The Coffee Rust Situation in Latin America in 1980

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At first, coffee (*Coffea* sp.) was eaten as solid food by African hunters and warriors; tribal chiefs owned trees that were given holy names (14). The food's stimulating effect resulted in jungle inhabitants setting apart bearing trees and clearing around and protecting them from close weed and bush encroachment. It was not until the dry seeds (they are actually nutlike) were roasted, ground, and steeped to make a drink, that coffee trees were brought out of the jungle and given the benefit of some cultivation. It became widely used as a drink and entered world markets. Hundreds of years before this, coffee trees, whether wild in the jungle or African chief-owned and sacred, were being attacked by *Hemileia vastatrix* Berk. & Br., the fungal pathogen that causes yellow leaf rust.

The cropped species, *Coffea arabica* L., although sometimes ill cultivated, brought money to planters and owners in many African, Asian, and tropical island economies. Wherever the rust fungus attacked coffee trees in these eastern hemisphere lands, it caused leaf drop and eventual tree death; rust was the most severe of all coffee diseases. Conditions were favorable for its increase and spread. Effects of coffee rust were dramatic; crops failed year after year, people emigrated from where their families had been for generations, shipping lanes were empty, banks and companies failed, and whole countries became poverty stricken (2,7,9,12,14).

Fortunately for coffee drinkers, the crop was introduced into the western hemisphere tropics where there was no rust. Planters adapted old methods of cultivation to the Americas, and invented some new ones of their own. Coffee growing without rust flourished and the crop kept and shipped well, so metropolitan coffee drinkers turned to Latin America for most of their stimulating drink. Coffee production was profitable; it became a way of life in the West Indies, Mexico, and in Central and South America. With abundant labor and vast lands available, broad fields were transformed into huge coffee plantations in Brazil, and that country became the world's primary source of coffee. Coffee growing and shipping has been, and still is, the most important agricultural business in Latin America; it employs millions of workers and is a significant stabilizing force in the politics of several countries (10).

In 1903, during the early years of research on coffee in Latin America (13), growers and scientists were distressed and fearful to learn that a shipment of rust-infected experimental seedlings had been sent by mistake across the Pacific Ocean to an experiment station in Puerto Rico. The story is well known of how experts who received the seedlings recognized the leaf spots on them as rust. They destroyed the glass shipping cases, the plants, pots, and soil, and washed everything down with pure formaldehyde so thoroughly that no rust spores escaped into Latin America at that time.

This was a close call, and it was never forgotten by plant pathologists in tropical America. Coffee research workers were familiar with the century of coffee rust control studies in the eastern tropics. They also knew that the high producing, high quality coffee cultivars in Latin America were susceptible to rust. It was obvious to them that fortune would smile on Latin America only so long as there was no coffee rust. Coffee pathologists have ever since remained especially vigilant about rust. They have feared it. Some good popular education developed from that; from it there is now a widespread understanding that resulted in a remarkable self-imposed quarantine by planters. Intelligent growers visited eastern coffee lands, but did not bring back living specimens of unusual coffee species because they knew that it is on seedlings that there is the greatest danger of bringing in rust. Men have long feared that rust pathogens might cross the Atlantic from the west coast of Africa to the east coast of Brazil; the distance is not too great for the prevailing winds to carry the spores across that expanse of water.

The Two Rusts

The longest known, and apparently the most devastating and feared of the coffee rusts, is the yellow rust, which is caused by *Hemileia vastatrix* Berk. & Br. It was found by an official explorer on wild coffee in east central Africa and mentioned in a report in 1861. From there it has spread worldwide in coffee-growing countries; almost always when coffee rust is mentioned this is the fungus species involved. It brings excessive costs to coffee planters and disruption to national economies.

The second coffee rust is called the gray rust, which is caused by *Hemileia coffeicola* Maubl. & Roger. It was described in 1934 from Cameroon in west central Africa, is now outside that country, and is slowly spreading into contiguous lands. There is reason to believe it also will eventually spread worldwide.

The well-known symptoms of yellow rust are the classic orange-yellow, dusty round pustules on undersides of coffee leaves. The gray rust causes fuzzy gray pubescence on the underside of enlarging more-or-less transluscent leaf blotches. Both diseases are characterized by severe leaf drop and eventual branch dieback.

The special reason for mentioning gray rust is that it will eventually extend to Latin America, and when it does, it may arrive when all Latin American coffees are resistant to yellow rust. Research has shown that the present yellow-rust-resistant coffees are susceptible to the gray rust and research techniques are still being sought for the best ways to study it. The coffee growers in the African tropics, not to mention those in Latin America, do not have coffee cultivars needed that are both agronomically satisfactory as well as resistant to the two rusts.

Rust in Brazil and Further Spread

In 1970, Brazilian coffee growers and pathologists were startled to find and identify yellow rust in their country. It was on trees that had been growing under natural shade in the eastern state of Bahia. The plantation was an old one and near the city of Itabuna (2,7,8,11,12). The rust was found over a very wide area. Specialists were quickly called and programs of containment were outlined. These programs cost immense amounts of money and consisted of spraying, cutting down and burning rusted trees, and establishing official sanitary corridors or zones between rusted and healthy plantations. The sanitary corridors were wide and everything possible was done to clean up rust in them and then prevent passage through them of people and materials that might carry rust spores. It did not work; the rust pathogen continued to spread.

It spread from Bahia into Minas Gerais and onward to Paraná, which was frightening because the latter state is the greatest arabica coffee-growing state in Brazil or any other country. Plantations

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there are huge and situated next to one another. Rust started in them and made rapid progress. To those seeing it and knowing about it, the appearance of rust presented a bleak future to coffee growers in Brazil, as well as to those in all the rest of Latin America (2,3,5,8,12,13,15).

Meanwhile, the pathogen moved onward. It went from the states of east and south Brazil across to parts far west and north. Nothing stopped it; valleys, hills, quarantine methods, wide stretches of jungle, nothing. Not surprisingly, by 1974, it had reached Argentina and Paraguay, and from there it reached Bolivia by 1978. Moreover, it spread north and west across the great and sparsely settled Amazon basin and by 1974, to the region near the city of Acre at the eastern edge of Brazil. In South America, by 1978, the rust was present in Peru and on its border with Ecuador. This spread over many thousands of kilometers had occurred within only 8 yr. In 1976 it had spread beyond South America, suddenly appearing in Nicaragua, which is near the center of the coffee-growing countries of Central America. By 1979, a short 3 yr later, rust was found in El Salvador at the end of the dry season.

In Latin American coffee countries, in which only arabica coffee is grown, there are at present hundreds of millions of trees wholly susceptible to rust. From a century of previous research work on the rust in Africa, Java, and India (now confirmed in Brazil) it is known that environmental conditions good for coffee trees are good for rust. This fungus is a highly specific tree parasite, confined to its broad-leaved tropical evergreen host. The conditions are ideal for severe disease, and for large losses from it.

However, world coffee business does not need to depend on a current year's crop of coffee from one area. Rust that wipes out production may be ruinous to local growers, but there is considerable stored coffee. It is typically dry-processed, and the so-called "beans" or "grain" can withstand years of proper storage and long shipments without deterioration. Futures in the Latin American coffee market continue to look good after the advent of the rust epidemic. Manufacturers (roasters, grinders, and packagers) apparently now see the coffee source as dependable. This conclusion is particularly valid when it is known that vigorous coffee disease control research is well advanced in the Americas.

Impact on Growers

When it becomes obvious to Latin American plantation owners that their cherished coffee trees either have been, or are going to be attacked by the dreaded rust pathogen, their first feelings are naturally of fear. They are well aware that the standard quarantine measures to stop it (the setting up of "clean zones" between their holdings and rusted plantations, eradication systems, and spraying operations to halt rust spread) all have failed (2,3,7,11) and that every one of their trees is susceptible to rust. One encouraging thing that has happened is that growers are consulting with each other and with agricultural agents to understand all they can about the coming danger. Much already has been published (eg, 1,4,6,9,11,13,15,16).

Coffee is a long-lived, broad-leaved evergreen tree crop and a leaf disease on it does not suddenly wipe out a plantation as can occur with rust in a field of a cereal crop. The first phase of coffee rust attack may not even be seen. A cluster of slightly infected trees requires over a year to build up enough pustules on current and last year's leaves to be a disturbing sight. It may take 3–4 yr before rust symptoms and signs become serious enough to attract a grower's notice.

In the interval from the first few spots to when leaves are dropping rapidly enough to form a blanket under the branches, a massive load of spores is released into the air. It is about then that the grower usually sees for the first time effects of this rust, spreading and more severe than any leaf spotting he ever encountered before. One of the important impacts the rust epidemic has had is to stimulate, as never before, increased attention of plant pathologists to diseases on coffee. There is no coffee-producing country in Latin America that has not increased the responsibility and funding of its professionals to study the disease problems of the crop and to publish special descriptions and illustrations of rust on coffee.

Observers know that certain trees initially are not as severely stripped of leaves as others. In spite of many rust spots, but with leaves still hanging, these trees set and mature a light crop. If there is only about a third of the leaves rusted on a tree, it may bring to maturity almost a full crop. In the first few years, a large number of such trees in a plantation will give the impression the rust is something that can be overexaggerated as a threat, and some growers feel that consultants and publications may have overestimated the dangers of the disease.

However, history is clear. The Latin American planter learns not only how serious the early rust scourge was, but also how in the eastern tropics, after over a century of research, coffee is produced now where it was once killed by rust. Western hemisphere planters, who are backing local people in research studies, are confident their rust problems are being, and will be, solved. Literature has shown that Ceylon (Sri Lanka) between 1868 and 1873 fell from being the richest and biggest shipper of arabica coffee in the world to being a poor country because of rust. Shortly afterward, Java became the top shipper of coffee, but when rust came in there, coffee yields quickly dropped to less than one third of normal. Rust losses in India and the Fiji Islands left planters bankrupt; businesses in those countries fell into ruin. Meanwhile, the disease had come under vigorous study and it appeared that it could be controlled. Pathologists now know that these rusts will continue to need continuous study, in both old and new world tropics (2,4–6,10,12,13,15,16).

To the rust-conscious coffee planter in Latin America, a revoluntionary change is occurring in his farming methods. In some moist localities coffee traditionally is planted in a mixture with shade and other trees, which becomes almost a self-sustaining semiforest, requiring only minimal attention except for replants and harvesting. Sooner or later this primitive type of coffee farming loses out. With the new information available, leading growers are viewing their future as surely to be affected by the presence of coffee rust. Attention is being given to more effective practices: the right amount of yearly pruning and weeding, the placing of shade trees, better spacing between rows and within rows, trying new cultivars, applying fertilizer, and using sprays (these are mostly copper-based combined with good stickers).

Spraying Problems

After coffee rust was found in Brazil, some scientists and growers realized that spraying would be essential to control it. Fortunately, trained pathologists were on hand who knew about spraying problems, and this treatment was vigorously adapted to Brazilian conditions (2,7,8). Brazilian pathologists were familiar, by visits and by reading the literature, with the results of decades of coffee spraying in the Old World tropics. In Brazil, further studies of this disease were made about spore spread, climatology, and spraying with organic, as well as copper fungicides, for rust control, growth habits of the host tree related to spraying, better arrangement of trees under Latin American field conditions to help in rust control, and the effects of bringing in the process of spraying on farm operation and organization. In remarkably few years, as expensive as it is, spraying is no longer foreign to coffee growers, and in some plantations it has become an established practice.

Spraying to control crop disease has long been used successfully in temperate zone agriculture, but it was not readily accepted in the tropics. Besides the shortage of trained labor and the extra expense, there also are technical problems. Spray equipment, chemicals, and containers brought in from the temperature zone deteriorate rapidly in the tropics. Often adequate water for spraying is not available because rains sink so quickly into the permeable, volcanic soils. Shipping problems can be colossal and sometimes transport costs greatly exceed those of the spray chemicals and the machines. In addition, in many parts of the tropics, tradition is against spraying coffee. In any case, planters reluctantly turned to spraying in Latin America.

Recommendations for controlling coffee rust by knapsack spraying differ among countries and different regions of a country. It may take two to five sprays per year (more in some localities where wet seasons are extended) and this must be done for years to come. It depends, of course, on climate, the economy of a country, and the amenability of the labor force to spraying technology.

Spraying has to pay for itself. There may be no alternative to it where rust stares the grower in the face and he has nothing but susceptible trees. Yields of coffee vary tremendously, and the cost of spraying adds at least 10–20% to total expenses of production. In fields that yield only 300 or 400 kilograms per hectare, spraying is not worthwhile. Better growers who average 800–1,200 and even 1,500 kg/ha can increase those yields even more by spraying and find it profitable (if they do not spray, their crop eventually will fail completely). Where conditions, soils, tree cultivars, and husbandry are the best, production may reach 2,500 or more kilograms per hectare if spray is applied.

Severely affected plantations, with diseased trees that are languishing and nearly dead, can be salvaged if spraying is started before trees have died. Where rust is established it is found that, on the average, spraying increases yields at least from twofold to threefold. Where it can be done, and other factors are not limiting, spraying against coffee rust is economically feasible (2,7,10,11).

Resistance to Rust

Spraying is not always practical in the tropics; costs have continued to rise and Latin American plant pathologists know it is necessary (1–3,6,9–15) to develop acceptable coffee cultivars resistant to the rust. Rust-resistant coffees are widely planted in the Old World tropics. From Brazil, researchers were sent decades ago to Portugal where they worked on rust resistance (1,9); when the rust was finally seen in Brazil in 1970, they were ready to grapple with resistance for that country and all of Latin America.

The spectacular successes of breeding for rust resistance in cereals has influenced much of the thinking on rust resistance in coffee. However, in coffee it is more complex; the coffee plant is a tree and it is grown under tropical conditions. Arabica coffee is a self-pollinated plant, but the characteristics and productivity of the trees are subject to considerable environmental variation. Selecting for productivity requires much more time than for cereals. From coffee tree seed to the first crop is three years. Coffee tends to bear heavily one year and lightly the next. Data from several years are required to verify a selection's productivity. We have observed (*unpublished*) that a leaf disease attacking coffee trees during a heavy bearing year causes less crop loss than if the trees become diseased during a light bearing season. A tree completely stripped of leaves on a light-bearing year is seriously injured by root collapse, and foliage recovery is slow. Of course, no matter when it occurs, repeated leaf loss eventually ends in the death of the tree. Such repeated leaf falls happen with rust. Counts of leaf fall in many leaf spot diseases often give confusing results. The season when data are taken makes a great difference. Also, the amount of toxicity affecting a tree from its diseased leaves requires estimation. There is no dormancy period and rust spores are ever ready to attack. Moreover, this parasite has been shown to have many races (1,2,9,14). This all means complications. Similar to cereal crops, when selected for simple resistance to one race or a certain group of them, coffees will eventually become diseased by attack from a physiologically different rust race.

Before coffee rust was found in Brazil, many Latin American coffee growers, with their superb but rust-susceptible varieties such as bourbon, caturra, mundo novo, typica, and others, were not likely to worry about rust. However, some research workers and others were concerned. For this reason, a mission backed by the Federation of Coffee Associations and the U.S. Government was sent in 1952 into 25 countries around the world to become acquainted with coffee growers of the East, to obtain rust-resistant and wild coffee seeds, to see rust control measures, and to study rust ecology (14,15). There was considerable impact from this action. Coffee growers became more knowledgeable about the drastic effects of rust should it come to the Americas. Information was spread widely about the probabilities and steps to be taken in anticipation, and seeds of many kinds of coffees were secured for Latin America (12–15). During this trip, special impetus was given to acknowledging and supporting the Coffee Rust Research Center in Portugal. While the mission was in Africa and Asia, live samples of yellow rust were obtained and sent by special means back to the Center in Portugal where they were used to study rust races (2,9).

All seeds from outside the Western Hemisphere were handled with extreme care by U.S. Plant Quarantine officers. Samples of coffee collections were offered and sent by air as guaranteed rustfree seedlings to several Latin American agricultural experiment stations. In some cases only a few seedlings grew, and the most complete array of the coffees (12) went to the tropical station of the Organization of American States in Turrialba, Costa Rica. (These collections have been much increased by several workers; the core comes from the 1952 mission.)

When "wild" arabica coffees have been tested growing rustfree in Central America next to the best arabica selections, the "wild" ones are seen to yield less. However, many "wilds" are rust resistant or rust tolerant and in the presence of the disease gave regular crops, while the crops of exceptionally fine Latin American cultivars failed. One of the "wilds" (eg, "Geisha") is not only a reasonably good producer, but it also is commercially acceptable and is being used in breeding programs. The mostly rust-susceptible, much grown *C. arabica* coffees are genetically tetraploid, open-pollinated plants and are readily crossed to give progenies that can be tested for disease effects. However, *C. canephora* Pierre, a less acceptable "robusta" type, is diploid, small-seeded, and open-pollinated, but it is highly rust tolerant. Desirable crosses between these species are difficult to secure by artificial means, but a few are known, even some by natural accidental crossings. One of these, the "híbrido de Timor," is a good coffee resistant to a wide range of races of the rust fungus and is being used in backcrosses with some of the highest yielding, best quality arabica coffee trees in Latin America.

As coffee geneticists have worked worldwide, they have found that specific genes must be present to insure resistance to certain rust races. In some instances, the genetic system is quite complex. In any case, wide resistance in coffee is dependent on multiple genes and the best possibilities for this resistance appear to be from interspecific crosses. The "híbrido de Timor" mentioned above seems to be promising in this regard. There is another interspecific hybrid possibility between the arabica coffee and *C. liberica* Bull. This latter coffee is a diploid, large-fruited, tall, and rugged tree. A rare accidental hybrid of this, now in Turrialba, was found in the East Indies and is known as the "Kawasari." It has been shown to possess usable rust resistance and is being backcrossed with susceptible arabicas. Resulting descendents from it are being multiplied and studied. Some of these; eg, breeding lines S.288-23 and S.333 show good rust resistance and are being used commercially.

CONCLUSIONS

Coffee rust is the most serious plant disease problem in all of Latin America. A good degree of rust control is obtained by spraying, but expense and terrain will make it impossible in some places. It is believed that humans can survive without the benign stimulus of coffee (probably unhappily in some instances). However, until it becomes too expensive, it will continue to be a popular world market product of tropical agriculture. Millions of people in many important tropical countries can continue to depend upon coffee culture for their livelihood. It is reasonable to predict that there will always be good and accepted rust-resistant coffees. Growing methods have changed as a result of the rust incursion in some parts of Latin America, and will be modernized and improved even more. When all this comes about, the metropolitan and other consumers, and the intelligent coffee growers and research workers of coffee, will be on a sounder basis than ever for profitable mutual exchange.

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