coffee leaf rust (Hemileia vastatrix)

Host plants / species affected
Coffea (coffee)
Coffea arabica (arabica coffee)
Coffea canephora (robusta coffee)
Coffea liberica (Liberian coffee tree)

List of symptoms/signs
Fruit - lesions: scab or pitting
Fruit - lesions: on pods
Leaves - necrotic areas
Leaves - abnormal colours
Leaves - abnormal leaf fall
Leaves - fungal growth
Stems - discoloration of bark

Symptoms
Yellow to orange powdery blotches appear on the underside of leaves, with corresponding chlorotic patches on the upper side. Initially these are only 2-3 mm diameter, but steadily expand and can eventually reach a diameter of several centimetres. Young lesions may appear as small chlorotic spots before sporulation occurs. The centres of older lesions become necrotic and the sporulating zone is restricted to the outermost zone. On older leaves, several lesions may merge to produce irregular diseased areas covering much of the leaf. However, diseased leaves are usually shed before this stage and a major effect of rust is to cause defoliation. Under humid conditions, hyperparasitic fungi such as Verticillium lecanii grow over the lesions, producing a pale mycelial growth. Very occasionally, rust lesions may occur on young green stems and berries.

Prevention and control

Chemical Control
Due to the variable regulations around (de-)registration of pesticides, we are for the moment not including any specific chemical control recommendations. For further information, we recommend you visit the following resources:
Resistant Cultivars

Early attempts to use resistance in Africa and India were thwarted by the development of new virulent races of the pathogen. The Kents cultivars which had performed well in India soon succumbed to the disease in Africa. Application of fungicides is still the most widely used method of control (Muthappa et al., 1989), but cultivars combining high yields with good quality and apparently durable resistance to rust are now being produced.

The establishment of the International Coffee Rust Research Centre in Portugal enabled the genetics of the coffee rust pathosystem to be elucidated (Rodrigues et al., 1975) and it was shown that this was based on five resistance genes and five corresponding virulence genes in the pathogen. The 32 races of H. vastatrix which were possible could overcome all known major gene resistance in arabica coffee at that time. The discovery of Hybrido de Timor, a natural hybrid between Coffea arabica and C. canephora with resistance to all races, and its use in breeding programmes in Brazil and elsewhere, enabled new resistant varieties to be produced. Other interspecific hybrids with resistance to rust have been used in India. Crosses with cultivar Caturra produced the 'Catimor' hybrids and have been used in breeding programmes to produce rust-resistant cultivars (Van der Vossen and Walyaro, 1981); these are now being widely planted in several countries (e.g. cultivar 'Colombia' in Colombia, cultivar 'Ruiru 11' in Kenya and cultivar 'Cauvery' in India). Hybrido de Timor and other C. arabica and C. canephora hybrids such as lcatu can possess both major gene and polygenic (partial) resistance to rust. Eskes (1989b) provides a detailed review of rust resistance in coffee and Carvalho et al. (1989) review breeding programmes. New races able to overcome the rust resistance of interspecific hybrids now seem to be emerging.

Biological Control

Although not in commercial practice, fungal hyperparasites such as Verticillium lecanii are being developed and tested for potential uses as biocontrol agents against coffee rust (Eskes, 1989a; Alarcon and Carrio, 1994). Certain Pseudomonas spp. may induce resistance (Porras et al., 1999).

Impact

Introduction

When coffee rust first appeared in Sri Lanka during the latter part of the 19th Century, it caused enormous damage to coffee productivity and resulted in the collapse or conversion of many coffee estates as reduced yields made coffee growing uneconomic. Many of these were replanted with tea, which is supposed to have reinforced the tea drinking habit in the UK. As the disease subsequently spread to arabica coffee areas in southern India and other warm, moist coffee-growing areas in South-East Asia, it continued to cause havoc in the coffee industry (for full accounts see Large, 1940 and Carefoot and Sprott, 1969). However, coffee grown at the higher altitudes of these countries (for example, western Ghats in India) largely escaped the ravages of the disease (Muthiah, 1993) and the situation eased as control measures based on shade management and use of fungicides were instigated. In the East African highlands, in the Andean countries of South America, and elsewhere coffee rust is of little significance at higher cooler altitudes (>1700 m asl in equatorial areas). Coffee rust is now endemic in all major coffee producing countries and requires control wherever
arabica coffee is grown under warm humid conditions.

**Effect on Yield**

The major effect of coffee rust is to cause premature shedding of leaves; this reduces the photosynthetic capacity of the plant and restricts the growth of new stems on which the next season's crop is borne. Disease severity in one year therefore directly affects the cropping potential in the following year and the disease has an insidious debilitating effect on the plant over successive seasons. The disease can render coffee cultivation uneconomic wherever it reaches epidemic proportions. Severe disease can also affect the crop of the current season, as defoliation causes carbohydrate starvation of heavily bearing trees. This leads to premature ripening of berries that produce poor-quality, 'light' coffee beans. Because developing berries are a strong physiological sink for nutrients, a condition known as overbearing dieback may occur when shoots and roots die back as nutrients are preferentially translocated to berries. This may eventually kill the tree. The tendency of the disease to be more severe on heavily bearing trees can lead to a biennial bearing cycle where seasons of vegetative growth alternate with seasons of heavy cropping and severe rust. However, the relationship between disease severity and yield loss is complex, not only because of the inter-seasonal effects, but also because other factors affecting tree vigour inevitably interact (Kushalappa, 1989). Attempts have been made to develop regression coefficients between disease severity and yield loss but these are variable (Chalfoun, 1981). Generally, low levels of rust have no discernible effect and as a rule of thumb 5-10% incidence 3 months after flowering has been taken as a threshold level (Waller, 1982; Sierra et al., 1995).

**Factors affecting Disease Severity**

The disease is most severe on arabica coffee grown at lower altitudes (below about 1500 m asl) where warmer temperatures permit greater infection during wet periods and a shorter latent period (Rayner, 1961). The physiological state of the tree also has a direct influence on susceptibility to rust. Heavily bearing trees or branches are more susceptible (Monaco, 1977). Rust severity is known to be less under shaded coffee and this may be related to yield levels as fully exposed coffee produces higher yields but is more susceptible. Thus the use of shade in managing coffee rust has an economic impact as potential yields are reduced. Susceptibility has also been related to the mineral content of leaves (Carvalho et al., 1996) and to starch content (Zambolin et al., 1992). Some genetic resistance to rust is present in many cultivars but is seldom effective against many races of the pathogen. Race non-specific or durable resistance is partially effective in some commercial cultivars grown in India and Kenya, but effective resistance against all races is present in some derivatives of crosses with Hybrido de Timor, for example Catimor hybrids. These now offer the most economically effective control of the disease. H. vastatrix also occurs on robusta coffee (C. canephora) but is much less severe. However, in some countries such as Uganda certain clones of C. canephora are susceptible, with moderate defoliation leading to some yield reduction (Hakiza, 1997).

**Disease Costs**

The economic impact of coffee rust occurs not only through reduction of both quantity and quality of yield, but also through the need to undertake expensive control measures on susceptible cultivars. Because of the difficulty of accurately partitioning and measuring losses caused by coffee rust from those caused by other pests and disease, agronomic factors and their interactions, there are few records of quantified yield losses caused by rust. Most published data comes from the early experiences in Ceylon. Between 1871 and 1878,
the years immediately after coffee rust became widespread, yields declined from 4.5 cwt/acre to 2 cwt and the area under coffee decreased from 68,787 ha to 14,170 ha by the 1890s as uneconomic plantations were abandoned. Coffee production was reduced by 75% and amongst other knock-on effects the Oriental Bank collapsed (Large, 1940). Monaco (1977) estimated a 30% reduction in coffee yields in Brazil if no control measures were undertaken. Costs of control using a complete fungicide control schedule were estimated at US$67/ha or US$74m for the whole coffee area of Brazil under threat, representing some 9% of the value of coffee exports. Costs of chemical control vary between countries but relative to coffee prices the costs of inputs in the form of fungicides, sprayers and labour have increased relentlessly. These were estimated to have risen in equivalent ‘farm gate’ costs per hectare from approximately one 60 kg bag of coffee to 4 bags between 1976 and 1982 (Waller, 1982). In Brazil (Eskes, 1989) and India (Narasimhaswamy, 1961), control costs were estimated to be about 10% of production costs. In Kenya, Nutman and Roberts (1970) estimated that the annual costs of protecting 18,700 ha of coffee at most risk from rust were US$810,000 for a yield benefit worth US$2.9m. Eskes (1989) estimated overall global costs of the disease at between US$1 and 3 b/year. Before the advent of effective resistance in the form of Catimor hybrid derivatives, much effort was put into improving the economic effectiveness of coffee spraying both through disease forecasting techniques (Kushalappa, 1989) and through improvement in spray application technology (Waller, 1982). Problems are particularly acute for smallholder growers who can ill-afford investment in spraying machinery, chemicals and labour before receiving payment (often delayed through complex marketing channels) for their crop and in marginal or mountainous areas where potential yields are low and labour costs of spraying are high. Lack of rural credit facilities and static prices on the international coffee markets exacerbate the problem. In many areas substantial savings can be made in the costs of fungicide application through improved application technology such as the use of low volume controlled droplet applications (Waller et al., 1994). Integrated management of coffee rust using a combination of shade, some chemical control and some resistance is effective in India, but the economic costs lie both in the two chemical applications per year usually used and the reduced yielding potential of shaded coffee. The increased deployment of completely resistant cultivars such as the multiline ‘Colombia’ in Colombia and the hybrid Ruiru 11 in Kenya (King’ori and Masaba, 1994), clearly provide the most economic solution (assuming continued durability of resistance). Apart from initial replanting and lower yields from young plants, they require no economic input for rust control from the farmer. However, the long term research and development costs borne by the industry, national governments and international aid agencies in producing and deploying these varieties, although difficult to calculate, must be very large.