ROYA RECOVERY PROJECT

A Coffee Professional's Guide to Coffee Leaf Rust

FOREWORD

The 2013 Roya outbreak across Central America has proven to be one of the most devastating in history. Unpredictable weather patterns as a result of climate change, inconsistency in farming practices, and economics all contributed to a situation that has resulted in significant crop revenue and job loss.

Thousands of smallholder coffee producers were hit hard by the outbreak, and in response, Sustainable Harvest launched the Roya Recovery Project in 2013. Envisioned after a series of conversations and site visits with our coffee producer partners, the manual and DVD aimed to provide a comprehensive source of technical information based on insight and recommendations from the most trusted sources in the Central American coffee industry.

While our efforts helped farmers battle Roya, the disease is still wreaking havoc. A February 2014 report from the Famine Early Warning Systems Network (FEWS NET) forecasted that coffee production in Guatemala, El Salvador, Honduras, and Nicaragua will decline between 16 and 32 percent in the 2013-14 season. Mexico's national coffee association, AMECAFE, has also reported that its 2013-14 crop will be down 40 percent due to Roya. In addition to creating shortened supply, this translates to fewer dollars going to growers affected by Roya.

This year, Sustainable Harvest launched a new initiative, Let's Talk Recovery, aimed at helping coffee-producing organizations by implementing technical support, food security programs, and risk management workshops. While Let's Talk Recovery will help battle any disease or environmental emergency at origin, right now its chief target is Roya, as the crisis initiated by the disease continues.

In the following pages, you'll find details about where Roya comes from, how it affects cup quality, and how growers can fight it. Once you've reviewed the information and shared it with your staff, please visit **sustainableharvest.com/letstalkrecovery** for options on how your company can get involved in Let's Talk Recovery. With your help, we can help growers survive the crisis of Roya, and in turn strengthen our supply chain.

Sincerely,

David Griswold
President & Founder
Sustainable Harvest Coffee Importers

PARTNER SPONSOR

CAFE MOTO, SAN DIEGO, CA

"Climate change is here, and it's a very real threat to the future of specialty coffee. Some of the most recent evidence of that is the outbreak of Roya. As a roaster who has long relationships with our partner growers, I've seen first-hand the disastrous effects of Roya on our producers' communities and livelihoods. At Cafe Moto, we felt compelled to take some type of action. Because of the special nature of the Sustainable Harvest Relationship Coffee Model, we have direct conversations about needs and project ideas to improve the quality and sustainability of community and coffee crop, including last year's Roya Recovery Project. One example is a recent effort in which we worked with a group of young men and women in Nicaragua's Soppexcca Cooperative to produce a line of chocolate bars to generate extra income. (Look for Soppexcca Bars to arrive in the future.) Our partnerships with Sustainable Harvest have proven to make immediate, substantial improvements in the lives of coffee growers. I urge you to review the Roya materials within, and if you believe your dollars will make an impact in continuing our efforts to combat Roya, help communities, and protect the quality of the future crop, please consider working with us."

– Torrey Lee
Owner

PARTNER SPONSOR

CAFE MYSTIQUE, MONTREAL CANADA

“Coffee Rust Disease has had a devastating effect on the coffee producers we work with. Since the initial outbreak of Roya at the end of 2012, Cafe Mystique has been committed to doing our part to fight the disease. By joining forces with Sustainable Harvest and other partners on this project, we're able to make our dollars go further as we support our farmers and make a much deeper impact than we could on our own. By combating Roya, we can strengthen the most important link in the supply chain: the farms on which we all depend. Roya isn't the problem of a single farm—in truth, it's an international problem, and it's our collective responsibility as an industry to help solve it. As we make collective investments in our growers, we can help quicken their recovery from the havoc wreaked by Roya, and in turn create a stronger supply chain.”

– Sevan Istanboulian
Owner

Special thanks to first responders who made this project possible

Green Mountain Coffee

Café Moto

Dillanos Coffee Roasters

café coffee Mystique

OIKO CREDIT
invertir en las personas

Progreso

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BACKGROUND

Coffee-producing regions from Indonesia to Africa to Central America have experienced the detrimental effects of the airborne fungus Roya, also known as Coffee Leaf Rust. The disease is believed to have originated in the mountains of Ethiopia and Uganda; the first formal report of Roya has been traced to 1861, when an English explorer noticed affected leaves of wild coffee plants in the Lake Victoria region of East Africa.

Soon after, in 1869, Coffee Leaf Rust disease made a name for itself by devastating vast swaths of coffee plantations in Sri Lanka, which at the time was a coffee-producing powerhouse. In less than 30 years, annual coffee production on the island declined from 42 million pounds to just 3 million. After trying many ways to combat the disease to no effect, many landowners on the island ceased coffee production.

By 1932, scientists had begun focusing on Coffee Leaf Rust and had characterized it as a fungus. At first, four breeds of the fungus (found in India) were classified. By 1972, however, 26 different types of the fungus, named Hemileia vastatrix, had been identified by scientists around the world, each categorized by a number. For example, in the coffee regions of Africa, races I, II, III, VII, and XV attack Arabica varietal coffees, while races IV, V, and VI attack robusta. Of the 26 identified races, race II has been most frequently observed and is the most widespread, followed by race I.

In 1970, the first reports of Coffee Leaf Rust in the Western Hemisphere came from Bahia, Brazil. This caused considerable alarm in the coffee industry, as the region was responsible for more than 65 percent of the world's coffee. In the 1980s, more areas in the Western Hemisphere reported incidences of the disease, including Colombia and several countries in Central America. Colombia's handling of the outbreak and use of technique for controlling its spread helped limit devastation.

Coffee Leaf Rust emerged again in the Americas in 2008 through 2011. Experts attribute that attack to the phenomenon called La Nina, which caused a 44 percent increase in rainfall one year, decreasing daylight hours by 22 percent and average temperatures by 1 degree. This created ideal conditions for the fungus to proliferate wildly. In 2010, some Central American coffeelands saw as much as a 40 percent drop in coffee production due to this perfect storm.

SRI LANKA

1860

In Sri Lanka, H. Vastatrix devastated coffee plantations, and anual production declined from 42 million pounds to just 3 million in less than 30 years.

BRAZIL

1970

H. Vastatrix was reported in Brazil, causing justifiable alarm in the American continent, which produces over 65 percent of the world's coffee.

MEXICO

1981

H. Vastatrix came to Central America and Mexico, instigating exploration into resistant varietals.

COLOMBIA

1983

H. Vastatrix appeared in 1983 but the devastation was kept to a minimum due to the country's ability to manage and control the attack.

CENTRAL AMERICA

2008-11, 2013-14

H. vastatrix repeated its attacks thanks to perfect weather conditions, significantly lowering coffee output throughout the region and Mexico.

CHAPTER I
Definition, Production Cycle and Propagation

WHAT IS COFFEE LEAF RUST?

Coffee Leaf Rust is a disease caused by the fungus Hemileia vastatrix, which feeds on the living cells of the coffee plant, consuming the plant's nutrients for its own reproduction. The fungus' lifecycle starts when it come into physical contact with coffee and generates spores through germ pores. These spores seek out natural openings in the plant's cell structure to enter and begin building structures that feed on the coffee plant's nutrients. This cycle usually lasts between 40 and 50 days, enough time for the fungus to produce new spores and begin the cycle anew.

Coffee Leaf Rust attacks many varieties of Arabica coffee, including Caturra, Bourbon, Typica, Maragogipe, Catuai and Mundo Novo.

RACES OF RUST

While there are 26 types of Coffee Leaf Rust, race II is the most famous, as it is very aggressive and can attack all of the coffee genotypes grown today. So far, other races have not caused significant damage to coffee growth, so in these pages we will focus on race II.

FACTORS OF PROLIFERTION

There are a few factors that must be present for Coffee Leaf Rust to attack and damage coffee plants. These are: a susceptible plant or host; the presence of the pathogen; favorable weather conditions for growth; and agronomic mismanagement or poor agricultural practices.

Unsatisfactory practices in plant care and cultivation, along with increased effects of climate change, are thought to be the foremost factors contributing to the strength of the 2013 Coffee Leaf Rust outbreak in the Americas. La Niña's effects, such as increased rainfall, diminished sunlight hours, and more saturated soil, favors Rust cycles, encouraging an epidemic.

When the fungus is not living within cells feeding off of a plant's nutrients, it is very weak. Its survival depends on being able to travel between living tissues fairly quickly, and coffee is the only crop it can feed off. Only when trees are improperly managed and thus weakened do they become the perfect medium for the spread of fungus to healthy trees in the area.

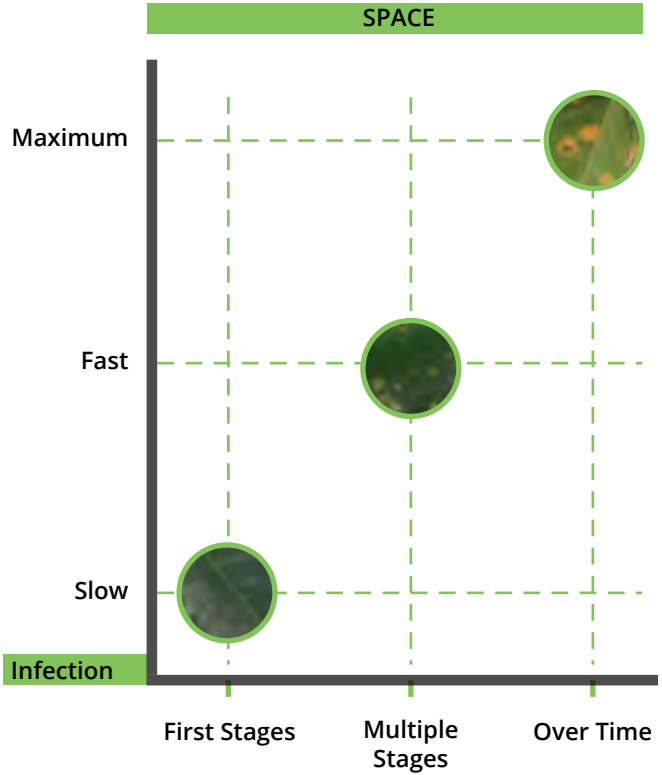
STAGES

Dissemination: Dissemination occurs through spores that look like yellow or orange powder, found on the underside of the coffee plant's leaves. If conditions permit, the fungus will disseminate its spores among coffee trees in the same plot, causing many trees to go through the same stages at the same time. Additionally, the fungus will spread to several leaves on the same tree quickly. Within two or three weeks of initial infection, the fungus can be found on as many as 30 leaves in 100.

Germination: Once it settles on the underside of a coffee leaf, the fungus will produce 4 germ tubes over a period of 6 to 12 hours. These tubes grow until they reach the leaf stomata. From there, the fungus will require water, low light and temperatures below 82.4 degrees Fahrenheit.

Colonization: Once the fungus has penetrated the leaf, it begins to extract nutrients. Plant cells that have been parasitized lose their green coloration and begin to look yellowish. This stage can last from 21 to 24 days in the sun, or 18 to 22 days in the shade.

Reproduction: After 30 days of colonization, the fungus will be mature enough to start the cycle again. The fungus is polycyclic, meaning it can produce spores and reinfect plants on any given day throughout a growing season.



CHAPTER II:
Impact on Cup Quality

Generally, the coffee beans that come from a plant attacked by Coffee Leaf Rust have a noticeable difference in size, stemming from unevenness in the ripening process. This affects all of the coffee's attributes, notably reducing acidity, body and aroma. Woody, baggy, and immature notes begin to appear. Sweetness decreases, and legume and herbal notes become more apparent.

Similarly, when farmers harvest a plot affected by Coffee Leaf Rust, immature beans often get mixed with ripe beans, affecting the overall cup profile. These cups can be astringent, rough, and flat, with notes of pea.

The coffee bean has many components, as shown in the table at right.

Therefore, if we have a nutritional imbalance, we may have repercussions in the cup.

COMPONENT	ARABICA COFFEE
Caffeine	0.8 - 1.4%
Caffeine in Wild Varieties	0.3 - 2.0 High fluctuation/ altitude
Chlorogenic Acids (CGA)	5.5 - 8.0%
Quinic Acid	4.7 - 5.6% (Santos - Kenya)
Citric Acid	11.6 - 13.8% (Santos - Kenya)
Phosphoric Acid	1.1 - 1.4% (Santos - Kenya)
CGA in wild varieties (biological pressure)	4.1 % Low Fluctuation
Trigonelline	1.0%
Diterpenes: Cafestol, Kahweol	0.5 - 0.9%
Total lipids Oleic Acids	15 - 17% 6.7 - 8.2%
Sucrose	6.0 - 9%
Sucrose in Wild Varieties	9.2% High fluctuation/altitude (7.4 - 11.1%)
Amino Acids	0.5%
Amino Acids (free)	0.3 - 0.6%
Protein (free and combined)	8.7 - 12.2%

CASE STUDY
Coffee Leaf Rust and Coffee Quality

By Hernando Tapasco, R&D at Café Granja La Esperanza, and Claudia Rocío Gómez, Coffee Quality Manager at Sustainable Harvest Coffee Importers.

Hypothesis:

At Sustainable Harvest's 2013 Let's Talk Coffee event in El Salvador, we presented a case study examining Coffee Leaf Rust's impact on cup profile. Centered in Colombia, the study explored how Rust affects coffee trees differently depending on which stage of the flowering process they're in at the time of impact. The study looked at Roya's effect on two varieties: Castillo, which was developed to be disease-resistant, and the less-resistant Caturra. Harvest times, processing details and other variables were kept as consistent as possible to allow for accurate results.

Results:

1.Roya's effect on yield and cup quality is directly related to which stage of maturation the tree is in when Roya hits. If the cherry is at or near maturation at the time of the Roya onset, the effect is minimized. But if Roya attacks a tree in the early stages of cherries' maturation cycle, the results can be disastrous, as those trees lose leaves and the cherries aren't able to fully develop.

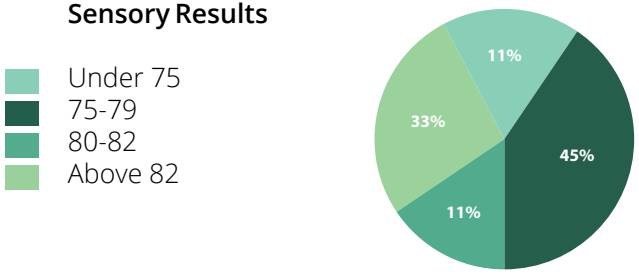
2.The trees affected by Rust will produce coffee that still has a clean cup profile, but the yield from those trees will be lower. That lower yield is one of the most worrisome consequences of Rust.

Impact on quality:

Coffees affected by Rust yield these tasting notes:

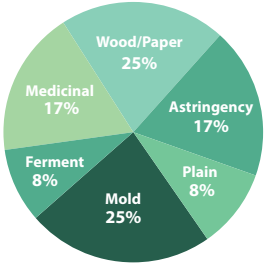
* Fragrance and aroma of cereal, vegetable, herbal notes and dry straw
* Sandy body
* Herbal flavor—peas and legumes
* Shorter finish, with woody notes

Scores found in the samples tested:



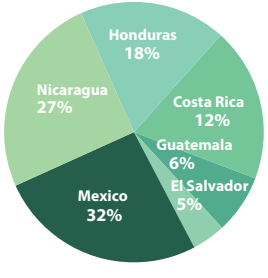
The most common notes found in our cuppings were:

* Wood/Paper
* Astringency
* Plain
* Mold
* Ferment
* Medicinal



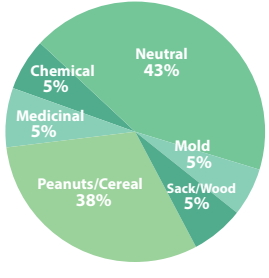
In addition to the case study, Sustainable Harvest performed analysis in different areas of Central America, and we presented the findings at a 2013 Let's Talk Coffee regional event in Honduras. The goal of this analysis was to link cup profiles to the presence of Rust in the area.

Samples evaluated by origin: Total of 221



These were the defects found that significantly affected the profile:

* Neutral
* Mold
* Sack/Wood
* Peanuts/Cereal
* Medicinal
* Chemical



CHAPTER III
How Growers Can Protect Against Roya

PLANTING DENSITY

Planting density refers to the number of coffee trees per unit of land (hectares, manzanas or acres). A very high density of plants—10,000 trees per hectare, for example—facilitates the rapid development of Coffee Leaf Rust while creating ideal temperature and humidity conditions for mold to grow.

High planting density also hinders the ability to apply fungicide that covers all the coffee leaves, and requires much more fertilizer to supply ample nutrients. For these reasons and more, it's very important that growers choose the right planting density for the particular environment of their plot.

MANAGEMENT OF PLANT PLACEMENT

The proper placement of coffee plants and shade trees in a parcel helps growers create spaces where wind and air enter. This helps stimulate the production of new tissues and stabilizes yields, thereby decreasing the normal biannual cycle of high and low coffee yields. It also regulates the relative humidity of the coffee plot, which helps in the control of diseases.

NUTRITION

In the coffee plant production cycle, trees suffer fairly serious physical and nutritional wear and tear each year, as they transfer energy from the sun, soil, and nutrients into the fruit that bears the coffee bean. This wear and tear is particularly accentuated in the absence of calcium, magnesium, and potassium, which are essential in the plant's defense against Rust.

Thus, coffee plants require a proper nutrition program to maintain healthy defenses against disease. The proper regimen for nutrition is location specific and can be determined with a soil and leaf laboratory analysis.

Laboratory analyses target hidden deficiencies in soil and plant compounds that are not visible on the leaves and also bring to light any risk of toxicity due to excessive application of chemicals onto the plant's.

Proper plant nutrition allows a farm to recover more easily from attacks of Coffee Leaf Rust and other diseases. If plants are not well nourished, they will have a lower resistance to the disease. Incidence and severity will be much greater, and the recovery will be much slower.

A proper nutrition program involves amending soil with nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur, as well as using a liquid compost that is absorbed through the plant's leaves, helping to maintain the plant's nitrogen levels and aiding with chlorophyll production.

It's important to note that when a coffee plant has little or no fertilization, or if it is grown without any shade, it is weak and therefore much more susceptible to disease.

WEED MANAGEMENT

In organic agriculture, it is recommended to leave weeds as natural cover. However, weeds can compete for nutrients with the coffee plants, and if they grow too much they can generate temperatures and humidity levels that are favorable for Rust reproduction. Farms should establish management programs to find the right balance of providing cover without breeding Rust.

SHADE MANAGEMENT

The management of shade trees in coffee helps regulate the amount of sun that hits the coffee plants, as well as the temperature and relative humidity of the plot of land. All of these factors affect the photosynthesis of the plant. Optimal shade levels for coffee production range between 45 and 60 percent.

High levels of shade (for example, more than 100 shade trees per hectare) shrink the range of maximum and minimum temperature levels on the plot of land. This creates a favorable micro-climate with a higher, more consistent level of humidity that contributes to increased leaf area and leaf lifetime.

Proper shade management creates a micro-climate that fights diseases that can affect the coffee crop. This includes a range of heights in the shade tree canopy, including trees of 15, 30, and 50 feet or more.

DISEASE PREVENTION THROUGH CHOICE OF VARIETY

Before planting any coffee variety, it's necessary to know how it will behave in specific climate and soil conditions. Different behaviors arise from plants depending on these factors.

When speaking of disease-resistant coffee variety, it's very important to have in mind the market quality standards for each variety and to always monitor their cup profile. This can be supervised and followed with regular cupping sessions. Adaptation—or how the plant will perform in specific growing conditions—is another important criteria, but it also must be linked to quality and should be evaluated through sensorial analysis.

There are two additional factors that influence the quality of a variety: weather and soil. These can influence cup profiles of coffees from different areas. The choice of varieties, in the end, depends not only on intrinsic quality but also on good agricultural practices and crop management.

When making the decision to plant a specific variety, it should be noted that the tree will remain in production in the field for at least 25 years, so farmers must weigh decisions about plant and quality parameters very carefully.

CHAPTER IV
Facts About Coffee Leaf Rust

* Coffee Leaf Rust attacks only coffee leaves; it does not attack any other parts of the plant.

* The disease cannot survive without coffee as its host. It always moves from leaf to leaf.

* In its advanced stage, Roya can often be confused with mancha de hierro or other coffee fungus diseases.

* To verify that there is presence of Coffee Leaf Rust, farmers can place a leaf against the light to notice spots that may not be visible at first glance.

* Roya is not transmitted by any another organism. It only affects coffee and needs no other host plant to complete its cycle.

* Coffee Leaf Rust leaves an orange powder that can be seen throughout the harvesting months; its development coincides with coffee beans' development.

CHAPTER IV
Facts About Coffee Leaf Rust

* Roya normally affects yields for the next cycle, but in extreme cases, it can affect the ripening process of the current cycle as well.

* It is said that a loss of leaves greater than 20 percent can affect bean development, productivity and quality, but if the loss of leaves is less than 20 percent, the plant still has the ability to reach a successful ripening.

* Because Coffee Leaf Rust requires high humidity to thrive, any method of control must be applied early in the morning, before the fungus begins to reproduce.

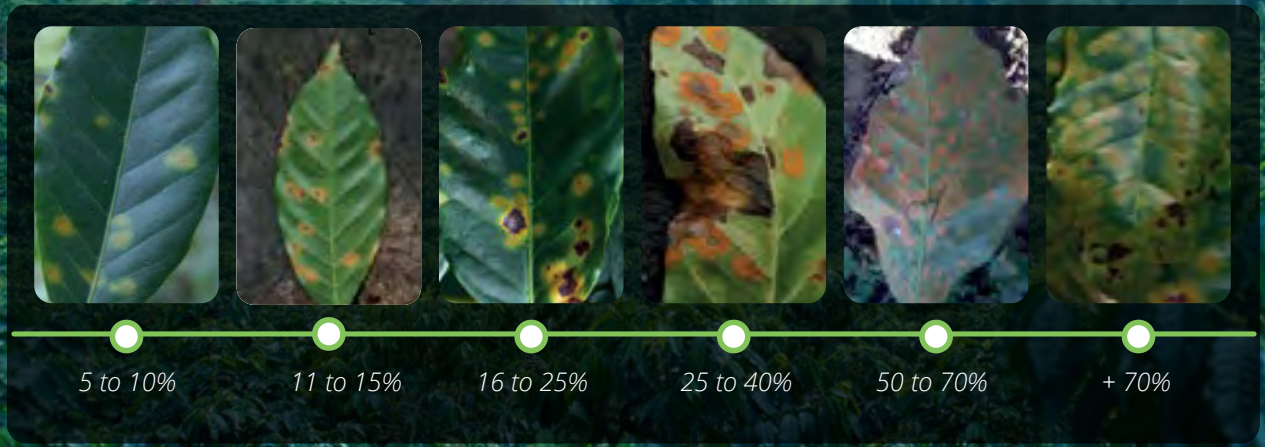
* Good shade regulation helps control the fungus.

* Farmers should apply copper-based fungicides at the first detection of Roya, before the orange powder is visible.

* The economic impact of Coffee Leaf Rust will vary depending on the degree of incidence. It affects revenues and causes unit costs to rise because susceptible coffee plantations will require more fungicides, which will translate to increased production costs and decreased incomes.

ANNEX:
A Look at Roya

TISSUE DAMAGE BY COFFEE LEAF RUST



MEASURING INCIDENCE AND SEVERITY

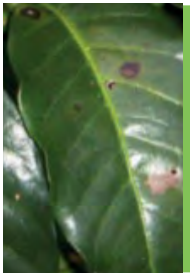
There are several methodologies that growers use to measure impact. One is to take 60 trees as a sample and measure 3 branches per tree—one from the top third, one from the middle third, and one from the bottom third. A farmer will count the number of leaves affected with Rust and take them as a percentage against those not affected by Rust. The percentage obtained is the incidence rate of the disease.

DAMAGE (%)	INCIDENCE	SEVERITY	DEVELOPMENT STAGE
<5	Low	Acceptable	Slow
5 - 30%	Medium	Medium	Fast
>30	High	High	Maximum

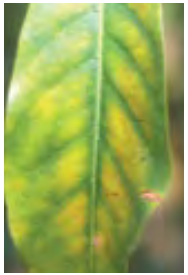
Source: Personal Interviews

DISEASE IDENTIFICATION GUIDE

LEAF RUST
Hemileia Vastatrix

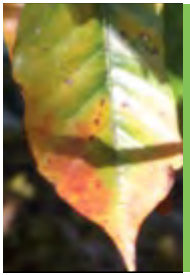


BROWN EYE SPOT
Cercospora Coffeicola



DAMAGE BY FROST

OJO DE GALLO / SOUTH AMERICA LEAF SPOT
Mycena Citricolor



LACK OF NUTRIENTS

GET INVOLVED

Sustainable Harvest's Let's Talk Recovery initiative is focused on helping coffee growers combat environmental emergencies at origin. The most pressing challenge farmers continue to face is Roya, and we are committed to providing them with efficient ways to fight the disease so that they may protect their livelihoods and continue to make a living growing coffee.

If you'd like to join our efforts, please visit **sustainableharvest.com/letstalkrecovery**, where you can learn more about Roya through several videos shot by our teams at origin. These show the disease at the source, as well as innovative methods being used to fight it.

At the website, you'll also find a list of affordable items you can purchase to help producer organizations in their efforts against Roya. Through our work at origin, we've identified tools and other additions that would significantly improve growers' chances of combating Roya, ensuring that your small investments will translate to real change.

This is now the second year that the coffee world is dealing with the Roya outbreak. Its effects continue to wreak havoc on all sides of the supply chain, and output levels remain down. We as a coffee community must come together to fight Roya. With your help, we can be a stronger presence in that fight.

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