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Current research trends on coffee wilt disease tracheomycosis

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Abstract

Coffee is an important and leading cash crop in Uganda. Pests and diseases are among the major production constraints, which reduce both productivity and quality of coffee. Coffee wilt disease due to Fusarium xylarioides Steyaert (Gibberella xylarioides Heim & Saccs) on robusta coffee was confirmed in Uganda in 1993 in Bundibugyo district bordering the Democratic Republic of Congo. By the end of 1998, the wilt was confirmed in 18 districts, to the south and east of the point of origin. Disease incidence varies from a few infected trees to over 90% tree mortality. The control measures being implemented are sensitisation of farmers and civic leaders about the disease, urging farmers to cut and burn affected trees in situ, restriction of movement of unhulled coffee, a ban on use of coffee husks as mulch in coffee and replanting on new land. Little information is available on the biology and epidemiology of the disease, which would form a basis for formulating control measures. Considerable loss of trees and in revenue is likely to continue in the absence of effective control measures. There is, therefore, urgent need to intensify research in these areas to identify sources of resistance which are basic in formulating effective control strategies. This paper examines research directed towards the search for durable solution to the coffee wilt problem.

Key words: Coffee wilt; *Fusarium xylarioides*, research trends.

Introduction

Coffee is the chief foreign exchange earner contributing over 50% of the country's entire foreign exchange earnings, valued between 300-400 million dollars annually. Over 2.5 million people directly depend on coffee cultivation and trading for their livelihood. Both arabica (Coffea arabica L) and robusta (C. canephora Pierre) are cultivated. Robusta is cultivated at lower and warmer elevations (1000-1300m) on 240,000ha, while arabica is grown from 1300-1800m, on 39,000ha. Total annual production is about 4 million bags (60kg) of clean coffee (Anon., 1997). About 85% of the coffee-growing districts cultivate robusta. Robusta comprises 90% of total production and arabica makes up the other 10%.

Pests and diseases are among the production constraints in coffee production. Diseases such as coffee leaf rust (Hemileia vastatrix Br. & Br.) and coffee berry disease (Colletotrichum kahawae Sp. Nov.) have well-established control strategies. The appearance of coffee wilt disease *tracheomycosis* in Uganda has caused grave concern due to limited available information on the disease, lack of effective control measures and the ability of the disease to spread quickly causing devastating losses. Since the re-emergence of coffee wilt in Central Africa in the 1980s, the disease has caused widespread losses of C. canephora in the Democratic Republic of Congo (Flood, 1996). Guillemat (1946) reported the disease for the first time on Coffea excelsa in the Central African Republic in 1946. Muller (1997) indicated that the first case of the wilt disease was reported by Figures in a plantation of C. excelsa located near Bangui in 1927. Coffee wilt disease is a major economic threat to Robusta coffee production and trade in Uganda and to the rest of the countries in the Eastern and Central African countries. Tracheomycosis has so far attacked only robusta coffee in Uganda but remains a threat to arabica coffee. Pieters and Van der Graaff (1980) and Girma (1997) reported that in Ethiopia no wilt occurs on robusta coffee though robusta may be adjacent to infected arabica coffee field. Wilt is of economic importance in arabica coffee in Ethiopia.

In contrast to some other coffee diseases, which may cause losses to the farmer for one season or loss of a few trees, tracheomycosis causes death of all affected trees. This means that if coffee is the only source of income, all previous investments put into coffee production is completely lost. Tracheomycosis, therefore threatens the livelihood of millions of smallholders who depend on coffee for income, in Uganda and other parts of Africa. Though rate of spread in Uganda has not been established, the spread from 1 (one) district in 1993 (Hakiza, Unpublished report, 1993) to 16 districts in 1998 is very rapid. Studies conducted by Scientists of the Coffee Research Centre at selected sites show that rate of spread varied from site to site and from month to month (from 5% - 35% tree loss/ month). Some farms at some sites lost over 90% of coffee trees in their plantations in 7 months, though the majority lost 45 – 70% of their trees within the same period. Tracheomycosis is therefore one of the major factors which is likely to escalate in poverty, food insecurity and backwardness at grass roots level. At the national level, revenue loss from coffee will reduce domestic savings and reduce the capacity of government to improve services to the people. To combat coffee wilt, there is dire need to conduct research to add to our store of knowledge on the disease. This paper reviews the status of the disease in Uganda and discusses some of the control measures being advocated and research in progress to combat the disease.

Symptoms

The symptoms exhibited by infected coffee trees in Uganda are similar to those reported in literature (Van der Graaf and Pieters, 1978; Potchet, 1988; Coste, 1992).

- On multiple stems, usually only a single stem is affected at a time, in both old and young coffee.
- The first symptoms are seen as leaves curling inwards. The leaves may also wilt and feel dry to the touch. Yellowing may or may not occur.
- Sudden leaf fall may occur within a few days of the first symptoms.
- Primaries/bearing branches remain bare after leaf fall. A few leaves may sometimes remain at the top of the main stems.
- Black or brown to violet streaks/bands are observed on the wood when bark is peeled off the stem.
- Sometimes cracks or cankers occur at the collar region. Black granular structures may sometimes be observed in bark crevices at the colar or just above the collar region. These are perithecia of the sexual stage (Gibberella xylarioides (Heim and Saccs)). F. xylarioides is heterothallic, thus male and female conidia (macroconidia) are produced. The female conidia are more curved than male conidia. Chlamydospores are rarely produced.
- Affected trees remain firmly rooted to the ground and do not topple on pushing
  and may take a few weeks to die and dry up. Affected trees never recover. Even if they produce suckers, these later dry up and also die.

Control strategies in operation

Immediate intervention

The first step taken in this direction was training of both extension staff and farmers in disease recognition, followed by sensitisation of farmers and civic leaders. Sanitary control measures were then implemented which include:-

- Regular inspection and destruction of affected trees by cutting trees at ground level, chopping and burning in situ. Uprooting and burning of the entire plant produces best results. Neighbouring trees should be cut back and thick mulch applied. Diseased trees when left standing in the field continue to discharge spores to neighbouring or distant trees for several months.
- Destruction of dead or severely diseased trees proceeded by superficial burning of the upper parts before any handling/uprooting trees assists in reducing dispersal of spores. Wounding trees should be avoided, since wounds provide entry points for the pathogen (Muller, 1997).
- Restriction of movement of infected plants as firewood, coffee husks and kiboko from infected areas to other areas.
- Restriction of movement of planting materials from infected to non-infected areas.
- Banning the use of coffee husks as mulch in coffee fields, as a precaution.
- Use of volunteer seedlings from forests on infected coffee plantations is discouraged. Seedlings from infested plantations may harbour the disease without showing obvious symptoms.
- Milling coffee should be done in the district of production.
- Continuous surveillance of disease in all coffee growing areas to keep track of spread and ascertain the effectiveness of control measures.
- Training and sensitisation of all stakeholders on dangers of the disease etc.

Research strategies

Prospects for long-term control measures depend on research activities, which will be implemented to generate information on:-

- Epidemiology and biology of the pathogen, to cover mode of spread and transmission, survival, presence of alternate hosts particularly, major food crops generally intercropped with coffee eg. bananas.
- Host plant resistance/tolerance is being explored by inoculation of all available germplasm, breeders' materials and current recommended arabica and robusta varieties. The same materials are also planted out on farmers' fields where coffee has been destroyed by wilt. Before release to farmers, it is essential to screen all materials for resistance to tracheomycosis.
- The effects of production systems (intercropping, soil fertility management and cultivation on non-host crops for 5 or more years followed by coffee) on wilt incidence and severity will be elucidated.
- The role of weather factors e.g. rainfall, temperature, etc. as well as soil types, effect of organic manures, are also to be assessed and correlated to wilt incidence.
- The role played by other Fusarium species found associated with F. xylarioides needs to be clearly spelt out.
- Factors responsible for the appearance and disappearance of wilt disease are to be investigated.
- The use of biocontrol agents e.g. a strain of Fusarium *oxysporum* to suppress Fusarium and use of systemic fungicides as drench in planting holes etc. are to be investigated. These could find use for spot treatments on large plantations where the farmers have invested a lot of money.

- Collaboration in research at regional and international levels needs to be strengthened in order to speed up progress through exchange of information, resistant materials etc. These will eventually provide information required for formulation of an integrated control procedure.

Progress

Inoculation methods for use in screening have been evaluated. Root dipping proved consistent and able to separate resistant and susceptible reactions and have been adopted for screening work. Results are shown in table below.

Table 1. Comparison of 3 inoculation methods: Number of plants infected (means)

Clone type	Inoculation method			
	Root dip	Stem pricking	Soil infestation	Clone means
1s/2	4.333	1.667	1.000	2.333A
1s/3	4.333	1.667	0.333	2.111A
1s/6	5.000	1.333	0.667	2.333A
223/32	5.000	1.000	0.333	2.111A
257s/53	3.333	0.333	0.333	1.333B
258s/24 (0)	3.000	0.667	0.667	1.333B
Inoculation means	4.167A	1.056B	0.556C	

Means followed by the same letters are not significantly different (P = 0.05).

Table 2. Response of coffee clones to F. xylarioides (using root dip inoculation method).

Clone type	Parameters	
	Days to 1^{st} symptoms	Days to mortality
$1^s/2$	63.0 AB	71.1 C
$1^s/3$	55.2 B	72.5 C
$1^s/6$	59.8 B	72.2 C
223/32	61.5 AB	80.5 BC
$257^s/53$	69.2 A	85.7 B
$258^s/24$ (0)	63.3. AB	99.1 B
LSD	7.5	9.6 A

Means followed by the same letters are not significantly different (P = 0.05).

Inoculations of the 6 robusta clones under laboratory Inoculations of the 6 robusta clones under laboratory conditions showed all of them to be susceptible to wilt ($1^s/2$, $1^s/3$, $1^s/6$, 223/32, 257/53 and 258/24). Symptoms appeared within 48-66 days and test plants died within 55-80 days. Reports from the field of wilt attack on clonal coffee have been received and confirmed from several districts.

Possibility of major food crops and weed species in coffee plantations acting as alternative hosts for F. xylarioides is being studied. In Nigeria, F. xylarioides was isolated from tomato plants (Onesirosan and Fatunla, 1976) following the isolation of F. xylarioides from banana (Musa sp.) roots and combs.

The fungus was recovered from a few samples of coffee husks at frequency of only 0.3%. Frequency of isolation was highest in twigs (86%) followed by stems (78%) and roots (64%) (Hakiza, 1998 unpublished reports). The pathogen can survive in these materials which can be transported long distances.

Discusions and conclusion

The availability of epidemiological data on coffee wilt, particularly, the effects of rainfall, temperature, soil types and crop management systems on the manifestation of this disease, would greatly facilitate coffee cultivation in Uganda. It is not clear whether new outbreaks in Uganda and the reappearance of the disease in the Congo could be attributed to mutation in the pathogen or a confluence of environmental conditions favouring the disease. Such environmental conditions or changes in the pathogen has been observed in many pathosystems (Martin and English, 1997). The answers to these questions have implications for implementation of immediate control strategies and defining the direction of breeding (Martin and English, 1997).

According to Muller (1997), early epidemiological studies showed that infection takes place throughwoundsin the upper part (above ground) of plants, and incubation period was a function of the age and volume of the plant, but ranged from a few days to 4-6 months, followed by death of plants within 2 weeks of the appearance of the first symptoms. Micro and Macroconidia form abundantly before and at death of the plant. Infection probably occurs through microconidia, macroconidia and ascospores. There is still a lot of in-depth information required in the infection and transmission process.

The spread of wilt is probably by movement of diseased plant parts mostly as firewood, muvement in rain splash, wounds made by farming tools and animal activities such as grazing. Direct observations in the field have revealed occurrence of the disease along tracks where grazing animals are allowed in infected fields. Farmers have observed that wilt symptoms tended to be more severe on bearing trees than on non-bearing trees.

Symptoms were also observed to appear soon after flowering, thus implying stress due to bearing is a predisposing factor in the host plant. This view is shared by Levoy and Berry (1997) who also observed that the disease was worse in trees under stress.

Management practices influencing the disease will have to be more clearly sorted out. Under Uganda conditions the disease affects robusta irrespective of management practices, an observation shared by Flood (1996). However, Pieters and Van der Graaff (1980) reported that in Ethiopia, the disease was not a problem in arabica coffee under traditional low management conditions, but when coffee was grown under modern cultural practices it often reached epidemic proportions.

The nature of soil supporting F. xylarioides should also be looked into. Studies in oil palms – with Fusarium indicated that acid soil and presence of substances which increase soil acidity (Kebe, 1997) favoured Fusarium wilt of oil palms. Clearly there is a role played by natural and cultural environment in the epidemiology of the disease. Cultivation of robusta coffee cultivars with resistance to wilt is the only effective method to reduce losses due to tracheomycosis. Use of resistant cultivars has made it possible for countries like Ivory Coast, Central African Republic and Democratic Republic of Congo to continue cultivation of robusta coffee since the first appearance of wilt. Resistance may occur among the indigenous trees, which might show different levels of resistance. Similarly, resistance may occur in different countries (Ivory Coast, Democratic Republic of Congo etc) which if accessed will provide a gene pool for breeding and selection. It is known that resistant cultivars have poor agronomic characters as well as inferior liquor qualities (Levoy and Berry, 1997). Once resistant/tolerant genotypes have been identified, ways to utilise them have to be found. This may take 5-10 years to polish them prior to release to farmers.

There are indications of occurrence of alternative host plants besides coffee as revealed in an MSc. study project (Serani, 1998). Samples collected from wilting bananas at 2 sites (Mpigi and Kibale) intercropped with coffee which was also drying of wilt, revealed presence of F. xylarioides in the banana corms. This needs a follow-up to prove that certain banana types can act as reservoir for F. xylarioides.

Although wilt is widespread, replanting on fresh land not previously under coffee is advocated, to keep coffee cultivation going, while the search for resistance continues. Robusta coffee is currently being expanded to areas previously not cultivating the crop, to minimise losses. All effort to devise a plan to prevent or delay the advance of wilt to other areas still free from the disease, especially arabica should be made. Coexistence of coffee with the disease will depend on cultivars with some tolerance to the disease, and the implementation of integrated control measures to reduce risk. It is imperative that the National Research Programme for wilt control in Uganda joins forces with other programmes in the region to successfully investigate this disease.

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