibits strong translaminar and systemic activity. Autoradiography with ^{14}C-labeled Indiflin revealed rapid movement from application sites to untreated leaf areas, confirming its capacity to protect plant tissues comprehensively. The fungicide's systemic movement through xylem tissues was further validated in seed treatment trials. When used to coat corn seeds, Indiflin not only protected the germination zone but also reached mesocotyls and coleoptiles within seven days, providing control against Rhizoctonia root rot.

Why Indiflin Stands Out?

Indiflin's appeal lies in its multifaceted strengths:

1. **Chemically Innovative**: The novel SDHI scaffold offers enhanced target affinity, making it more effective at lower doses.
2. **Preventive and Early Curative**: Its ability to act before and shortly after infection offers flexibility in application.
3. **Extended Residual Control**: Long-lasting protection reduces spray intervals, optimizing labor and costs.
4. **Rainfastness and Translaminar Action**: Ensures reliable control even under challenging weather.
5. **Systemic and Seed Treatment Compatibility**: Expands usage across foliar and soilborne disease complexes.
6. **Eco-compatibility**: Lower toxicity to beneficial insects and minimal environmental persistence.

Commercial Availability and Formulations

Indiflin is commercially available under various brand names and combinations, allowing flexibility across crop segments:

- **Excalia (Solo)**: Marketed for use on soybeans, fruits, and vegetables.
- **Excalia Duo**: Combination with Trifloxystrobin (QoI) for dual-site activity against powdery mildew and Botrytis.
- **Future Combinations**: Mixtures with Difenoconazole (DMI) and Mancozeb (multi-site) are in development to enhance spectrum and mitigate resistance.

These combinations support resistance management strategies and broaden the efficacy against multiple pathogen classes.

Resistance Management Considerations

Like all single-site fungicides, Indiflin must be used judiciously. Resistance management is crucial to maintain its efficacy. Growers are advised to:

- Rotate with fungicides from different FRAC groups (e.g., DMIs, QoIs).
- Limit consecutive applications within a growing season.
- Integrate with non-chemical practices such as resistant cultivars, crop rotation, and biological agents.

Key Takeaways

- **Fruit crops (apples)** and **processing sugar beet** currently hold official product registrations for foliar use of Indiflin/Excalia.
- In **soybean**, **wheat**, **rice**, and **peanuts**, Indiflin is actively registered or being introduced in combination formulations (e.g., Excalia Max).
- Additional crops like **vegetables, groundnuts, and citrus** are under trial or pending registration in different markets.
- Indiflin's compatibility with integrated pest management (IPM) makes it a valuable partner in sustainable agriculture.

Conclusion

Indiflin embodies the future of fungicide innovation—targeted, robust, and environmentally conscious. As part of the SDHI family, it offers exceptional preventive and early curative action against a wide spectrum of crop diseases. Its extended residual control, systemic mobility, and eco-friendly profile elevate its value for growers seeking durable disease solutions. When used responsibly, Indiflin is not just a new fungicide—it is a strategic asset in ensuring global food security through smarter crop protection.

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