“Lucky” is not likely to be the first descriptor you’d hear from coffee farmers when discussing their careers. Successful coffee production isn’t the result of chance. The job takes skill, dedication, intuition and resilience. Yet coffee is fickle, and prone to innumerable afflictions; even the most fastidious farmer’s trees fall victim to disease. One of the vilest afflictions known to coffee is a fungus known as rust.

Among the coffee producers I’ve been privileged to meet is a subset of proactive conservationists and forward-thinkers. Their fields were not immune to recent epidemics of coffee leaf rust (CLR, or roya in Latin America) sweeping through the coffeelands. They were unlucky, like the rest, but they were quick to learn and adapt.

By Chris Kornman
One such producer is Alejandro Solis, who manages his family’s farms, Finca Injertal and Finca Huixoc, near the cities of San Pedro Necta and La Democracia in Huehuetenango, Guatemala. A third-generation farmer, Solis has the privilege of running large and successful operations blessed with abundant spring water. Even so, he has also observed climatic changes over the years. He is a conscientious coffee caretaker, and it became apparent to him that investment in climate technology throughout his farms would provide his family, his farm and his employees with security to continue growing coffee into the future.

His gathered climate data has been used to help predict temperature and rainfall, and contributed toward an impressive scientific report led by Dr. Peter Baker at Climate Edge, a U.K.-based firm that aims to empower farmers with predictive weather and temperature models.

Not long ago, Solis confided in me that roasters “need to know what coffee farmers are facing these days. With unpredictable and unstable weather, the risks of producing coffee have increased. Flowering, planting, fertilizing, harvesting and all other labors are greatly influenced by weather—as is, of course, quality. So, I think this topic is always important for everybody to learn.”

On Huixoc, at 150 hectares, farm management is no small undertaking. The farm crosses a wide range of elevations, from 1150 meters to nearly 1700 meters, and in recent years it has experienced rather dramatic average high temperature increases. “During our rainy season, which lasts between five and six months,” Solis explains, “there are ample conditions for outbreaks, especially when temperatures rise and there is enough humidity.” On Huixoc, rains begin as early as February, usually peak in April, May and June, and can extend through August. These wet summertime conditions—warm and damp weather—are ripe for roya.

Solis’s approach to containment must be clinical to be successful on a farm at his scale.

“We have implemented an integrated management system to manage [rust] and keep it below levels which would not affect our productivity too much,” he says. “We do careful...
monitoring every month. We regulate our shade trees in very moist areas. We try to provide the best nutrition possible, and we have replanted some specific areas where rust is more prevalent with rust-resistant varieties. We have also opened our row spacing in some areas. We also use fungicides to keep inoculum at low levels. If you let the rust level get too high, there is nothing you can do to stop it.”

He elaborates, “After the rust outbreak in 2012–2013, we have seen how the rust fungus adapts to higher altitude and moist climates, where we have most of our coffee planted. We know we are never going to eradicate it.” That word “never” hangs in the air, thick like smoke.

Coffee’s most recent rust crisis was an alarm bell for a fire that’s been smoldering for more than a century. Without a deep knowledge of rust’s history and behavior, and the preventative measures in which roasters can participate, I fear we’re just fanning the flames. Let’s take a deep look at the interaction between rust, coffee and ourselves as we prepare for the next steps into an uncertain future.

GROUND ZERO

On November 6, 1869, a three-paragraph report with three footnotes and an illustration ran in The Gardeners’ Chronicle and Agricultural Gazette. Written by Reverend M.J. Berkeley and his assistant C.E. Broome, the notice identified a newly described species on the island of Sri Lanka (called Ceylon at the time). It was not a coffee species, or even a plant, but a fungus.

“We have recently received from our excellent friend Mr. Thwaites a specimen of a minute fungus which has caused some consternation amongst the coffee planters in Ceylon, in consequence of the rapid progress it seems to be making amongst the coffee plants,” reads the first sentence (biodiversitylibrary.org/page/33107926). Berkeley and Broome proposed *Hemileia vastatrix* as its scientific name and classified it under the order of rust fungi. Somewhat coy in their description of “consternation,” the
having wrested colonial domain from disease or its treatment, the infection farmers had little knowledge of the forests. It may have caused—likely the fortuitous without much noting significant problems have been aware of its existence for years, in 2016. Many Ethiopian farmers Pathology the tropics,” published in Molecular Plant Pathology in 2016. Many Ethiopian farmers have been aware of its existence for years, without much noting significant problems it may have caused—likely the fortuitous means “devastation.” The Latin word vastitas pair buried the lede in the translation of 1861 per Talhinhas, et al., in their article “The Coffee Leaf Rust Pathogen Hemileia vastatrix: One and a half centuries around the Arabian Sea, however, would notice a few years earlier in western Kenya, near Lake Victoria, sometime in 1861 per Talhinhas, et al., in their article “The Coffee Leaf Rust Pathogen Hemileia vastatrix: One and a half centuries around the tropics,” published in Molecular Plant Pathology in 2016. Many Ethiopian farmers have been aware of its existence for years, without much noting significant problems it may have caused—likely the fortuitous means “devastation.” The Latin word vastitas pair buried the lede in the translation of the Dutch at the turn of the century, were populating plantations at a fever pitch, establishing their first coffee farm in 1825. The boom and bust of Sri Lanka coffee plantations is shocking both in its magnitude and brevity. By 1840, just 15 years after the first plantings, coffee was the island’s leading export commodity. In 1873, exports peaked at over 111 million pounds (more than 840,000 bags), enough to place it third in global production volume at the time, trailing only the stalwart Dutch colonial coffee mainstay of Java and 19th-century breakout super-producer Brazil (Kushalappa, Ajjamada, C. & Albertus B. Elke. Coffee Rust: Epidemiology, Resistance, and Management. CRC Press, Inc. (1989) 178). Yet by the late 1890s, there would hardly be a tree left on Réunion Island were not spared. Sri Lanka’s coffee leaf rust outbreak would pull the linchpin in an unprecedented shift of arabica production to the Western Hemisphere in the span of less than 30 years.

KNOW YOUR ENEMY

Coffee leaf rust is a member of a vast order of problematic fungi. While most fungal species contribute to the complex circle of life by feeding on decomposing matter found on the dead, rust fungi are not so easily sated. The 8,000 identified rust species are “obligate biotrophs,” which means they require a living host to survive. They are parasites. Rust fungi are ancient, likely evolving around the same time as the first flowering plants on Earth. Other than CLR, one of the most familiar species, Puccinia graminis, known as “stem” or “black” rust, affects wheat.

In ancient Mesopotamia, a sweeping epidemic decimated wheat crops around 1300 B.C. Without the knowledge of microorganisms, farmers called the disease “red barley sickness” and had little option for respite other than prayer to the gods of harvest. Most scholars denote this as the first recorded rust outbreak in human history.

In fifth-century southern Europe another wheat rust epidemic left vulnerable a once venerable empire. The fungus caused a wheat shortage likely bearing partial responsibility for the fall of the Roman Empire (www.aimelab.aimelab.aimelab/the-rust-fungi). To this day, rust fungi are among the most complex organisms known to science. They engage in up to five highly specified life stages and are heterocyclic—meaning that to complete their five-stage life cycle they require two separate host species. (See illustration on page 50)

For wheat rust, the heterocyclic host is the ornamental barberry plant, with which the United States engaged in a war after a devastating epidemic around 1916. Since the 1950s, resistant wheat strains have been bred and widely used around the world to so much success that farmers largely turned a blind eye to the relationship between barberry and wheat rust. Breeding resistance and ignoring barberry worked pretty well, at least until 1995 when a new strain of wheat rust emerged in Uganda, spread rapidly, and wreaked havoc throughout Africa, the Middle East and Asia. The most obvious symptom of any rust infection is the presence of colorful yellowish or reddish spores that cluster together, on a coffee leaf the circular splotches are immediately recognizable like the curse of a fungal evil eye. The aflamella eventually causes the leaves to drop off plant, incapacitating the coffee tree. Those trees lucky enough to survive typically lose the fruit from both the infection season and that of the following year.

The burnt orange blisters, calledurediniospores, represent just one of rust’s natural life stages. These spores are cloned, rapidly reproducing and infecting plants on Earth. Other than CLR, one of the most familiar species, Puccinia graminis, known as “stem” or “black” rust, affects wheat.

Puccinia graminis is one of the most familiar rust species. The fungus causes a wheat shortage likely bearing partial responsibility for the fall of the Roman Empire (www.aimelab.aimelab/the-rust-fungi). Prior to the civilization’s fall, ancient Romans even had a god for rust: Robigus. Sacificial red animals—frequently puppies—were offered to the rust deity during the spring festival of Robigalia, as frightened farmers hoped to avoid the scourge on their crops. To this day rust fungi are among the most complex organisms known to science. They engage in up to five highly specified life stages and are heterocyclic—meaning that to complete their five-stage life cycle they require two separate host species. (See illustration on page 50)

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nearby trees, floating across large distances on the wind. This epidemic stage of rust can easily devastate coffee populations if uninterrupted. However, its weaknesses are its genetic monoculture and its sensitivity to low temperatures and dry weather.

Yet rust has built-in biological protection from cool, and climates. Under these conditions, the fungus enter dormancy with a specified alternate teliospore, which begins the process of creating genetic variance. Teliospores are harder than urediniospores and may live for long periods on dead plant matter, until they fuse a pair of nuclei, then split into four basidiospores—airborne agents that seek a secondary host plant. When they find one, the basidiospores germinate and colonize on top of a leaf, creating a lesion that acts similar to a sexual organ.

These basidiospore colonies, called spermagonia, launch reproductive pycniospores into adjacent colonies, fertilizing receptive cells called hyphae. The fertilized hyphae grow rootlike tendrils that plunge through the underside of the infected leaf and eject an aeciospore, the birth of a microscopic colony; liberated by a light breeze or the coat of a passing traveler, these return genetically unique rust to the primary host.

This twisted two-host relationship is well documented on wheat and barberry, and likely evolved to help rust fungus survive cold winters. Coffee, however, grows in the hot and humid tropics, and arabica will barely tolerate frost, much less freezing temperatures. As a result, Hemileia vastatrix may not even need a second host. While roya has been observed to produce basidiospores, it is speculated this could simply be an evolutionary remnant of a failsafe for hard times. The fact remains, coffee leaf rust can survive easily as epidemic urediniospores, and science is currently unaware of the fungus’s alternate host to the coffee tree.

Think about that for a second. Coffee leaf rust is so versatile and virulent that it doesn’t even need to complete its circuitous life cycle to obliterate a coffee farm. This hints at an immense problem engraved into its nature: Rust will adapt, continuing to prey on coffee well into the future.

RESISTING THE INEVITABLE

Recent research on Hemileia vastatrix, presented by Juan Carlos Herrera at the biannual ASC (Association for Science and Information in Coffee) convention in October 2018, in Portland, Oregon, shed new light on the blight’s behaviors. Cenicafé, the science arm of the Federación Nacional de Cafeteros de Colombia (FNC, Colombian Coffee Federation), found that stressors—including too much sunlight and too little nitrogen in the soil—can increase coffee’s susceptibility to the rust fungus. It’s worth noting that non-hybrid arabica varieties like Bourbon and Caturra were especially prone to stress-related increases in infection. Planting different species of coffee in the field together, such as robusta and arabica, surprisingly increased rust’s potency.

Agronomists’ first response to rust, regardless of the species or its host, has overwhelmingly been to select and breed resistance. In 1911, one of coffee’s earliest known selections was made on Doddengooda Estate in Mysore, India, from a Typica tree that showed an uncanny ability to withstand the fungus. Named Kent—likely the surname of the man who discovered it—the cultivar became popular in India, Uganda, Tanzania and Kenya (all British colonies) in the 1920s and ’30s, and was an early ingredient in resistant hybrid “recipes,” most notably contributing its genes to Jember (S795), still planted widely in Indonesia. Kent is just part of Jember’s genetic base, however. The other half is a selection known stoically as S228, a wildly underwhelming name for an extraordinary spontaneous interspecific hybrid of West Africa’s native liberica species with Ethiopia’s indigenous arabica.

Breeding and selection take significant time, evidenced by Kent’s decade-plus lag between discovery and proliferation. Unsurprisingly, in areas affected by the 19th-century rust epidemic, the notion of waiting for the...
plodding science to answer a pressing economic concern was unpopular. Impatient and desperate, farmers turned to rust-resistant coffee species Coffea libicica, which had been only sparingly planted before rust. It was quickly distributed through Indonesia and the Philippines. In Indonesia, the Dutch also began experimenting with robusta. Robusta (Coffea canephora), well known to indigenous groups near its genetic origins along the modern border of Tanzania, Uganda and the Democratic Republic of Congo, wasn’t added to botanical taxonomies until the end of the 19th century. Having now mapped both the arabica and robusta genome, scientists are confident that robusta is one of arabica’s genetic parents. The other is a commercially unviable species called eugenioides.

When robusta was introduced to Southeast Asia, it would make another important genetic contribution to arabica. The improbable occurred on the Pacific island called Timor, now split between Indonesian sovereignty and that of the independent nation of Timor-Leste. There, arabica spontaneously crossed-bred with robusta, creating a new interspecific hybrid. This was a singular feat: Arabica is tetraploid; it has four sets of chromosomes. This makes it theoretically incompatible for natural breeding with its diploid (two sets) ancestor.

Regardless of plausibility, the Timor hybrid, often called “Tim Tim” locally, became a regional favorite shortly after it was first observed in the early 20th century. It now provides the baseline genetic source for nearly all disease-resistant arabica cultivars, the most common of which are collectively referred to as Catimors and Sarchimors. Despite their robusta heritage, these cultivar groups are classified genetically as arabica and are widely planted throughout the world.

Resistance, interlinked with genetic complexity and variation, continues as the foundation of farmer support research worldwide. Many specialty coffee professionals are familiar with World Coffee Research (WCR), whose genetic collection network includes seed and tree banks in Costa Rica (CATIE), Cote D’Ivoire (CNRA), Ethiopia (EBI) and Madagascar (FOFIFA), each of which has developed its own resistant hybrids and selections. Ethiopia’s Jimma Agricultural Research Center (JARC) is one of the world’s most important gene banks for coffee. There are numerous others. These few examples stand testament to the fact that nearly every coffee-producing country has at least one such organization.

A 6-cent-per-pound tax on exported coffees funds the FNC—one of the world’s largest and most high-profile coffee organizations. Laser-focused on improving volumes and prices countrywide, the FNC has been developing and releasing productive coffee cultivars for decades under its Cenicafé research division.

In Colombia’s central department of Caldas, just a few hours’ drive from Bogotá, a beautiful brick compound nestled...
into the green rolling hills of Chinchiná serves as Cenicafé’s flagship and neurocenter.

Along its balconies, visitors can stroll among rare coffee plants, potted and labeled, laden with ripening fruits that passersby might be tempted to pick. Within its halls, however, white lab coats are the norm, and a hushed, bent-back urgency muffles the echoes as specialists go about the serious business of coffee science.

Cenicafé’s early rust-resistant cultivars—Tabi and Colombia, essentially backcrossed Catimors—were longstanding and somewhat popular alternatives to the country’s aging stock of Typica and Caturra. However, Colombia captured the world’s attention in 2005 with the release of Castillo. That cultivar is now the most commonly grown plant in the country, thanks in part to heavy marketing, national taste competition victories, and subsidized seed pricing.

Castillo’s benefits include high yields and disease resistance, but it is its multi-line composite of fifth-generation (F5) breeding that allows for genetic diversity sufficient to resist rust and other diseases holistically within a single field of trees. On a monoculture Caturra farm, in the increasingly likely event of a “super-roya” epidemic, the entire field would succumb to such a monstrous predator.

However, only part of the Castillo grove would be susceptible because—despite being 100 percent Castillo—there are multiple variations, each made up of thoroughly unique genetic compositions, in each bag of seeds. Additionally, Castillo has been divided into 16 “regional” quality variations in addition to a “general” profile. Genetic variation was injected into the very fabric of Castillo’s rust resistance.

AN EPIDEMIC WITHOUT A CURE

Shortly after Castillo arrived in Colombia, so did rust. Beginning in 2008 in Colombia, and sweeping across Central America by 2012, an especially virulent strain of CLR caught international attention. Guatemala, Costa Rica, and Honduras declared states of phyto-sanitary emergency. The losses in coffee harvest from Central America in the 2012–2013 season were estimated to be close to 2.7 million bags, around $500 million in unrealized revenue. Colombia’s harvest was down 31 percent from 2008 to 2011, Central America’s production was reduced by 16 percent.

One of the laboratories at Cenicafé. | Photo courtesy of Chris Kornman

Castillo is bred for resistance to coffee leaf rust. | Photo courtesy of Chris Kornman

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Coffee leaf rust in Guatemala. | Photo by Lily Kubota

in 2013, and another 10 percent the following season. Compound this with lost labor opportunities on the farms, harvest failures in following years (Promecafe estimated El Salvador’s harvest decreased by 54 percent in 2013–14, primarily due to rust), and the Mesoamerican coffee-growing world was in the midst of a substantial crisis.

Concurrent with CLR’s re-emergence in Colombia in 2008, the global economy took a long walk off a short pier, plunging into a worldwide recession. To add financial insult to rust’s injury, coffee farmers were hit with price increases for fertilizers. And Mother Nature did not cooperate—tropical anomalies contributed to problematic rainfall and temperature conditions, and strong winds spread the rust spores mercilessly (Avelino, J., Cristancho, M., Georgiou, S. et al. Food Sec. (2015) 7: 303. doi.org/10.1007/s12571-015-0446-9). As if this weren’t enough, scientists across the world reported the evolution of more virulent strains of many species of rust fungi as we sprinted through the early decades of the 21st century.

The epidemic of 2008–2013 was devastating. Even worse, its potential to resurface is not simply a probability, but an assured reality.

IS RESISTANCE FUTILE?

If the fight against rust starts with resistant cultivars, then it is hamstrung by specialty coffee cuppers’ tendency to regard those same cultivars as qualitatively inferior.

Castillo’s introduction in Colombia catalyzed a wave of reaction in the roasting sector, as terrified cuppers speculated that traditional varieties would go extinct in the shadow of the FNC’s drive for hardy plants. Castillo became a flashpoint that encapsulates the clash between genetic research and the specialty coffee roaster.

Setting out to test the presuppositions of willing participants, in 2014 Michael Sheridan (now Intelligentsia Coffee’s director of sourcing and sustainability, then affiliated with Catholic Relief Services as the director of the Borderlands Coffee Project), set up a series of blind trials in partnership with the Center for Tropical Agriculture (CIAT) in Colombia, WCR and the Sensory Analysis Center at Kansas State University (KSU). Twenty-five smallholder farmers in Nariño separated their Castillo and Caturra harvests, and these coffees were sent to trial by taster.

CONTINUED ON PAGE 38
Hosted at Intelligentsia’s Chicago Roasting Works, with tasting structure designed by veteran Cup of Excellence head judge Paul Songer, the panel included a strong showing of respected quality specialists: Roman Bondarenko (Keurig), Aleco Chigounis (Red Fox), Timothy Hill (Counter Culture), Jennifer Howell (George Howell), Doug Langworthy (Starbucks), Adam McClellan (Stumptown), Néstor Perilla (FNC) and Geoff Watts (Intelligentsia). I was there, too, as Intelligentsia’s national quality control manager (and like many above, my employment is now elsewhere). QC lab specialist at the time, Amanda Sawyer—who roasted every coffee twice—and I, with a great deal of help from Watta’s wife Vivi, dropped everything for a week in November, set all the tables, cupped every coffee, joined the discussion, and cleaned every cup.

Theories floated lazily around the cupping room like coffee grounds in the cooling glassware: Castillo might taste better with riper cherries and longer fermentation times, and probably had a lower quality ceiling. George Howell’s phrase “tail of the devil”—which he famously used to describe Castillo’s fabled harsh, astringent, or mouth-drying finish—was repeated with frequency. But at the end of a double-blind session, after cupping each set twice, the cultivars were in a virtual dead heat.

Cuppers were startled. The results seemed implausible. The panel agreed to reconvene and taste the same coffees, the same way, in January 2015. Perhaps Castillo would lose its edge after a few months of aging.

It didn’t. Overall, Castillo took three of the top five spots, with point scores brushing up against 90. However, Sheridan is quick to caution against moving to unjustified conclusions, as this single trial was by no means comprehensive. In his 2015 article for the Specialty Coffee Chronicle, he’s careful to mention that sampling from just 25 farms in a single Colombian department over the course of one harvest cycle is not statistically significant. “They represent a single sensory snapshot taken with a narrow-angle lens,” he states (scanews.coffee/2015/08/04/castillo-or-caturra-a-simple-question).

Yet, proof exists that resistant varieties don’t have to taste terrible. And so, it seems, the specialty coffee industry is at a crossroads. Science, slow as it may be, has forged a path toward resistant cultivars for farmers. Roasters, however, covet the romance and tradition of varieties like Caturra, Bourbon and Typica. Between the rocky reality of leaf rust and the hard place of a roaster’s scorn, how can a farmer choose?

The economics are surprisingly straightforward: Even if planting Castillo means a loss of the price premium associated with traditional varieties, the hybrid’s higher average yield and resistance to rust practically guarantee a consistent annual income close to break-even. It’s too attractive to resist.

For an established farmer with the ability to specialize in differentiated quality, Castillo acts as a safety net for lean years. But for a subsistence Colombian farmer, planting Castillo may well make the difference between destitution and keeping food on the table and kids in school. The same is true with hybrid plantings across the Americas; for the vast majority of farmers, the choice of cultivar may be a foregone conclusion. Bourbons and Caturras are dinosaurs, too slow to adapt to rapidly changing climates and diseases.

Will specialty roasters embrace the resistance? Cup of Excellence (COE) Executive Director Darrin Daniel was especially proud of the 2017 results from Nicaragua, in which the second-place COE finalist used a fungus-resistant F1 hybrid called Centroamericano (a Sarchimor crossed with Sudan Rume), and “skeptical farmers were converted based on the competition results.” Maybe the tide is turning.

Roasters in the future may not have much of a choice, however, as resistant hybrids sweep the coffee landscape. In recent years, I’ve had a number of conversations on a wide range of topics with Alfred Klein, who runs the quality-focused Finca San Carlos in Chiapas, Mexico. His Jade Centennial micro-lot is outstanding, persistently sweet with a sparkling orange acidity and notes of pear and plum. He explained recently that “the incidence of roya has
diminished ... due to the fact that very susceptible varieties have died out, and many plantations have been renovated in the last years with resistant strains.”

Yet even in fields of resistant varieties, preventive maintenance remains an imperative. “It is impossible to foresee weather and rain patterns nowadays in order to take action against the disease once the infection has started,” Klein says. “Waiting until you see the symptoms means it’s already too late.”

Resisting rust and maintaining an organic certification? Almost impossible. Finca San Carlos nearly decertified in 2017 in favor of rust prevention. Chemical solutions, too, have constraints. Klein laments that “different products the market offers are still controlling the disease, but the efficiency is not the same. All products basically come from a very small group of related chemical molecules, and sooner or later these molecules won’t work anymore. This has happened with almost all agrochemicals; it’s just a matter of time and spore mutation.”

“The other side of the equation,” he continues, “is the cost of the product and its application. With the current coffee prices, not many growers can afford preventative control, and the issue of resistant varieties is also only a matter of time. Costa Rica 95, one of the more planted resistant varieties, has lost its resistance already in some places like Honduras.”

The 2008–2013 rust outbreak began in the midst of a global financial crisis. New York “C” futures prices, as of press time, are still unsustainably low—having spent most of 2019 under $1 per pound. The current coffee price crisis may well spark another rust outbreak; the numbers simply don’t add up for farmers to practice good prevention techniques if they can’t even meet the basic costs of production.

Even with unlimited resources, the sad reality of resistance is that it is temporary. A survey of WCR’s variety catalog is riddled of production.

Coffee quality specialists don't have to give up SL-28 or Gesha micro-lot options. It's not an either/or scenario, at least not yet. But the expectation shouldn't be for the growth of Bourbons and Caturras to the exclusion of improved cultivars with proven yield and resistance, whose sensory quality is equally good.

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CHRIS KORNMAN

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