CROP PROTECTION PROGRAMME

An investigation of pesticide and microbial interactions on coffee as a means of developing an IPM strategy for economically important coffee pests in small-holder farming systems in Malawi

R6807 (ZA0173 and ZA0174)

FINAL TECHNICAL REPORT

(1 November 1996 – 30 April 2000)

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1. Project summary

TITLE OF PROJECT:	An investigation of pesticide and microbial interactions on coffee as a means of developing an IPM strategy for economically important coffee pests in small-holder farming systems in Malawi
R NUMBER:	R6807
PROJECT LEADERS :	Dr Rory Hillocks, Natural Resources Institute Dr Sarah Simons, CAB International-Africa Regional Centre
RNRRS PROGRAMME:	Crop Protection Programme
PROGRAMME MANAGER:	Dr S. Eden Green (NR International)
SUB-CONTRACTOR:	Ministry of Agriculture and Irrigation, Malawi
CPP PRODUCTION SYSTEM:	Forest/Agriculture Interface
CPP PROGRAMME PURPOSE:	Yields from cropping systems in tropical moist forest areas increased and their sustainability enhanced by minimising losses caused by agricultural pests
COMMODITY BASE:	Coffee
BENEFICIARIES:	Small-holder coffee farmers
TARGET INSTITUTIONS:	Small-holders Coffee Farmers Trust, Tea Research Foundation
GEOGRAPHIC FOCUS:	Malawi
START DATE: **FINISH DATE:**	November 1996 April 2000
TOTAL COST:	£213,745 (including add-ons and extension)

2. Executive summary

The project was conducted in Malawi from November 1996 to April 2000 with the objective of obtaining baseline data on the main pests and diseases for the development of an IPM programme for coffee smallholders.

The project began against the background of declining coffee production in the smallholder sector. Economic surveys showed that yields were among the lowest in the world and that the average yield of 300 kg/ha was below the threshold for an economic return if labour was accounted for. The main economic factors causing this was the poor producer price. However, the world market for ‘fair trade’ coffee is expanding and it was concluded that the prospects for Malawian smallholder coffee were good if the producer price could be improved .

Socio-economic surveys conducted in 1997 showed that input use had fallen almost to zero with 60% of farmers having abandoned the use of fertiliser and pesticides on their coffee in the four years up to 1997. The main reason again was the low producer price.

Most of the farmers interviewed considered pests and diseases their main biological production constraint and 60% reported white stem borer as their main pest, while coffee leaf rust (CLR) and coffee berry disease (CBD) were the main diseases. Aldrin was widely used for control of white stem borer and since its withdrawal there is no effective alternative.

Surveys of the pests and diseases of smallholder coffee were conducted in 1998 and 1999 and white stem borer was found to be a widespread problem, destroying bushes in all five of the districts in which smallholder coffee is grown. Antestia bug and green scale were also widespread. CLR was also found in all areas but it is not clear how important it is in terms of yield loss. CBD was found in three out of the five districts and was a major problem in two of these; Misuku Hills and Viphya North.

Disease incidence was greater where crop management was poor and disease was increased particularly by failure to prune the coffee bushes and by excessive shading. This offers the potential for managing CBD and CLR in areas of moderate incidence by promoting correct cultural practices. Pruning and shading also affected the incidence of insect pests and their natural enemies but, whether the effect was to increase or decrease their populations depended on the insect concerned.

CBD was increased by high rainfall, moderate temperatures and its incidence was therefore greater at higher altitudes. It was effectively controlled by fungicide application and 50% increase in yields was obtained compared to the unsprayed control. It was confirmed that the selection from Catimor 129 known as ‘Nyika’ has considerable resistance to CBD, in addition to rust resistance.

It was concluded that there is an urgent need for control measures against white stem borer and that there are insecticides available that might be effective. These should be tested in northern Malawi as soon as possible. Other methods of control such as the use of biocontrol agents or pheromones requires further research. Much can be done to manage CBD and CLR through implementation of an Integrated Crop Management (ICM) programme and this forms the basis of the proposal for a second phase of the project. Fungicide use would be recommended only where disease incidence is high after the correct crop husbandry procedures have been implemented.

3. Background

Arabica coffee (*Coffea arabica*) is one of Malawi's largest export commodities. Although most of the coffee is produced on large estates in the south of the country and only 5% is produced by smallholders, mainly in the north, it is nevertheless the main source of income for 6 – 9000 smallholder households. Yields in the smallholder sector were very low compared to the estate sector, offering the potential for increased yields which would make a substantial contribution to enhanced livelihood security if crop management practices were improved. The original aim of the project was to investigate the effects of present pesticide use on microbial dynamics, with a view to developing IPM systems that decreased pesticide dependency and promoted biological control. By the time the project began, pesticide use was found to have declined dramatically, due to the removal of subsidies on farm inputs under economic structural adjustment policies and to the poor producer price offered to coffee smallholders. Similar situations existed (and still do) in both Kenya and Tanzania.

The emphasis of the project shifted therefore to investigation of the socio-economic and biological factors influencing pest and disease levels and farmers' pest management decisions. The primary output from the project remained the same – to provide baseline data on pests, diseases and potential biological control agents to develop an IPM system in which pesticide use would be rationalised and used only where there was a clear need and the likelihood of an economic return.

4. Project Purpose

Develop improved methods for insect pest and disease control through the use of host plant resistance, biological and cultural control methods, which can be incorporated into an IPM strategy for small-holder coffee based cropping systems in Northern Malawi.

5. Research activities and Outputs

Four outputs were listed in the original project memorandum:

1. Economic trends affecting smallholder coffee in Malawi understood
2. Socio-economic factors constraining coffee growers in Malawi established
3. The distribution and relative importance of major pests and diseases of coffee in Malawi established
4. The efficacy of pest management techniques including pesticide application, mixed cropping, mulching and pruning and interactions with microbial antagonists determined
5. Recommendations for management of key coffee pests developed

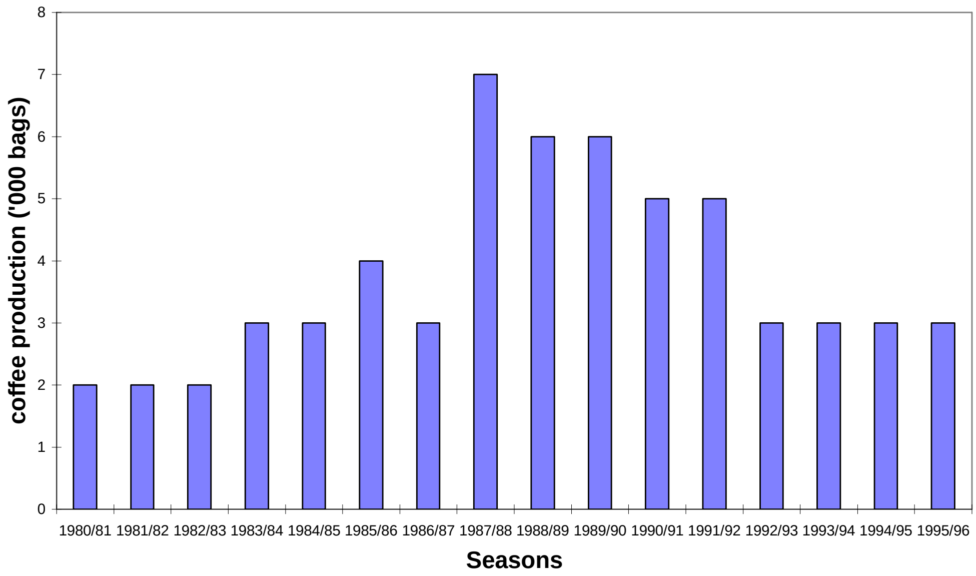
A one year extension was granted with the following outputs:

1. Completion of PhD programme linked to the project
2. Stakeholder workshop in Malawi to present project findings and set priorities for further development of the outputs.
3. Survey and current update on pesticide use by smallholders.

Output 1: Economic trends affecting small-holder coffee market in Malawi understood.

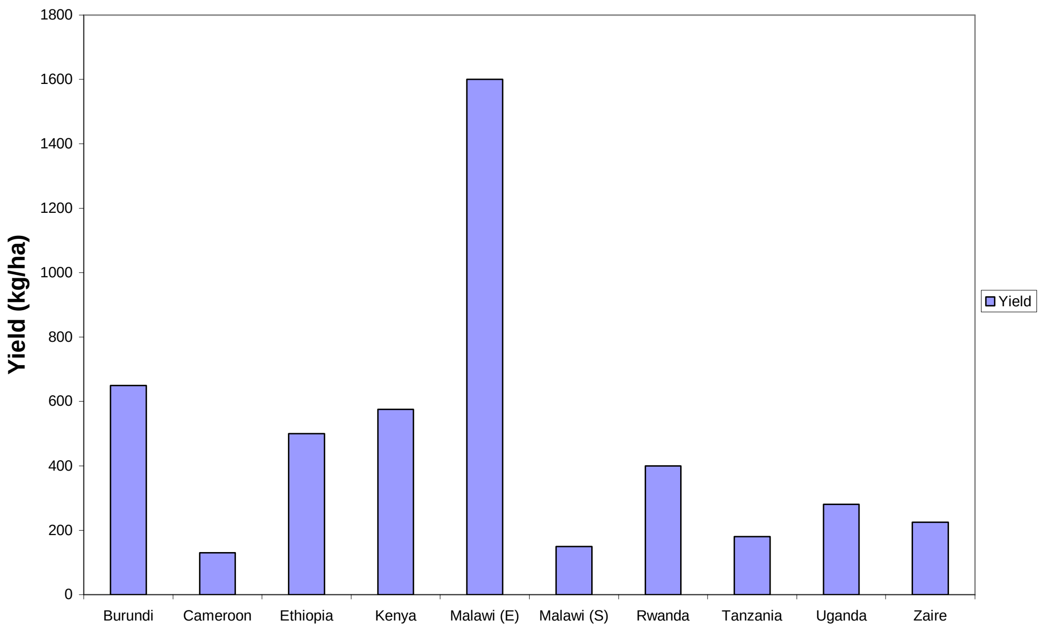
A report was commissioned from LMC International and was completed in May 1997. Smallholder coffee yield in Malawi reached a peak in 1987/88 and then began to decline, falling to half its peak output by 1995/96. This decline occurred at a time when production in the Malawian estate sector was increasing. Yields in the smallholder sector are low and economically it is regarded as a marginal activity and non-profitable if labour is accounted for. Average yield of smallholder coffee is 300 kg/ha of green coffee, compared to 1600 kg/ha in the estate sector. The quality of smallholder coffee is, however, superior to that in the estate sector due to the more favourable growing conditions in the north of the country. A yield of 500 - 600 kg/ha would be considered economically viable. The potential for smallholder coffee was considered to be good, especially by exploiting the organic and fair trade markets. The main constraints were poor organisation of the Smallholder Coffee Authority (SCA) and the low producer price which were the main factors leading to a decline in smallholder coffee production since 1989/90 (Fig.1).

Fig. 1. Smallholder coffee production in Malawi 1988/89 – 1996/97



The average yields produced in the smallholder sector are among the lowest in Africa and in marked contrast to the estate sector in Malawi which produces some of the highest yields in the world (Fig.2.).

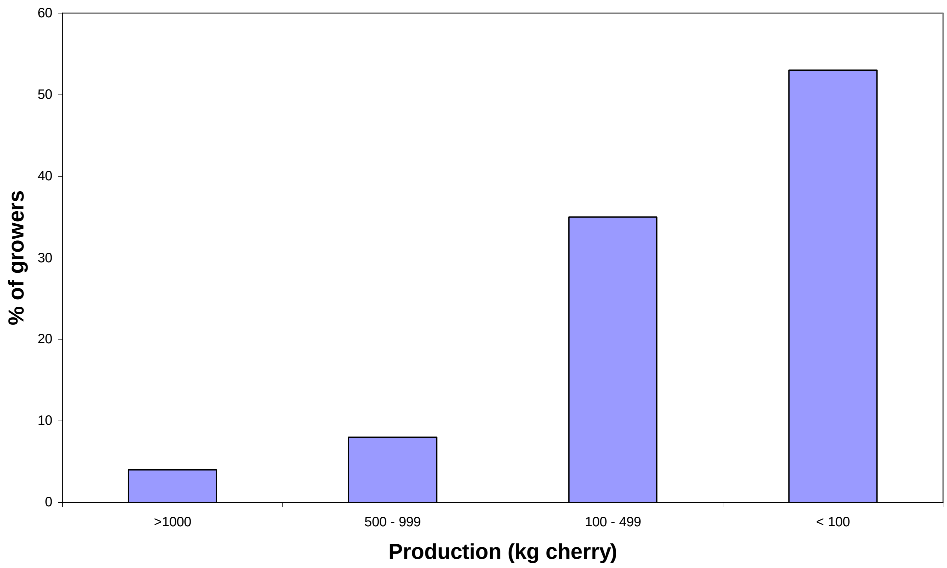
Fig. 2. Coffee yields from producer countries in Africa



At the time of the survey conducted by LMC, the use of inputs on coffee by smallholders was very low and consequently yields are also low. However, about 12% of smallholders achieve over 500 kg per hectare (Fig.3) which might be considered the threshold for an economic return. Reorganisation of the SCA which began towards the end of the project to provide better access to processing plants and supply of inputs and, also, an improvement in the producer price, would enable many of the 35% of growers who presently achieve 100 – 499 kg/ha to reach the economic threshold of 500 kg/ha.

The LMC report concludes that if average yields can be increased and more farmers reach the economic production threshold, the prospects for the smallholder sector are good. The main reasons for this optimistic outlook are the high quality of Malawian smallholder coffee and increasing demand for 'fair trade' arabica coffee on world markets.

Fig. 3. Smallholder coffee yields in Malawi



Output 2: Socio-economic factors constraining coffee growers in Malawi established

A socio-economic survey was undertaken in October 1997 based on 40 smallholder coffee farmers. Coffee was rated by 55% of farmers as their most important crop and 63% of households had no source of income other than coffee. The main constraints identified were:

a) Cessation of credit scheme for input purchase run by the SCA, resulting in a low input production system with low yields and 75% of farmers had stopped using fertiliser on their coffee during the last 4 years.

b) Dissatisfaction by farmers with the way the processing plants are run by SCA.

c) Poor access to markets following recent deregulation.

d) Low producer price discourages farmers from spending time and labour in their coffee gardens, many of which have become neglected.

e) Pest and disease attack

In the five Extension Planning Areas (EPAs) where coffee is grown in northern Malawi, coffee is the main source of cash income for over 6000 households and for over 60% of these, it is their only source of income (Table 1).

Table 1. Proportion of coffee growing households with income sources other than coffee.

Income source	No of households	% of all households
None	25	63
Animal sales	8	20
Salary/Pension	3	8
Brewing	2	5
Trade store	2	5
Dairy sales	1	3
Carpentry	1	3
Income from relatives	1	3

The poor producer price and the removal of subsidies on inputs under structural adjustment programmes led to a rapid decrease in the number of smallholders using fertiliser on their coffee (Table 2.).

Table 2. Changes in fertiliser use by forty households in northern Malawi over the least 4 years from 1993 - 1997.

Change in fertiliser use	Number of farmers	% of farmers
Completely stopped using it	30	75
Using decreased amount	1	3
Still using same amount	9	23

Table 3 shows the pests and diseases that respondents considered most important. Sixty percent regarded stem borer (mainly white stem borer, *Monochamus leuconotus*) as the most important problem (Plate 1.), with coffee berry disease (CBD) (Plate 2.) next, then green scale and coffee leaf rust (CLR) (Plate 3).

Table 3. Pest and disease problems on smallholder coffee in Malawi ranked by farmers in order of importance.

Pest/disease problem	No of times ranked first	% of farmers interviewed
Stem borer	24	60
CBD	5	13
Green scale	4	10
Leaf rust	4	10
Tip borer	1	3
Leaf miner	1	3

When asked about changes they had made in their pest control practices in the 4 years up to 1997 when the survey was conducted, it was clear that the use of insecticide and fungicide had declined. Sixty seven percent of respondents had abandoned chemical control of white stem borer (Table 4.). This was due largely to the withdrawal of aldrin, because of its hazardous nature. Aldrin provided cheap and effective control of stem borer and there is no equivalent chemical currently available to smallholders in Malawi. The 25% who said they still used chemical control were mainly using fenitrothion which is unlikely to be effective against *Monochamous*. The picture was similar for control of the other insect pests and for CBD and CLR.

Table 4. Changes in farmer's pest control practices over the 4 years up to 1997.

Pest/ disease and change in control method	No. of farmers	% of farms with this pest/disease
White stem borer		
From commercial chemical to physical[1]	24	67
From commercial chemical to no control	3	8
No change - still using chemical control	9	25
Green scale		
From commercial chemical to no control[2]	14	64
From chemical to traditional treatment	2	9
No change - still using chemical control	6	27
Coffee berry disease		
From commercial chemicals to no control[3]	10	63
No change - still using chemical control	6	37
Leaf rust		
From commercial chemical to no control[4]	18	36
No change - still using chemical control	3	14

[1] Mainly a change from using aldrin as a stem paint to the use of a wire spoke to kill the larvae in the stem.
[2] Mainly away from fenitrothion
[3/4] Mainly away from copper oxychloride

The main source for smallholders of pesticides and other inputs for use on coffee was the Smallholder Coffee Authority (SCA). Data collected from their records show a dramatic decrease in the amount of fertiliser (Fig. 4) and pesticide (Fig.5) purchased by smallholders in the period from 1993 to 1997.

Fig.4. Fertiliser sales by SCA to coffee smallholders 1988/89 – 1996/97
[DAP = Diammonium phosphate, CAN = Calcium ammonium nitrate]

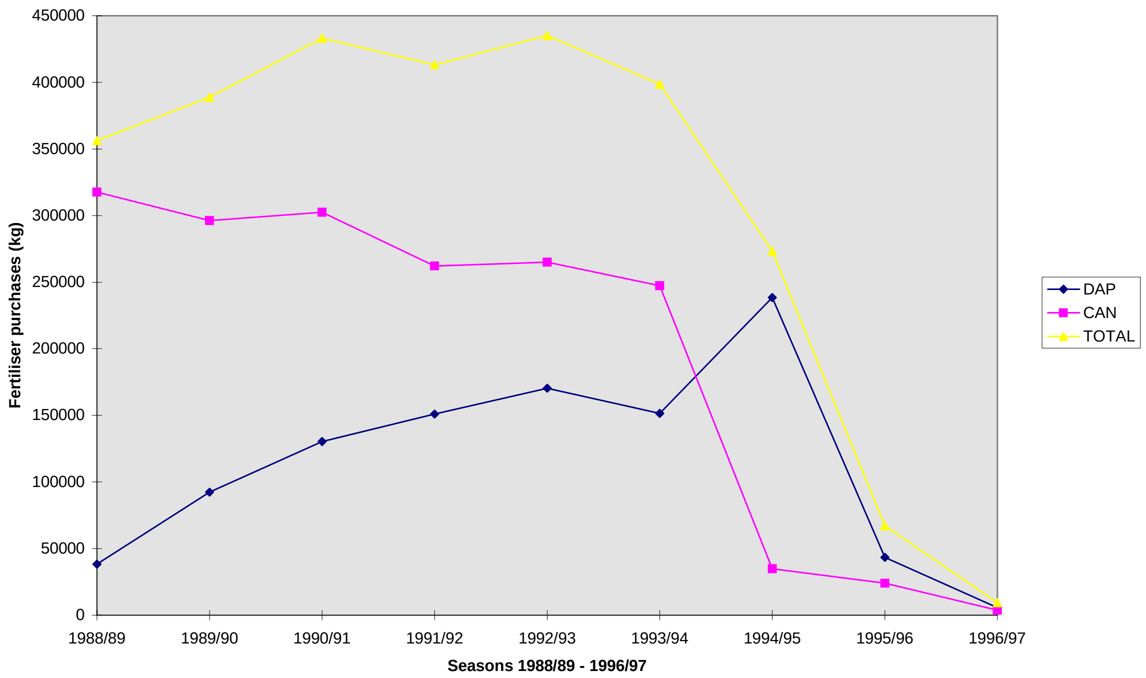
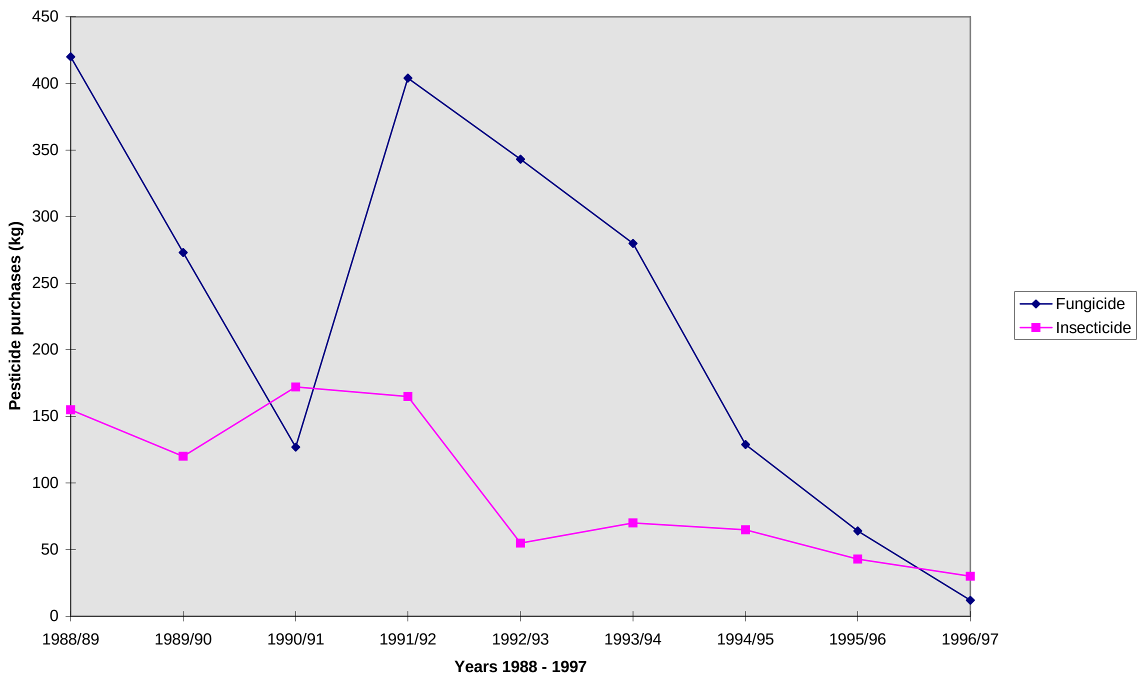


Fig.5. Pesticide sales by SCA to coffee smallholders in Malawi 1988/89 – 1996/97.



It was concluded from the LMC report and the socio-economic survey that three conditions were required to improve smallholder coffee production:

a) Reduce impact of pests and diseases on coffee yields.
b) Creation of an enabling environment for the effective development of a competitive marketing system, including access to rural pulperies (primary processing plants).
c) Development of a sustainable credit system for input purchase and increased access to high quality inputs.

Output 3: The distribution and relative importance of major pests and diseases of coffee in Malawi established.

At the beginning of the project it was soon realised that there was no information on distribution and importance of the pests and disease affecting coffee in northern Malawi, either with the SCA or the Tea Research Foundation (TRF). A number of surveys were therefore carried out in order to obtain that information which is an essential first step in the development of an IPM programme. Surveys for insect pests were conducted in three contrasting seasons i.e. warm/wet (January), cold/dry (August) and warm/dry (November) on 100 farms in the five main coffee-growing EPAs. Overall, stem borers were by far the most important pest problem (with white or yellow-headed borers found on 97% of farms surveyed). Most fields were affected and large numbers of trees killed or dying. According to farmers, stem borers have become much more of a problem following the withdrawal of the pesticides, aldrin and dieldrin, which were previously applied as a stem paint to control the borers. Antestia bug, leaf miner and green scale were also considered to be economically important (Fig. 6). Statistical analyses of the insect pest data were done using Generalised Linear Models, assuming a Binomial distribution for presence or absence data, and a Poisson distribution for counts. The analyses revealed that the distribution and relative importance of the three key insect pests i.e. white stem borer, yellow-headed stem borer and antestia bug were influenced significantly ($p<0.05$) by location (EPA), although this effect varied with season (Figs. 6 & 7). Thus the incidence of white stem borer was significantly higher in Phoka Hills and S.E. Mzimba throughout the three seasons (30-62% trees affected per farm) whereas in the three remaining EPAs, the incidence was much lower and varied with season (9-30% trees affected per farm). In contrast, the incidence of yellow-headed borer was generally higher in Misuku Hills and Viphya North (12-49% trees affected per farm) albeit that the incidence in Misuku Hills during the warm/wet season was unexpectedly low (i.e. 12% trees affected per farm). The incidence of antestia bug was also significantly higher in Misuku Hills (>5 antestia bugs per farm) but again, the incidence in the warm/wet season was unexpectedly low (<1 bug per farm).

Fig. 6. Incidence of insect pests on smallholder coffee in fine EPAs in Northern Malawi

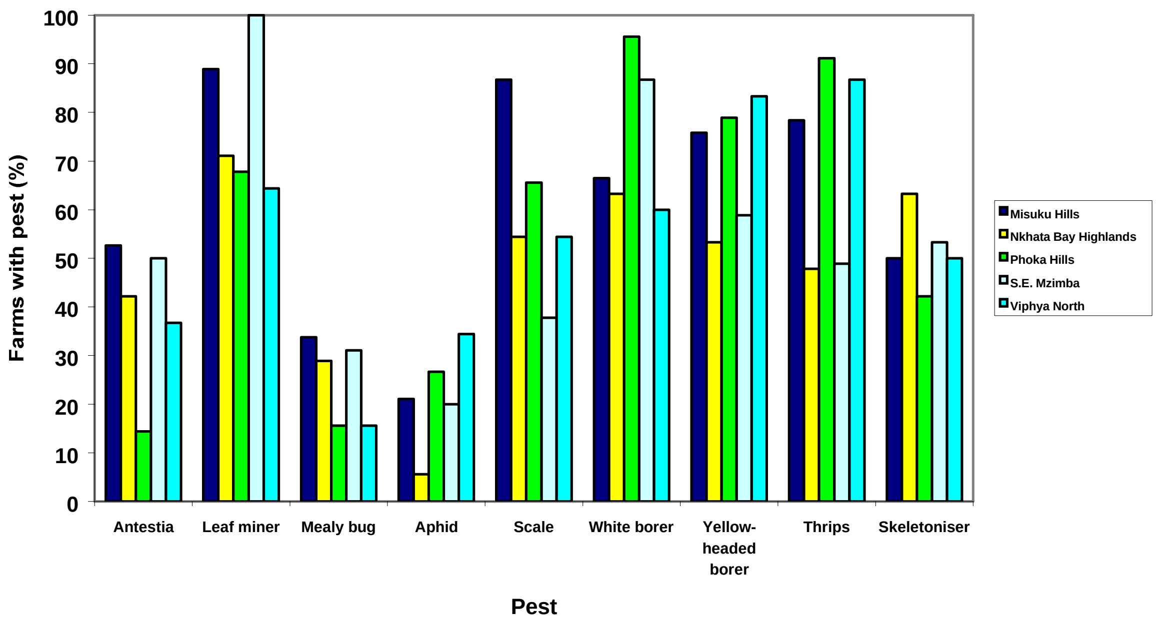
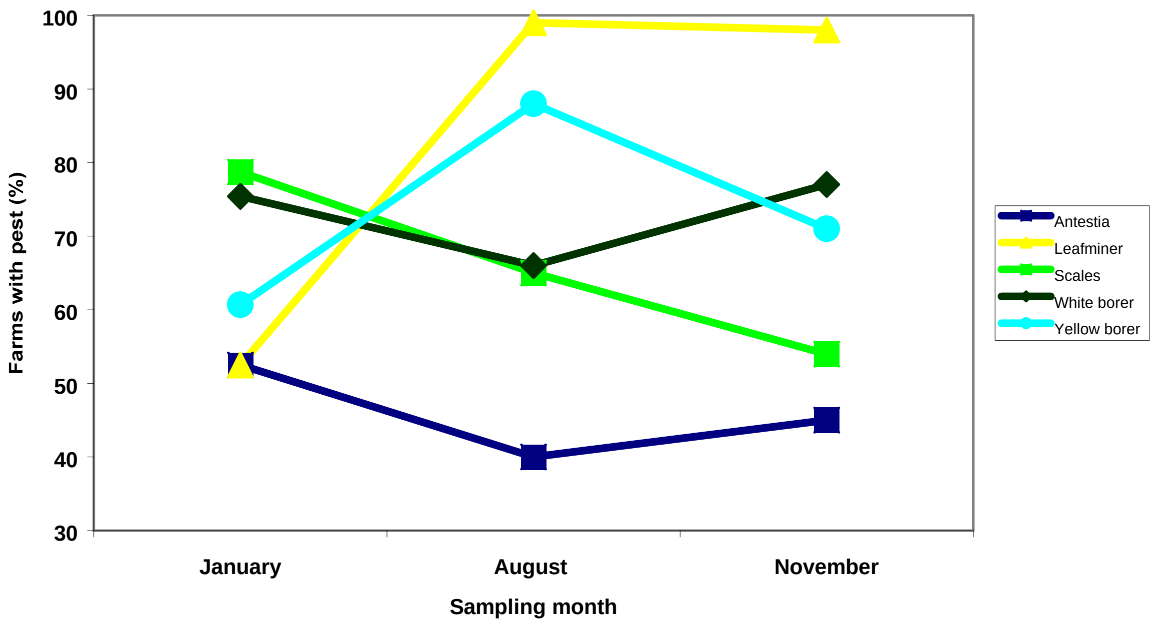


Fig. 7. Effect of season on key pests of smallholder coffee in Northern Malawi



The main diseases were coffee berry disease (CBD), coffee leaf rust (CLR) and fusarium bark disease (FBD). More than 100 farms were surveyed in 1988 and the survey was repeated in 1999 (Table 5). CLR was the more widespread of the two main diseases affecting the crop, occurring in all five EPAs. Although CBD was not recorded in two of the EPAs, it is probably the more important disease in Misuku Hills which is the main area of smallholder coffee production, where the disease occurred on over 90% of farms (Tables 6 and 7).

Table 5. Number of farms surveyed in each of the five EPAs where coffee is grown in northern Malawi.

EPA	Section	No of Farms Surveyed in 1998	No of Farms Surveyed in 1999
MISUKU HILLS	Katowo	11	10
	Chisi	9	10
	Kakomo	11	12
	Chibula	7	7
	Mondo	2	3
PHOKA HILLS	Salawe	7	7
	Junju	10	10
VIPHYA NORTH	Khanga	6	6
	Usowoya	2	2
	Uzumara	6	7
	Mphompha	4	5
S.E. MIZIMBA	Kapita	8	8
	Khosolo	6	6
	Msese	4	4
NKHATA BAY HIGHLANDS	Chigwere	3	3
	Chikwina	14	12
	Kavuzi	-	1
TOTAL		**108**	**113**

Table 6. Prevalence of CBD and coffee rust on farms in different EPAs surveyed in 1998

EPA	% farms with CBD	% farms with rust
Misuku Hills	92.5	90.0
Phoka Hills	0	47.1
Viphya North	55.6	77.8
S E Mzimba	0	47.1
Nkhata Bay Highlands	27.8	100.0

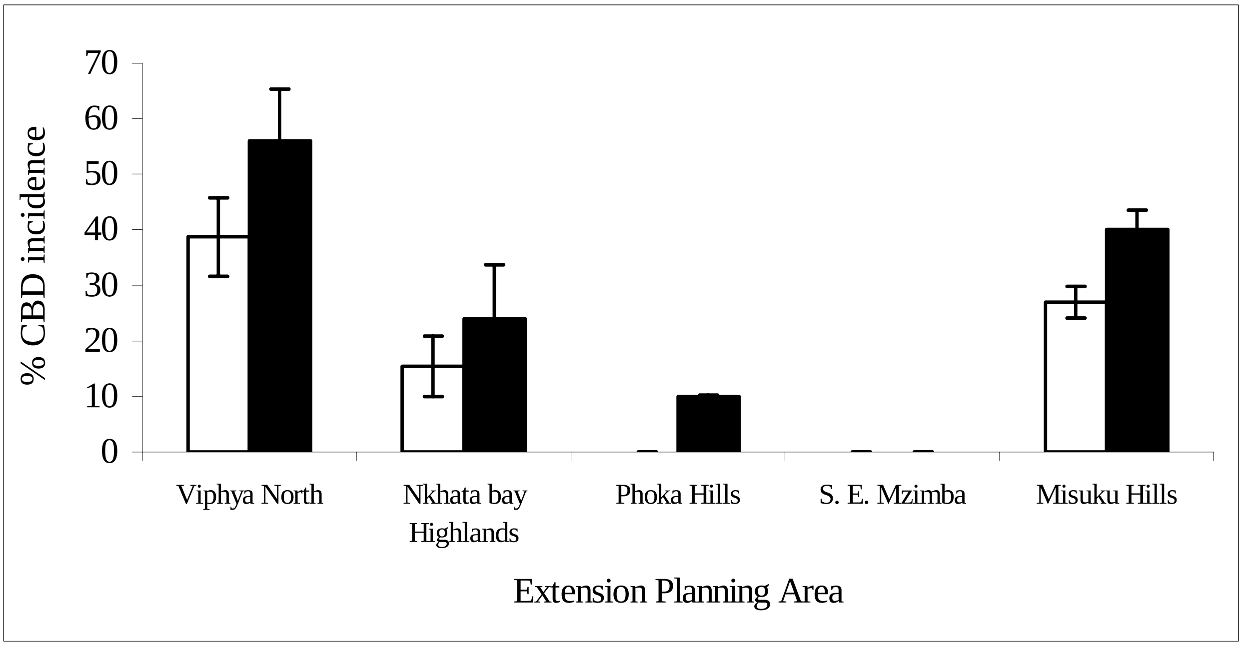
Table 7. Prevalence of coffee diseases on farms in different EPAs surveyed in 1999

EPA	% farms with CBD	% farms with rust	% farms with cercospora disease	% farms with fusarium berry disease
Misuku Hills	97.6	57.1	47.6	4.8
Phoka Hills	11.8	17.6	41.2	23.5
Viphya North	70.0	75.0	50.0	10.0
S E Mzimba	0	55.6	72.2	16.7
Nkhata Bay Highlands	18.8	43.8	37.5	0

In 1999 weather conditions were wetter in March/April leading to higher incidences of CBD (Fig.8.) and it was only in S.E. Mzimba that the disease was not found (Table 7). Incidences of cercospora leaf spot and fusarium berry disease were also recorded in 1999. Neither of these diseases is regarded as a major cause for concern at present.

For CBD disease incidence per field was greatest in Viphya north where over 50% of bushes were affected, followed by Misuku Hills with 40% affected (Fig.8.)

Fig. 8. Incidence of coffee berry disease expressed as % of bushes per field in five EPAs in 1998 (□) and 1999 (■). Bars = 2 X SE



The main coffee cultivars grown in northern Malawi are 'Geisha' and 'Agaro' with some 'local' cultivars and a few farmers have started growing 'Catimor'. The more recent cultivar is Geisha and this is preferred by farmers. Where new bushes are being planted they are either Geisha or more recently, Catimor 129. There was evidence from the surveys that Geisha is less susceptible to CBD than Agaro (Tables 8 and 9) but the difference in disease severity between the varieties was statistically significant only in 1999 (Table 9).

Table 8. Table of means for disease incidence and severity of CBD on the two main cultivars.

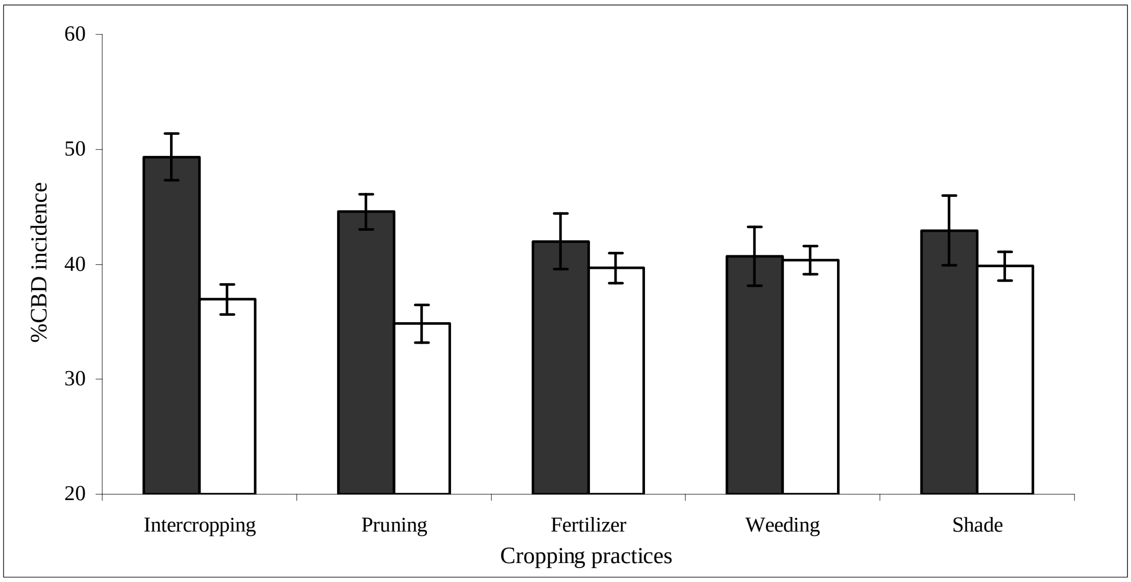
	Agaro	Geisha
Survey mean incidence	23%	11%
Incidence at sites where CBD occurred	39%	24%
Incidence at sites with CBD as % of total sites with this c.v.	59%	45%
Survey mean severity	0.91	0.64
Severity at sites where CBD occured	1.55	1.42

Table 9. Effect of varieties on CBD and rust scores in 1998 and 1999. Figures are means with S.E. in parentheses.

	Means score for disease		
Disease	Geisha variety	Agaro variety	P
1998			
CBD	1.44 (0.05)	1.57 (0.07)	Ns
Rust	2.42 (0.03)	2.44 (0.05)	Ns
1999			
CBD	0.88 (0.04)	1.75 (0.08)	<0.001
Rust	0.30 (0.02)	0.09 (0.03)	<0.001

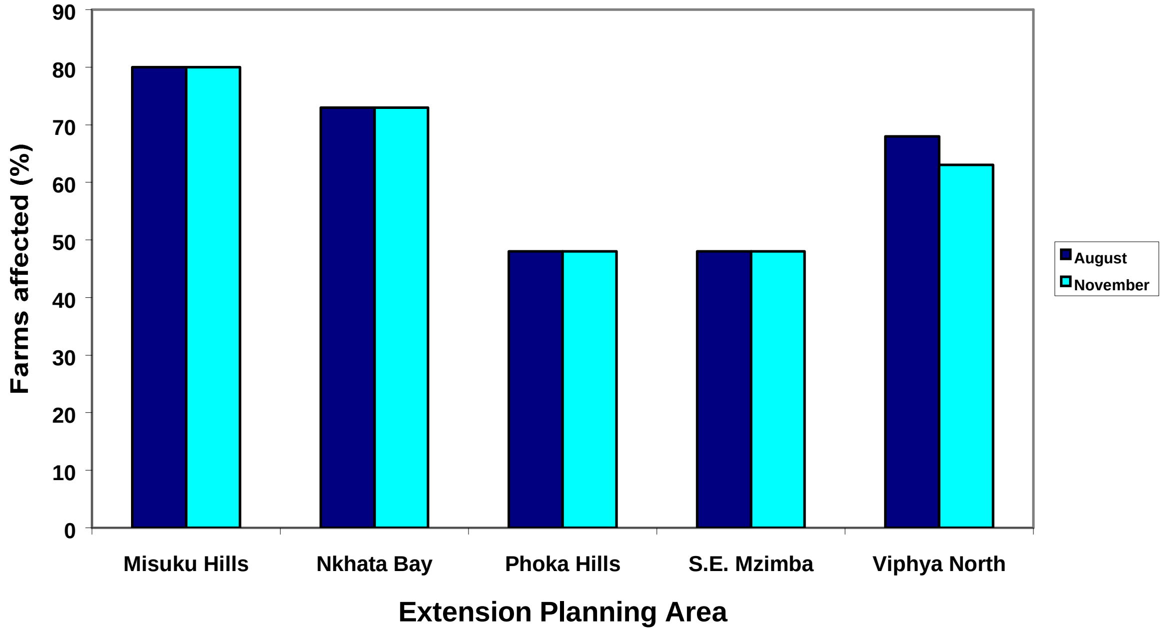
Cropping practice had some effect on disease incidence per field. Both intercropping and pruning appeared to be important. Lower incidences were recorded at sites where banana intercropping was practised and where pruning had been carried out than where they were not practised. There was also a trend towards lower disease incidence where there was no shading (Fig.9.).

Fig.9. Effect of cropping practice on CBD incidence (ν = not practised, □ = practised).



Additional surveys for CLR were conducted in two contrasting seasons i.e. cold/dry (August) and warm/dry (November) on 100 farms in the five main coffee-growing EPAs. The incidence of CLR was recorded per coffee bush using a scoring system of 0-4, where 0=absent, 1=<5%, 2=<25%, 3=25-50% and 4=>50% leaf area affected. In both seasons, the incidence of CLR was significantly higher in Misuku Hills and Nkhata Bay (73-80%) than in Phoka Hills and S.E. Mzimba (48%) (Fig. 10). Although >50% of farms were affected by CLR, it is considered to be less important than CBD because it is not a direct cause of berry loss. 10 trees per farm were tagged in order to be able to return to the same trees to estimate defoliation and then yield in relation to rust scores the previous season. However, the project ended before this study could be completed. The impact of rust on yield loss still needs to be assessed.

Fig 10: Effect of EPA and season on the incidence of coffee leaf rust in small-holder coffee in Northern Malawi



Output 4: The efficacy of pest management techniques including pesticide application, mixed cropping, mulching and pruning and interactions with microbial antagonists determined.

Much of the work under this output has investigated the relationship between CBD and berry loss and the effect of fungicide on disease progress. The effect of fungicide on surface microflora was also investigated. Surveys for natural enemies and the effect of cultural practice on insect pests and their natural enemies are also reported under this output.

Coffee berry disease progress

1998 cropping season : Disease progress on the marked bushes in 1998 showed a steep rise from 24th February to 14th April, then started dropping until about 3rd March when it started rising again up to the maximum of 60% infection, towards the end of the cropping season (Fig 11). There was very little berry loss until 24th March when there was an increase up to 12th May. The cesation of berry loss coincided with the attainment of physiological maturity by the coffee berries (hardening of berries).

1999 cropping season: There was more CBD in 1999 than in1998. There was a steady rise of CBD at the beginning of the cropping season (berry expansion stage), reaching a peak on 2nd March, then decreased on 9th March before rising again (Fig 12). Both scab and active lesions were common in 1999. The percentage of scab lesion followed the trend of CBD incidence.

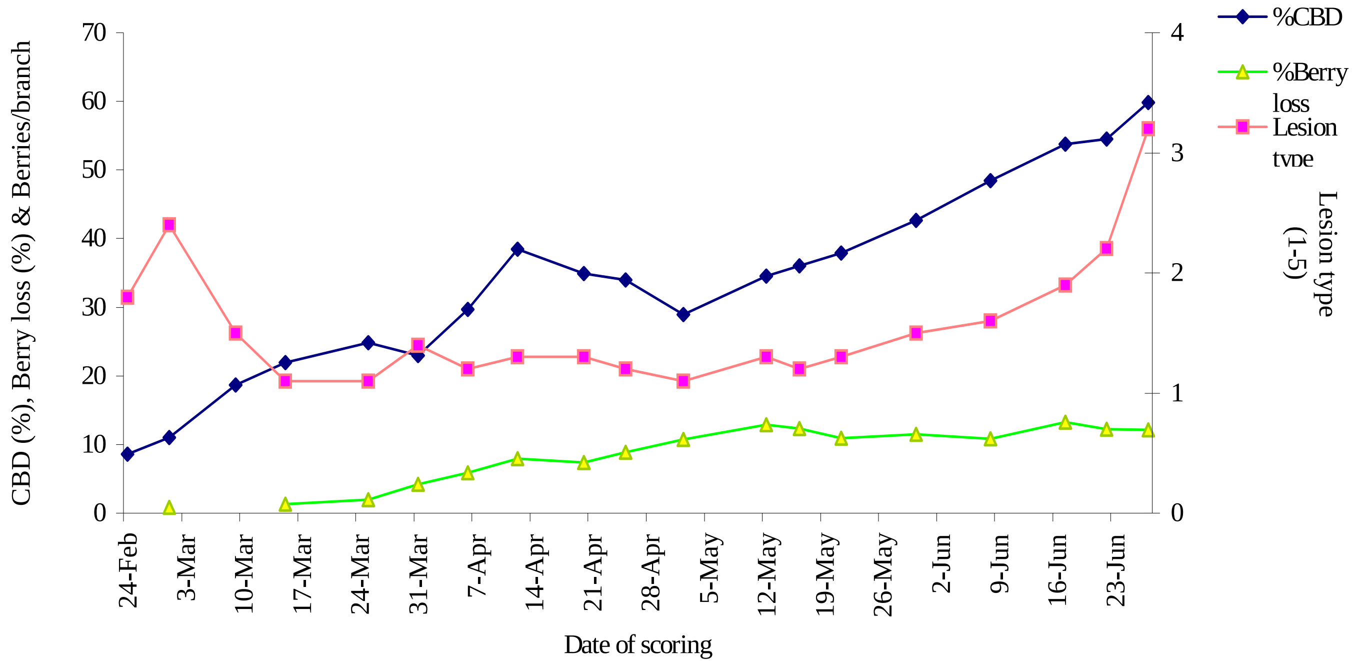


Fig 11. Development of coffee berry disease, scab lesions, and berry loss on 20 marked coffee bushes in 1998

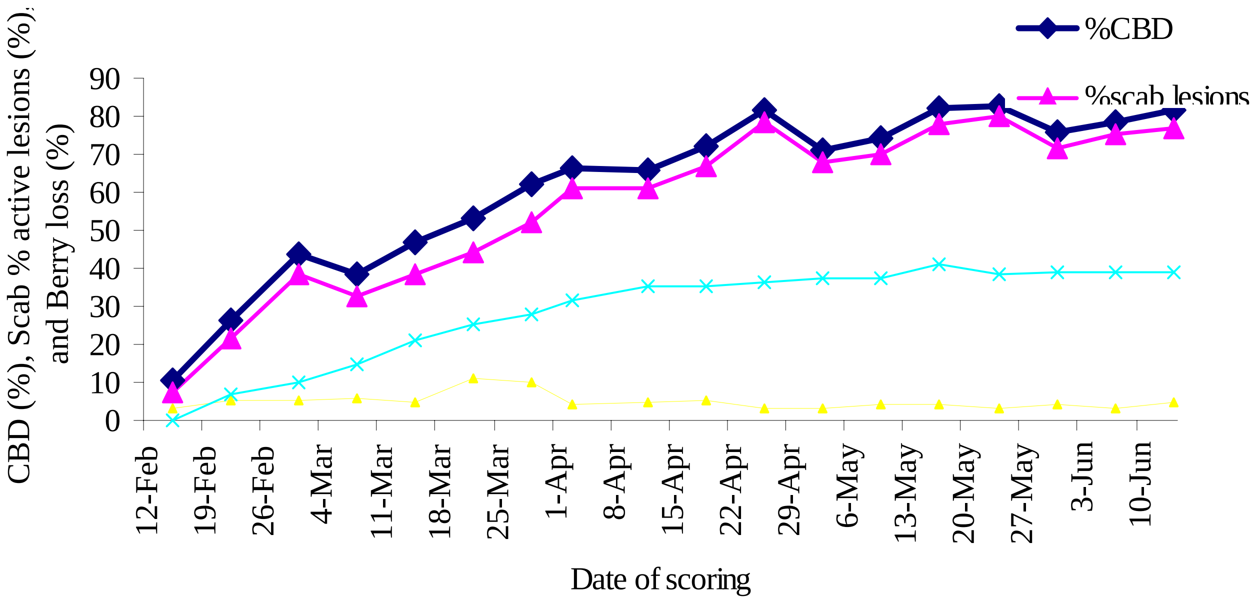


Fig 12. Development of coffee berry disease, scab and active lesions and berry loss on marked coffee bushes in 1999 (see Plate 3 for active and scab lesions).

Disease progress in fungicide applied and non fungicide (control) plot

1998 cropping season: The fungicides significantly ($P \leq 0.05$) controlled the disease, keeping it to below 13 % most of the time (Fig. 13)

1999 cropping season: *i) %CBD.* CBD incidence in the fungicide treatment was significantly lower than in the control from 11th March up to the end of the season. The maximum was only 12 % CBD in this particular treatment (Fig. 14.). There was generally low CBD at the beginning of the season (17th Feb to 11th March) as shown by both the control and fungicide treatment (Fig 14). This is in spite of the rainfall, low temperatures, fairly high RH, and dew falling every morning. There was a rapid increase in amount of CBD from 14% around 11th March to 50% around 11th April in the control treatment. This is during the expanding berry stage. This period precedes the period of the highest rainfall, very high RH, (night and morning RH), very low temperatures and a lot of dew falling at night

ii) Scabs and active lesions: An analysis of the two CBD induced berry lesions separately revealed an interesting trend. Scab lesions followed the same trend as that of CBD throughout the cropping season (Fig 14). However, active lesions followed a totally different trend. From 17th February to 11th March there was a rapid increase in amount of active lesions in fungicide treated plots while active lesions increased slightly in the control plots, but increased rapidly after 11th March reaching the peak of 25% on 1st April, before decreasing rapidly, then slowly up to the end of the season. Active lesions remained around 10% throughout the season in the fungicide treated plot (Fig 14).

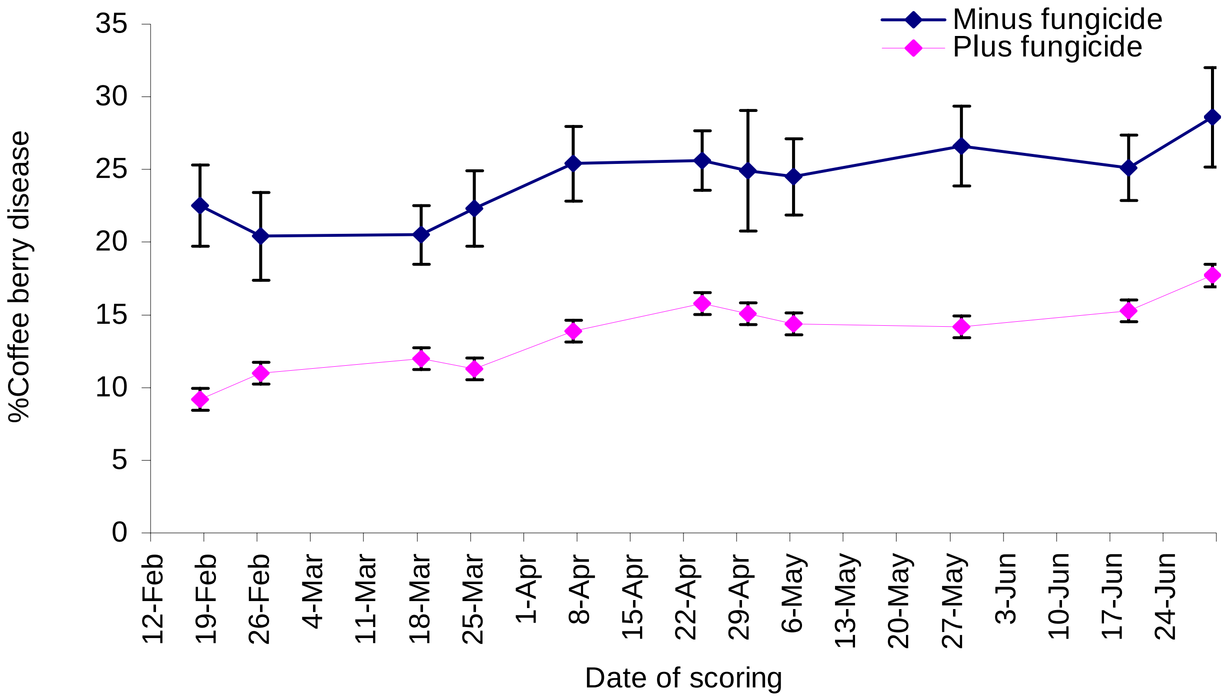


Fig. 13. Progress of CBD in the fungicide and non fungicide treated (control) treatments during the 1998 cropping season.

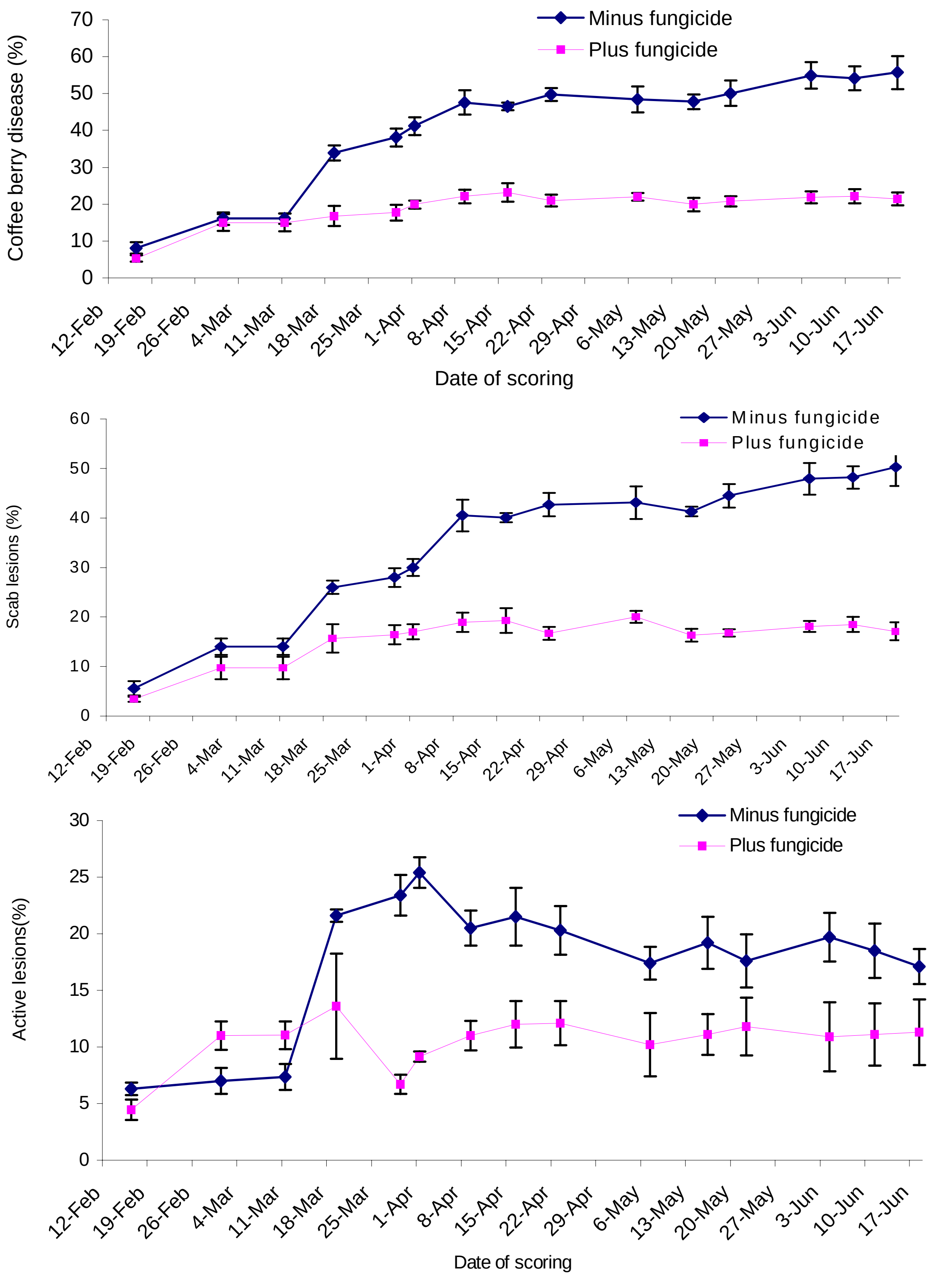


Fig. 14. Progress of CBD, development of scab and active lesions in the fungicide and non-fungicide treated treatments in 1999

iii) Berry loss and fungicides in 1999; Berry loss in cv Marchando was around 10% at the beginning of the season, but increased rapidly from 11th March (10%) to 11th April (45%) in the control plot. This period again coincided with the period of rapid disease and the favorable weather conditions and expanding berry stage. Berry loss in the fungicide treatment on cv. Marchando was 20% on 18th March when berry loss almost stopped. (Fig 15). The difference in berry loss between the two treatments was significantly different from 29th March up to the end of the season (Fig 15).

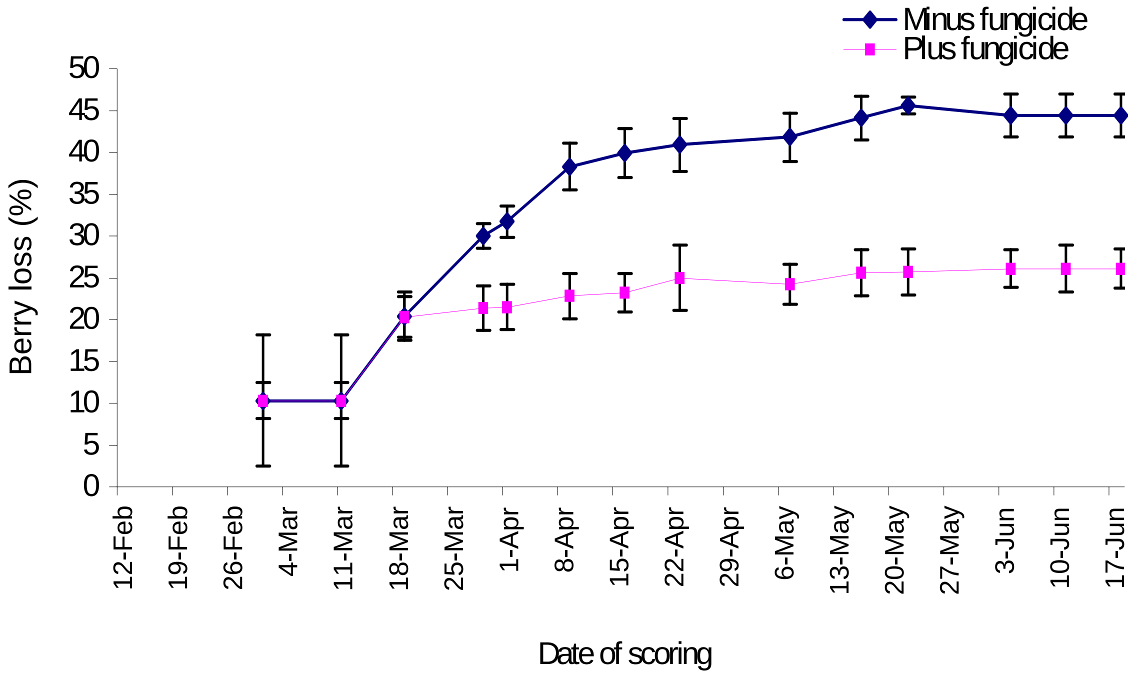


Fig. 15. Berry loss in the fungicide and non fungicide treated treatments in 1999

iv) Clean coffee yield: Fungicide treatment gave significantly (P≤0.01) higher yields than the control. There was a difference of 503.8 kg/ha which would represent an economic return on the inputs.

Table 10. Clean coffee yield for the fungicide, fertilizer and variety trial experiments

Treatment	Yield (kg)/ha Fungicide	Treatment	Yield (kg)/ha Foliar fertilizer	Cultivar	Yield (kg)/ha Variety
Minus fungicide	577.4	Minus fertilizer	679.2	Caturra	578.4
Plus fungicide	1081.2	Plus fertilizer	889.3	Nyika	962.1
P≤	0.01	P≤	ns	P≤	0.05

Disease progress on Caturra and Nyika coffee cultivars

CBD progress in 1998: There were significant differences in amount of CBD occurring on the two cultivars throughout the season until 29th June when the berries started ripening (Fig. 16). There was a rapid increase in CBD from 28 February to 8 April on cv. Caturra. This period of rapid increase in CBD coincided with periods of high rainfall, but unstable RH, and low minimum temperature.

CBD progress in 1999: There was significantly lower CBD on Nyika cultivar than on Caturra throughout the 1999 season (Fig. 16). Further more, there was a rapid disease increase from 16th February to 10th April (45%) on Caturra variety. CBD increased gradually up to 58% on 17th June.

Scab lesions followed the CBD trends throughout the season. There were significantly fewer scab lesions on Nyika cultivar than on Caturra. There was a rapid rise in amount of scab lesions at the beginning of the season up to 10th April then increasing gradually up to the end of the season when the scab lesions reached 50 % (Fig 13).

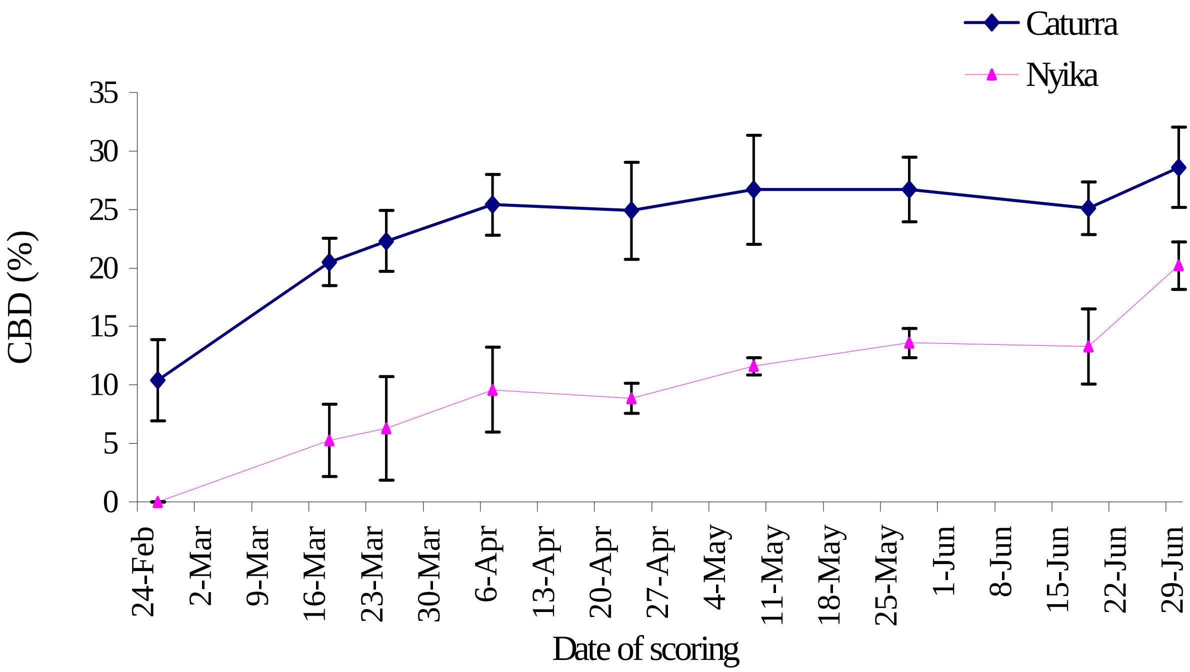


Fig. 16. The progress of CBD on Caturra and Nyika coffee cultivars in 1998.

Nyika cultivar also had significantly fewer active lesions than Caturra throughout the season except at the end when the berries were ripening.

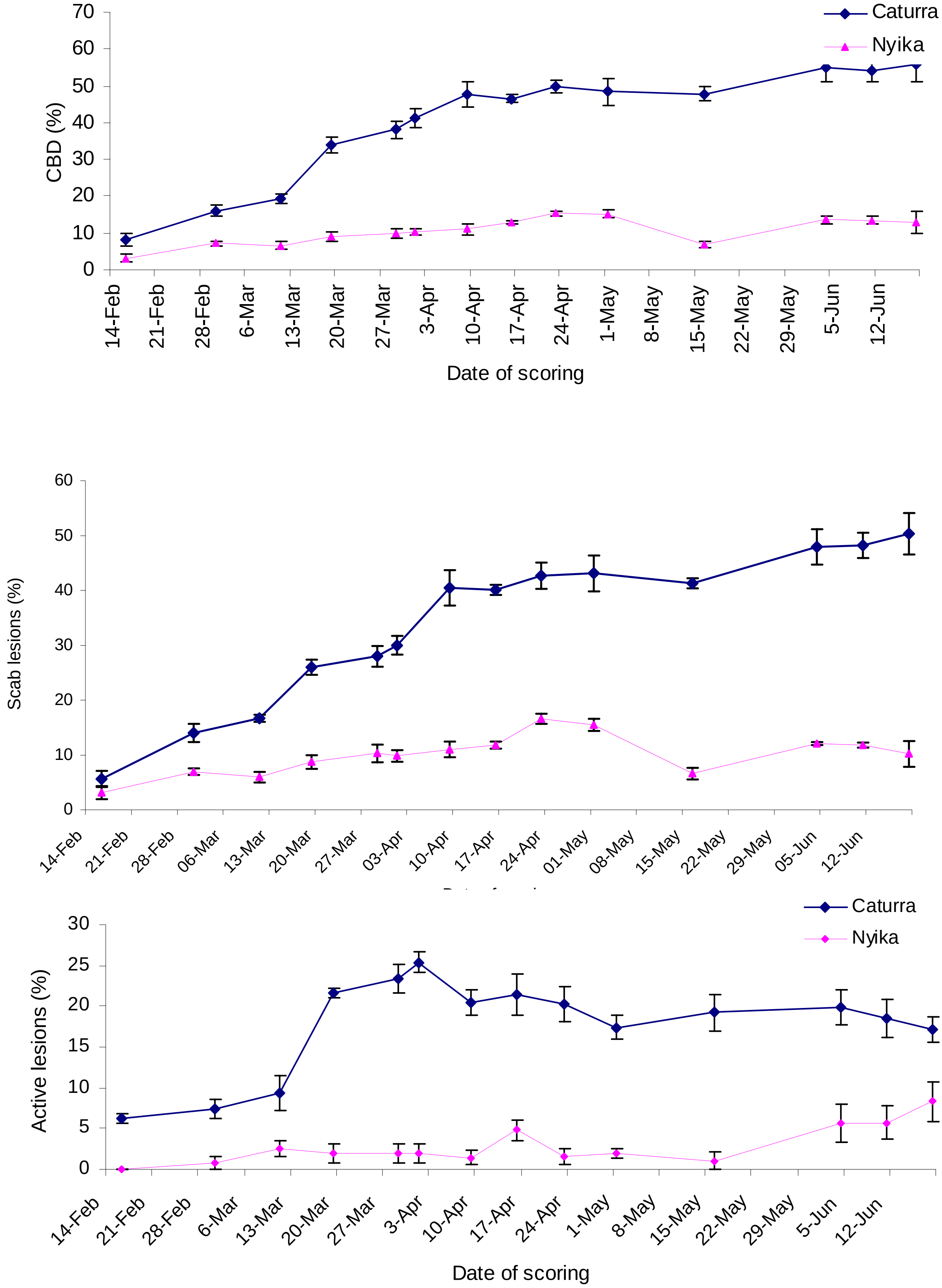


Fig .17. Progress of CBD, scab and active lesions on Caturra and Nyika in 1999 Berry loss.

There was significantly less berry loss on Nyika reaching only 10% throughout the season (Fig. 18). Most berry loss occurred between 30th March and 10th April. There was berry loss of up to 38% on Caturra (Fig 18).

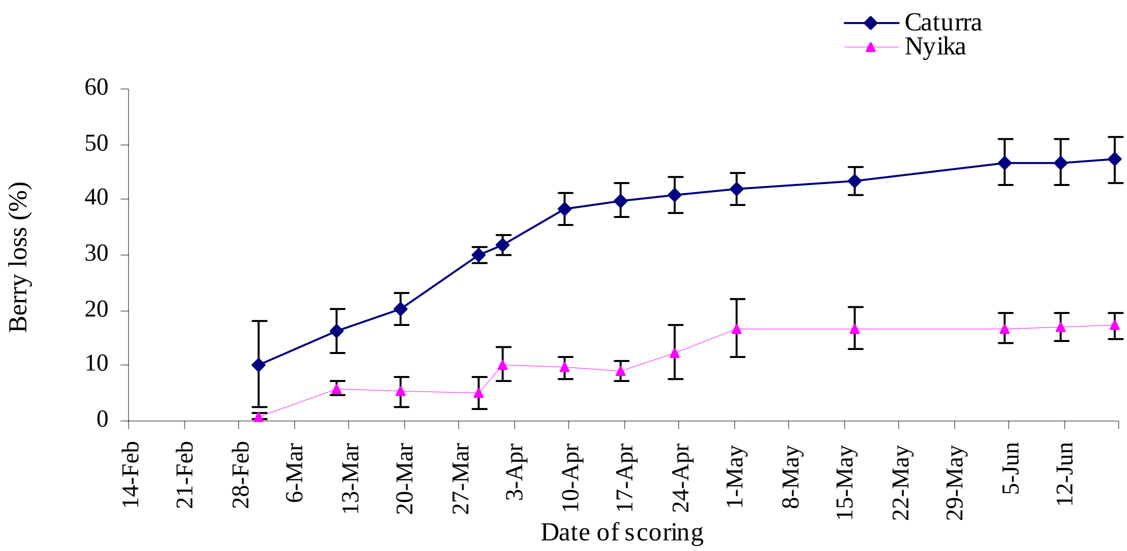


Fig. 18. Berry loss on Caturra and Nyika coffee cultivars in 1999

CBD and weather conditions

CBD and temperature: There was a significant negative relationship between temperature and CBD incidence (r = 0.741), implying that there is likely to be an increase in CBD when there is a decrease in temperature (or at higher altitude). There was a significantly negative relationship between CBD and weekly mean maximum temperature (Fig. 19)

Berry loss and temperature: There was a significant negative relationship between berry loss and mean maximum temperature (r=0.732). There was a significant negative relationship between CBD and minimum temperature (r=0.756) (Fig. 19).

CBD and symptoms, and berry loss

CBD and scabs: There was a very strong positive relationship between CBD and scab lesions (r=0.991) (Fig. 19).

CBD and berry loss: There was a very strong positive relationship between CBD and berry loss (R=0.9762) (Fig. 19).

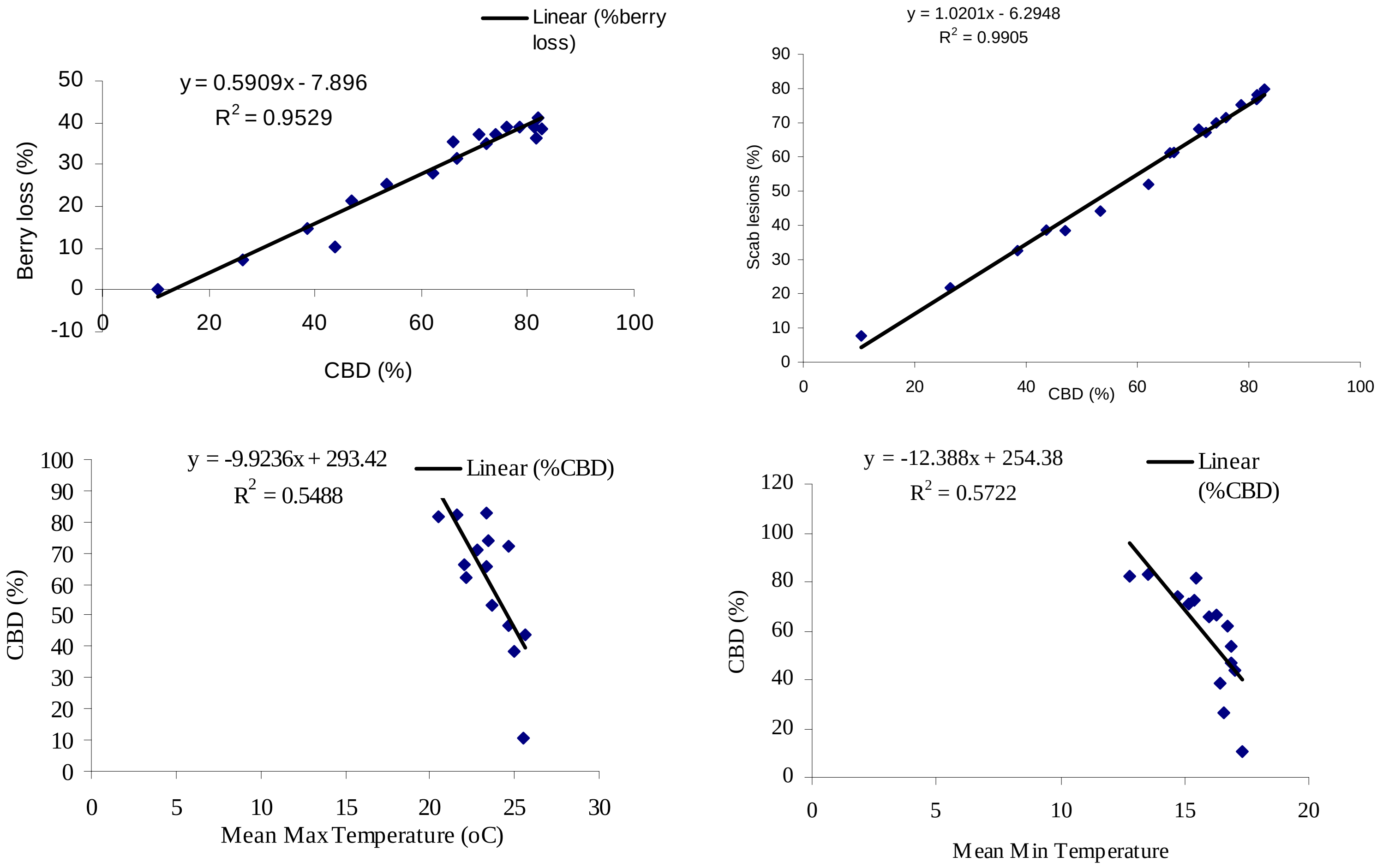


Fig. 19. Relationships between CBD and weather, CBD and berry loss, and CBD and scab lesions

Natural enemies of insect pests

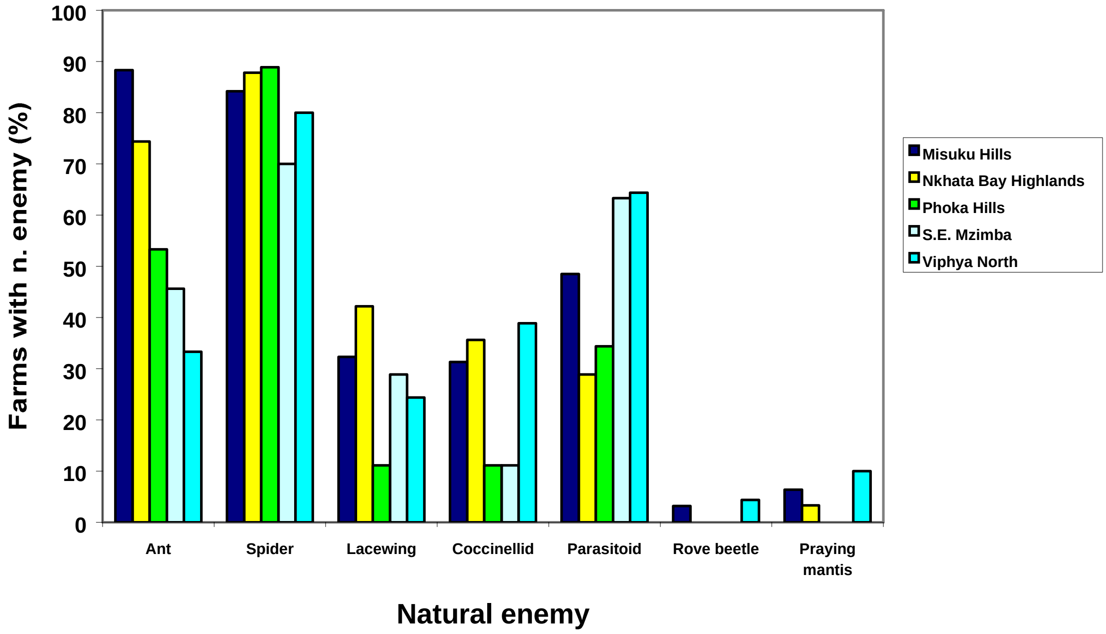
Natural enemies of insect pests were collected from the field and sent to CABI UK Centre for identification. A list of these natural enemies is presented in Table 11.

Table 11. Natural enemies collected during the surveys of smallholder coffee in Northern Malawi

Order	Family	Species	Host
(Predators)			
Araneae	Salticidae	*Asemonea murphae*	General predator
		Thyene ogdeni	“
	Theridiidae	*Dipoena* sp.	“
		Theridion sp.	“
	Thomisidae	*Diaea puncta*	“
Coleoptera	Coccinellidae	*Cheilomenes* spp.	Homoptera, Lepidoptera
Hymenoptera	Formicidae	*Pheidole* sp.	Homoptera (scales)
(Parasitoids)			
Hymenoptera	Encyrtidae	*Trichomasthus* sp.	Homoptera (scales)
	Eulophidae	*Quadrastichus* sp.	Diptera, Coleoptera larvae
	Ichneumonidae	*Enicospilus camerunensis*	Lepidoptera larvae
		Fotsiforia n.sp.	“
	Scelionidae	*Telenomus seychellensis*	Heteroptera eggs
		Trissolcus sp. near *mopsus*	“

Surveys for natural enemies were conducted at the same time, and using the same methods, as those described previously for insect pests. Spiders, ants and hymenopteran parasitoids (Fig. 21) were prevalent in all EPAs and seasons. Statistical analyses were complicated by the uneven occurrence of some natural enemies, nevertheless, most of the data were analysed using Generalised Linear Models, assuming a Poisson distribution for counts. It was found that only the population of parasitoids was influenced significantly ($p<0.05$) by EPA and this effect varied with season. Thus the population of parasitoids was generally higher in Viphya North and Misuku Hills (2-15 parasitoids per tree) compared to Phoka Hills and Nkhata Bay (0-2 parasitoids per tree), and this difference was particularly pronounced in the warm/dry season.

Fig 21. Incidence of natural enemies of coffee pests on small-holder coffee in Northern Malawi



Generalised Linear Models were again used to analyse the effect of cultural practices (shading, pruning and inter-cropping) on the incidence of pests or their natural enemies. Cultural practices were found to have no significant ($p<0.05$) effect on the incidence of pests, and they had only a limited effect on the incidence of natural enemies (see Figs. 23 a-c). For example, it was found that both shading and intercropping influenced the incidence of parasitoids. However, these effects were dependent on season and no overall trends emerged as a result of cultural practices.

Fig. 22a: Effect of shading on numbers of pests and their natural enemies on coffee trees (where scores are denoted by *, and percentages by ^) (Ants, no shading=245; shading=175)

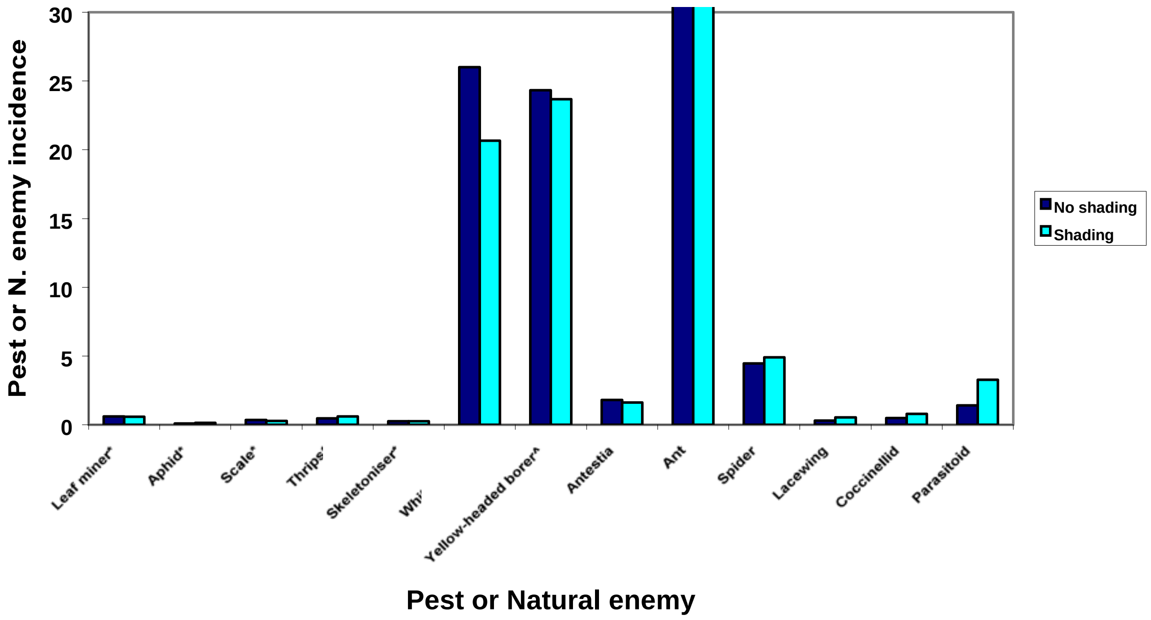


Fig. 22b: Effect of pruning on numbers of pests and their natural enemies on coffee trees (where scores are denoted by *, and percentages by ^) (Ants, no pruning=234; pruning=163)

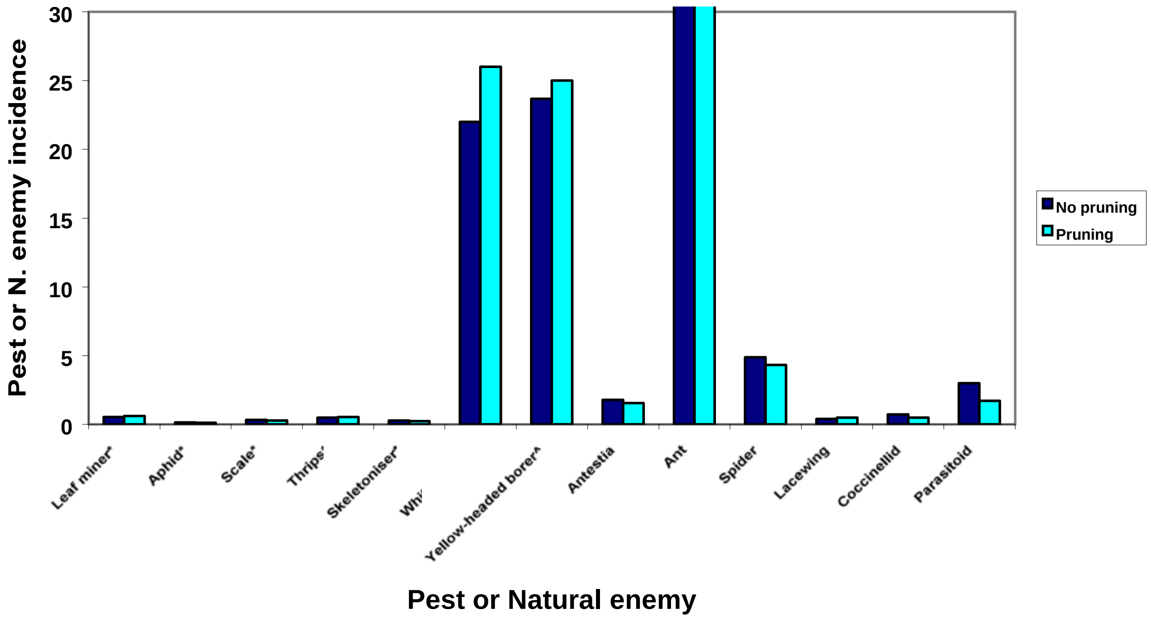
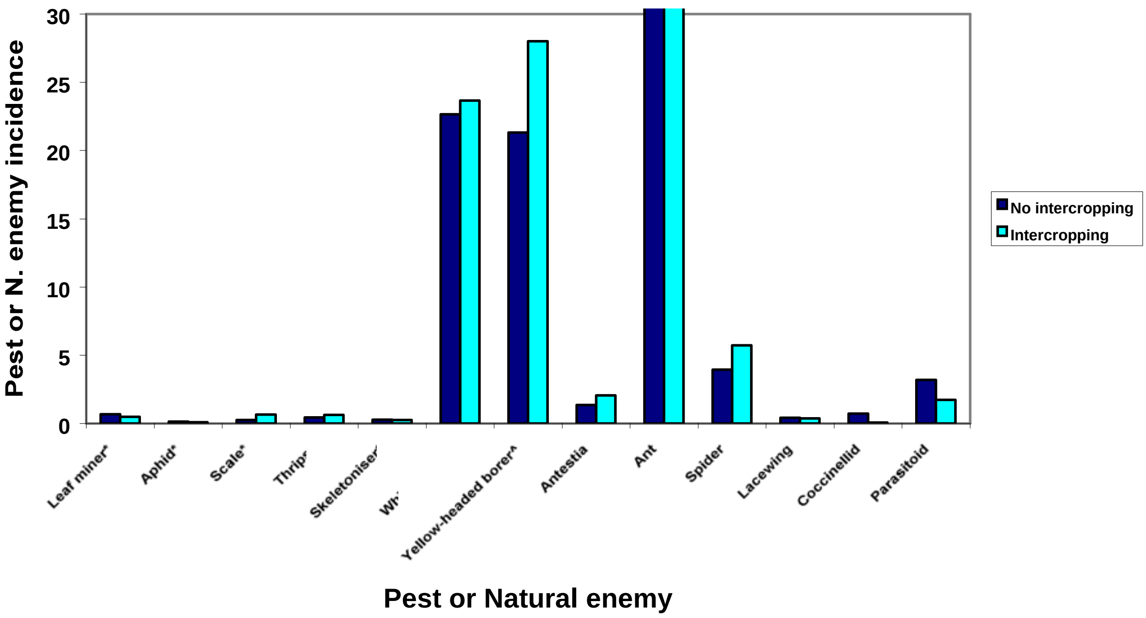


Fig. 22c: Effect of intercropping on numbers of pests and their natural enemies on coffee trees (where scores are denoted by *, and percentages by ^) (Ants, no intercropping=178; intercropping=248)



In an attempt to identify alternatives to chemical pesticides for the control of stem borer, an additional survey was undertaken to evaluate the potential of using entomopathogens. A total of 156 stem borers (white and yellow-headed) were collected from 15 farms (3 in each EPA), together with soil samples from farms in two EPAs, and shipped to the CABI UK Centre for laboratory examination and isolation of pathogens. Taxonomic identification of the stem borers revealed that the white stem borer was *Monochamus leuconotus*, and the yellow-headed borer was *Dirphya nigricornis*. The collected insects were found to be free of any pathogens (fungi, bacteria, viruses or nematodes), and baiting the soil samples with *Galleria mellonella* also failed to yield any pathogens.

A bioassay was conducted to test the efficacy of three exotic species of the entomopathogenic nematode, *Steinernema.* Three African isolates, *Steinernema* n.sp. (Code Z35), *Steinernema karii* (Code E9) and *Steinernema* n.sp. (Code 'Chipinge A') were imported into Malawi for laboratory experiments conducted at Mkondezi Research Station. The latter of the three isolates was recovered from *M. leuconotus* larvae in Zimbabwe and is already known to be pathogenic to *M. leuconotus* and *D. nigricornis.* White and yellow-headed stem borers were inoculated with a 1ml of a nematode suspension (1000 per ml). After three days, stem borers infected with *Steinernema* n.sp. (Code 'Chipinge A') died and subsequent dissection confirmed nematode infection. Further surveys of coffee stem borers are now required in other coffee growing countries, where their populations are naturally low, in order to find natural enemies which could be effective against coffee stem borers in Malawi.

A number of insecticides were evaluated against white stem borer. Wide variation between trees meant that the LSD was high but there was some evidence for control by chlorpyrifos and chlordane (Table 12). However, chlordane has subsequently been withdrawn for use on coffee because of its toxicity for humans, as well as its phytotoxic effects. This work needs to be replicated on-farm, and broadened to include a number of new chemical products which are now available e.g. fipronil, confidor.

Table 12. Effect of control measures on number of coffee trees affected by white stem borer.

Treatment	No. of stem borer-affected trees	
	Location 1.	Location 2
Chlorpyrifos (spray application to tree trunk)	1.3	1.5
Chlordane (stem paint)	1.3	0
Sumicidin (Spray application to tree trunk)	2.0	2.3
Wood ash (to base of tree)	2.3	2.5
Control 1.(normal phytosanitation)	2.7	2.3
Control 2.(unweeded)	2.7	3.3
Control 3. (weeded)	2.0	1.5
LSD	1.85	3.40

Output 5: Recommendations for management of key coffee pests will be developed.

Some progress has been made towards this on the basis of current practice and information obtained during surveys but it has not been possible during the project to field test our recommended interventions and this must await the follow-on.

The following control measures have been identified as possible components of IPM systems which require testing on-farm:

a) Alternative insecticides for stem paint formulation for stem borer control
b) Pheromones for stem borer control
c) Biocontrol agent for stem borer control (one has been identified by CABI in Zimbabwe).
d) Use of soil-applied fungicide for rust control where CBD is less important
e) Pruning for an open canopy on CBD and CLR.
f) Avoid over-shading to control CBD and CLR
g) Host-plant resistance - Catimor 129 for resistance to CBD and CLR

It is clear from the survey data that the importance of the main pests and diseases differs between EPAs (Table 13). Management of white stem borer is required in all five EPAs and there is an immediate need to address this problem. The most straightforward approach in the short-term, would be to evaluate insecticides that would serve as suitable replacements for aldrin in a stem paint. Research on alternative control measures such as deployment of biocontrol agents or use of pheromones requires longer term research.

Table 13. Relative importance in five coffee-growing districts (EPA) of northern Malawi of white stem borer, coffee berry disease (CBD) and coffee leaf rust (CLR).

EPA[a]	CBD	CLR	White stem borer	Overall score
Misuku Hills	***[b]	***	**	8
Phoka Hills	-	**	***	6
Viphya North	**	***	***	8
S. E. Mzimba	-	**	***	6
Nkhata Bay	*	**	**	5

a. EPA = Extension Planning Area.
b. *** = Over 50% of farms affected, with high incidences on some farms.
** = Up to 50% of farms affected, a few with high incidences.
* = Less than 30% of farms affected at low incidences.
- = Disease not recorded.

At present, management of CBD would be required only in Misuku Hills and Viphya North. Our data show that disease levels are lower where pruning is practised and CBD may be encouraged by over-shading. Under moderate disease pressure, the use of the correct crop management practises would probably provide adequate disease control without recourse to fungicides. The use of fungicide to manage CBD would be necessary only where farmers were already implementing the correct crop husbandry practices and where their yield potential was greater than 500 kg/ha.

Although CLR control may be required in three of the five EPAs (see Table 13), losses caused by the disease do not appear to be as severe in Malawi as they are in some Latin American countries for instance. Research initiated in this project needs to be continued to determine the effect of CLR on coffee yield under smallholder conditions. Where CLR occurs in the absence of CBD, those farmers who can afford to do so might be advised to use a soil-applied granular fungicide because the use of foliar fungicides for rust control has been known to exacerbate CBD.

CLR may be less important than CBD to the smallholder sector and with the information we have to date, the primary pest complex is white stem borer/CBD and the IPM system should be targeted primarily at this complex. The secondary targets would then be CLR, Antestia bug, leaf miner and yellow-headed tip borer.

The cultivar Catimor 129 is resistant to rust and certain selections have been shown to have some resistance to CBD in Malawi. Since 1998/99 a large number of seedlings of Catimor 129 have been supplied to smallholders wishing to expand their gardens. This has been done by the SCFT with support from the EU. This does not have the support of this project for the reasons given below and performance of the new plantings should be monitored closely in any follow-on project.

Catimor cultivars require careful management and are therefore not always suitable for smallholder production systems.

They require heavy fertilisation to achieve their yield potential without overbearing.

They are shallow rooted and may be unsuitable for shallow soils or steep slopes.

They have not been fully evaluated under smallholder conditions.

The CBD-resistant selection made at Lunyangwa (known as cv. Nyika) are not available as clones. The seedlings released to farmers were purchased from the Tea Research Foundation and may not be resistant to CBD.

The IPM system which now needs to be validated would be a flexible one such that the components could be selected according to the resource level of the farmer, the expected yield and the pest complex. In view of the influence of cultural practice on pest and disease incidence/severity, an integrated crop management approach (Table 14 and 15) should be adopted with pest management as one of the components. This will ensure that the correct framework is established for sustainable increases in coffee production based on rational pest management and sound crop husbandry.

Table 14. Summary of proposed ICM system for coffee smallholders in Malawi

Activity	Options under ICM
SITE SELECTION	For sloping sites, plant on contour and use bunds planted with bananas and/or e.g. Velvetier grass to prevent erosion.
PLANTING	At present varieties grown are Geisha or Agaro. Seedlings of disease resistant Catimor are available but farmers should retain at least some Geisha as Catimor requires careful management and high inputs.
FERTILISER	Use of inorganic fertiliser will increase due to improved producer price. This should be encouraged but soil organic matter should also be increased – green manure, crop residues, mulches etc.
WEEDING	Weeds can be suppressed around the bushes by use of mulches and cover crops/green manure can also be used. Cover crop would help to prevent erosion during establishment of new coffee gardens.
MULCHING	Mulching helps to retain soil moisture, suppresses weeds and provides organic matter to the soil.
PRUNING	Pruning can increase yields by opening the canopy to sunlight and improved air circulation reduces disease.
SHADING	Most smallholder coffee in Malawi is grown under shade with bananas often the shade tree. This should be encouraged especially where Catimor is grown to prevent over-bearing and die-back. Banana plants should be thinned when shading becomes dense which increases CBD.
CROP PROTECTION	(See Table 15).

Table 15. ICM-compatible crop protection options for coffee smallholders in Malawi

Pest/disease	Management options
White stem borer	Use alternative insecticides to replace aldrin as a stem paint although none are available for smallholders in Malawi at present. *Low input alternatives* – use paste made from wood ash or local botanicals
Antestia bug	Fenitrothion is available and is currently recommended. *Low-input alternatives* – The pest can be damaging at low populations (threshold is one per plant) so manual killing of individuals is worthwhile. Pruning for open canopy and avoidance of over-shading are necessary.
Green scale	Some farmers are using fenitrothion but it is of doubtful efficacy. Disulfoton is currently recommended but not readily available in northern Malawi. *Low-input alternatives* – Use sprays made from soap or botanicals.
Leaf miner	Several pesticides are recommended, including fenitrothion and deltamethrin. *Low-input alternative* – physical squeezing of infested leaves to kill larvae.
CBD	Copper oxychloride, chlorothalonil and hexaconazole are recommended fungicides. *Low-input alternatives* – Manual removal of affected berries, pruning for an open canopy, avoidance of over-shading. Use of resistant variety 'Catimor'. Catimor is reputed to have resistance to both CBD and CLR but it requires careful, management and high fertiliser inputs to perform well and avoid over-bearing. It may not therefore be ICM-compatible – requires further evaluation before being widely adopted.
CLR	Where both CBD and CLR are present and There is severe infection, sprays applied for CBD will control both diseases. *Low-input alternatives* – pruning, avoidance of over-shading and use of resistant varieties.

Outputs under project extension

Completion of PhD
Mr Noah Phiri was the principal collaborating scientist in Malawi and he was registered for a PhD at University of Kent. He has completed the thesis and is awaiting his viva.

Stakeholder workshop
The workshop was held in Malawi in December 1999 and was well attended by representatives from all sectors of the coffee industry, including farmers. All delegates participated in priority setting for a follow on phase of the project. A report summarising the workshop was submitted to CPP and a copy is included with this report. Table 16 summarises the pest and disease priorities set by the workshop delegates. The only departure from the priorities that emerged from the pest surveys is the importance delegates gave to CLR compared to CBD. This may reflect the conspicuous nature of CLR but further emphasises the need to obtain some data on the impact of CLR on yield.

Table 16. Crop protection priorities set by delegates at a coffee crop protection workshop in Malawi (December 1999).

	Importance Ranking[a] by EPA[b]					
Pest/Disease	NBH	SEM	VN	PH	M	Overall Ranking
White stem borer	3	3	2	2	3	13
Coffee leaf rust	2	2	3	2	3	12
Antestia bug	2	2	3	2	3	12
Yellow tip borer	3	3	3	2	1	11
Leaf miner	2	2	2	2	2	10
Coffee berry disease	1	1	3	1	3	9
Leaf spots	1	2	2	2	2	8
Scale insects	1	1	1	1	2	6
Leaf skeletoniser	1	1	1	1	1	5
Berry borer	1	0	1	1	1	4
Fusarium	0	1	1	1	1	4
Aphids	0	1	1	0	1	3

[a]Ranking scale: 0 = not important, 1 = minor, 2 = moderately important, 3 = serious problem.

[b]NBH = Nkhata Bay Highlands, SEM = South East Mzimba, VN = Viphya North,
PH = Phoka Hills, MH = Misuku Hills.

Update on pesticide use by coffee smallholders
Prospects for the smallholder coffee industry in Malawi have altered greatly during the period of the project. The SCA has been remodelled along co-operative lines with an elected board that includes farmers' representatives. Control over coffee production, including primary processing has devolved to the districts and is directly under the control of farmers groups. This process of reorganisation and devolution has been funded by the Export Stabilisation fund of the European Union (EU STABBEX). Some of these changes have been described in a separate project report and the impact of these changes on the prospects for adoption of ICM/IPM are outlined in Table 17. A survey was undertaken in 1999 to assess

the effect of these changes on pest management.

Table 17. Recent changes in the organisation of smallholder coffee in Malawi that are favourable to adoption of ICM.

Constraints to adoption of ICM 1990 - 1998	Favourable changes since 1998
Poor producer price	Farmers are now guaranteed a minimum of 60% of export price.
Late payment to farmers SCA as monopolistic buyer.	Liberalisation has opened the market to private buyers.
Dissatisfaction among farmers over SCA control of processing	Primary processing now under direct control of farmers groups.
Poor access to inputs due to lack of credit and distance from suppliers.	Credit systems available through the Business Centres and farmers better able to afford inputs, including pesticides with improved producer price.
Farmers had insufficient representation and control.	Extension/processing/marketing has devolved to the Districts and access to inputs and other matters concerning coffee promotion is handled by the Business Centres set-up with support from EU-STABBEX[a].
SCA had expanded to the point where running costs mitigated against the provision of effective extension help and acceptable producer price.	SCA has been reorganised as SCFT with representation by farmers as elected trustees.

[a]Eurpoean Union – Export Stabilisation Fund

Two surveys of pesticide use were conducted. The first in Misuku Hills in April 1999 and the second at the start of the following season, in Nkhata Bay Highlands in December 1999. The two surveys are not directly comparable as they were conducted in different seasons in different areas. However, the general impression was that there was increased enthusiasm for coffee as a reliable source of income among the farmers interviewed in December 1999, compared to the previous season. This was largely due to the impact of the increase in producer price for primary processed coffee.

Only 14% of farmers were applying pesticide to their coffee crop in Misuku Hills in the 1998/99 season (Table 18) but 31% said they intended to do so in the 1999/2000 season.

Around 90% said they used to use pesticides and the main reasons given for no longer using them were that they were too expensive, difficult to obtain and there were no credit facilities (Table 19). Every farmer said pesticides would be used if these constraints were removed (Table 18).

The main insecticide in use was fenitrothion and the main fungicide was copper oxychloride (Table 18). Sixty percent of farmers interviewed mentioned coffee leaf rust (CLR) as the target of their spraying, while 60% of farmers also said they targeted white stem borer (WSB). However, there is no evidence that fenitrothion provides any control of WSB. For the other pests mentioned there were conspicuous differences between the two districts. Green scale and leaf eaters were mentioned by 24% of farmers but only in Misuku, while leaf miner and mealy bug were mentioned only in Nkhata Bay. Antestia bug and black ants were the next most often mentioned pests in both districts. Coffee berry disease (CBD) was mentioned by only 6% of farmers in Nkhata bay as something they tried to control but by 21% in Misuku. This reflects the relative importance of CBD in the two districts from our disease incidence surveys.

Other indicators that coffee is now seen by smallholders as a worthwhile investment were the large number of farmers who were increasing the size of their holding (66%) and 90% said they wished to plant more coffee bushes (Table 19). Most farmers were members of their local business centre, where they had obtained seedlings of Catimor 129. Seventy three percent of interviewees had their own nurseries or access to a group nursery and many had already planted seedlings of Catimor (38% in Misuku and 63% in Nkhata Bay).

These results show a marked increase in confidence in coffee, widespread rehabilitation of neglected gardens and expansion of the number of bushes grown. The prospect is now good for adoption of any future project outputs on IPM. The most pressing needs are for a control measure against WSB and for a rational approach to management of CBD and CLR, so that fungicides are used only as a last resort and where there is the prospect of a cost benefit from their application.

6. Dissemination

6a. Publications:

Hillocks, R.J., Phiri, N.A. and Overfield, D. (1999) Coffee pest and disease management options for smallholders in Malawi. *Crop Protection* 18, 199 - 206.(A).

Hillocks, R. J (In press) Integrated crop management for smallholder farmers in Africa with special reference to coffee in Malawi. *Pest Management Science*.

6b. Internal Reports:

Briscoe, B. (1999) BTOR Report of a visit to Malawi to conduct a survey on Stem borers on smallholder coffee (8-20 March 1999). CABI-Bioscience.

Hillocks, R. J., Phiri, N. and Overfield, D. (1998). Factors contributing to low coffee yields from smallholder plantations in northern Malawi. Project R6807 Report No 5. Chatham, NRI. 13 pp. (C).

Hillocks, R. J (1998) BTOR Report of a visit to Malawi to monitor progress in a project on IPM for smallholder coffee. 13 - 19 January 1998. Project R6807 Report. 3 pp. (C).

Hillocks, R.J. (1998).BTOR Report of a visit to Malawi to review coffee IPM project and meet collaborators, 27 Nov - 5 Dec 1998. Project R6807 Report 4pp.(C).

Hillocks, R. J. (1999) FILE NOTE Report of a visit to Malawi to conduct a survey of coffee diseases. 17 - 26 April 1999. Project R6807 Report. 3 pp. (C).

Kapeya, E.H. (1998) Incidence and status of some insect pests on smallholder coffee farms in northern Malawi. Project R6807 Report No. 4. Chatham, NRI. 7 pp. (C)

Oduor, G.I., Simons, S.A. & Briscoe, B. (1999) Evaluation of entomopathogens for the control of coffee stem borers in Northern Malawi. Technical Report, CABI-Africa Regional Centre. 4 pp.

Overfield, D. and Phiri, N. (1997) Socio-economic report on initial survey of smallholder coffee growers in northern Malawi. Project R6807 Report No 1. Chatham, NRI 33 pp. (C).

Phiri, N.A. & Hillocks, R.J. (1998) Survey of coffee diseases in smallholder plantations in northern Malawi. Project R6807 Report No.2. Chatham, NRI. 12 pp. (C)

Phiri, N.A. (1998) Farm inputs sold to coffee farmers in northern Malawi. Project R6807 Report No.3. Chatham, NRI. 9 pp. (C)

Simons, S.A. & Oduor, G.I. (1999) BTOR Report on a visit to Malawi to conduct a survey of smallholder coffee pests and their natural enemies in Northern Malawi (8-21 Jan 1999). CABI-Africa Regional Centre.

Simons, S.A. & Oduor, G.I. (1999) BTOR Report on a visit to Malawi to conduct a survey of smallholder coffee pests and their natural enemies in Northern Malawi (1-14 Aug 1999). CABI-Africa Regional Centre.

Simons, S.A. & Oduor, G.I. (1999) Incidence of major coffee pests and their natural enemies in the five coffee-growing EPA's in Northern Malawi. Technical Report, CABI-Africa Regional Centre. 7pp.

Waller, J.M. & Nyambo, B.T. (1997) BTOR Report on a visit to Malawi to initiate an ODA (DFID) coffee IPM project (27 Jan–11 Feb 1997). CABI-Bioscience.

Waller, J.M., Simons, S.A. & Oduor, G.I. (1998) BTOR Report on a visit to Malawi to monitor coffee IPM project and conduct a survey of coffee stem borers (28 Nov-12 Dec 1998). CABI-Bioscience.

Publications planned

Phiri, N. A (2000) PhD Thesis: Coffee berry disease in Malawi and possible role of microbial interactions in disease management.(expected July 2000).

Phiri, N. A., Hillocks, R. J. and Jeffries, P. (2000) Incidence and severity of coffee berry

disease in smallholder coffee in northern Malawi. *Crop Protection* (Submitted June 2000)

Authors as above. Disease progress and yield loss due to coffee berry disease in northern Malawi.

6c. Other Dissemination pathways:

Annual Reports of Ministry of Agriculture, Lunyangwa Research Station.

Annual Reports of Smallholder Coffee Farmers Trust.

7. Project Logical Framework

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
Goal			
Yields from crops on sloping lands optimised and sustainability enhanced by minimising production losses.	To be completed by CPP Programme Manager	To be completed by CPP Programme Manager	To be completed by CPP Programme Manager
Purpose			
Improved methods for the management of priority pests of arabica coffee	To be completed by CPP Programme Manager	To be completed by CPP Programme Manager	To be completed by CPP Programme Manager
Outputs			
1. Economic trends affecting small-holder coffee in Malawi understood. 2. Socio-economic factors constraining coffee growers in Malawi established. 3. The distribution and relative importance of major pests and diseases on coffee in Malawi established. 4. The efficacy of pest management techniques including pesticide application, mixed cropping practices, cultural techniques and their interactions with microbial antagonists determined. 5. Recommendations for management of key coffee pests developed. <u>New outputs</u> 6. PhD thesis examined and papers prepared. 7. Priorities for follow-on project set. 8. Further information obtained on distribution and importance of stem borers and coffee leaf rust.	1. Data on macro- and micro-economic trends completed during first 6 months of project. 2. Data on socio-economic factors from 4 coffee -growing areas completed by end of year 1. 3. Data on the current status of pests and diseases of coffee in Malawi for 48 representative farmers from 4 coffee areas completed by end year 1. 4.1 The efficacy and optimal application conditions for at least 3 pesticides determined by August 1999. 4.2 Information on the effects of production practices gathered by August 1999. 4.3 An estimation of the potential for manipulating natural antagonists to achieve bio-control of key pests produced by December 1999. 5. Farmer and extension agent evaluation of recommendations during a workshop held in September 1999. 6. PhD thesis bound by March 2000. 7. Stakeholder workshop held in December 1999. 8. Surveys conducted in October 1999.	1.1 Reports and publications from project personnel and consultants. 1.2 Reports and publications from project personnel. 2. As above 3/4/5. As above 6. PhD approved by recognised University. 7. Report on the workshop and recommendations for follow-on. Follow-on proposal document. 8. Survey reports and scientific papers.	1. Coffee prices sufficient to support optimal use of inputs. 2. Inputs available to small-holders. 3. Key pesticides not withdrawn. 4. New virulent or pesticide resistant strains of CBD do not evolve. 5. Natural biocontrol of pathogens through action of microbial antagonists occurs in Malawi.

Activities	Inputs	Means of Verification	Important Assumptions

1. Economic trends affecting small-holder coffee in Malawi understood. 2. Socio-economic factors constraining coffee growers in Malawi established. 3. The distribution and relative importance of major pests and diseases on coffee in Malawi established. 4. The efficacy of pest management techniques including pesticide application, mixed cropping practices, cultural techniques and their interactions with microbial antagonists determined. 5. Recommendations for management of key coffee pests developed. New outputs 6. PhD thesis examined and papers prepared. 7. Priorities for follow-on project set. 8. Further information obtained on distribution and importance of stem borers and coffee leaf rust. 1. Malawi national scientist enrolled for higher degree research programme. 2. Desk study defined economic basis of Malawi coffee industry. 3. Socio-economic survey of farmers in Malawi to determine production and marketing constraints. Also to assess demand for pesticides and potential of alternative pest management methods. 4. Survey of pests and diseases and the occurrence of their natural enemies and antagonists. 5. Experimental sites selected in the Mzuzu area. 6. Experimental programme on pesticide application. 7. Experimental programme to address potential for manipulating	Total Budget here £213,745	1.1. Field visits, quarterly annual and final reports. 1.2 Scientific publications. 1.3. Workshops and conference presentations. 2-10. As above 11. PhD available and at least 2 papers in scientific journals. 12. Report and proposals for follow-on. 13. Survey reports	1. Re-structuring of coffee industry does not limit surveys. 2. Climate suitable for disease development during experimental period. 3. Pesticides available in-country. 5. Farmers able to attend workshop. Extension 6. PhD is passed by examiners 7. Stakeholders are available for a workshop before end of the year. 8. The surveys can be organised with problems of transport and manpower with main collaborator having returned to UK and also shortage of time.

8. Contribution of outputs

The project has contributed to minimising losses caused by pests and disease of coffee by identifying the major biological and socio-economic constraints to increased coffee production in the smallholder sector. The distribution, incidence and severity of the major pests and diseases has been determined. The effect of CBD on yield has been measured and information obtained on some factors affecting its distribution and severity. In addition, possible pest management interventions have been identified for further testing on-farm for stem borers and the two main diseases, CBD and CLR.

The economic survey showed that for many smallholders coffee production is a marginal activity if labour is accounted for. However, some farmers obtained an economic yield and there was the potential for about 35% of farmers to achieve this with improved management. There is a potential market for 'fair trade' coffee from northern Malawi.

The survey of farmers perceptions showed that pests and disease were of great concern and farmers views of the main pests were confirmed by the quantitative data obtained during the surveys. White stem borer is the most immediate problem and many farmers in Misuku hills and Viphya north would benefit from control of CBD. Losses to CBD varied greatly between districts and between farms, reaching 20 – 25%, although 50% yield increase was achieved in field trials in which fungicide was used to control CBD.

About 60% of farmers included in the survey at the outset of the project had abandoned the use of inputs on their coffee during the preceding four years. This situation must be addressed if coffee yields are to improve. There is now all the more need for good crop management as surveys conducted at the end of the project showed that 45% of farmers are expanding their coffee gardens and planting seedlings of cv. Catimor which requires careful management.

Cultural practices such as pruning have been neglected in recent years by coffee smallholders in Malawi due to the poor producer price on offer. Survey data indicated that the incidence of CBD and CLR was lower where correct pruning practices were followed. Over-shading also exacerbated these diseases. Insect pests and their natural enemies were also influenced by shading and pruning but the effect could be positive or negative, depending on the insect. Nevertheless, this data shows that much can be done to decrease the effects of the main diseases and pests by following correct husbandry practices. The first step in an ICM programme would be to ensure that the correct practices are followed and that pesticides are used only where there is significant pest damage in well managed gardens.

8a. What further research is necessary

The first phase of the project identified the main pest and disease problems, factors affecting their incidence and the most appropriate components of an IPM system for their management. A second phase is now required to validate and deliver the IPM systems to smallholders. Some of the components based on current practice and currently available pesticides can be immediately delivered through on-farm demonstration trials. Others require field validation, while others still require some basic research:

Basic research
Development of pheromones for management of white stem borer.
Development of biocontrol agents for white stem borer.
Strategic research
Testing of pesticides and other methods for white stem borer control.
Development of simple threshold levels for application of insecticides and fungicides.
Loss estimates for coffee leaf rust.
Adaptive Research
Validation of identified IPM components in on-farm trials.
Demonstration trials for ICM.

8b. Pathways whereby present and anticipated future outputs will impact on poverty alleviation or sustainable livelihoods.

Coffee is the mainstay of sustainable livelihoods in northern Malawi and living standards have fallen during the period when the low producer price discouraged farmers from spending time and money on their coffee gardens. In the last 12 – 18 months this situation has changed with the reorganisation of the SCA into the SCFT and the guaranteed producer price of 60% of the export price. During the last survey conducted in December 1999, all farmers interviewed expressed a wish to expand their coffee production and most had already obtained seedlings of Catimor 129. Farmers are now eager for knowledge that will increase their coffee production.

The changes in the organisation of the smallholder industry that has been supported by EU STABBEX have also facilitated delivery, uptake and adoption of present and future outputs. In each of the five EPAs there is a Coffee Business Advisor (salary presently supported by EU) and 40 Business Zones based around each of the primary processing plants that are controlled by farmers groups. Each Business Zone is subdivided into Business Centres, of which there are 144 that serve as contact points with farmers groups for training, extension advice and input supply. Each of the 10,000 registered coffee smallholders can become a member of his local business centre. During our survey in 1999 all farmers we spoke to were paid-up members of their business centre. This organisation is a tailor-made pathway for project outputs and the business centres provide the key entry points for the project to make direct contact with farmers groups and identify farmers for on-farm trials.

8c. Stakeholder support and the need for a phase 2.

The project has worked closely with the Ministry of Agriculture (MOA) and the Smallholder Coffee Authority (now Smallholder Coffee Farmers Trust) since the outset. The stakeholder workshop was attended by representatives from the MOA, Extension Service and Farmers, all of whom gave their full support for the need for a second phase.

During the course of the project, the prospects for smallholder coffee have greatly improved. Reorganisation of the smallholder sector has been funded through EU STABBEX and a second phase of the project would complement the activities of the EU-funded work.

The first phase of the project was originally designed as a basic research project with some strategic research components. In practice due to the decrease in the use of inputs in the period leading up to the start of the project, the activities became more strategic with some adaptive components. The pest and disease priorities have now been identified in each of the five EPAs where coffee is grown smallholders in Malawi. The socio-economic and biological factors affecting pest and disease incidence and farmers decisions about how to manage them are understood and appropriate components of an IPM system have been identified. As farmers begin to rehabilitate and expand their coffee gardens in response to the guaranteed producer price, sound pest management, particularly of white stem borer and CBD will be essential if recovery in the smallholder sector is to be sustainable. The need now is for an adaptive phase to validate the IPM components identified in the first phase and to provide support to the SCFT to train extension officers and farmers groups in the implementation of IPM, within an ICM framework.

Name and signature of author of this report and date signed.

Drs Rory Hillocks & Sarah Simons May 2000

Table 18. Summary of survey conducted in Misuku Hills and Nkahta Bay Highlands of pesticide use among coffee smallholders.

Pesticide use etc.		Percentage of respondents		
		Misuku Hills (N = 44) April 1999	Nkhata Bay (N = 16) December 1999	Total (N = 60)
Farmers currently using pesticide (1999)		14	31	18
Farmers using pesticide in the past		90	88	90
Farmers wishing to use pesticide		100	100	100
Which pesticides[2]?	Fenitrothion	79	75	78
	Copper[1]	79	69	77
	Daconil	10	6	8
	Dieldrin	52	0	37
Target pests	Stem borers	66	44	60
	Green scale	24	0	18
	leaf eaters	24	0	18
	Antestia	10	25	13
	black ants	10	31	15
	mealy bug	0	19	5
	leaf miner	0	31	8
	CBD	21	6	17
	CLR	52	81	60

[1]Copper oxychloride
[2]Pesticides that farmers said they used or had used in the past

Table 19. Reasons given by respondents for not using pesticides and those expanding the size of their coffee plantation.

Enquiry	Percentage of respondents		
	Misuku Hills	Nkhata Bay Highlands	Total
Reasons for no longer using pesticides			
Too expensive	41	44	42
No credit for purchase	17	13	15
Discouraged by buyers/extension	17	0	12
No source of chemicals	34	31	33
Lack of sprayers	7	0	5
Ineffective against CBD	7	0	5
Farmers wishing to increase coffee bushes	93	82	90
Those expanding this year (1999)	69	63	66
Farmers with own or group nurseries	69	88	73
Farmers with Catimor 129 seedlings	38	63	45
Members of local Business Centre	83	100	88