8
Screening of Arabica for Resistance to CWD

8.1 Main Findings

- Stem nicking of seedlings at the cotyledon stage was found to be the quickest and the most effective way to screen for resistance to Arabica coffee wilt disease (CWD).
- A Robusta strain of CWD caused no mortality to Arabica seedlings of several genotypes. Conversely, Arabica strains of CWD caused no mortality to Robusta seedlings.
- A range of mortalities of Arabica genotypes was found when assayed with a CWD spore suspension using the stem-nicking method.
- None of the tested Ethiopian Arabica cultivars displayed a repeatable low mortality (less than 20%), suggesting that presently there are no Arabica genotypes available that are highly resistant to CWD.
- The most resistant Arabica genotype tested was a Catimor variety. Caturra and Catuai were highly susceptible.
- One CWD strain from the historical outbreak (DSMZ62457) was found to cause at least some mortality of seedlings of three *Coffea* species: *C. canephora*, *C. Arabica* and *C. liberica*. However, no currently extant CWD strain exhibits this lack of specificity.
- The existence of a broad-spectrum CWD strain underlines the importance of carrying out regular surveys of coffee in all African countries to monitor any new disease occurrences and carry out prompt eradication, before it could spread.
- It is concluded that the Ethiopian Arabica CWD would present a serious threat to Arabica production in other countries if it spread, as has happened with Robusta CWD.

8.2 Assessment of Resistance

As with Robusta (Chapter 7), a quick and effective screening procedure is needed to screen many candidate Arabica genotypes for resistance to CWD strains. This chapter is based largely on the work of Girma Adugna (Girma *et al.*, 2009) to which the reader is referred for greater detail.

8.2.1 Artificial inoculation

Several methods for inoculation were listed in Chapter 7. Historically, the stem-nicking method, inoculating 2–2.5-month-old coffee seedlings with a suspension of a *Gibberella xylarioides* isolate (2 to 2.5 × 10^6 spores per millilitre) using a scalpel at a height of 2 cm above the soil level has been adopted as the preferred standard practice on Arabica

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in Ethiopia (Pieters and van der Graaff, 1980; Girma and Mengistu, 2000; Girma *et al*., 2005b, 2007).

In order to develop a reliable optimal protocol, a comprehensive study was carried out on three Arabica cultivars (designated resistant, intermediate and susceptible) from known field observations, which were inoculated with a standard Arabica CWD isolate (Gx2 = IMI 71975) at four different growth stages of seedlings (between 'soldier' and '2 pairs of true leaves') employing five inoculation methods, namely stem nicking, stem injection, root cut and dip, root wound and transplant into artificially and naturally infested soil. The fungus inoculum was uniformly adjusted to 2×10^6 spores per millilitre for the treatment combinations.

8.2.2 Results

There were highly significant differences between coffee cultivars, inoculation methods and growth stages of the seedlings. As indicated in Table 8.1, cotyledon and one pair of true leaf stages showed significantly higher seedling deaths, while seedlings at 'soldier stage' failed to open the cotyledon leaves which may be due to physiological shock and did not reveal typical wilting although the seedlings eventually died. When means of inoculation methods are compared, significantly higher percentage deaths were recorded for stem nicking followed by the root-dip and stem injection methods and revealed differences among coffee cultivars in their response to the disease (Table 8.2).

Artificially and naturally infested soil tests resulted in low plant deaths, though detectable treatment differences were found. Seedlings inoculated by the root-dip method developed symptoms very slowly and sometimes failed to recover after transplanting and did not show typical CWD symptoms. The stem injection method was technically

Table 8.1: Percentage of seedling death[a] in three Arabica cultivars inoculated with the coffee wilt disease (CWD) isolates at different growth stages in the greenhouse.

Coffee cultivar[c]	Growth stages[b]				
	Soldier	Cotyledon	1 pair of true leaf	2 pairs of true leaf	Mean[d]
200/71 (R)	24.5 fg	46.3 cd	48.6 c	21.6 g	35.3 A
21/79 (I)	32.5 ef	45.2 cd	48.1 c	35.8 e	40.4 A
20/85 (S)	48.1 c	68.3 a	58.8 b	38.9 de	53.5 B
Mean	35.1 X	53.3 Y	51.8 Y	32.1 X	43.1

[a] Percentage of deaths calculated from cumulative number of dead plants over total number of seedlings (20 per treatment) 6 months after inoculation; actual wilt values were arcsine square root transformed to normalize the data.
[b] Growth stages were 'soldier or hypocotyls' when the seeds emerge from the soil before the opening of the cotyledon, 'cotyledon' fully opened butterfly, '1 pair of true leaf', when one pair of true leaves are fully opened, '2 pairs of true leaf' when two pairs of true leaves were fully opened.
[c] Coffee cultivars field resistance classification: R resistant, I intermediate (moderate) resistance and S susceptible reactions.
[d] Means followed with the same letter(s) are not significantly different from each other at p = 5%. Least significant difference (LSD) values for mean comparison for cultivars, stages and interactions are 6.93, 4.61 and 7.99, respectively.

Table 8.2: Percentage of seedling death in three Arabica cultivars inoculated with the coffee wilt disease (CWD) isolates with different inoculation methods in the greenhouse.

Coffee cultivar[a]	Inoculation methods					
	Stem nicking	Stem injection	Root dip	Artificially infested soil	Naturally infested soil	Mean[b]
200/71	53.1 d-f	45.0 f	46.9 ef	24.0 g	7.3 h	35.3 A
21/79	70.5 ab	55.5 c-e	57.8 cd	17.0 g	1.2 h	40.4 A
20/85	61.1 cd	62.1 bc	71.5 a	47.2 ef	25.7 g	53.5 B
Mean	61.6 w	54.2 x	58.7 wx	29.4 y	11.4 z	43.1

[a] Coffee cultivars 21/79, 201/71 and 20/85 had resistance, moderate resistance and susceptible reactions under field conditions, respectively.

[b] Means followed with the same letter(s) are not significantly different from each other at p = 5%. Least significant difference (LSD) values for mean comparison for cultivars, methods and interactions are 6.93, 5.61 and 8.93, respectively.

inefficient in screening large number of accessions since it is difficult to pierce the seedling stems and place the required amount of inoculum at the later growth stages. The resistant (200/71) and the moderately resistant (21/79) coffee cultivars were found to be different from the susceptible cultivar (20/85), with seedling deaths of 35.3, 40.4 and 53.5%, respectively (Tables 8.1 and 8.2).

Thus, the best standard protocol in screening Arabica germplasm was deemed to be the stem-nicking seedling inoculation at the cotyledon stage using a spore concentration of 2×10^6/ml and maintaining the inoculated seedlings at high humidity (>95%) and temperature of about 23 °C for 1 week. After such a post-inoculation period, the seedlings should be transferred into the greenhouse for further disease development. The seedlings should not be uprooted and transplanted as this practice disturbs the plant system and may predispose them to the disease.

8.3 Screening Arabica Genotypes Versus CWD Isolates

Four CWD isolates obtained from infected Arabica trees, Gx12 (IMI 375906), Gx26 (IMI 375907), Gx31 (IMI 375908) and Gx43 (IMI 375909), were used to inoculate nine Arabica cultivars observed to possess a range of resistance to the disease under field conditions.

8.3.1 Results

Highly significant ($p < 0.01$) differences among the coffee cultivars and the CWD isolates were recorded with a significant ($p < 0.05$) cultivar–isolate interaction both in terms of percentage seedling death and incubation period (from inoculation to first symptoms) (Girma and Mengistu, 2000; Girma and Hindorf, 2001).

When comparing all cultivars, 61/85, 24/85 and F-17 showed significantly ($p < 0.05$) higher disease levels with 62.6, 60.5 and 51.4% seedling death, respectively (Table 8.3), with a shorter incubation period of about 30 days (Table 8.4).

Table 8.3: Percentage of seedling death in Arabica cultivars inoculated with the coffee wilt disease (CWD) isolates collected from representative fields in south-west Ethiopia.

Coffee cultivar[b]	*Gibberella xylarioides* isolates[a]				
	Gx12	Gx26	Gx31	Gx43	Mean
74165 (R)	0.0 j	40.5 e-i	33.9 f-i	22.6 g-j	24.3 E
7440 (MR)	0.0 j[d]	17.1 h-j	11.6 ij	19.3 h-j	12.0 F
74304 (S)	0.0 j	64.6 a-f	48.8 b-h	38.0 f-i	37.8 CD
F-17 (R)	0.0 j	77.8 a-c	52.6 a-g	75.1 a-d	51.4 AB
F-61 (MR)	0.0 j	54.8 a-g	57.1 a-f	70.8 a-e	45.7 BC
SN-5 (S)	0.0 j	70.8 a-e	62.4 a-f	46.8 c-h	45.0 BC
35/85 (R)	0.0 j	43.8 d-h	35.3 f-i	36.0 f-i	28.8 DE
61/85 (MR)	0.0 j	80.4 ab	85.1 a	85.1 a	62.6 A
24/85 (S)	0.0 j	73.8 a-d	83.0 a	85.2 a	60.5 A
Mean	0.0 N	58.2 M	52.2 M	53.4 M	

[a] Gx12, Gx26, Gx31 and Gx43 were the CWD isolates obtained from Bebeka, Teppi, Jimma and Gera, respectively.
[b] Under field conditions Cvs74165, F-17 and 35/85 were resistant (R); 7440, F-61 and 61/85 moderately resistant (MR); 74304, SN-5 and 24/85 susceptible (S) to CWD.
[c] 0.0 indicates no external symptoms were observed during the trial.

In contrast, a significantly ($p < 0.05$) lower percentage of seedling death (28.8, 24.3 and 12.0%) was observed on cultivars 35/85, 74165 and 7440, respectively (Table 8.3), with longer incubation periods ranging between 84 and 112 days (Table 8.4). Isolates Gx26, Gx43 and Gx31 caused more seedling death (58.2, 53.4 and 52.2%, respectively) than isolate Gx12, which induced no symptoms throughout the trial (Table 8.3). Teppi isolate (Gx26) induced wilting symptoms in a significantly shorter incubation period (82 days) as compared to Jimma isolate (Gx31), which induced symptoms in around 100 days (Table 8.4). Comparing the combined effect of cultivar–isolate interactions (Table 8.3), Gx26 (Teppi isolate) induced a higher rate of death on cultivars SN-5 (70.8%), 74304 (64.6%) and 74165 (40.5%) than Gx43 (Gera isolate) on the same cultivars suggesting that Teppi isolate was more aggressive than Gera isolate (Gx43) on these cultivars although Gx26 was less aggressive than Gera isolate (Gx43) on cultivar F-61.

8.4 Relationship Between Laboratory and Field Infestation Rates of CWD

A number of researchers have reported the existence of marked differences in resistance levels in Arabica coffee populations to CWD under field conditions at various locations (Van der Graaff and Pieters, 1978; Merdassa, 1986; Girma and Hindorf, 2001; Girma, 2004). Merdassa (1986) assessed the incidence of the disease in single tree progenies of different coffee accessions for 6 years (1979–1984) at Gera, and obtained tree loss ranging from 0.3 to 87%.

Table 8.4: Incubation periods (in days) for Arabica seedlings inoculated with the coffee wilt disease (CWD) isolates collected from representative fields in south-west Ethiopia.

Coffee cultivar[b]	*Gibberella xylarioides* isolates[a]				
	Gx12	Gx26	Gx31	Gx43	Mean
74165 (R)	0.0 h[c]	126 a-c	154 ab	154 ab	108.5 A
7440 (MR)	0.0 h	133 a-c	168 a	147 ab	112.0 A
74304 (S)	0.0 h	35 gh	112 a-e	119 a-d	66.5 CD
F-17 (R)	0.0 h	84 c-g	98 b-f	63 d-g	61.2 CD
F-61 (MR)	0.0 h	56 e-h	77 c-g	84 c-g	54.2 D
SN-5 (S)	0.0 h	98 b-f	77 c-g	105 b-f	70.0 C
35/85 (R)	0.0 h	105 b-f	133 a-c	98 b-f	84.0 B
61/85 (MR)	0.0 h	56 e-h	35 gh	28 gh	29.7 E
24/85 (S)	0.0 h	49 f-h	49 f-h	28 gh	31.5 E
Mean	0.0 R	82.4 Q	100.3 P	91.8 PQ	

[a] Gx12, Gx26, Gx31 and Gx43 were the CWD isolates obtained from Bebeka, Teppi, Jimma and Gera, respectively.
[b] Under field conditions Cvs 74165, F-17 and 35/85 were resistant (R); 7440, F-61 and 61/85 were moderately resistant (MR); 74304, SN-5 and 24/85 were susceptible (S) to CWD.
[c] 0.0 indicates no external symptoms were observed over the test period. Means followed with the same letter(s) are not significantly ($p < 0.05$) different from each other according to the Department of Medical and Research Technology (DMRT). Least significant difference (LSD) values for the cultivars, the isolates and the interactions comparisons were 13.7, 17.5 and 55.6, respectively.

In a field at Bebeka, 23 cultivars (including four introduced Catimor lines) were planted in a completely randomized block design with three replications and 90 trees per plot. Cultivars 785, 1185, 1785 and 4485 were uniformly attacked in all plots and showed significantly high mean death rates of 80.0, 72.9, 83.4 and 97.4%, respectively, indicating their susceptibility to the coffee wilt. In contrast, the Catimor lines (1579, 1779, 1979 and 2179) and some French collections (F-15, F-27 and F-59) had the lowest infection levels of less than 10% (Girma, 2004). The introduced coffee lines such as Caturra Rojo, Caturra Amarillo and Catuai showed significantly ($p < 0.05$) higher mean incidences of 83.0, 80.5 and 80.0% and were more susceptible to CWD than the indigenous cultivars 7454, 74110, 74112, 74140 and 74165 at Teppi (Girma, 2004). In all cases, the disease developed dramatically into large foci starting from a single tree and spread faster in plots composed of susceptible trees.

At Gera, cultivars SN-5, F-51/53 and 248/71 showed 100% tree loss, whereas F-35 and F-51 had significantly ($p < 0.05$) lower mortality rates of 9.3 and 27.9%, respectively (Girma, 1997; Girma *et al.*, 2001). At the same locality in another highly infested field planted with the coffee berry disease (CBD)-resistant selections ($n = 30$), disease incidence ranged from 12% for selection 8150 to 96% for 74304 (a susceptible control) (Girma, 1997; Girma and Hindorf, 2001).

Artificial inoculation tests suggested that cultivars 1579, 200/71 and 8136 were resistant to CWD with low percentage deaths (12.7, 15.2 and 25.2%, respectively) accompanied

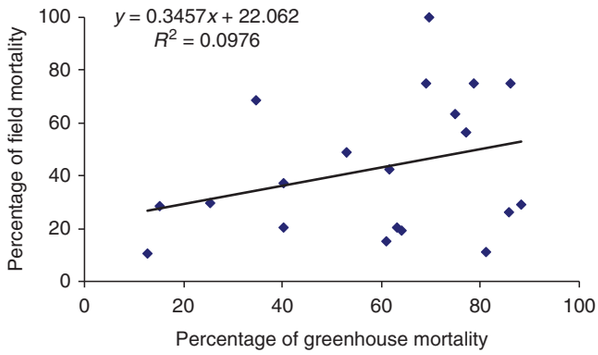
by long incubation periods (Table 8.4) before symptoms appeared. Cultivars 146/71, 206/71 and 8144 showed moderate CWD infection, while others including Caturra and Geisha had the highest wilt severity (>90%), indicating their susceptibility to the disease. However, there was generally a poor correlation between death rates in the greenhouse and percentage mortality in the field (Table 8.5 and Figure 8.1). It seems

Table 8.5: Reactions of some coffee cultivars to coffee wilt disease (CWD).

Coffee cultivar	Actual value (mean % death)	Transformed value[a]	Incubation period (mean number of days)	Incidence in the field[b]
1185	86.0	75.1 ab	90.0 op	75.0
1785	78.7	67.9 a-h	80.0 p	75.0
1579	12.7	16.9 s	157.5 a	10.2
2179	63.3	53.4 i-o	140.8 a-d	20.5
4/70	77.2	62.0 b-l	117.5 d-m	56.2
36/70	60.9	56.0 f-n	92.5 n-p	15.3
146/71	34.6	35.1 qr	122.5 d-k	68.4
200/71	15.2	20.3 s	152.5 ab	28.2
206/71	52.8	46.1 m-q	125.0 d-j	48.9
8112	74.9	63.2 a-k	112.5 f-o	63.1
8133	64.2	54.1 g-n	122.5 d-k	19.2
8136	25.3	29.6 rs	150.0 a-c	29.4
8143	61.6	52.7 j-p	125.0 d-j	42.4
8144	40.2	39.1 o-r	137.5 a-e	37.0
F-27	81.0	67.0 a-j	90.0 op	10.9
F-35	85.7	70.9 a-e	97.5 l-p	26.2
Caturra	68.9	59.2 d-m	130.0 b-h	74.5
Geisha	88.1	73.9 a-c	97.5 l-p	29.1
7440[c]	40.4	38.7 p-r	135.0 a-f	20.3
SN-5[d]	69.7	56.7 e-n	119.2 d-l	99.9
Mean	68.8	58.3	115.5	-
LSD ($p < 0.05$)		14.4	23.5	-
CV (%)		21.8	17.9	-

[a]The actual data (2 years) were transformed to arcsine square root values before analysis. Means followed with the same letter(s) are not significantly different from each other.
[b]The CWD incidences (mean %) summarized from various fields and localities (Girma, 1997, 2004; Girma and Hindorf, 2001).
[c]Resistant/tolerant cultivar.
[d]Susceptible checks.

Figure 8.1: Correlation between mortality of 20 Arabica cultivars induced in greenhouse experiments through stem nicking and mean mortality measured over several field experiments. (Data from Table 8.5.)



that greenhouse inoculation is overestimating field mortality and is generally a poor predictor for survival in the field.

8.5 Interactions Among Arabica and Robusta Versus CWD Isolates from Both Host Species

Eleven CWD isolates were compared, of which ten were from Arabica trees in Ethiopia and one from Robusta in Uganda (Table 8.6). The Arabica isolates represented ten major coffee-growing districts in Ethiopia, at varying altitudes (1000 to 2000 m asl) and production systems: semi-forest, garden and plantation coffee. The isolates were inoculated with the coffee seedlings in two sets of experiments following the standard inoculation protocols.

8.5.1 Results

Highly significant ($p < 0.001$) differences were found among Arabica cultivars, isolates and cultivar–isolate interactions, both in percentage mortality and incubation period (Girma, 2004; Girma *et al.*, 2005 a,b). Robusta was very susceptible to the Uganda Robusta CWD isolates (GxU12), but there were no deaths observed when Robusta seedlings were inoculated with any Arabica isolates (Gx1–Gx9 and Gx11) up to 12 months after the trial had been completed. In contrast, Arabica isolates caused varying mortalities with the Arabica genotypes, but were completely non-pathogenic to Robusta seedlings (Table 8.6).

Among the Arabica cultivars, Catimor J19 showed a significantly ($p < 0.05$) lower mean percentage of dead seedlings (22.2%), followed by cultivar 7440 (47.4%) with incubation periods of 70 and 83 days, respectively. Cultivars F-59 and Caturra Rojo were highly susceptible to the disease with the highest seedling deaths of 71.4 and 67.4%, respectively (Table 8.6) (Girma, 2004; Girma *et al.*, 2005 a,b).

There were significant ($p < 0.05$) ranges of variation in aggressiveness among the isolates of Arabica. Isolates Gx3, Gx5 and Gx8 caused lower seedling infections than isolates Gx1, Gx4 and Gx11 (Table 8.6).

Table 8.6: Percentage of seedling death[a] among Arabica cultivars and 1 Robusta line inoculated with 11 coffee wilt disease (CWD) isolates collected from various geographical origins.

Isolates[b]	*Coffea arabica* cultivars					*Coffea canephora*	Mean
	Catimor-J19	7440	F-59	Caturra Rojo	24/85		
Gx1	30.6 p-r	66.2 f-j	90.0 a	83.5 a-c	78.2 a-f	0.0 v	58.1 B
Gx2	19.9 r-u	52.5 j-n	78.2 a-f	81.7 a-d	69.6 c-i	0.0 v	50.3 C
Gx3	17.4 r-u	30.8 p-r	64.6 f-j	64.9 f-j	50.3 k-o	0.0 v	38.0 E
Gx4	27.9 q-s	65.8 f-j	83.9 ab	85.7 ab	80.3 a-e	0.0 v	57.3 B
Gx5	8.8 uv	30.5 p-r	67.3 e-i	47.6 l-o	44.6 m-o	0.0 v	33.2 E
Gx6	8.3 uv	42.3 n-p	77.4 a-f	65.2 f-j	68.4 d-i	0.0 v	43.6 D
Gx7	24.3 r-t	62.7 g-k	81.7 a-d	81.8 a-d	68.9 d-i	0.0 v	53.2 BC
Gx8	14.4 tu	27.1 q-t	75.0 b-g	58.7 h-l	38.0 o-q	0.0 v	35.5 E
Gx9	15.0 s-u	57.5 i-m	85.7 ab	81.6 a-d	62.5 g-k	0.0 v	50.4 C
Gx11	77.2 a-f	86.0 ab	81.5 a-d	90.0 a	72.2 b-h	0.0 v	67.8 A
GxU12	0.0 v	0.0 v	0.0 v	0.0 v	0.0 v	84.1 ab	14.0 F
Mean	22.2 T	47.4 S	71.4 P	67.4 Q	57.6 R	7.6 U	

[a] Percentage of death calculated from cumulative dead of total seedlings (20 per treatment) 6 months after inoculation. Values were arcsine square root transformed. Means followed by the same letter(s) are not significantly different; Least significant difference (LSD) values (p =0.05) for the cultivars, the isolates and the interactions comparisons are 3.5, 4.7 and 11.6, respectively. Coefficient of variation = 15.8%.
[b] Gx1, Gx2, Gx3, Gx4, Gx5, Gx6, Gx7, Gx8, Gx9, Gx11 and GxU12 designate the CWD isolates collected from Jimma, Gera, Chira, Gechi, Yayu, Mettu, Tepi, Bebeka, Ayraguliso, Yirgacheffe and Uganda (Robusta strain), respectively.

8.6 The Effect of Current and Historical CWD Isolates on *Coffea* Species

Experiments were carried out beyond the Arabica and Robusta genomes to determine the amount of cross-reactivity that might be occurring in the field, for instance wild coffees and remnant individuals of Liberica and Excelsa may harbour CWD or be resistant to it. Knowledge about possible cross-reaction is very useful information to have in order to plan control strategies and breeding programmes.

A selection of the present and the historical CWD strains were assayed with different coffee species. Table 8.7 summarizes some of the interactions found; for more detailed studies see Girma *et al*. (2009).

Arabica strain CAB007 was deemed specific to Arabica, though a low (5%) mortality on *C. dewevrei* and Robusta was also recorded. Historical isolates CBS74979 and CBS25852 from West Africa confirmed their pathogenicity on Robusta and also were found to be pathogenic on *C. dewevrei*, though they were not collected from that species.

Table 8.7: Cross-reactions between strains of coffee wilt disease (CWD) and coffee species. Sign indicates degree of susceptibility (data incomplete due to lack of available material).

CWD strain	Strain origin	Collected from	Date collected	Robusta	*C. liberica*	Arabica
CAB003	Uganda	*canephora*	2000	+++	+	–
CAB007	Ethiopia	*arabica*	1997	–		++
DSMZ62457	CAR	*excelsa*	1955	+	+++	++
CBS25852	Côte d'Ivoire	*Coffea* sp.	1951	+	+	
CBS74979	Guinea	*canephora*	1963	+	+	
ATCC15664		*Coffea* sp.	1964	+	+	
ATCC36325	CAR	*excelsa*	1960s	–	–	–

Key: +++ highly susceptible; ++ moderately susceptible; + slightly susceptible; – no effect; blank no data.

Historical isolates ATCC15664 and DSMZ62457 were collected from *C. dewevrei* and were found to be also pathogenic to Robusta and *C. liberica*, with DSMZ62457 also pathogenic to Arabica.

8.7 Conclusions

For a number of technical reasons, the stem nicking of late cotyledon stage (2–2.5 months old) coffee seedlings with inoculum concentration of about 2×10^6 conidia per millilitre is recommended as a standard assay for Arabica.

The stem injection method was rejected because it is time consuming. The root-dip method was also rejected because mortality due to handling was unacceptably high. The stem-nicking method also has a drawback of sometimes causing seedling damage, but this was outweighed by its speed and simplicity. However, it is clear that results of the stem-nicking method do not correlate well with studies of mortality in the field. Further work is needed, therefore, to develop a more reliable predictor.

Experiments confirmed that all Arabica CWD isolates were pathogenic to seedlings of the host cultivars with varying levels of aggressiveness but entirely non-pathogenic to Robusta. Conversely, the strain from Robusta was highly pathogenic to seedlings of its host but not to the Arabica cultivars indicating incompatible host–pathogen interactions.

Van der Graaff and Pieters (1978) reported that Ethiopian coffee lines of *Coffea arabica* displayed differences in resistance to the CWD pathogen that theoretically at least could be developed into a resistant variety. Although this was also found in the present study, the level of resistance exhibited by Arabica genotypes was fairly low with few cultivars showing high resistance. These few genotypes may not be enough to develop a breeding programme. Therefore, a much larger effort is needed to find more genetic material that might display higher levels of resistance.

The situation in Ethiopia is, therefore, of some concern; on the one hand the disease seems to be getting worse (Chapter 2), on the other hand the chances of developing a resistant variety still seem to be far off. Additionally, Ethiopian coffees command a premium because of the high quality that is believed to be at least partly due to genetic differences, so even if a resistant variety were to be produced and widely adopted, Ethiopian coffees could lose much of their distinctiveness.

Thus, should Ethiopia learn to live with CWD – which, judged by rising national production it seems to be managing – or should there be an eradication effort, or could CWD's significance be appreciably diminished through developing resistant varieties? Clearly, much further work is needed before a clear answer can be found to this question.