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APPLICATION OF TRIAZOLES FOR CONTROL OF COFFEE LEAF RUST (HEMILEIA VASTATRIX)

Technical Paper

The Rainforest Alliance is creating a more sustainable world by using social and market forces to protect nature and improve the lives of farmers and forest communities.

Introduction

Coffee leaf rust, caused by the fungus Hemileia vastatrix, is the main disease affecting coffee plants globally (Talhinhas et al. 2017). This disease is found in all regions where arabica (Coffea arabica) and robusta (C. canephora) coffee are grown and negatively impacts coffee plant health and productivity. In Latin America, coffee leaf rust has caused yield reductions of up to 50% in Brazil, 30% in Colombia, and 16% in Central America (Avelino et al. 2015; Zambolim 2016).

Leaf rust can be sustainably managed by using resistant coffee cultivars, implementing early warning systems, and designing crop management systems that account for threats posed by climate change and other environmental conditions (Belan et al. 2020; de Resende et al. 2021; Sera et al. 2022). Nonetheless, chemical control consisting of protectant and systemic fungicides is widely used to prevent and control coffee leaf rust, despite their potential negative impact on human and environmental health. Copper-based compounds are the most effective protectant fungicides, and triazoles are the most common systemic fungicides. Triazoles can be used alone or in mixtures with Qo Inhibitors (strobilurin) and are applied either on the leaves or in the soil (Zambolim 2016).

In Latin America, different active ingredients from the triazole family are used to control leaf rust, depending on the country. These include cyproconazole, difenoconazole, epoxiconazole, metconazole, tebuconazole, tetraconazole, triadimenol, propiconazole, and others. Many triazoles are toxic to mammals, including humans, and to birds, insects, fish, and other organisms. Of triazoles commonly used on coffee farms, cyproconazole, epoxiconazole, propiconazole, and triadimenol are classified as Highly Hazardous Pesticides by the FAO/WHO and are included in the Rainforest Alliance's list of prohibited substances, meaning that their use is banned on Rainforest Alliance Certified coffee farms.

The purpose of this technical paper is to explain Rainforest Alliance's position on triazole use and summarize the scientific literature underpinning that position.

A coffee plant affected by coffee leaf rust. Photo: Giuseppe Cipriani

EXCEPTIONAL USES

In exceptional circumstances, the Rainforest Alliance grants producers limited authorization to temporarily use prohibited pesticides. Exceptions are developed for specific crops, countries, and pests in line with Rainforest Alliance's Integrated Pest Management (IPM) strategy in response to exceptional use requests received from producers. Exceptions are granted after careful review and are based on a determination of whether farms are reliant on a given pesticide to remain economically viable. These temporary authorizations are intended to give producers time to transition away from reliance on hazardous substances while specifying risk mitigation measures that must be in place in the meantime. More information is available on our page on the Rainforest Alliance's Exceptional Use Policy (EUP).

Regarding triazole use, exceptions have been granted for foliar applications of cyproconazole until 2024 and for epoxiconazole until 2023 for controlling leaf rust in the Latin American coffee sector. However, soil applications of triazoles listed in the EUP, including commercial formulations of cyproconazole + thiamethoxam, are prohibited under clause 2k, as explained below.

RAINFOREST ALLIANCE POSITION ON TRIAZOLES

The Rainforest Alliance discourages the use of triazoles via soil application, as research suggests that foliar application is more effective for controlling coffee leaf rust. Foliar application methods also reduce the risk of contamination to soil and aquatic ecosystems by minimizing runoff and leaching.

Additionally, clause 2k of Rainforest Alliance's Exceptional Use Policy (EUP) prohibits soil application of triazoles listed in the EUP, since these substances must be used in the most precise and efficient way possible. As detailed below, research suggests that foliar applications of triazoles are more efficient and better protect environmental health.

EVIDENCE ON TRIAZOLE STRATEGIES: SOIL VS. FOLIAR APPLICATIONS

Efficacy for coffee leaf rust (Hemileia vastatrix)

Multiple studies suggest that triazoles are less effective in controlling coffee leaf rust when applied via soil drench, compared to foliar application. Research from Costa Rica has revealed that three times as much triazole active ingredient is required in soil applications, and that soil applications are less effective than foliar applications against diseases including leaf rust and Ojo de Gallo (Mycena citricolor; M. Barquero-CICAFE, personal communication, March 2, 2022). A five-year study in Brazil also found that foliar application with epoxiconazole was more effective at controlling rust in C. arabica compared to systemic fungicides applied to the soil at the beginning of the rainy season (de Souza et al. 2011). The study showed that, although soil applications were effective at keeping rust under control until March, the disease reached an incidence level of up to 30% by the early summer, when climate conditions favour rust progression. At this point, foliar treatments were needed to control progress of the disease, suggesting that soil applications on their own are not sufficient (de Souza et al. 2011). Similarly, Honorato et al. (2015) found that spraying C. arabica leaves with systemic fungicide controlled rust as effectively as strategies that combined soil and foliar applications, suggesting that the foliar strategy is more cost-effective, since it involves fewer applications and less active ingredient overall.

A separate study in Brazil found that foliar application of epoxiconazole was more effective than soil drench with flutriafol, as foliar applications could be tailored to disease incidence (Belan et al. 2015). These two strategies – foliar and soil application – were tested on 13 C. canephora clones and in some cases rust incidence stayed below a 5% threshold for the entire growing season in the absence of treatment, suggesting that treatment with fungicide is not always needed and should be selected based on the presence of disease (Belan et al. 2015). In general, studies show that strategies where fungicide is applied based on a fixed calendar are not as effective or efficient as adaptive strategies based on rust incidence or forecast systems (Capucho et al. 2013; Hinnah et al. 2020). For example, soil-based fungicide strategies often involve applying triazoles to coffee plots at the beginning of the rainy season, or to coffee seedlings in nurseries. As a result, these strategies are not tailored to current rust outbreaks or incidence levels, which can lead to over-application (additional foliar sprays needed) and lower the cost-effectiveness of fungicide treatments.

Foliar application of agrochemicals.

Effect on productivity

Although the use of fungicides can boost coffee productivity, studies do not find a productivity benefit of soil application of triazoles over foliar application. Research from Costa Rica and Brazil has found no difference in productivity between coffee plants treated with foliar and soil applications of triazoles (M. Barquero-CICAFE, personal communication, March 2, 2022; de Souza et al. 2011). In fact, one study from Brazil found that foliar applications alone resulted in marginally higher yields for C. arabica than a strategy that combined soil and foliar applications (Honorato et al. 2015).

There is some evidence that soil application of triazoles can cause a "tonic effect" in coffee plants, which is characterized by thickening leaf tissue, increased foliage, and greener leaf tone (Silva et al. 2018; Moura et al. 2013). Although this effect can give the impression of improved plant health, studies show that the tonic effect can ultimately cause metabolic stress in coffee plants, affecting longer term growth and plant vigor, with potential negative impacts on productivity (Martins et al. 2011; Carvalho et al. 1997).

The negative metabolic impact of triazoles applied via soil may be especially pronounced if fungicides are applied to young plants in the nursery or field, or to soil that is not nutritionally balanced or lacking proper moisture (Martins et al. 2011). For example, in a controlled greenhouse experiment, soil applications of cyproconazole + thiamethoxam significantly reduced vigor in C. canephora seedlings compared to a control where no fungicide was applied, suggesting a phytotoxic effect of triazoles applied via soil (Martins et al. 2011). A separate study found that an increase in the concentration of triadimenol applied to the soil was associated with a decrease in the size of C. arabica plant sprouts (Carvalho et al. 1997).

Environmental impact

Many triazoles that are commonly used to control coffee leaf rust are known to have negative impacts on human and environmental health. These impacts can be exacerbated when triazoles are directly applied to soil due to runoff and leaching. Compared to soil applications, foliar applications are more precise since they can be targeted to specific leaf rust outbreaks. The soil application strategy therefore generally involves more active ingredient overall (M. Barquero-CICAFE, personal communication, March 2, 2022) and results in direct contact of triazoles with soil, surface water and groundwater.

Leaching of triazoles into soil and runoff into waterbodies can have serious negative impacts on soil-dwelling and aquatic organisms. Soil application of triazoles can also impact human health if these substances make their way into waterbodies that are used for drinking or washing, as many triazole fungicides are highly toxic to mammals, including humans.
For example, cyproconazole and thiamethoxam are highly soluble in water and are persistent in soil. These chemicals also have a high potential to leach into ground and surface water and are moderately to highly toxic to mammals, birds, insects including earthworms and pollinators, and aquatic organisms including fish, invertebrates, crustaceans, and aquatic plants (PPDB 2022).

Other popular triazoles, including flutriafol, triadimenol, and propiconazole are also water soluble and therefore readily make their way into groundwater and nearby aquatic ecosystems with moderate toxicity to mammals, birds, insects, and aquatic organisms (PPDB 2022). A study from Brazil demonstrated these impacts in the field: of 38 active ingredients commonly used in coffee (across insecticides, herbicides, and fungicides), flutriafol, epoxiconazole, and cyproconazole were the most likely to leach into soil and were found in the greatest concentrations in groundwater (de Queiroz et al. 2018). Further, flutriafol and epoxiconazole were found in concentrations that were toxic to local aquatic ecosystems. Based on these findings, the authors of this study recommend that applications of these triazoles be avoided in coffee plantations that are close to surface or groundwater, due to the risk of toxic contamination (de Queiroz et al. 2018).

Conclusion

Given their potentially toxic impacts, triazole fungicides should be applied in a manner that maximizes effectiveness while minimizing environmental contamination. Evidence shows that foliar application of triazoles is more efficient and effective than soil application and reduces negative environmental impacts. The Rainforest Alliance therefore discourages soil applications of triazoles generally and does not allow soil applications of triazoles listed in the EUP due to their heightened toxicity. Through the 2020 Standard, supporting guidance, training initiatives, and the EUP, the Rainforest Alliance provides a suite of resources and services to help producers transition away from reliance on toxic triazoles to treat coffee leaf rust.

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