Convention Project
Chemical Safety

Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH

Plant Protection in Coffee

Recommendations for the Common Code for the Coffee Community-Initiative

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Final Version, July 2005

Common Code for the Coffee Community

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EXECUTIVE SUMMARY

Coffee production and processing on its way towards sustainability is the common interest of many stakeholders. The coffee crisis of 2001 to 2003 highlighted the need to develop a long-term strategy for economic, social and environmental sustainability in the sector.

Since 2003, the “Common Code for Coffee Community” (4C), an initiative of producer organizations, coffee trade and industry, trade unions and NGOs aims to develop a long-term concept for the growing, processing and marketing of mainstream coffee on its way towards sustainability. This will help to establish a new understanding of quality, including the intrinsic and sensory quality of the product ***and*** the quality of sustainability in the production process. The 4C initiative aims at increasing the supply of and demand for coffee on its way to sustainability according to market mechanisms.

The 4C initiative was initiated by the German Coffee Association (Deutscher Kaffee-Verband e.V.) and the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) on behalf of the German Ministry for Economic Development and cooperation (BMZ). Currently, the main sponsors of 4C are the European Coffee Federation (ECF), the Swiss State Secretariat for Economic Cooperation (SECO) and GTZ, on behalf of BMZ.

The 4C initiative has developed a code matrix, defining principles and criteria in the economic, social and ecological dimension of sustainability (www.sustainable-coffee.net). With regard to the ecological dimension, a working group of the 4C initiative defined a guiding principle, which is applied to the use of agrochemicals: “**The use of pesticides and the effect on human health and on environment is minimized**”.

Based on the concept of continuous improvement, the code matrix applies a “traffic-light system”. Improvements in the coffee production systems are monitored, from unwanted practices (red criterion) to a desirable system (green criterion), with an intermediate phase in between (yellow criterion). Many of the criteria of the Code refer to already existing international agreements and conventions. With regard to pesticides, the three most important international agreements are the Stockholm and Rotterdam Conventions and the International Code of Conduct on the Distribution and Use of Pesticides (FAO, 2002). Pesticides listed in the two conventions are considered unacceptable for coffee production on its way towards sustainability.

Currently, none of the pesticides of the Stockholm Convention is legally used in coffee production in the most important coffee producing countries. Some of the pesticides subject to the Prior Informed Consent (PIC) procedure are commonly used in some of the coffee producing countries where they are or might be used in coffee.

Safe use of pesticides is one of the most important preconditions for avoiding negative impacts on human health. This requires specific knowledge and access to equipment and financial means to follow the recommendations for personal protection. Coffee production is dominated by smallholders and low safety standards for workers. Therefore, safe use of pesticides is difficult to achieve under prevailing conditions in coffee production. Risks can be reduced by using less toxic chemicals or even non-chemical technologies. High-risk chemicals that are toxic, persistent and bioaccumulative and whose use cannot be adequately controlled should be phased out within a reasonable time frame.

In this study, pesticides commonly used in coffee producing countries are evaluated considering acute toxicity, cholinesterase inhibition, carcinogenic potential and endocrine disruption potential. Using the “traffic-light system” each pesticide is recommended to be included in the red, yellow or green criterion of the code matrix of 4C.

Red criterion pesticides are those with high acute toxicity (WHO Ia and Ib), and/or with very strong evidence to be carcinogenic and/or pesticides with known and probable endocrine disrupting effects. Production systems depending on pesticides of this group are considered to lack the basic characteristics of sustainability.

Yellow criterion pesticides: This group includes pesticides classified by WHO as moderately hazardous (class II). Into this group fall also all other pesticides with less acute toxicity but with cholinesterase-inhibition, those with a strong evidence to be carcinogenic and those suspected to be an endocrine disruptor. Besides the limitation to less toxic pesticides, application of the chemicals has to be based on a monitoring system.

Green criterion pesticides: Pesticides in this group include those, which might be used within an integrated pest management strategy.

In the insecticides group, a high number of active ingredients fall into the WHO I class. Small farmers and workers, who constitute the majority of the coffee producers, have usually little knowledge about how to use pesticides and most farmers in the coffee producing countries can normally not afford the recommended safety requirements. According to the FAO Code of Conduct of the FAO, pesticides with a very high acute toxicity should not be marketed under these circumstances.

No fungicides of WHO class I are registered in the five case study countries, Brazil, Viet Nam, Costa Rica, El Salvador and Tanzania. However, some other pesticides are ranked as very hazardous, because of chronic effects (benomyl, chlorothalonil, cyproconazole, iprodione, mancozeb, tetraconazole and thiophanate-methyl).

Some herbicides are considered too hazardous for further use (2,4-D, alachlor, acetochlor, diuron and paraquat). Therefore, they should be phased out in coffee production.

Coffee plantations are generally confronted with a multitude of pests and diseases, such as Coffee Berry Borer (*Hypothenemus hampei)*, coffee leaf miners (*Leucoptera* spp.), stemborers, scales, mealybugs and coffee bug. Diseases causing worldwide or locally important losses are Coffee Leaf Rust (*Hemileia vastatrix*), Coffee Berry Disease (*Colletotrichum kahawae)*, black rot (*Corticium koleroga*), brown eye spot (*Cercospora coffeicola)*, American leaf spot (*Mycena citricolor)* and coffee wilt disease (*Gibberella xylarioides)*.

To reduce or substitute hazardous insecticides, a combination of cultivation techniques, protection of natural enemies, biological control, use of traps, botanicals and pesticides with a low toxicity should be applied.

Diseases are managed with resistant varieties, a balanced nutrition of the plants and a plantation management, which regulates shade, humidity and temperature to prevent diseases. With the use of antagonists, copper and systemic fungicides applied in a monitored system, higher level of infestation can be avoided.

In a sustainable system, soil sterilisation in nurseries cannot rely on hazardous soil fumigants. Thermal sterilisation, e.g. solarization and antagonistic microorganisms should be preferred.

Research institutes play a crucial role for the continuous development of resistant varieties and for the intensification of research on biological control. Regional initiatives aiming to implement IPM should be supported.

LIST OF ABBREVIATIONS

ANACAFÉ	Asociación Nacional de Productores de Café, Guatemala
BBC	Bacterial Blight of Coffee
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung
CBB	Coffee Berry Borer
CBD	Coffee Berry Disease
CCCC, 4C	Common Code for the Coffee Community
CENICAFÉ	Centro Nacional de Investigación de Café, Colombia
CLR	Coffee Leaf Rust
EPA	Environmental Protection Agency
GTZ	Gesellschaft für Technische Zusammenarbeit
IARC	International Agency for Research on Cancer
ICO	International Coffee Organisation
IHCAFÉ	Instituto Hondureño del Café
IPCS	International Programme on Chemical Safety
IPM	Integrated Pest Management
PIC	Prior Informed Consent
POP	Persistent Organic Pollutants
PPE	Personal Protective Equipment
UNEP	United Nations Environment Programme
USDA	United States Department of Agriculture

INTRODUCTION

Coffee is an important cash crop for millions of farmers in more than 50 countries. It plays an important if not essential role in the economy of numerous producer nations. Coffee production and processing on its way towards sustainability is the common interest of many stakeholders. The coffee crisis of 2001 to 2003 highlighted the need to develop a long-term strategy for economic, social and environmental sustainability in the sector. Especially small-scale producers and plantation workers play a central role in the debate of how sustainability can be defined.

Since 2003, the "Common Code for Coffee Community" (4C), an initiative of producer organizations, coffee trade and industry, trade unions and NGOs aims to develop a long-term concept for the growing, processing and marketing of mainstream coffee on its way towards sustainability. This will help to establish a new understanding of quality, including the intrinsic and sensory quality of the product ***and*** the quality of sustainability in the production process. The 4C initiative aims at increasing the supply of and demand for coffee on its way to sustainability according to market mechanisms.

The Code has been formulated on the basis of existing international agreements and conventions. The following unacceptable practices are to be excluded from coffee production:

- worst form of child labour,
- bonded or forced labour,
- trafficking of workers,
- destruction of primary forest to establish new coffee plantations.

All agricultural production systems have to deal with plant protection problems and coffee is no exception. Since the early 20^{th} century, coffee production suffers from numerous pests and diseases. The Coffee Berry Borer, the white stem borer, leaf miners, mealybugs, the Coffee Berry Disease and Coffee Leaf Rust represent the most serious examples. These pests and diseases can be faced to a different extent by different agrochemicals, the synthetic pesticides. However, their toxicity to humans and the environment, their persistence in the soil and their impacts on the system are of great concern and must be addressed in the discussion about sustainable production systems. Some international conventions provide guidelines for the correct use of agrochemicals. However, there are still unacceptable practices.

The 4C initiative has developed a code matrix, defining principles and criteria in the economic, social and ecological dimension of sustainability (www.sustainable-coffee.net). With regard to the environmental dimension, a working group of the 4 C initiative defined a guiding principle, which is applied to the use of agrochemicals: "**The use of pesticides and the effect on human health and on environment is minimized**".

Based on the concept of continuous improvement, the code matrix applies a "traffic-light system". Improvements in the coffee production systems are monitored, from unwanted practices (red criterion) to a desirable system (green criterion), with an intermediate phase in between (yellow criterion). Red means that the practice in question needs to be discontinued within a period of 3 to 5 years. Yellow means that this practice needs to be improved within the next 10 years. The evaluation "Green" describes a practice considered as adapted to the sustainable production of mainstream coffee.

In the first part of this paper, the agrochemicals used in different coffee producing countries are listed and classified according to their toxicological characteristics in red, yellow or green.

In this context it should be realised that the majority of the farmers are smallholders, who are not familiar with the use of agrochemicals and who often do not know how to use them safely. For this reason, the categorization of the different agrochemicals follows mainly their acute toxicity.

In the second part, the relevant pests, diseases and weed problems are described and some suggestions about the possible strategies to control them are given. The different strategies are then categorised as red, yellow or green practice in the spirit of the 4C.

1. GENERAL INFORMATION ON MAJOR COFFEE GROWING COUNTRIES

World green coffee production reached 7.0 million tonnes in the crop year (October-September) 2002/03. The world's largest coffee producer is Brazil accounting for a third of total exports (Tab. 1). In some of the countries the data about the area used for the coffee production differs significantly from one source to another. In the case of Ethiopia for example, FAO reports only 260,000 ha for coffee where the ICO counts 450,000 ha (2004).

Tab. 1 The 20th most important exporting members, their export in 60-kilo bags, the percentage of total export in 2003 (ICO, 2004), acreage, average yield (FAO), percentage of small farmers and their holding size

Country	Country Code	Export 60 kg bags 2003	% of world export	Area (000 ha)	Yield kg/ha	% small farmers	average ha/small farmer
Brazil	BRA	25 685 412	30.19	2 400	819		
Viet Nam	VNM	11 631 109	13.67	550	1542	80	1-2
Colombia	COL	10 244 402	12.04	800	863	70	<2
Indonesia	IDN	4 604 621	5.41	1 100	701		
Guatemala	GTM	3 820 800	4.49	245	857	80	
India	IND	3 670 955	4.31	323	851	98	<10
México	MEX	2 594 508	3.05	743	418	60	<2
Uganda	UGA	2 523 030	2.97	264	704		0,6
Cote d'Ivoire	CIV	2 466 072	2.90	500	320		1,5 – 5
Honduras	HND	2 425 237	2.85	215	967	71	<3,5
Peru	PER	2 412 192	2.84	230	695		2
Ethiopia	ETH	2 229 143	2.62	260	846		
Costa Rica	CRI	1 716 884	2.02	113	1480	83	<3
El Salvador	SLV	1 304 488	1.53	165	662	87	<7
Papua New Guinea	PNG	1 147 168	1.35		770		
Nicaragua	NIC	1 013 237	1.19	115	518	94	<7
Tanzania	TZA	882 665	1.04	120	304		1-2
Kenya	KEN	867 352	1.02	170	379		
Cameroon	CMR	814 341	0.96	300	260		
Ecuador	ECU	622 706	0.73	293	282	80	<5

From the average yield one might suggest (Tab. 1) that the level of productivity differs significantly between the various countries. Small farmers make up the majority of coffee growing farmers growing often not more than 1 or 2 ha of coffee. In countries such as Costa Rica, for example, average yields are almost the same for the different holding sizes, but they can be impressively different in countries such as Honduras. This depends mainly on the production system used and the influence of government policies.

Production systems of coffee can be divided in:

Rustic systems

- Extractive with low-maintenance and minimal external input; low-yields; systems where coffee is planted within the natural forest; little change and impact on environment (no use of pesticides)

Traditional policulture

- Coffee associated with productive shade-producing trees
- Commercial policulture: coffee associated with other commercial crops: for example fruit trees, bananas and shade trees

(some use of herbicides, fungicides, rarely insecticides, income not only from coffee of the same area)

Specialized production

- Coffee as the unique product of interest, planted intensively with shade trees

or as

- Sun-grown coffee**,** high plant densities, high yielding varieties, high inputs in agrochemicals (intensive use of fertilizers and pesticides)

Organic

- extensive or intensive with diversified shade, management that reduces external inputs to a minimum, maintenance or improvement of soil fertility of special interest.

(sometimes intensive use of organic fertilizer and biological pest control)

Brazil

In Brazil about 2.4 millions of hectares are planted with coffee, 74% of which is Arabica. The Brazilian varieties Catuai (60%) and Mundo Novo (35%) represent the most important varieties for Arabica. Apart from that Icatu, Obatã, Catuai are introduced because of their resistance to diseases. The variety of Robusta is Conillon. The coffee growing area ranges from 300 to 1000 m of elevation. Coffee is grown in a wide climatic range mostly as sun-grown coffee with problematic parts due to frosts or dry seasons. In the last decade, new coffee plantations were established in frost-free regions.

It is estimated that there are about 221 000 coffee farms in Brazil (1999). The average area devoted to coffee is approximately nine hectares. However, although many producers are small scale, there is a considerable number of estates with over 1000 ha using technified methods of cultivation with high inputs in agrochemicals and mechanized harvesting and irrigation reaching yields of 2 500 kg/ha and more.

Production costs vary widely depending on the area, size of the farm and the mode of cultivation, which largely determines the yield. Labour is the principal cost ranging from 80 to 110 man-days annually used for producing coffee on one hectare of land with traditional methods. Mechanization of cultivation reduces the labour requirement to 50 - 70 man-days. If harvesting is mechanized, the labour requirement for this task is cut into half.

The most important diseases are Coffee Leaf Rust (*Hemileia vastatrix*), Anthracnose (*Colletotrichum gloeosporioides*), *Cercospora coffeicola* and *Phoma costarricensis*.

Pests are Leaf Miners (*Leucoptera coffeella*), Coffee Berry Borer (*Hypothenemus hampei*), scales and mealybugs (*Coccus viridis, Planococcus citri, P. café, Dysmicoccus cryptus, Saisettia coffeae)*, mites (*Oligonychus coffeae*) and nematodes.

Viet Nam

Although the land area of Viet Nam is more than 330 000 km², about 75% is covered by mountains and midlands. The area cultivated is about 8.3 million ha, of which 4.2 million ha is used for rice production and around half a million hectares for coffee growing. The average area for cultivation per head is approximately 0.1 ha. Viet Namese growers are watering their coffee plantation in dry season and with good care and adequate application of fertilizers very high productivity is achieved (Tab. 1).

Most of the coffee plantations in the Western Highland are grown at an altitude of 500 to 700 m. The high differences in temperatures between day and night result in high quality and good aromatic flavour. In addition to the Robusta coffee production in the South, Viet Nam has enormous potential for growing Arabica in the North.

The most important pathogen is *Hemileia vastatrix*, which is the causal agent of Coffee Leaf Rust. Important insect pests are Coffee Berry Borer, scale insects and mealy-bugs.

Colombia

In Colombia about 68% of the coffee grown is technified coffee, which means that high yielding varieties with high plant densities are grown. About 70% of the farms are smaller than 3 ha, 23% are between 3–10 ha, and 7% of holdings are larger than 10 ha.

Plantations can be found between 1000 to 2000 meters above sea level. The medium temperature ranges from 17ºC to 22ºC and the annual rainfall varies between 1500 and 2500 mm. Soils are highly fertile due to their volcanic origin and are considered to be perfectly adapted to the production of high quality coffee.

Three varieties are grown: Typica (30%), Caturra (40%) and Colombia (30%). The variety Typica is usually grown in a traditional way under shade. Due to its small size, Caturra and Columbia are cultivated in high plant densities on technified estates The variety Colombia has the major advantage that it is resistant to the main disease, the leaf rust (*Hemileia vastatrix*).

Formerly, coffee was considered to be a crop without serious pest and disease problems. But with the introduction of coffee rust (1983) and especially the Coffee Berry Borer, CBB (1988), which poses a serious threat, coffee was converted into a pesticide-demanding crop. Climatic conditions favour a year-round production of coffee, permitting a continuous reproduction for the CBB. Massive use of highly toxic insecticides (especially endosulfan) and a deficient recollection generated a dependency on chemical products. CENICAFÉ propagates integrated pest management since many years.

With the introduction of the rust resistant variety Colombia, the use of fungicides (mainly copper products) has been reduced. Continued breeding efforts are required, however, due to the virulence of the fungus.

Indonesia

The total area of coffee planting in Indonesia has reached 1.1 million ha, 84% of which is Robusta coffee. Robusta was introduced to Indonesia in order to combat Coffee Leaf Rust attacking the Arabica coffee. Production is largely based on the labour of one million coffee households cultivating smallholdings with an average size of 1.44 ha. Coffee is rarely the sole crop grown, but provides the main cash income for about 5 million people. Most coffee can be classified as organic because smallholders hardly use any chemical fertilisers and controls. Moreover, a number of Arabica growths can be categorised as speciality or gourmet coffees.

The common coffee diseases are Coffee Rust (*Hemileia vastatrix*), Root Disease (*Rigidoporus lignosus*) and Pink Disease (*Corticium salmonicolor*). Breeding for resistance of Arabica coffee to Leaf Rust *(Hemileia vastatrix)* has been intensified in Indonesia since the end of 1970s. The activities consist of selecting mother trees and introducing resistant varieties as well as creating new genotypes by crossings.

The common insects infecting coffee are the Coffee Berry Borer (*Hypothenemus hampei*), scales (*Coccus viridis)* and mealybugs *(Planococcus citri).*

Guatemala

The coffee of Guatemala grows at an altitudinal range of 300 to 2000 mm. A very high, internationally recognized quality is reached on the mountain slopes. The production area is about 245 000 ha. 80% of the 62 500 producers are small-scale farmers. About 10% of the farmers are producing 80% of the coffee, owning 75% of the coffee producing area.

Traditionally, coffee is grown under shade. The main varieties are: Arábigo, Bourbon, Caturra, Pache, Mundo Novo, Maragogype, Robusta. There is a great variety in the technological standard with some highly specialized farms on the one hand and small farms on the other hand, where coffee is the only cash crop and thus income besides the subsistence crops.

One hectare cultivated in a big farm costs about 1466 dollars, labour, inputs and administration included. This equals production cost/kg of 1.61 US$ calculating 20 qq/ha. As Guatemala is the country with the highest number of labour-force in coffee within Central America (an average of 221 days/ha), a price below these production costs creates a higher unemployment compared to other countries. Since part of the labour is used for pest management, less working hours mean at the same time greater pest problems in the forthcoming years because of the neglected management.

The Asociación Nacional del Café (ANACAFÉ) is the institute responsible for coffee dealing - among other services - with research and extension work. With regard to pest control they develop integrated pest management programmes.

ANACAFÉ recommends for nematode control the use of genetic control with Arabica on the variety Nemaya (Robusta). The use of nematicides should be limited to the nurseries and should be permitted in the plantations only for the first two years.

To control the CBB, a combination of methods is recommended, which recently also includes the use of traps. Endosulfan, the most effective pesticide, is applied normally only in hot spots. A prohibition of this product would raise the control costs, but it is not indispensable.

Important diseases are *Mycena citricolor* and Leaf Rust.

Weeds can largely be controlled with glyphosate, paraquat can be used to a minor extent.

The “Unidad de Normas y Regulaciones del Ministerio de Agricultura de Guatemala (MAGA) is the institution responsible for permitting import and use of pesticides. Registration, however, is not specific to the different crops.

India

Coffee cultivation is largely confined to the hilly regions of the three southern States. India produces both Arabica and Robusta in almost equal proportion though Robusta shows a comparatively higher production rate. Arabica coffee is grown at higher altitudes (1000-1500 metres) than Robusta (500-1000 metres). Soils cropped to coffee are generally well drained and slightly acidic in nature. Arabica areas obtain greater annual rainfall (1600-2500mm) than Robusta areas (1000-2000mm). Rains which occur normally between March and May, known as blossom and backing showers, are critical for flowering and fruit-setting in coffee. Cultivation of coffee under well-maintained shade greatly facilitates integrated management of pests and diseases, thus reducing reliance on chemicals.

Most coffee holdings are on a small scale. Smallholder farms cover about two-thirds of the area with an average holding size of 1.4 hectares. Largeholders, with an average size of 38.4 hectares cover 35 percent of land and account for 40 percent of the output. Generally, the small and marginal holdings adopt traditional farming practices with little or no use of chemicals. In these holdings the pest and disease management is primarily based on phytosanitation and manual control methods. The medium and large holdings adopt chemical control of pests and diseases in an **IPM** programme.

Important pests are the Coffee White Stem Borer (*Xylotrechus quadripes),* Coffee Berry Borer, the Shot Hole Borer *(Xylosandrus compactus),* mealybugs and scales.

Diseases are the Leaf Rust, Black Rot (*Corticium koleroga*), Die-back (*Colletotrichum gloeosporioides)* and different root diseases.

Mexico

Coffee is cultivated in the southern half of the country in Chiapas, Veracruz and Oaxaca at altitudes of between 400 and 1700 metres.

90% of the 282 000 farmers are smallholders with less than 5 ha. Only 6% are medium-sized farms (5-10 ha). Coffee production methods in Mexico focus on protecting the environment and improving the livelihoods of local communities. The coffee is mainly shade-grown.

There is a small area where Robusta is grown. The main Arabica varieties planted are: Typica, Caturra, Mundo Novo, Garnica, Bourbon and Maragogype.

The most important pest in Mexico is the Coffee Berry Borer, introduced in 1978. Others are leaf miner, mealybugs, scales, mites and nematodes. Diseases are Leaf Rust, *Corticium koleroga*, *Mycena citricolor*, *Cercospora coffeicola, Colletotrichum, Rhizoctonia solani*. In most cases pest and diseases in Mexico never caused very high losses. Smaller farmers used pesticides only in years of high coffee prices and then mostly only if donated by the government.

Uganda

Most of Uganda's coffee is produced by family farms in smallholdings (500,000 farms and 94% smallholders on a total area of about 264,000 ha). In traditional households women take responsibility for coffee cultivation, picking and marketing. Income from coffee often makes up the majority of household cash out of which school fees, clothing and food budgets are covered. Coffee earns over 60% of Uganda's foreign exchange and involves nearly 30% of the total population. Thus, the health of Uganda's coffee industry is more directly linked to the well being of Uganda's families than any other crop or industrial activity.

Besides a small area (30,000 ha in mountainous regions) where premium Arabica is grown (1300–2300 meters in altitude) coffee production mainly consists of Robusta coffee (87%), planted at an altitude of about 1200 m above sea level and grown at densities of 1,100 plants/ha.

The main diseases are Coffee Leaf Rust and since 1993, Tracheomycosis or Coffee Wilt Disease, the latter causing high loss of plants (estimates in 2002 go to 12 millions Robusta trees or 5% of planted area). However, as an estimated 80% of the plants are more than 40 years old, this might also provide the opportunity for the renovation of plantations.

Cote d´Ivoire

Coffee and cocoa account for the largest crop area and contribute significantly to export earnings. Production of coffee in Côte d'Ivoire has been falling steadily over the last five years, partly due to political reasons. The area planted to coffee is approximately 1.2 million hectares, with 800,000 hectares in production. Robusta is the only type of coffee grown in the country. Production is predominantly in the hands of smallholders farming an average of 0.5–5 hectares.

Average pesticide use is low (in 1995 2.2% of total pesticide use), mainly herbicides, some insecticides and no fungicides. Though severe problems of indiscriminate use were reported, farmers' knowledge in crop protection remains very low.

In general, coffee does not have pest and disease problems besides some attacks of the CBB. Generally, less than 2% of the farmers apply endosulfan. An IPM system with recollection of attacked fruits is considered to be very important because of the presence of natural enemies, which reduce and control the expansion of the CBB.

Honduras

Coffee production in Honduras is of great social and economic importance. It represents 8.2% of the GDP and 33% of the agricultural GDP. About 100,000 families benefit directly from the coffee production and 350,000 families are occupied in crop management and harvest (IHCAFE, 2001). The coffee area is 245,000 hectares.

With regards to the holding sizes of the 88,900 producers 71.9% are smallholders cultivating less than 3.5 ha. They hold 27.1% of production area and cover 6.9% of the national production, with yields of 236 kg/ha. 21.1% are medium-sized farms with properties from 7 to 10.5 ha accounting for 29.7% of the coffee area and 13.4% of the national production. 7.2% are farms between 10.5 and 35 ha accounting for 29.8% of land and 36.9% production (yields of 1150 kg/ha). 1% of the total are estates of more than 35 ha holding 13.3% of the area and contributing with 26.5% to national production. 95% is shade-grown coffee.

A characteristic of the Honduran coffee growers is that their productive activities are highly diversified. That allows them to control risks and to diversify sources of income.

The varieties used are Typica, Caturra, Catuai, Villa Sarchi, Bourbon, Mundo Novo, Pacas and Ihcafé 90. About 58% of the coffee is technified using resistant varieties, fertilization and other crop maintaining measures. Because of their limited resources, the smallest farmers can rarely use fertilization to optimise productivity.

The main pest problem is the CBB, controlled normally with one to two insecticide (endosulfan) applications. There are currently programmes for the use of traps. Biological control of natural enemies and *Beauveria bassiana* are/were carried out to some extent. Diseases like *Cercospora coffeicola* and *Mycena citricolor* are not a big concern as long as a good shade management is carried out. The rust *Hemileia vastatrix* is controlled with copper oxychloride (until 4 applications). Weeds are controlled manually, with glyphosate, 2,4-D or paraquat.

Peru

At the level of producers, the sector is highly atomised. There are around 200,000 producers producing on 2 ha on average. But some have as small as 0,25 ha. There is a large number of cooperatives in place, but most of them provide some services only.

On this level, the use of pesticides is very low. Mostly, they are used in nurseries against *Rhizoctonia solani.* In the plantations, the most problematic pest seems to be the leaf-cutting ant, which is controlled with Mirex (pers. comm. 2004). In coffee plantations at low level altitudes some control measures of aphids and mealy bugs might be necessary. In the fight against the Coffee Berry Borer, the national service (SENASA) carries out an integrated pest management programme propagating the use of traps, *Beauveria bassiana* and predators. With some frequency, fertilization with NPK 20-7-20 with micronutrients or Guano is applied.

Ethiopia

331,130 farms cultivate about 450,000 ha (ICO, 2004), mostly Arabica. Small coffee farmers (94%) are the major coffee producers in Ethiopia cultivating 0.5 ha on average. Depending largely on the family for labour requirements, there are four types of production systems in Ethiopia: forest coffee and semi-forest coffee are very rustic systems; garden coffee is planted at low densities ranging from 1000 to 1800 trees per hectare, and is mostly fertilized with organic waste and intercropped with other crops and plantation coffee.

Plantation coffee includes the coffee, which is grown on plantations owned by the former state and some well-managed smallholder coffee farms. In this production system recommended seedlings are used, and proper spacing, mulching, manuring, weeding, shade-regulation and pruning is practised. However, numerous coffee varieties are used as the planting material usually originates from the forest. Only state-owned plantations use chemical fertilizers and herbicides, accounting for approximately 5 percent of the total production. Well-managed smallholder coffee farms account for about 15 percent of Ethiopia's total production.

Domestic consumption, which accounts for 42.3% of total production, ensures the survival of the coffee sector despite low world prices. Nevertheless, some farmers abandon coffee growing in favour of prohibited crops like khat, which has a market value almost ten times higher than coffee.

The Coffee Berry Disease (CBD) caused by *Colletotrichum kahawae* was the major coffee disease in Ethiopia after its accidental introduction from neighbouring countries during the early 1970s. The importance of CBD declined significantly with the selection and development of resistant coffee strains that are commonly found in forest coffee. Some plantations are seriously damaged by Tracheomycosis and in some area Leaf Rust can be observed with severity. Pests of importance are CBB and Antestia bug.

Costa Rica

In Costa Rica coffee grows in hilly areas at altitudes from 600 to 1700 m above sea level. The soils are slightly acidic enriched by volcanic ashes and rich in organic matter. This provides a good distribution of the coffee plants' roots contributing to the high quality of Costa Rican Coffee.

The coffee sector of Costa Rica is characterized by a much higher productivity and technification compared to other Central American countries. 40% is sun-grown coffee. 83.5% are holdings with less than 2.8 ha producing 28% of the national production on 31.9% of the land. The medium sized farms (13.2%) are between 2.8 and 20 ha or 24.4% of the land and 22.1% of the production. 3.3% holdings correspond to 43.7% of the land and 49.9% of the production. There is a slight difference in yields in small farms (1340 kg/ha) to bigger farms (1650 kg/ha). Plant pruning, use of fertilizers (chemical and organic), and chemical pest and weed control are common. The varieties used are Caturra, Catuaí, Catimor, Costa Rica 95, Sarchimor and some others.

Before the introduction of CBB in 2000, only diseases (Leaf Rust, *Cercospora, Mycena citricolor, Colletotrichum gloeosporioides, Corticium koleroga*) and nematodes caused problems. Especially the control of nematodes generated high cost in plant protection measures. An intense debate was held to avoid the contamination of the surrounding rivers.

El Salvador

As in most Central American countries, coffee has a long tradition in El Salvador. The natural soil properties, weather conditions, and the expertise of the Salvadoran people are the main factors contributing to the country's high quality coffee. Production is mostly concentrated in mountain ranges and volcanic slopes between 500 and 1400 meters in altitude.

Coffee remains a crucial economic activity contributing to the generation of hard currency and employment. Coffee also contributes to the conservation of natural resources due to the fact that 92% of the coffee in El Salvador is shade grown. El Salvador is one of the most deforested countries in the Western hemisphere; 98% of the country's original forests are gone. If shade grown coffee plantations - which have many of the same biological characteristics as forests - are regarded as forests, coffee plantations represent about 80% of the nation's remaining forest area.

El Salvador only produces Arabica. The main varieties found are Bourbon, which comprises 80% of coffee grown, Pacas (15%), Pacamara and other varieties such as Caturra or Catuai.

Coffee is an important employment generator. There are more than 20,000 coffee farmers in the country. 83.8% are smallholdings with less than 14 ha, producing 23.1% of national production on 24.8% of the land, the medium sized farms (9.8%) have between 14 and 35 ha, 19.9% of the land and 23% of the production, while 6.4% holdings correspond to 55.3% of the land, and 53.9% of the production. The average yield is 632 kg/ha without much difference in relation to farm size.

The main pest is CBB and important diseases are Leaf Rust*, Mycena citricolor*, *Cercospora*, Anthracnose (*Colletotrichum gloeosporioides*) and *Corticium koleroga.*

Nicaragua

Agroclimatic conditions are similar to that of the other Central American countries. Similar to Guatemala and Honduras the smallest farmers produce more on a subsistence level and with very low inputs. About 98% of the holdings have less than 15 ha producing around 24% of the coffee. 1.5% of farmers between 15 and 35 ha are representing only 10% of production area contribute with 39%, the big ones, 16% of the area, with 36% to the national production. Yields differ from average 143 kg/ha (small farmers) to 1,357 kg/ha (big farms).

The introduction of Leaf Rust in the 1970s, the change to sun grown coffee and the arrival of the CBB changed the formerly "auto sufficient" crop to one with a higher need for management or intensive use of agrochemicals.

The main pest is CBB and important diseases are Leaf Rust*, Mycena citricolor*, *Cercospora*, Anthracnose (*Colletotrichum gloeosporioides*) and *Corticium koleroga.*

Tanzania

Some 400,000 smallholders on average plots of 1-2 hectares produce about 95% of coffee in Tanzania. Coffee yields are relatively low and reaching about 70% of the output which farmers in Kenya can produce under similar ecological situations. Most people cannot afford inputs such as agrochemicals and fertilizer.

Important diseases are Coffee Berry Disease and Coffee Leaf Rust. Important pests are Coffee Berry Borer and stemborer.

Kenya

Coffee cultivation in Kenya began around 1900 when Arabica coffee, brought from Ethiopia, was planted near Nairobi by Christian missionaries. From this initial farm of about 250 hectares, the industry has grown considerably to 170,000 ha. About 60% are small-scale growers, which are organised into co-operatives. Large-scale farmers, whose coffee estates are often larger than 250 ha, produce about 30% of the production. Coffee is the major employer (250,000 Kenyans are involved in coffee production) and contributes 20% of the foreign exchange.

Almost all varieties used are Arabica: K7, SL28, SL34, Ruiru 11, Blue Mountain, Bourbon and Kent.

Coffee is grown between 1400 and 2100 meters above sea level along contour lines or on terraces on steep slopes. It is also grown on flat areas. There is little shading except in certain areas for protection against hail and wind. There are two rainy seasons and two harvest periods. Only ripe cherries are picked by hand in about 7 pickings. The result is a very satisfying quality of the final product.

The main problems are droughts, Coffee Berry Disease (*Colletotrichum kahawae*), Leaf Rust and bacterial blight (*Pseudomonas syringae*). Important pests are Antestia bug (*Antestiopsis spp.*), CBB, leaf miners and mealybugs.

Cameroon

Cameroon produces both Robusta and Arabica. But with 90% of the total production its Robusta production is more significant.

Ecuador

Coffee is grown in almost all provinces of the country in a wide ecological range in altitudes between 1300-1800 m for Arabica and 300-400 m for Robusta. Half of the area is coffee in association with other crops like banana, cocoa or citrus trees. About 90% is managed in the traditional system with shade trees of native species.

Of the 57,153 farms of monocultural coffee about 50% are small farms with 1 to 10 ha, 13% up to 20 ha, 22% up to 50 ha and 15% are bigger than 50 ha. 48,116 farms cultivate coffee under traditional policultural systems (54% with 1 to 10 ha, 19% 10 to 20 ha, 18% from 20 to 50 ha and 9% farms with big extensions). Yields are generally very low (270 kg/ha) due to technical and financial deficiencies, but also partly due to marginal sites for coffee. In plantations with a certain level of inputs and management, yields of 1300 kg/ha are reached.

In the case of very small farmers (less than 1 ha, about 20%) coffee production is very extensive without any use of inputs. Normally, in years with low prices, there is no recollection of the crop, which result in higher pest problems. As long as coffee contributes to the subsistence of families, it will be maintained. There are tendencies, however, that it will be substituted by animal husbandry, fruit crops, annual crops or illegal planting of coca.

The planted Arabica varieties (62%) are Caturra, Pacas, Mundo Novo and Catimor.

Important diseases are *Cercospora coffeicola, Colletotrichum gloeosporioides,* Leaf Rust (*Hemileia vastatrix*), *Rhizoctonia solani,* Black Rot (*Corticium koleroga*), *Mycena citricolor* and *Ceratocystis fimbriata*. Predominant pests are CBB (*Hypothenemus hampei*), the Leaf Miner (*Leucoptera coffeella*) and Twig Borer (*Xylosandrus morigerus*). As the entire plantation management in general is at a low level, the use of pesticides is not very intensive either.

Overall Situation

Coffee growing takes place in a very wide range of ecological and social conditions. On the one hand, coffee is grown in a very simple way, where just some clearing, planting and harvesting is done. Good examples are Ethiopia or Ecuador where almost no changes occur to the natural environment. On the other hand, there are plantations of monoculture coffee in an highly mechanized, irrigated, fertilized and chemically pest-controlled surrounding like it is the case in relatively new, immense plantations in Brazil. This often leads to a complete destruction of the surrounding vegetation.

Numerically, small farmers are the predominant coffee growers in all countries. With some exceptions, they have little access to knowledge and inputs. Considering the use of pesticides, this group is normally not very important as the quantity per hectare is relatively low. But if used, these coffee growers are a group of concern because of their limited knowledge on how to handle the different toxicities of products and on how to assess the necessities and possibilities for a safe use. Programmes to train these farmers require a considerable amount of time and they hardly reach most of the farmers. Additionally, inadequate use of agrochemicals has a social dimension as it affects the health of farmers.

Generally, the medium-sized and big holdings use more agrochemicals per area unit. They are responsible for the social welfare of their workers and for environmental contamination, if agrochemicals are not properly used and good working practice is violated.

2. PESTICIDES

The control or management of pests, diseases and weeds is a major topic in agricultural production. Nowadays, the use of pesticides is one of the most common practice. During the last decades, the negative impacts on human health and livelihood and on the environment became obvious.

The main concerns about pesticide use in coffee production are the impacts on the health of farmers and workers handling and applying them as well as negative environmental impacts. Pesticide application in coffee production is only of limited concern to the coffee consumer. Processing of coffee beans, especially during the roasting process reduces residues to a level where they are normally insignificant. Concerns about the health of human beings and the environment are based on scientific evidence and awareness of the general public that a wide range of chemical substances in the environment is persistent. These concerns led to the establishment of international agreements to end and/or reduce the use of the most hazardous pesticides and to control the use of the others. There also seems to be a common understanding for a certain responsibility of the chemical industry in the commercialisation of chemicals. However, rigorous implementation of the already established international agreements is still lacking in many countries.

As the Common Code for the Coffee Community targets the mainstream coffee market, these already internationally agreed conventions and guidelines listed in 2.1 should be accepted as the basic standard. Chemicals mentioned in these conventions for phase-out should not be allowed in the coffee production.

For the 20 major coffee producing countries information was gathered about the legal situation of the internationally recognized most hazardous pesticides. It is indicated if these substances are banned, restricted or allowed for some use in the different countries (Tab. 2, Tab. 3). The most hazardous pesticides are to be considered as **unacceptable** substances for use in a production under the criteria of the 4C code matrix. The same applies, of course, for all substances prohibited in a specific country.

Based on the concept of continuous improvement, the code matrix applies a “traffic-light system”. Improvements in the coffee production systems are monitored, from unwanted practices (red criterion) to a desirable system (green criterion), with an intermediate phase in between (yellow).

In this report, the following factors have been considered for the evaluation of the risk of pesticides commonly used in coffee:

1. acute toxicity,
2. cholinesterase inhibition,
3. carcinogenic potential and
4. endocrine disruption potential.

Acute toxicity for humans is used by the World Health Organisation (WHO) to classify the hazard of pesticides. The WHO established a classification as follows:

- extremely and highly hazardous substances (class Ia and Ib),
- moderately hazardous substances (II),

- slightly hazardous substances (III) and
- the ones unlikely to be hazardous (U) (www.who.int/pcs).

This classification is used by international organisations in their pest management or safeguard policies in order to prevent negative impacts on human beings. Thus, the World Bank does not finance formulated products that fall in WHO classes Ia and Ib, or formulations of products in Class II, if (a) the country lacks restrictions on their distribution and use; or (b) they are likely to be used by, or be accessible to, lay personnel, farmers, or others without training, equipment, and facilities to handle, store, and apply these products properly (wbln0018.worldbank.org/Institutional/Manuals/OpManual.nsf).

Besides the classification based on acute toxicity, chronic effects are an important issue in risk assessment. Pesticides that inhibit the enzyme acetyl cholinesterase are nerve poisons or neurotoxins. Symptoms of nerve poisoning include tremors, nausea and weakness (at low doses). Paralysis or death can occur at higher doses. Both, organophosphates and carbamates act as cholinesterase inhibitors, but the former blocks the cholinesterase enzyme for several hours. Based on the time scale of a cell, this inhibition is virtually an irreversible process.

Pesticides applied for registration are submitted to evaluation of cancer risk. Active ingredients with carcinogenic potential (information by EPA: www.epa.gov/pesticides or IARC: http://monographs.iarc.fr/monoeval/allmonos.html) are chemicals to be considered as very hazardous, especially for persons exposed repeatedly to a contamination.

There is an ongoing discussion among health experts that the "*endocrine disrupting chemicals*" (EDCs), which interfere with the female or male hormonal system, have to be considered more intensively in risk assessment. Until now, no internationally accepted test procedure exists to define a substance as an EDC. The WHO considers that the potential risks to humans and wildlife posed by EDCs in many areas of the world (particularly in developing countries) have not been addressed adequately until now. Nevertheless, for some chemicals there exists a very strong evidence to act as EDCs. Those listed by EPA are taken into consideration for a phase out in the 4C (http://www.epa.gov/osa/spc/htm/Endoqs.htm).

Based on those classifications the commercial formulations of pesticides have to indicate to the users which precautions are necessary to avoid risk. For a quite high number of products a very sophisticated personal protective equipment (PPE) is recommended to assure a safe use of the product.

Safe use with low impact for the humans and the environment may be possible under the following conditions: A functioning legal system and control mechanisms, well educated farmers with a high responsibility for their own health and that of their workers and with some financial resources to invest in well functioning application equipment and in PPE.

Since a number of years, the chemical industry carries out training programmes for small farmers in third world countries in the safe use of pesticides (for example CropLife International, former GIFAP http://www.croplifeasia.org/ref_library/agrochemicals-/safeResUse/SU.PDF or "Agrovida" by the company Bayer).

Likewise, FAO/OECD has a programme with the purpose that farmers reduce pesticide use, apply fewer highly toxic pesticides (especially pesticides from WHO Ia and Ib category) and use pesticides appropriately to contribute to a reduction of adverse effects of pesticides on users, consumers and environment (overall goal) (http://www.fao.org/AG/AGP/AGPP/Pesticid).

However, as surveys show the safe use of pesticides is far from being reality. The 'safe use of pesticides' interventions are expensive campaigns and are not very effective, especially with small farmers (Atkin and Leisinger, 2000). It is hard to imagine that these programmes reach a high number of smallholders within a reasonable time period.

Growing awareness of the limited possibilities to achieve safe use of pesticides led to the adoption of the FAO International Code of Conduct on the Distribution and Use of Pesticides, a worldwide guidance document on pesticide management for all public and private entities engaged in or associated with the distribution and use of pesticides. The Code of Conduct is designed to provide standards of conduct and to serve as a point of reference in relation to sound pesticide management practices, in particular for government authorities and the pesticide industry.

The responsibilities of governmental and non-governmental organisation including the industry are to assure that the product is used safely and that the impact on the environment is minimized. If the local conditions do not allow the safe use of a product, for whatever reason, this product should be withdrawn from the market.

In coffee growing countries, a high percentage (around 70 to 80%) of the coffee farmers are smallholders. They generally know little about the health and environmental risks related to pesticides and the meaning of the colour codes on the label or the indications of the hazard. Even if they received training, they often lack the resources to purchase the recommended PPE to protect them and to safely use the pesticides.

Beside the hazard to the health of people handling the pesticides, they also present risks to contaminate drinking water sources, damage natural resources like fish or pollinators or cause loss of biodiversity. Even though all these factors have to be considered in a cost/benefit analysis of the use of pesticides and the sustainability of a production system, the following is focused to the hazard to users of pesticides. To avoid hazards, this already needs a change in the production system with positive effects on environmental aspects.

The 4C initiative has developed a code matrix, defining principles and criteria in the economic, social and ecological dimension of sustainability (www.sustainable-coffee.net). With regard to the ecological dimension, a working group of the 4C initiative defined a guiding principle, which is applied to the use of agrochemicals: "**The use of pesticides and the effect on human health and on environment is minimized**". Based on the concept of continuous improvement, the code matrix applies a "traffic-light system". Improvements in the coffee production systems are monitored, from unwanted practices (red criterion) to a desirable system (green criterion), with an intermediate phase in between (yellow). Practices that need to be discontinued within a period of 3 to 5 years fall under the **Red Criterion**. The **yellow criterion** is a practice that needs improvement within the next 10 years. The **green criterion** describes a practice considered consistent with sustainable production for mainstream coffee.

Red criterion pesticides are those with high acute toxicity (WHO Ia and Ib), and/or with very strong evidence to be carcinogenic (using the categories of EPA: A, B (86), known/likely (96) carcinogenic and likely (99)) and/or pesticides with known and probable endocrine disrupting effects. Production systems depending on pesticides of this group are considered to lack the basic characteristics of sustainability.

Because safe use cannot be achieved within a reasonable period of time for the majority of users, these pesticides have to be substituted with other control measures as soon as possible.

Yellow criterion pesticides: This group includes pesticides classified by WHO as moderately hazardous (class II). Into this group fall also all those other pesticides with less acute toxicity but with cholinesterase-inhibition, with a strong evidence to be carcinogenic and those suspected to be an endocrine disruptor. Progressively, they have to be substituted with less toxic substances or other control measures. Besides the limitation to less toxic pesticides, application of the chemicals has to be based on a monitoring system.

Green criterion pesticides: Pesticides in this group include those, which might be used within an integrated pest management strategy. As new evidence of harmful side-effects might appear, the list has to be revised on a regular basis. If farmers are using pesticides mentioned in this list, this does not necessarily mean that they have reached sustainable plant protection. Green criterion pesticides are just the least hazardous for human health and the environment currently available on the market.

A sustainable strategy for controlling pests, diseases and weeds has to be based on management practices able to prevent or reduce these problems. Selective weed management, healthy plant growth through good soil management, shade and ventilation control and protection of natural enemies have to be measures applied first in a pest management strategy. Green criterion pesticides are only complementary tools for controlling problems.

Upcoming EU regulations might be an important guideline for future decisions about the acceptance of pesticide in a commodity of international importance such as coffee. In the European Union a process was started to revise all pesticides used in the different member countries with the objective to determine those, which should still be used in the future. Substances considered to be safe for the use under the European conditions are included in the Annex 1 to the Council Directive 91/414/EEC. Chemicals not included in this Annex 1 should be considered as pesticides to be phased out also in the coffee sector.

In order to get some ideas about the situation in the coffee producing countries, a compilation of registered pesticides will be presented (Tab. 4-Tab. 8). For each important region, a representative country will be chosen and discussed. It is not intended to give a complete list of all pesticides used, which might require some action. It will give more an overview about the task and the necessary steps to be taken.

2.1 INTERNATIONAL CONVENTIONS AND LOCAL POLICIES

International Agreements

The range of agreements covers reduction of production and use of persistent chemicals, information exchange, trade issues related to pesticide residues and trade of pesticides dangerous to human health or to the environment. They provide a framework for national policies. Compliance can be monitored by stakeholders such as civil society.

Stockholm Convention on Persistent Organic Pollutants (POPs)

Over 100 countries negotiated the "Stockholm Convention" (http://www.pops.int/) mandating actions to reduce contamination from **persistent organic pollutants (POPs),** some of which are organochlorine pesticides. These are considered to be very problematic substances for human beings and the environment, as they constitute a long-term risk to individual species, to eco-systems and to human health. POPs are chemicals that persist in the environment, accumulate in high concentrations in fatty tissues and are bio-magnified through the food chain.

The subscribers to the Convention agree to stop producing and using persistent pesticides and industrial chemicals. The initial list includes twelve POPs: aldrin, chlordane, DDT, dieldrin, dioxins, endrin, furans, heptachlor, hexachlorobenzene, mirex, polychlorinated biphenyls (PCBs) and toxaphene. More chemicals may be added to the list of substances to be banned or restricted in the member countries.

The Convention was signed in 2001. After the ratification by fifty countries, it came into force 17 May 2004.

Subscribing countries are bound to take the following steps:

- End the production and the use of these chemicals.
- Clean up stockpiles of unwanted and obsolete chemicals. Many of these chemicals are stored in unsafe conditions, and are poisoning water, animals and people.
- Develop a plan within two years that shows how the country will meet its obligations towards the convention.

The Convention allows countries to continue using substances for some pre-defined purposes (DDT for malaria control, if necessary).

Among the coffee producing countries listed above (Tab. 1) the following have already ratified the Stockholm Convention: Brazil, Viet Nam, Mexico, Côte d´Ivoire, Ethiopia, Papua New Guinea, Tanzania and Ecuador.

Prior Informed Consent Procedure

The **Prior Informed Consent (PIC)** (http://www.pic.int) procedure was developed chiefly by the United Nations Environment Program (UNEP) and the Food and Agriculture Organization (FAO) of the United Nations (UN). It improved the level of protection against health and environmental risks, which was needed because of the global trade in pesticides and industrial chemicals. This is especially the case for those substances that were manufactured in countries where they were banned or severely restricted and exported to countries with insufficient information structures or weak regulatory systems. The PIC Procedure became a legally binding convention in 2004.

Following the procedure, a participating country must notify the Joint UNEP/FAO Secretariat of its domestic actions banning or severely restricting the use of a particular chemical. UNEP/FAO then notifies participating importing countries, and the importing country indicates whether, or under what conditions, it would accept further shipment of the chemical. There are industrial chemicals, pesticides (active ingredients) and pesticide formulations on the PIC list.

International Code of Conduct on the Distribution and Use of Pesticides (FAO, 2003)

One of the basic functions of the Code, http://www.fao.org/AG/AGP/AGPP/Pesticid/, which is voluntary in nature, is to serve as a point of reference, particularly until the countries have established adequate regulatory infrastructures for pesticides. In the absence of an effective pesticide registration, processing and lacking a governmental infrastructure for controlling the availability of pesticides, some pesticide-importing countries must heavily rely on the pesticide industry to promote the safe and proper distribution and use of pesticides. In these circumstances foreign manufacturers, exporters and importers, as well as local formulators, distributors, repackers, advisers and users, must accept to assume a share of the responsibility in terms of safety and efficiency in the distribution and the use.

A concern of high priority related to the health of farmers and workers is the safe use of pesticides, as to see from article 3.5 of the Code of Conduct:

> "Pesticides whose handling and application require the use of personal protective equipment that is uncomfortable, expensive or not readily available should be avoided, especially in the case of small-scale users in tropical climates (5). Preference should be given to pesticides that require inexpensive personal protective and application equipment and to procedures appropriate to the conditions under which the pesticides are to be handled and used."

Prohibition of the importation, sale and purchase of highly toxic and hazardous products, such as those included in WHO classes Ia and Ib, may be desirable if other control measures or good marketing practices are insufficient to ensure that the product can be handled with acceptable risk to the user.

Montreal Convention

Global cooperation for the protection of the stratospheric ozone layer began with the negotiation of the Vienna Convention for the Protection of the Ozone Layer in 1985. The details of the international agreement were defined in the Montreal Protocol (http://www.uneptie.org/ozonaction/) on Substances that deplete the Ozone Layer. The Montreal Protocol was signed in September 1987 and became effective in 1989. At a meeting in London in 1990, the Parties to the Montreal Protocol agreed to a phase-out of controlled substances. Controlled substances include CFCs, halons, carbon tetrachloride, methyl chloroform, HCFCs, HBFCs, and methyl bromide.

In coffee production, the substance methyl bromide might still be used in nurseries for soil disinfection.

Codex Alimentarius

The "**Codex Alimentarius"** is a joint FAO/WHO programme designed to protect the health of consumers and to ensure fair practices in food trade. It develops and updates international food safety standards, including maximum residue limit (MRL) recommendations. These limits recommend permissible levels for pesticide residues on food. These values are most important for products like vegetables, which are directly used as food (www.fao.org/waicent/afoinfo/economic/esn/codex/codex.htm).

National governments can choose whether or not to use the Codex MRL in food quality monitoring programmes.

Those levels are established for the green coffee beans for the following pesticides (http://faostat.fao.org/faostat/collections?subset=FoodQuality):

Active ingredient	MLR mg/kg	Active ingredient	MLR mg/kg
Aldicarb	0.10	Oxamyl	0.10
Carbendazim	0.10	Permethrin	0.05
Carbofuran	1.00	Prochloraz	0.20
Cypermethrin	0.05	Propiconazole	0.10
Deltamethrin	2.00	Terbufos	0.05
Disulfoton	0.20	Triadimefon	0.05
Fenamiphos	0.10	Triadimenol	0.10
Flucythrinate	0.05	Triazophos	0.05
Hexaconazole	0.05		

Besides international conventions and agreements, regional attempts like the African Plant Protection Strategy to combine food production, world market standards and environmentally acceptable plant protection should be supported by the 4C.

Baseline and Vision by Common African Plant Protection Strategy (CAPPS)
Increased threats of pest introductions and their spread are due to:

- weak capacities in African national plant protection and quarantine services
- the ongoing process of liberalisation of African economies
- increased trade
- the absence of adequate plant protection and quarantine measures

Further, the inability of most countries to respond to the new challenges and requirements of importing countries, international agreements, and conventions makes it imperative and urgent to develop and coordinate a common plant protection strategy for Africa.

Plant protection in Africa is visualised as an instrument that can provide substantial input towards the sustainable development of agriculture until 2020. Through this vision, three basic elements in African agriculture can be brought to bear: 1. Sufficient food and feed with satisfying quality is available at any point in time for the entire population of the African continent. 2. African agricultural exports increase and meet world market standards at competitive prices. 3. Environmentally acceptable plant protection policies and practices that are safe for human health and which do not impede trade and/or exchange in plants and plant products.

Principles:

Systems Approach: The most promising approach for a common African plant protection strategy is a system approach - Integrated Pest Management (IPM):

Most farming systems are complex, with several interrelated sub-systems, thus making IPM the most rational approach for prevention of losses during production, storage and processing. The IPM approach should be adopted for all pest control practises and in this context, should underlie any plant protection policy at national and regional level. Some of the key elements are:

1. Sound national and regional agricultural and plant protection policies,
2. National legislations that are harmonized with existing international standards (e.g. Codex Alimentarius recommendations), conventions (e.g. IPPC, POPs, PIC) and trade regulations (the Agreement on the Application of Sanitary and Phytosanitary Measures of WTO).
3. Capacity building for highly performing enforcement mechanisms for legislation and regulations at national and regional levels.
4. Support for participatory research, development, extension programmes with M&E

2.2 PESTICIDES IN COFFEE PRODUCING COUNTRIES

Based on the information of UNEP (www.pic.int) the situation of the pesticides of the Stockholm Convention is compiled for the twenty most important coffee exporting countries (Tab. 2). Some chemicals are not registered in some of the countries, in others a restricted use is allowed. The restriction might be for other than agriculture use like wood preservation or vector control of Malaria vectors. In agriculture it might be helpful to control some problematic pests like termites or locusts.

None of the mentioned pesticides (Tab. 2) is registered for the coffee production. Aldrin, Dieldrin, Chlordane and Heptachlor are restricted in their use against termites and other soil pests. DDT (inclusive production in India) is restricted to the medical and veterinary vector control. But as long as they are available in the countries and they are cheap and effective, some farmers will probably use them, as it is the case of Mirex in Peru where it is used against ants.

Tab. 2 Pesticides of the Stockholm Convention and its situation in the twenty most important coffee producing countries (n=not registered, nc= no consent in PIC, r=restricted, x=registered)

Chemical	**BRA**	**VNM**	**COL**	**IDN**	**GTM**	**IND**	**MEX**	**UGA**	**CIV**	**HND**	**PER**	**ETH**	**CRI**	**SLV**	**PNG**	**NIC**	**TZA**	**KEN**	**CMR**	**ECU**
Aldrin	**r**	nc	n	nc	nc	nc	nc	nc	n	nc	n	**r**	n	nc		n	**r**	n	x	nc
Chlordane	**r**	nc	n	nc	nc	nc	**r**	n	n	nc	nc	**r**	n	nc		n	**r**	n	n	nc
DDT	**r**	**r**	nc	nc	nc	**r**	**r**	nc	n	nc	nc	**r**	n	nc		n	**r**	**r**	n	nc
Dieldrin	**r**	nc	n	nc	nc	**r**	nc	**r**	n	nc	nc	**r**	n	nc		n	**r**	n	nc	nc
Endrin	n		n			n	n		n	n	n		n			n			n	n
Heptachlor	**r**	nc	n	nc	nc	nc	nc	n	nc	nc	nc	**r**	**r**	nc		n	**x**	n	nc	nc
Hexachlorobenzene	**r**	nc	nc	n		nc	n	n		n	nc	-	n	nc		n	n	n	nc	nc
Mirex	n					n	n			n	n		n			n			n	n
Toxaphene	**r**	nc					n		n	n	nc		n	nc		n	n			nc

Substances that are not subject to the Stockholm Convention but to the PIC procedure are more common in the following countries (Tab. 3). At least where the active ingredients are not restricted to a special use, they are or might be used in the coffee production. Lindane is/was recommended in India against the White Stem Borer (*Xylotrechus quadripes*). Methamidophos, methyl-parathion, monocrotophos are still widely used in a lot of agricultural crops.

Tab. 3 Pesticides, subject to the PIC procedure, and their situation in the twenty most important coffee producing countries; n=not registered, nc= no consent in PIC, r=restricted, x=registered (PIC-Circulars)

Chemical	BRA	VNM	COL	IDN	GTM	IND	MEX	UGA	CIV	HND	PER	ETH	CRI	SLV	PNG	NIC	TZA	KEN	CMR	ECU
Captafol	r	nc	n	nc		r	x	n	nc		nc		n	nc			n	n	n	nc
Lindane	r	nc	nc	n		x	r		nc	n	nc		n	nc		n	r	x	r	nc
Methamidophos*	r	nc					r		n		x		nc			x	x	n	n	nc
Methyl-parathion*	r	nc	r			r			r		n		r			x	n	nc	n	nc
Monocrotophos	r	nc						x	r		nc	x	r	nc		x	x	nc	n	nc
Parathion	r	nc		n		nc			nc		n		n	nc		n	n	nc	n	nc
Phosphamidon	r	nc							n		nc		n	nc			x	nc	n	nc

* only certain formulations in PIC

Registered pesticides

To get an idea about the range of pesticides registered for use in the coffee production, the fungicides, herbicides and insecticides allowed in Brazil, Viet Nam, Costa Rica, El Salvador and Tanzania are listed in Tab. 4-8. For the first three countries, there is an electronic database. The information for El Salvador and Tanzania was gathered from the respective ministries. In countries like Guatemala or Honduras, the registration of pesticides is not crop specific, although there are normally recommendations which pesticides can be used to face different coffee pests. For a few countries, these recommendations and/or the commonly used pesticides will be presented.

In the following tables the active ingredients are listed according the recommendations for the 4C using the "traffic-light" concept of red, yellow and green. The recommendations are based as described on the classification given in "The WHO recommended classification of pesticides by hazard and Guidelines to classification 2000-2002" (IPCS) and additional toxicological information. Remarks on possible substitutes and alternative control methods are made in the following parts (3. 7.) of this paper, which details the most important pests, diseases and weeds.

Fungicides:

No fungicides of WHO class I are registered in the five case study countries, Brazil, Viet Nam, Costa Rica, El Salvador and Tanzania (Tab. 4). But chlorothalonil, cyproconazole, iprodione, mancozeb, tetraconazole and thiophanate-methyl have been evaluated by EPA as being carcinogenic. For this reason it is advisable to substitute their use in coffee as soon as possible.

Even though it is WHO U, Benomyl is one substance that should be considered as belonging to the red criterion. The chronic effects of Benomyl are of major concern and its inclusion in the PIC procedure is currently discussed. With regard to Annex 1 of the Council Directive 91/414/EEC of the European Union, Benomyl is not included. Decisions for other pesticides, like those mentioned above, are still pending.

The substance anilazine is known to be a discontinued chemical, but it is still registered in some countries.

Tab. 4 Fungicides used in coffee in a few exemplary countries (x: registered), their main use, hazard information and listed after recommendation for the 4C criteria red, yellow and green.

active ingredient	use (mainly)*	WHO	Ch	Ca	ED	4C	BRA	VNM	CRI	SLV	TZA
Anilazine	*Phoma*	O				**r**	x				x
Benomyl	CBD	U	n	C	b,1	**r**		x	x	x	
Chlorothalonil	CBD, CCC, *Phoma*	U	n	li		**r**	x	x	x	x	x
Cyproconazole	CLR	III	n	B2		**r**	x	x	x	x	x
Iprodione	Phoma	U	n	li	c	**r**	x			x	
Mancozeb	CCC, CLR	U	n	B2	b,1	**r**	x	x	x	x	
Tetraconazole	CCC, CLR	II	n	li		**r**	x				
Thiophanate-methyl	CCC, Phoma	U	n	li		**r**	x		x	x	
Boscalid		nl	n			**y**	x			x	
Bromuconazole	anthracnose	II	n	E		**y**		x		x	
Carbendazim	Koleroga	U	n	C	c	**y**		x	x	x	
Copper sulfate	foliar diseases	II	n	-		**y**	x	x		x	x
Cuprous oxide	CCC, CLR, CBD	II	n			**y**	x				x
Difenoconazole	CCC	III	n	C		**y**	x	x			
Fentin acetate	CLR, non systemic	II	n	-		**y**	x				
Ferbam		U	n	nD		**y**			x		
Hexaconazole	CLR,	U	n	C	nl	**y**	x	x	x	x	x
Myclobutanil	CLR	III	n	E		**y**	x				
Oxytetracycline	bacteric., fungicide	nl	n	nD		**y**	x				
Prochloraz	CBD, *Mycena*	III	n	C		**y**			x	x	x
Propiconazole	CCC, CLR, *Ascochyta*	II	n	C		**y**	x	x	x	x	x
Propineb	CCC	U	n	-		**y**		x	x	x	x
TCMTB (Benzotiazol)	*Corticium*	nl	n	C		**y**				x	x
Tebuconazole	CLR, CCC, *Phoma*, *Ascochyta*	III	n	C	nl	**y**	x			x	
Tolclofos-methyl		U	x	-		**y**			x		
Triadimefon	CLR	III	n	C	1	**y**	x	x	x	x	x
Triadimenol	CLR	III	n	C	1	**y**	x	x		x	
Azoxystrobin	CLR, CCC. CBD	U	n	nli		**g**	x		x	x	
Bitertanol		U	n	-		**g**			x		
Bordeaux mixture	CLR, CCC	nl	n			**g**			x		
Copper hydroxide	CLR, CBD, CCC, *Phoma*	III	n	nD		**g**	x		x	x	

active ingredient	use (mainly)*	WHO	Ch	Ca	ED	4C	BRA	VNM	CRI	SLV	TZA
Copper oxychloride	CLR, CBD, CCC	III	n	nD		**g**	x	x	x	x	x
Dazomet	nursery	III	n	nc		**g**				x	x
Diniconazole		III	n	-		**g**		x			
Dithianon	CBD, CLR	III	n	-		**g**					x
Epoxiconazole	CLR	nl	n	nD		**g**	x		x	x	
Flusilazole	CCC	III	n	nD		**g**				x	
Flutriafol	CLR	III	n	-		**g**	x	x			
Fosethyl-Al	*Phoma*, CLR	U	n	nli		**g**	x			x	
Kasugamycin	bacteric., fungicide	U	n			**g**	x	x			
Metconazole	CLR, Phoma	III	n			**g**	x				
Pencycuron	*Rhizoctonia solani*	U	n	-		**g**	x			x	
Propamocarb	damping off	U	n	nli		**g**				x	
Pyraclostrobin	CLR, CCC, *Mycena*, *Phoma*	nl	n	nD		**g**	x				
Sulphur	fungicide, insecticide	U	n			**g**	x				
Validamycin		U	n	-		**g**		x	x		

* CBD: Coffee Berry Disease, CCC: *Cercospora citricola*, CLR: Coffee Leaf Rust
WHO: Ia: extremely hazardous; Ib: highly hazardous; II: moderately hazardous; III: slightly hazardous; U = unlikely to present acute hazard; O: obsolete or discontinued; nl: not listed
Ch: Cholinesterase inhibitor; x=yes; n=no (http://www.pesticideinfo.org)
Ca: carcinogenic: EPA Information (www.epa.gov/pesticides):
1999: ca:carcinogenic, li: likely, su: suggestive, iD: inadequate datas, nli: not likely
1996: k: known or likely; iD: cannot be determined, nli: not likely
1986-1996: A: human carcinogen, B1, B2: probable, C: possible, nD not classifiable, E: no evidence
ED=Endocrine Disruptor: EPA: known (a) or probable (b) (www.epa.gov/osa/spc/htm/Endoqs.htm); list of WWF (www.wwf.de/imperia/md/content/pdf/umweltgifte/Pestizide_Biozode.pdf): 1
4C: r=red, y=yellow, g=green, n.a.: not accepted

Insecticides

In the following tables (Tab. 5-7), the registered pesticides are divided according to the WHO classification. In the insecticide group, a high number of active ingredients fall into the WHO I class.

Methyl-parathion and methamidophos, already in the PIC-list (Tab. 3) are again mentioned in Tab. 5. Methyl-parathion in emulsifiable concentrates with 19.5%, 40%, 50%, 60% a.i., and dusts with 1.5%, 2% and 3% a.i. and soluble liquid formulations of methamidophos that exceed 600 g active ingredient/l are in the PIC procedure. But also for the less highly-formulated products as for all belonging to the WHO class I, safe application requirements for this class are normally impossible for most farmers in coffee producing countries. Applications with a knapsack-sprayer on a crop that is taller than the people is highly risky. Following the “Code of Conduct” of the FAO, pesticides with this extreme toxicity should not be on the market, considering the contamination risks given the limited possibilities for protection.

Tab. 5 Insecticides of the WHO class I, their main use, hazard information, their registration in a few exemplary countries (x: registered), and recommendation for the 4C criteria red, yellow and green.

active ingredient	use (mainly)*			WHO	Ch	Ca	ED	4C	BRA	VNM	CRI	SLV	TZA
Aldicarb	I		N	Ia	x	E	c,1	**r**	x		x	x	
Disulfoton	I	A		Ia	x	E		**r**	x		x	x	
Ethoprophos	I		N	Ia	x	li		**r**		x		x	
Methyl-parathion	I			Ia	x	nli	b,1	**r**				x	
Phorate	I	A		Ia	x	E		**r**	x		x	x	
Terbufos	I		N	Ia	x	E		**r**	x		x	x	
Cadusafos	I		N	Ib	x	E		**r**	x				
Carbofuran	I		N	Ib	x	nli	1	**r**	x		x	x	x
Dicrotophos	I	A		Ib	x	su		**r**					x
Fenamiphos	I		N	Ib	x	E		**r**			x	x	
Isoxathion	I			Ib	x			**r**		x			
Methamidophos	I	A		Ib	x	E		**r**					x
Methomyl	I			Ib	x	E	c,1	**r**	x			x	
Monocrotophos	I	A		Ib	x			**na**			x		
Omethoate	I	A		Ib	x			**r**		x			
Oxamyl	I	A	N	Ib	x	E		**r**			x	x	
Triazophos	I		N	Ib	x			**r**	x				
Zeta-Cypermethrin	I			Ib	no	C	1	**r**	x				

*I: insecticide, A: acaricide, N: nematicide; further legend explanation see Tab.4

Out of the toxicity class WHO II (Tab. 6), one of the insecticides, endosulfan, is on the list to be included in the PIC procedure. EPA classified Endosulfan as a highly hazardous substance. It is highly toxic if ingested orally and very toxic when absorbed through skin. Endosulfan is easily absorbed by the stomach, by the lungs and through the skin, meaning that all ways of exposure can pose a threat. It is an organochlorine insecticide as DDT and a known endocrine disruptor chemical.

Environmentally, it is extremely toxic to fish, moderately to highly toxic to birds, and moderately toxic to bees. But it is relatively non-toxic to beneficial insects such as parasitic wasps, ladybird beetles and some mites. It breaks down faster than the other organochlorines, leaving the body fairly quickly. Despite its rapid degradation in water, it can bind to soil particles and persist for a relatively long period of time. Endosulfan has only a moderate potential for bioaccumulation. It does not leach into groundwater, but is particularly prone to runoff immediately after spraying. Endosulfan is moderately persistent in the soil environment with a reported average field half-life of 50 days. Endosulfan in soil inhibits the degradation of other organochlorines.

Endosulfan is banned at least in the following countries (Denmark, Germany, Netherlands, Sweden, Belize and Singapore, Colombia) and worldwide campaigns have been going on for several years to completely ban endosulfan. As it is highly effective in the control of numerous pests, the decision to ban it, is a difficult task for numerous countries. However, the indirect costs caused by its negative impacts on human health and/or environment are often not well known, as they are not so easy to assess.

Tab. 6 Insecticides of the WHO class II, their main use, hazard information, their registration in a few exemplary countries (x: registered), and recommendation for the 4C criteria red, yellow and green.

active ingredient	use (mainly)*			WHO	Ch	Ca	ED	4C	BRA	VNM	CRI	SLV	TZA
Endosulfan	I			II	n	nli	a,1	**r**	x		x	x	x
Alpha-Cypermethrin	I			II	n			**y**	x				
Benfuracarb	I		N	II	x			**y**		x			
Beta-Cyfluthrin	I			II	n			**y**	x				
Carbosulfan	I	A		II	x			**y**		x			x
Cartap	I			II	n			**y**	x				
Chlorpyrifos	I	A		II	x	E		**y**	x			x	x
Cyfluthrin	I			II	n	nli		**y**	x			x	
Cypermethrin	I			II	n	C		**y**	x		x	x	x
Deltamethrin	I			II	n			**y**	x		x	x	x
Diazinon	I			II	x	nli		**y**			x	x	x
Dimethoate	I	A		II	x	C	1	**y**		x		x	x
Esfenvalerate	I			II	n	E	c	**y**	x				
Ethion	I	A		II	x	E		**y**	x				
Fenitrothion	I			II	x	E		**y**	x		x	x	x
Fenpropathrin	I	A		II	n	E		**y**	x				
Fenthion	I	A		II	x	E		**y**	x		x		x
Fipronil	I			II	n	C	1	**y**				x	
Imidacloprid	I			II	n	E		**y**	x		x	x	
Lambda-Cyhalothrin	I			II	n		c	**y**	x		x	x	
Metaldehyde	I			II	n			**y**	x		x	x	
Permethrin	I			II	n	C	c	**y**	x			x	
Profenofos	I	A		II	x	E		**y**	x				x
Prothiofos	I	A		II	x			**y**				x	
Trichlorfon	I			II	x	li		**y**	x				

*I: insecticide, A: acaricide, N: nematicide; further legend explanation see Tab. 4

Tab. 7 Insecticides of the WHO class III and class U, their main use, hazard information, their registration in a few exemplary countries (x: registered), and recommendation for the 4C criteria red, yellow and green.

active ingredient	**use (mainly)***			**WHO**	**Ch**	**Ca**	**ED**	**4C**	**BRA**	**VNM**	**CRI**	**SLV**	**TZA**
Methoxychlor	I			U	n	D	a,1	**r**			x		
Propargite		A		III	n	B		**r**			x		
Acephate	I			III	x	C		**y**					x
Buprofezin	I			U	n	su		**y**		x			
Fosthiazate			N		x			**y**	x				
Hydramethylnon	I			III	n	C		**y**			x	x	
Malathion	I			III	x	su	c,1	**y**	x				
Nereistoxin	I				n			**y**		x			
Pyridaphenthion	I	A		III	x			**y**	x				
Thiamethoxam	I				n	li		**y**	x				
Abamectin		A			n	E		**g**	x				
Acetamiprid	I				n			**g**	x	x			
Lufenuron	I				n			**g**	x				
Sulphur	I	A		U	n			**g**			x		
Teflubenzuron	I	A		U	n			**g**	x				

*I: insecticide, A: acaricide, N: nematicide; further legend explanation see Tab. 4

Herbicides

Some herbicides are considered too hazardous for further use (2,4-D, alachlor, acetochlor, diuron and paraquat). Therefore, they should be phased out in coffee production.

One of the most traditional chemical for weed control, Paraquat, is currently under an intensive, controversial discussion. It could be banned in the near future, because of its high toxicity to animals and because of its serious and irreversible delayed effects if absorbed. Not more than one teaspoon full of the active ingredient is fatal.

At spray concentration paraquat is of relatively low acute toxicity, classified as WHO II. While paraquat is poorly absorbed through intact skin, penetration is increased when the skin is damaged. Scratches and broken skin are common in physical agricultural work, and paraquat itself is skin irritant. Inhalation is not considered as a high risk. Accidental oral exposure can occur through splashes in the mouth during mixing, eating with contaminated hands, blowing or sucking blocked spray nozzles, or eating contaminated food. As paraquat is absorbed and binds quickly to the soil, its leaching into water sources is not generally a problem. Its use as an herbicide does not lead to residues in food.

Tab. 8 Herbicides registered for use in coffee in a few exemplary countries (x: registered), their main use, hazard information and recommendation for the 4C criteria red, yellow and green.

active ingredient	use	WHO	Ch	Ca	ED	4C	BRA	VNM	CRI	SLV	TZA
2,4-D	postemergence	II	n	D	b,1	**r**	x			x	x
Acetochlor	preemergence	III	n	B2	1	**r**	x				
Alachlor	preemergence	III	n	Li	b,1	**r**	x			x	
Diuron	preemergence	U	n	k		**r**	x	x		x	
Paraquat	burndown	II	n	E	1	**r**	x	x	x	x	x
Ametryn	pre-, postemergence	III	n	-		**y**	x	x		x	
Cyanazine	preemergence	II	n	C	1	**y**	x				
Diquat	burndown	II	n	E		**y**	x		x	x	
Fluazifop-p-butyl	postemergence	III	n	-		**y**	x			x	
Metribuzin	pre-, postemergence	II	n	D	c,1	**y**	x				
Oryzalin	preemergence	U	n	C	1	**y**	x				
Oxyfluorfen	pre-, postemergence	U	n	C		**y**	x		x	x	
Pendimethalin	preemergence	III	n	C	1	**y**	x				
Simazine	preemergence	U	n	C	1	**y**	x			x	
Azafenidin	pre-, postemergence	nl	n	iD		**g**	x				
Carfentrazone-Ethyl	postemergence	nl	n	nli		**g**	x				
Clethodim	postemergence	nl	n	nD		**g**	x				
Dalapon	postemergence	U	n			**g**					
Flumioxazin	postemergence	nl	n	nli		**g**	x				
Glufosinate	postemergence	III	n	nli	1	**g**	x	x		x	x
Glyphosate	postemergence	U	n	E		**g**	x	x	x	x	x
Metsulfuron	postemergence	U	n	-		**g**			x		
MSMA	postemergence	III	n	nli		**g**	x				
Sulfentrazone	preemergence	nl	n	E		**g**	x				
Sulfosate	postemergence	nl	n	E		**g**	x	x			
Terbuthylazine	preemergence	U	n	D		**g**			x	x	

legend explanations see Tab. 4

The Scientific Committee of Plants of the EU holds the position that when paraquat is correctly used according to the prescribed good working practices, it does not pose any significant health risk for its operators. However, a number of governments in industrialized countries like Austria, Denmark, Finland and Sweden have banned it.

As the prescribed good working practices are often not followed in the coffee growing countries, and as there is no antidote, paraquat should be banned as soon as possible in coffee production. Compilations about pesticide poisonings made by the Pesticide Action Network (PAN) suggest that the good working practices are not in place.

The herbicide 2,4-D is highly suspected to be an EDC and alachlor, acetochlor and diuron have carcinogenic effects.

Only in few of the important coffee-producing countries, exhaustive lists of registered coffee pesticides were made available or are accessible electronic ally. Some of the other countries provide information which pesticide is recommended or mainly used. They will be presented in the following.

India

The Indian coffee is primarily an export-oriented commodity. Nearly 70% of the country's production is exported to various destinations around the world, especially to developed countries such as Germany, Italy, Japan and the USA. In recent years all importing countries are increasingly adopting stringent Sanitary & Phytosanitary measures to protect their consumers from health risks through contaminated food. This is likely to pose the threat of restricted market access for all exportable commodities, also for coffees. Based on these preoccupations, the Coffee Board of India compiled some information about used pesticides and possible risks of residues on coffee beans. Recommended pesticides are:

Chemical	**Remarks**
Lindane	Application twice as stem swabbing against White Stem Borer. Being discouraged now
Chlorpyrifos	As stem application against stem borer. Also recommended as an alternative to endosulfan spray against berry borer
Endosulfan	Need based one spray against Coffee Berry Borer at least 90 days prior to harvesting
Quinalphos	Need based spray against mealybugs, green scales, Hairy caterpillars
Phorate	Need based use in young fields against Cockchafers or white grubs
Aluminium Phosphide	Used as fumigant against Coffee bean weevil during shipment
Bordeaux Mixture	Two sprays of 0.5% against leaf rust disease and also need based one spray with 1% BM against black rot disease in endemic areas
Triadimefon	Need based spot sprays against leaf rust disease
Propiconazole	Need based spot sprays against leaf rust disease
Hexaconazole	Need based spot sprays against leaf rust disease
Carbendazim	Need based one spot spray against black rot disease in endemic areas Soil application against root rot diseases in endemic areas Spray against collar rot disease in nursery
Glyphosate	Used as herbicide in coffee fields in large plantations
Paraquat-di-chloride	Used as herbicide in coffee fields in large plantations

Guatemala

Generally, the application of pesticides has been reduced during the last years due to economic limitations because of the very low price for the crop. Currently, the most common pesticides used in coffee plantations (pers. comm. Dr. Anzueto, ANACAFÉ) are:

Active ingredient	Commercial name	Utilization	4C
Hexaconazole	Anvil	Fungicide	y
Cyproconazole	Alto	Fungicide	r
Copper	Oxicloruro, hidróxido, óxido, otros.	Fungicide	g
Endosulfan	Thiodan, Thionex, Endosulfan	Insecticide	r
Glyphosate	Roundup, Ranger, Touchdown, Rival, others	Herbicide	g
Terbufos	Counter, Terbufos, others.	Nematicide; nursery	r

From a toxicological point of view, the most critical pesticide is Terbufos belonging to the WHO class I. But as it is used principally in nurseries against nematodes, the risk is limited. The use of endosulfan is to be reduced or eliminated with the use of traps. Intensive campaigns were started recently, to get farmers informed about this tool. Additionally to the information about the use of traps (Brocap®, commercially available), in this campaign even poor farmers are shown how they can produce their own traps with locally available cheap materials.

The lessons learned from the use of the traps against the Coffee Berry Borer will be very helpful as they could answer the question, if endosulfan should be eliminated from coffee production immediately.

Costa Rica

Pesticides used in the coffee production in Costa Rica (pers. com. Ramirez, ICAFE) and the average amount used some years ago (GEF, 2000) with 4C criteria

Active ingredient	Use	kg a.i./ha/year	4C criteria
Copper hydroxide	Fungicide	1.93	g
Cyproconazole	Fungicide	0.05	r
Hexaconazole	Fungicide		y
2,4-D	Herbicide	0.60	r
Glyphosate	Herbicide	0.12	g
Oxyfluorfen	Herbicide		y
Paraquat	Herbicide	0.51	r
Terbuthylazine	Herbicide	0.75	g
Chlorpyrifos	Insecticide		y
Endosulfan	Insecticide		r
Terbufos	Insecticide	2.50	r (if used in plantations)

Based on information from ICAFÉ, the use of nematicides in the plantations (mainly Terbufos) has been significantly reduced or stopped, mainly because costs were to high. There are at least 23 commercial products officially registered which contain active ingredients of WHO class I, most of them nematicides (www.protecnet.go.cr). The use of pesticides for crops is relatively high in Costa Rica and supported by the government. Even in smaller coffee holdings the applications of herbicides, fungicides and nematicides were very common in the nineties (Agne 2002).

Supported by a regional project of the German Ministry of Technical Cooperation and Development (BMZ), the chamber of biopesticide producers of Costa Rica (CANIAN) are promoting the use of biopesticides (www.bioplaguicidas.com) in the cultivation of different crops. Registered biopesticides, which may also be used in coffee plantations, are the fungicides *Streptomyces hygroscopicus*, Calcium carbonate and oil of mustard, the insecticide Sincosin, an extract of plants, and *Beauveria bassiana.* Sulphur is used to control pest and diseases. CBB can be controlled with a CBB pheromone and with the production of the parasite wasps *Cephalonomia stephanoderis* and *Phymastichus coffea*.

According to expert opinion (Ing. A. Llobet, allobet@racsa.co.cr, who works since many years in the coffee production as advisor, mainly in Costa Rica), a management system which is based on a healthy, vigorous plant growth, aimed at good and reasonable yields needs, is based on the use of the following plant protection and crop management practices:

- Fungicides: Triazoles (especially cyproconazole).
- Herbicides: Glyphosate. In countries with high labour costs an economic management without herbicides is not possible. Here, a good pre-emergent herbicide with low toxicity would be appropriate.
- Insecticides: there are many products and ways to work with biological products
- Nematicides: Sincosin, an organic product.
- Fertilizers: first, the nutrition of the coffee plant has to be detached from a radical system. The use of chemical fertilizers has to be controlled. In accordance to the needs of the plant, this can be combined with shade management, the utilization of organic fertilizer and a good soil management.

Nicaragua

There was no information available on the pesticides currently used, but it can be assumed that the pesticides used today are probably the same like some years ago, with the exception of prohibited products like Mirex. Due to high costs, it is likely that the amounts used have changed. With the help of international cooperation (NORAD/CATIE), a long-term project are conducted with smallholders, aiming to establish a sustainable coffee production based on low external inputs. Through management practices and the application of *Beauveria bassiana*, produced by farmer organizations, an efficient control of the Coffee Berry Borer is attempted.

Pesticides and doses used in coffee based on information of 1994 (GEF, 2000) and 4C criteria of the pesticides:

Nombre común	Nombre comercial	Acción	Tipo	Dosis	4C
Deltamethrin	Decis 2.5 EC	Insecticida	Piretroide	0.42 l/ha	y
Chlorpyrifos	Lorsban	Insecticida	Fosforado	2.1 l/ha	y
Endosulfan	Thiodan	Insecticida	Clorinado	2.0 l/ha	r
Mirex Gr.	Mirex	Insecticida	Clorinado	1.4 kg. a.i./ha	unacceptable
Methyl-parathion	M. parathion 48EC	Insecticida	Fosforado	2.8 l/ha	r
Methamidophos	Filitox	Insecticida	Fosforado	0.5 l/ha	r, if low concentration
Carbofuran	Furadán 10%G	Insectic. Nemat	Carbamato	63-170 /-plant	r
Terbufos	Counter 10%G	Insect., Nemat.	Fosforado	170 g/plant	r
Glyphosate	Round-up	Herbicida	Glicina	4.2 l/ha	g
Paraquat	Gramoxone	Herbicida	Bipiridilo	4.2 l/ha	r
Simazine	Simazina	Herbicida	Triazina	5.6 kg/ha	y
Fluazifop – butyl	Fusilade	Herbicida	Piridilo	2.8 l/ha	y
Hexacloruro de cobre	Exacloro	Fungicida	Cúprico	5.6 kg/ha	g
PCNB	PCNB	Fungicida	Clorinado	0.7 kg/ha	

(Source: Castillo & de Vos, 1988, up dated for M.A. Vaughan, 1994)

Tanzania

Information about pesticides used in coffee in Tanzania is already included in the tables 4-8. To reduce the use of pesticides, some IPM recommendations to the farmers on the management of their most important coffee problems (pers. com. MWAIKO, Min Agric. 2004) were elaborated.

Husbandry management of planted coffee fields:

- Emphasis on the use of resistant/tolerant varieties to Coffee Leaf Rust and Coffee Berry Disease
- Shade management especially with high sun is recommended, as coffee is traditionally intercropped with bananas. The recommended spacing for bananas in this system is 9x18feet or 2.7x5.5meter. Shade trees help to keep the air and soil cool and moderate shade helps to prevent the build up of trips, leaf rust and leaf miner.
- Organic manure and mulching: This improves soil structure and provides hiding places for beneficial organisms also microorganisms that suppress soil borne diseases and pests.
- Irrigation techniques: Timely irrigation stimulates early flowering before long rains and thus the crop could escape CBD. Trips and CLR could be reduced.
- Weeding: when ground cover is over 50%, coffee should be weeded or slashed (about 4-5 times per year). In particular *Oxalis* should be removed, as it is a host of Coffee Leaf Rust.

- Pruning and desuckering: To be done 3 times per year. Apart from improving yields and stimulating growth this reduces insect pests and diseases attack by allowing light and air into the trees and enhance coverage and penetration of sprays into the foliage.
- Crop hygiene/sanitation: This involves continuous harvesting of ripe berries to avoid attacks by Coffee Berry Borer. This also improves coffee quality. Stem cleaning by removing loose bark to reduce white stem borer eggs and CBD spores present on the bark. Stripping off of old remaining berries after harvesting and burying them (ie CBD - affected ones). Rogue and burn stemborer or Fusarium- affected branches or trees.
- Scouting: Scout and treat immediately if insects are in their vulnerable stages
- With Fusaruim wilt (*Gibberella stilboides*): Rogue and burn Fusarium–affected branches or trees and replant earliest after 6 months.

Cameroon

The following list of registered coffee pesticides was provided by a GTZ project in Cameroon.

Common name	**Function**	**4C**
Dimethomorph + Copper oxychloride	Fungicide	g
Copper hydroxide	Fungicide	g
Metalaxyl + Copper oxide	Fungicide	g
Copper oxide	Fungicide	g
Copper oxide + cymoxanil	Fungicide	g
Glyphosate	Herbicide	g
Paraquat	Herbicide	r
Acephate	Insecticide	y
Chlorpyrifos	Insecticide	y
Diazinon	Insecticide	y
Endosulfan	Insecticide	r
Fenobucarb (BPMC)	Insecticide	y
Fipronil	Insecticide	y
Methyl-parathion	Insecticide	r
Thiamethoxam 141 g/l + Lambdacyhalothrine 106g/l	Insecticide	y
Dichlorvos + Malathion *(traitement du café et cacao à l'exportation par l méthode de nébulisation)*	Insecticide	

3. PESTS

Coffee plantations are generally confronted with a multitude of pests and diseases. Over 900 insect species have been reported to feed on coffee plants. However, relatively few cause significant damage, and few are sufficiently widespread to cause major losses. An infestation of either pests or diseases is always an indication that there is an imbalance in the coffee eco-system. The causes need to be investigated. The selection of control methods to pest and disease problems has to consider the specific requirements of the crop.

Coffee plants prefer well-drained and airy soils. Due to a network of surface roots, it can grow on shallow ground. Humus-rich, lightly acidic soils are advantageous. The best conditions are those to be found on virgin soils of volcanic origin.

The ideal temperature range for Arabica coffee plants lies between 18°C and 24ºC. At higher temperatures bud formation and growth are stimulated, but the greater proliferation of pests increases the risk of infection, and quality sinks. Coffee plants are susceptible to frost, and temperatures below 10ºC inhibit growth. Robusta plants can withstand higher temperatures and are more resistant against infection.

The ideal amount of rainfall lies between 1500 mm and 1900 mm. Coffee plants react positively to a drought period that should nevertheless not be longer than 3 months. The rainfall should be evenly spread throughout the rest of the year. Irregular rainfall causes uneven blossoms and fruit maturity.

Coffee is a half-shade plant, which can only utilize around 1% of the sunlight (ideal is around 1500 hours per year) photosynthetically.

If there are coffee plantations with high incidences of pests, diseases and weeds, possible causes are:

- Unsuitable site (too low altitude, too warm, too humid, stagnant water, too dry).
- Degenerated and poor soils, lack of organic material.
- Too little diversity and too few shading trees.
- Non-adherence of the correct succession of the forest system, trees too old or wrong variety.
- Varieties too close together, which have an identical status in the system.
- Failure to trim the shading trees (too much shade)

The most common pests and diseases are described in the following. Their distribution and requirements show clearly that coffee is not always grown in suitable areas or that the management is not appropriate to keep pests and diseases at a low level.

3.1 COFFEE BERRY BORER (*HYPOTHENEMUS HAMPEI*)

The Coffee Berry Borer (CBB) has a worldwide distribution and is considered as the most important pest of coffee. Originating from Africa, it has dispersed to nearly all major coffee producing countries of the world. It was introduced into Brazil (1913) and Indonesia in the early part of the 20th century, into India in the early 1990's. Costa Rica, one of the major coffee producing countries, which for a long time could avoid the pest, has also been infected since 2000. The CBB has caused substantial production losses, mostly everywhere in its newly colonized range.

Low temperatures and humidity under 50% are limiting factors for its development. For this reason, it is less problematic in areas above 1500 m in the tropical belt.

Damage is caused by the female, which bores into green coffee berries to lay her eggs producing legless white larvae that feed on the substance of the beans for up to 3 weeks. Economic damage is twofold: - premature fall of cherries and hence total loss for production purposes; - damaged cherries remain on the tree, but the commercial value decreases due to reduced weight of the bean, downgrading in quality and affected flavour of the coffee. The CBB is difficult to control because of its hidden life-style. Control is easier in countries where coffee harvests are concentrated.

Control measures:

Plantation management: maintaining optimum shade and good drainage.

Cultivation techniques: One of the most important control and management practice is the punctual, complete harvest and rigorous collection of remnant berries from the tree and the ground (so called Re-re method). The infested berries should be boiled or buried. Carefully done, it is a successful method to control the CBB. It avoids health risks, is environmentally clean and does not require any equipment or specialization. But as it is labour intensive this method is costly, and therefore disadvantageous in particular in countries with high wages. However, it is still an applicable method, especially for small farmers.

Biological control: There are mainly four species of natural enemies, *Cephalonomia stephanoderis*, *Prorops nasuta, Heterospilus coffeicola, Phymastichus coffea,* reared until now for the CBB control. The latter seems to be the most effective parasitoid wasp to control CBB. It attacks the adult CBB, lays eggs into the body of the female and can parasitize about 6 CBBs. In Honduras, native wasps associated with CBB could be found already.

The expensive mass production of the host CBB is until now the most decisive obstacle to make biological control more economic and thus attractive to farmers. However, in 2003, mass rearing at USDA has achieved some important improvements. It is now possible to continuously rear CBB without replenishment from the field, and without vigour losses for about 20 generations. Although some technical hurdles remain, there is a clear indication that it will become possible to mass-produce *Phymastichus* wasps at prices that are comparable or even cheaper than standard methods (hand removal or insecticides). A recent cost model makes a compelling case that this technology is now worthy of passing to a pilot stage. *Phymastichus* mass rearing has quickly become a plausible alternative to laborious or toxic alternatives.

Besides the wasps, the entomopathogenic fungus *Beauveria bassiana* also controls CBB. It can be found naturally, particularly in humid conditions. Strains with different virulence are present in most countries. Depending on the climatic conditions, infestation rates vary widely and lie somewhere between 20% and 80%. With an adequate plantation management, the climatic conditions can be influenced to maximize the infestation level. Even if commercial products are available, local production is possible and can be conducted by the farmers with little training. But the formulation has to be improved, because of the light sensitiveness of the spores. Application techniques and conditions have also to be known by farmers to get desired results. There are some indications from projects in Nicaragua that the quantity of spores applied can be gradually reduced.

Mechanical control: Since new traps have been developed in Central America (El Salvador), their ability to control the population have been recently (since 2001) tested.

Commercial (BROCAP®) and homemade traps have been used, placing about 15 traps in one hectare. The results seem to be promising, but the traps are to be part of a management programme and not the only control measure.

Chemical control: The most common active ingredients are endosulfan, chlorpyrifos, fenitrothion and fenthion. The first one is the most used and seems to be the most effective. The insecticides are only effective before the CBB has penetrated the berry. With high infestation situation and considering only the direct costs on a short-term basis, the cost effectiveness is the big advantage of chemical control.

As the coffee trees are often densely planted and taller than the persons spraying them, inhalation of the pesticides is likely. None of the mentioned chemical ingredients, and especially endosulfan, can be recommended because of their toxicity and their present application practices.

To reduce substantially or even avoid the use of chemical control in the future, a management programme for each country has to be developed based on a combination of available non-chemical methods. As already practiced in some countries, the use of pesticides is to be delimited to spot spraying. According to BAKER (1999), all of the current control methods have either cost or efficiency disadvantages. The phase out of Endosulfan, and the use of less toxic products (chlorpyrifos, fenitrothion and fenthion) may have an effect on natural enemies of *Leucoptera*. But this possible negative impact can be reduced through spot applications.

The recommendations in India for controlling the Coffee Berry Borer (since 1990 in India), include clean and timely harvesting. This means avoiding that fruits fall on the ground while harvesting (gleanings) through the use of picking mats and removal and destruction of off-season berries to minimize pest build-up. It also includes the spraying of fungal biocontrol agent *Beauveria bassiana* during the bean filling stage when there is adequate atmospheric humidity and one spray of endosulfan if the infection rate is high and when the beetle is still waiting at the navel region. Finally the use of 'Brocap Traps' throughout the cropping season, especially after harvesting is recommended in order to trap the adult beetles. In the last few years, the exotic parasitoid *Cephalonomia stephanoderis* has been successfully employed against Coffee Berry Borer in many locations and the results are highly encouraging. Large-scale field releases of this parasitoid have being undertaken in the berry borer infested areas and in many cases this practice has been established and applied to nearby areas. Another parasitoid, *Phymastichus coffea,* is also under field evaluation now. The large-scale use of CBB traps and the establishment of the parasitoid resulted in a considerable reduction of pesticide use. At present, irrespective of the holding size, spraying of endosulfan or chlorpyrifos is adopted only as spot applications.

Mexico: In an official regulation (NORMA OFICIAL MEXICANA NOM-002-FITO-2000) it is stated that the damage could reach 80%. Between the harvests, traps (16/ha) have to be installed, even in CBB-free areas. To create adverse development conditions for the pest, agronomical practices have to be carried out:

a) Pruning
b) Regulation of shade
c) Weed elimination
d) Recollection of infested fruits from plant and soil
e) Introduction of infested fruits with CBB in boiling water. Unsaleable fruits should be buried after a chemical treatment with malathion or burned.

The biological control of CBB is realised with liberations of *Cephalonomia stephanoderis*, spraying of the entomopathogenic *Beauveria bassiana* or other agents of control,

which proved to be effective. Production and management of *C. stephanoderis* is carried out by special rearing stations.
In places with new infestations, chemical products have to be applied. The appropriate doses are authorized and registered at the organisation CICOPLAFEST. Official personnel or verification units supervise this activity.
In pest control areas, chemical applications are authorized, if the infestation rate exceeds 5%.

Colombia, where CBB was introduced in 1988, seems to be the most affected country with high losses due to the CBB. This is caused by agroclimatic conditions allowing a fructification over a long period, high plantation densities, difficult topography for control measures and high wages. A lot of efforts were made to develop integrated pest management programmes aiming to reduce the use of the pesticide endosulfan. Since 2001 endosulfan is prohibited in Colombia. However, since the use of endosulfan is easy, effective and economic, farmers continue to use it to fight the CBB. This is specially true, if on behalf of a low coffee price, the recollection of infested berries is neglected causing outbreaks of CBB hard to control in a short time with other than chemical methods. Considering that 70% of Columbian farmers are small farmers with less than 3 ha, cultivation techniques combined with biological control and trapping on the long run is a viable solution.

Management and control options with regard to 4C criteria:

red	yellow	green
Endosulfan	Chlorpyrifos	Biological control
	Fenitrothion	Cultural control
	Fenthion	Traps
		Plantation management

3.2 STEMBORERS (*XYLOTRECHUS QUADRIPES, MONOCHAMUS LEUCONOTUS, DIRPHYA NIGRICORNIS*)

Stemborers are the most destructive pests of arabica coffee in Asia and Africa. The females of the beetles lay eggs in the crevices on the main stem of coffee. The larvae bore into the stem causing the death of young plants. If they survive the attack, the yield of the older plants is drastically reduced. The susceptibility to diseases and termites may increase.

The Coffee White Stemborer (*Xylotrechus quadripes)* is the most serious pest of arabica coffee in India, as well as Sri Lanka, China, Viet Nam and Thailand. In India, arabica coffee is cultivated on more than 125 000 ha by both smallholders and estates. It is estimated that over nine million trees are destroyed each year because of attacks by *X. quadripes*.

The White Stemborer (*Monochamus leuconotus)* and the Yellow Stemborer (*Dirphya nigricornis)* can be found in different African countries as well.

To fight stemborers, it is important to maintain optimal shade, to periodically cull out affected plants, to debark (labour intensive) and to apply lindane prophylactically on the stems. In Africa the stemborers have become particularly hard to control since the withdrawal of dieldrin and aldrin as environmental contaminants. However, a highly recommended way of applying insecticide with minimal non-target effects is the application of insecticide to the stem of coffee bushes.

As an alternative to Lindane, chlorpyrifos is now suggested to control the stemborer. The use of eco-friendly products like 10% lime solution, which is found effective in the trials, should also be encouraged as it reduces the dependence on chemical pesticides for borer control.

There are projects in India, Malawi and Zimbabwe funded by the Common Fund for Commodities (CFC) to establish alternative methods to fight this pest, and, as part of this, to work on the male-produced pheromone. Indian investigators showed female *X. quadripes* beetles were attracted to traps baited with male beetles. The production of a male pheromone, which attracts females, was confirmed in a laboratory bioassay. Semi-commercial production of lures and traps will be introduced to enable a large-scale evaluation in India. The presence and nature of pheromones in *M. leuconotus* will also be investigated.

Hints for small, resource-poor farmers in Tanzania to manage the stemborer:

Scrape and brush off old bark of trees to remove insect stages (do not injure tree)

Paint stem and branches up to 90 cm (or usual height of attack according to experience) with a paste out of the following substances (repeat painting, if material comes off):

- lime - this dries out insect stages i.e. eggs
- fine soil - this dries out insect stages, i.e. eggs
- wood ash - this dries out insect stages, i.e. eggs
- manure (any animal) - this have insecticidal, repellent effect
- urine (slurry of any animal) - insecticidal, repellent, ferment 2 weeks before use
- botanicals like neem, *Tephrosia, Euphorbia, Datura, Tagetes, Lantana*

Manure, urine and botanicals can also be used against Antestia bug, berry moth and Coffee leaf rust. When coffee trees are heavily attacked by the stemborer, farmers should destump them to allow new branches to grow.

Management and control possibilities with regard to 4C criteria:

unacceptables	**red**	**yellow**	**green**
Aldrin		Chlorpyrifos	Cultural control
Dieldrin			Plantation management
Lindane			Botanicals
			Traps, biological control (needs further development)

3.3 SHOT HOLE BORER (XYLOSANDRUS COMPACTUS), TWIG BORER (XYLOSANDRUS MORIGERUS)

These are pests in robusta coffee causing considerable damage in the secondary and tertiary branches. Damages to coffee plants are primarily caused by extensive tunnelling within the branches limiting the sap flow. The affected branches then dry up. The presence of withering and dead branches with shot holes is a symptom for an attack.

To control these borers cultivation methods are mainly applied by pruning the affected twigs a few centimetres beyond the shot hole and burning them. This operation should commence as soon as the first symptom of attack like dropping of leaves is noticed, and continue as a routine measure at regular intervals. The pest prefers to breed in the suckers during dry periods. All unwanted and/or infested suckers should be removed and destroyed.

3.4 COFFEE LEAF MINERS (*LEUCOPTERA CAFFEINA, LEUCOPTERA MEYRICKI, LEUCOPTERA COFFEELLA*)

Leucoptera caffeina and Leucoptera meyricki are recorded for Africa, *L. coffeella* for Latin America. Leaf miners are one of the main pests in Brazil. They became serious pests where the natural antagonists were decimated through pesticide use. In production systems with low use of pesticides and balanced climatic conditions leaf miners are not a big problem. There are a variety of natural enemies, mainly parasitic wasps, predatory trips and mites.

The pests prefer dry conditions, low humidity and high temperatures.

Eggs are laid on the upper surface of the leaves. The larvae - small, white caterpillars - mine their way into the leaves just below the upper epidermis. In a severe attack they cause high loss of leaf tissue and subsequentially premature shedding of the leaves. Plant vigour and yield are reduced.

Cultivation techniques: Creating shady and humid conditions reduce pest outbreaks. The better the nutrient conditions for the plant, less the damage due to infestation.

Biological control: Despite the existence of many natural enemies, until now no single species is sufficiently effective for use as control agent.

Chemical control: A wide range of insecticides - organophosphates, carbamates, pyrethroids and others - are used to control leaf miners. Applications should only be carried out after reaching a critical threshold. In order to preserve the natural enemies applications should be reduced as much as possible to spot applications. Monitoring can be facilitated with pheromone-traps.

Recommended insecticides in different countries are for example:

red	yellow		green
Aldicarb*	Beta-cyfluthrin	Fenitrothion	Preserve populations of parasites by avoiding broad spectrum sprays
Carbofuran*	Cartap	Fenpropathrin	Shade and high humidity
Disulfoton*	Chlorpyrifos	Fenthion	Hot spot applications
Endosulfan	Cypermethrin	Imidacloprid	Abamectin
Phorate	Deltamethrin	Malathion	Spinosad
Terbufos*	Diazinon	Permethrin	Teflubenzuron
Zeta-cypermethrin	Dimethoate	Thiamethoxam	
	Esfenvalerate		

The marked* pesticides in the red criterion on the one hand have the advantage that they are applied to the soil and thus control the larvae inside the plant. This avoids decimation of natural enemies. On the other hand, the very high mammalian toxicity of these insecticides as well as their ecotoxicological risk factors (water contamination, wild bird toxicology) suggest to restrain from using them. An alternative insecticide which is also applied to the soil but which is less problematic is imidacloprid.

In Brazil there are more than 50 products registered for the use against the leaf miner (ANVISA). Almost one third of the active ingredients belong to WHO class I. This high number of products already shows the importance of the pest for Brazil. The existence of resistant *Leucoptera* populations to disulfoton, ethion, methyl-parathion, and chlorpyrifos, however, also stresses the urgent need for more integrated management concepts.

Transgenic plants: CIRAD, in collaboration with Nestlé, initiated in 1994 a study on genetic transformation of coffee for resistance to coffee leaf miner *Leucoptera coffeella*. CIRAD proved that the cryIA(c) *Bacillus thuringiensis* (Bt) gene produced efficient endotoxin against the leaf miner. In order to assess agronomic characteristics, resistance to leaf miners and transfer of pollen to non-transgenic coffee trees planted around the trail plot, GM *Bt* robusta plants are currently being planted in French Guiana for field testing.

As in a perennial crop like coffee, a resistance management is quite difficult; transgenic plants are not considered as a solution to the *Leucoptera* problem. In the long run, a combination of management of the crop, preservation of natural enemies and a very specific, spot control including the use of traps seems to be more sustainable.

3.5 KENIAN COFFEE MEALYBUG (PLANOCOCCUS KENYAE), OTHER MEALYBUGS (*PLANOCOCCUS CITRI*, *P.* SPP.) AND GREEN SCALE (*COCCUS VIRIDIS*)

Mealybugs and scales are worldwide pests, with some species of only local importance. They live in colonies on the underside of younger leaves and along young stems and branches. Large populations may result in the loss of growth vigour and smaller shoots and leaves. Their feeding reduces terminal growth and vigour interfering with photosynthesis, resulting in smaller berries and poor quality. During new terminal growth especially after rains, they grow rapidly, secreting copious amounts of honeydew. Scales suck plant juices from the inner bark by inserting their mouthparts into twigs and branches. Mealybugs may feed also in the root zone. A small shell covers the scales, which make control difficult. A waxy white powder covers mealybugs. Newly hatched nymphs move from under the shell or waxy powder and settle on branches and twigs. The best time to control scales and mealybugs is immediately after hatching. The life cycle of scales and mealybugs takes around a month and may have more than 10 generations per year. Heavy populations may reduce production by as much as 15% if left uncontrolled.

Biological Control: Several natural enemies control scale and mealybug populations. Some predacious beetles such as the ladybird beetle, green lacewings and minute pirate bug prey on these pests. They occur in large numbers and can keep low to moderate populations under control. Several species of parasitic wasps also help as a barrier to population increase. However, once populations are high, these natural enemies may not respond fast enough to prevent damage, and chemical control is needed. Natural fungi (*Verticillium lecanii*) also control populations, especially when humid conditions are favourable. Serious infestations are often the result of suppression of natural enemies by insecticides.

Cultivation techniques: Control of ants, as they protect scales and mealybugs and interfere with parasites.

Chemical Control: As scales and mealybugs spend most of their life protected underneath the covering, correct timing is important. In most cases only part of the plants are infested and should be treated. Plantations should be monitored, looking for scales or mealybugs on twigs and branches. The best time for chemical control measures is right after hatching before the covering is well developed.

red	**yellow**	**green**
Carbofuran	Dimethoate	Protection of natural enemies
Methidathion	Ethion	Oils
	Fenitrothion	Insecticidal soaps
	Fenthion	Azadirachtin
	Imidacloprid	Spinosad
	Malathion	
	Thiamethoxam	

3.6 COFFEE BUG (*ANTESTIOPSIS* SPP.) AND COFFEE MOTH (*PROPHANTIS SMARAGDINA*)

The coffee bug is a serious pest in Africa, especially in East African countries and is found more on arabica coffee. The adults and nymphs suck on the green berries and after the harvest also on different parts of the trees. However, the main damage is caused by a secondary infestation of the berries with the fungus *Nematospora* spp. that destroys the seeds. Serious damage is also likely if sucking on the buds causes them to drop.

The larvae of the moth feed on the berries. The infested fruits are covered with a thin thread.

Cultivation techniques and biological control: As the bugs have a high water requirement, all methods allowing fast drying of the plants help to reduce the damage. Correct pruning and avoidance of heavy shade can provide some control. A high number of natural enemies, such as parasitic wasps, flies and predatory bugs attack the pest, parasitize the eggs, feed on nymphs or attack the adults. The coffee moth larvae are also heavily attacked by parasites. All management possibilities should be used to maintain the natural enemies for these different pests.

Chemicals used and recommended for chemical control measures, in particular chlorpyrifos, fenitrothion or fenthion, are not suited to preserve the natural enemies.

4. DISEASES

4.1 COFFEE LEAF RUST (*HEMILEIA VASTATRIX*)

The Coffee Leaf Rust (CLR) has a worldwide distribution. It is known since 1869 as a devastating disease in Sri Lanka. 1970 it arrived in South America in Bahia, Brazil and 1984 in Colombia.

The CLR attacks the leaves causing premature shedding. The vegetative growth of the diseased trees is reduced, diminishing the production in the following season. Yield losses are mostly between 15 and 20%, but also up to 80% are known.

Resistant varieties: Timor hybrid, Catimor, Colombia, Cavimor, Icatu, Sarchimor, Icatu vermelho, Icatu amarelo, Obatã, Iapar 59, Tupi, and the more recently developed varieties in Central America: CostaRica-95, Lempira and MIDA-96, in Brazil: Catiguá MG1, Catiguá MG2 and Sacramento MG1. Research work and development of new varieties is important because of high numbers of races and mutations.

A short leaf-retention period after initiation of sporulation by the pathogen in the varieties Mundo Novo and Catuai, and the usually low infection rate of *Hemileia vastatrix*, is enough to keep the disease under control in many areas of Brazil without any need for chemical sprays. In other areas, however, up to 4 sprays are applied.

Cultivation techniques: vigorous plant growth through adequate fertility of the soil with special attention to calcium and magnesium; regulation of shade to reduce humidity. Pruning of infected parts to reduce inoculum.

Biological control: there are some indications of effectiveness of *Pseudomonas* spp., *Bacillus thuringiensis* and *Verticillium lecanii* due to resistance inducing effects.

Chemical control: Controlling *H. vastatrix* is a daunting task, because chemicals such as propiconazole, triadimenol, triadimefon and copper oxychloride are just partially effective. Amongst them, copper containing fungicides like copper oxychloride are the most effective and widely used. High solubility, variability in the target, the inability of pests to evolve resistance, high adhesiveness to leaves and the ability to serve as a nutritional supplements among other properties account for the exceptional utility of this metal complex. Control programmes actually are a combination of this protective fungicide with one systemic. Early intervention usually can prevent the spread of this disease.

red	yellow	green
Chlorothalonil	Fosethyl	Resistant variety
Cyproconazole	Hexaconazole	Shade control, fertilization
Mancozeb	Tebuconazole	Bordeaux mixture
	Triadimefon	Copper oxychloride
	Triadimenol	Azoxystrobin

There are also some products with a combination of tebuconazole and triadimenol on the market if CLR and other leaf spot diseases (*Cercospora coffeicola, Mycena citricolor, Ascochyta coffeae or Phoma costarricensis*) have to be controlled.

In Brazil, the strategy to manage CLR and *Leucoptera coffeella* is based on the application once a year of a mixture of the systemic fungicide (triadimenol or cyproconazole) and a systemic insecticide (disulfoton, imidacloprid) to the soil. It seems to be adequate for control of the leaf rust and of the leaf miner *Leucoptera coffeella* and there is less harm to the environment, because of no need of leaf-applied products, which more easily harms the natural enemies. But it has to be considered if the combined solution is always the correct time schedule for both problems.

In India for controlling leaf rust disease in arabica coffee, a 0.5% Bordeaux mixture is commonly used in almost all plantations in two applications once during pre-monsoon and post-monsoon periods each. Systemic fungicides like triadimefon, hexaconazole or propiconazole are used as spot applications especially in large holdings when there is a likelihood of disease flaring up due to favourable climatic conditions.

In Colombia are different scheduled control programmes developed with reference to the harvest time of crop. It is a combination of applications of copper fungicides and systemic fungicides (cyproconazole, hexaconazole, triadimefon).

4.2 COFFEE BERRY DISEASE (*COLLETOTRICHUM KAHAWAE*)

The Coffee Berry Disease (CBD), formerly with the name *Colletotrichum coffeanum,* until now is distributed only in Africa. Here, it is the most important disease problem (losses between 20 to 50%) with more damage done than by any of the other diseases. It attacks buds, flowers and berries. If the green fruit is infested, no seeds will develop. Yields are not or only little affected, if the fruits are already in a later stage, but it is more difficult to separate the seeds from the pulp, which reduces the quality of the coffee.

The optimum temperature for the development of the disease is between 16ºC and 26ºC. Water is needed for infection. Infested berries remaining on the branches are the main source of infection. The change of the pruning system from a single-stem to a multiple-stem system in Kenya favoured the disease's development.

Resistant varieties: Differences in susceptibility to CBD are known: particularly susceptible cultivars are: Harar, SL selections and Bourbon. Resistant varieties are Ruiru 11 (also resistant to Coffee Leaf Rust), K7, Blue Mountain, progenies of Timor hybrid or Rume Sudan.

Cultivation techniques: Pruning practices should result in a concentrated fruit setting at one main harvest and in a reduced ripening of fruits outside this period. This reduces a potential inoculum reservoir. The pruning should also open up the canopy to avoid prolonged moist conditions and thus spore exudation and spreading. Furthermore, this improves fungicide penetration and coverage.

In some places early irrigation helps to reduce infestation pressure during the most sensitive stage of the crop.

Chemical control: Although several different and effective fungicides for control of CBD are known, their use in the field has been inconsistent. Numerous studies suggest that fungicide applications early in the season are only effective if both flowering was early and the rainy season finished early. The crucial point appears to be to protect the immature crop throughout the rainy season. In years when flowering was normal or late and the rainy season extended longer into the season, early season fungicide applications were ineffective and CBD became worse during the season.

Numerous fungicides have been evaluated for CBD control. The most effective are: 50% copper formulations, captafol, chlorothalonil, benomyl, thiophanate-methyl, thiabendazole, and dithianon.

On plantations in Kenya, the standard practice a decade ago was to carry out on a specified schedule about 13 applications of a mixture of copper fungicides and captafol or chlorothalonil. The decision on timing and frequency of spraying depends on cropping level, disease magnitude and variability of the two over time and space. From a cost-benefit point of view reduced but well-timed sprays and fungicide mixtures produces the best outputs.

In some instances, fungicide applications have resulted in higher disease incidence. It has been reported that some plantations that never used fungicides for CBD have lower disease incidence than neighbouring plantations with regular spray programmes for CBD. It is generally believed that changes in the coffee bark ecology for microorganisms antagonistic to the CBD pathogen may have resulted from repeated fungicide applications, destroying the natural antagonistic flora to *Colletotrichum kahawae.* Similar situations could be found with the anthracnose in trees, where chemical control was inconsistent and some biocontrol agents (for example *Bacillus subtilis*) were tried. This suggests a stronger focus on research on the recovery of antagonistic organisms as well as the identification of new biological control agents.

unacceptables	**red**	**yellow**	**green**
Captafol	Benomyl	Cuprous oxide	Resistant varieties
	Chlorothalonil	Prochloraz	Copper products
	Thiophanate-methyl		Dithianon
			Azoxystrobin
			?antagonistic organisms?

Since CBD is limited to Africa, precautions need to be taken when importing coffee seeds from this region into countries free of the disease as not to risk introducing CBD. Import of cultivars should occur only through appropriate quarantine facilities.

4.3 BLACK ROT (*CORTICIUM KOLEROGA*)

It has a worldwide distribution and can cause high losses as for example in India. The infestation starts with a greyish-white, silky covering on twigs, leaves and berries before it results in their die back. It is found in humid regions with high temperature.

Cultivation techniques: As dense shade favours the disease, a light overhead shade should be maintained. The leaf litter of the shade trees on bushes have to be removed. Proper pruning and good weed control is recommended to ensure air circulation and drainage and to reduce humidity,

Chemical control: Normally, applications against leaf rust helps also to control this disease. But with an adequate plantation management, the disease should not need any chemical treatment. Out of the commonly used fungicides (see beneath) none of the more hazardous needs to be applied.

unacceptables	red	yellow	green
Captafol	Benomyl	Carbendazim	Bordeaux mixture
	Chlorothalonil	Cuprous oxide	Copper products
	Thiophanate-methyl		

No effectivity is achieved with chemicals like hexaconazole or cyproconazole.

4.4 BROWN EYE SPOT, MANCHA DE HIERRO (*CERCOSPORA COFFEICOLA)*

Cercospora fungus is found in coffee-growing areas worldwide. It can be an important disease in nurseries, but also attacks adult plants. Symptoms appear as small chlorotic spots on leaves. The outer portion of the leaf spot becomes brown; the centre becomes grey-white. The spot's eye-like appearance distinguishes it from other leaf spot diseases. Spots can occur on the cherries, appearing as sunburn, a black, dried, elliptical scar on the skin. These make the cherry difficult to pulp and may reduce the quality of the green bean. The disease is favoured by high humidity, rain, warm temperature, and drought stress after flowering. Exposed, unshaded trees and nursery seedlings are most susceptible.

Resistant varieties: not developed

Cultivation techniques: In nurseries balanced and good soil fertility with nitrogen not in excess, and shadow are very important. In plantations, good growing conditions, sufficient air circulation, adequate fertilization, and irrigation if necessary to avoid drought will normally prevent the problem. Shadow management has to be adapted to the local situation: too much sun favours *Cercospora*, more shadow the Leaf Rust.

Chemical control: In nurseries a chemical control may be more important than in plantations, where generally copper fungicides are used only in very isolated cases with some serious outbreaks.

red	yellow	green
Chlorothalonil	Carbendazim	Bordeaux mixture
Mancozeb	Cuprous oxide	Copper products
Thiophanate-methyl	Propineb	Diniconazole
	Triadimefon	Epoxiconazole
		Flusilazole

4.5 ANTHRACNOSE (*COLLETOTRICHUM GLOEOSPORIOIDES)*

Colletotrichum gloeosporioides is known to infect a wide variety of hosts worldwide. It affects most parts of the plant, leaves, flowers or fruits. If flowers are badly infected, the shedding of it may result in considerable yield reduction, but it is rarely an important disease. In most of the countries there are no recommendations for chemical control.

Varieties: use of less susceptible varieties

Cultivation techniques: good nutrition, regulation of humidity through good air circulation, shade regulation and pruning, plant densities reduction and weed control.

Chemical control: a variety of fungicides are mentioned to be effective like azoxystrobin, bromuconazole, carbendazim, cyproconazole, folpet, hexaconazole, copper hydroxide, copper oxychloride, mancozeb, propiconazole, triadimenol, but with a good management they should not be necessary.

4.6 AMERICAN LEAF SPOT, OJO DE GALLO (*MYCENA CITRICOLOR)*

The American Leaf Spot, occurring only in Latin America, is a disease, which affects around 500 different crops. The disease is important in some of the Central American countries. The infestation occurs normally on leaves, but in severe cases appears also on fruits. It is a typical disease of plantation under heavy shade in high altitudes and is more important in old, neglected plantations.

Cultivation techniques: Shade management to reduce humidity is most important in preventing the disease.

Biological control: *Trichoderma* spp.

Chemical control: there are varies fungicides mentioned for the control: Bordeaux mixture and calcium, copper fungicides, cyproconazole, hexaconazole, propiconazole, validamycin. It seems that also the propionic acid is able to reduce infections with this leaf spot.

4.7 BACTERIAL BLIGHT OF COFFEE (*PSEUDOMONAS SYRINGAE)*

The Bacterial Blight of Coffee (BBC) is a disease found in East Africa, mainly Kenya, and in Brazil. BBC symptoms include dark, water-soaked necrotic lesions on leaves, tips and nodes of vegetative and cropping branches culminating in a die-back. It can be a serious problem in high altitudes, where plants are injured from heavy winds.

Plantation management: Protection of the plantation against wind.

Chemical control: where the BBC occurs, various numbers of applications of copper fungicides are applied, organic fungicides increase the disease.

4.8 COFFEE WILT DISEASE (*GIBBERELLA XYLARIOIDES)*

The fungus causing Coffee Wilt Disease or the Tracheomycosis was earlier reported to be a well-known pathogen in coffee mainly in West and Central Africa in the 1950s. 1993 it is recorded for the first time in Uganda and it is now causing economic losses on Robusta coffee. A survey along with the earlier works implicates that tracheomycosis develops to an important disease on Arabica coffee, too. It can attack all parts of plants, but young plants are more susceptible.

Infected plants have to be eliminated as no other control methods exist. The control strategy for the future is the search for resistant varieties.

4.9 DIE-BACK, MUERTE DESCENTE *(PHOMA COSTARRICENSIS, P.* SPP.)

The Die-back is occurring worldwide. It is a disease attacking leaves, branches and fruits, and occurs in nurseries and plantations. It is found in higher altitudes with low temperature, high humidity and cold winds. It needs water for infection. The disease causes the death of young shoots and marginal necrosis of leaves.

Cultivation techniques: Special care to produce healthy plant material. In areas with high disease pressure, some prevention is possible through planting of wind braking trees to protect against cold winds. Infected parts should be eliminated by cutting back.

Chemical control: Fungicides which are in use: chlorothalonil, cyproconazole, metconazole, tebuconazole, anilazine, iminoctadine, fosetyl-Al, mancozeb.

4.10 PINK DISEASE (*CORTICIUM SALMONICOLOR*)

The Pink Disease is widely distributed and affects many other crops (140) like cacao, mango or eucalyptus causing in some of them very high losses. The fungus destroys the tissues, which are transporting water and nutrients. Branches or whole trees might die. It is typical in areas with high temperature and humidity. The infection is favoured with high plant density, accumulation of plant debris on plants and a deficient drainage of soil.

Plantation management: A good circulation of wind and a shade management are a preventive method. All plant debris on the trees should be removed and infested branches cut out and burned.

Biological control: The parasitic fungi (*Gliocladium* spp., *Trichoderma* spp., *Verticillium* spp.) showed control properties.

Chemical control: copper oxide, cuprous oxide.

4.11 CANKER, LLAGA MACANA (*CERATOCYSTIS FIMBRIATA)*

It has a worldwide distribution and appears in other crops like cacao or rubber. It needs high temperature and high humidity.

The canker infects woody stems via artificial lesions, wounds caused by careless work with working tools (machete), - in Latin America the disease is called mal de machete -, and insect damage. It is causing a canker, die-back and wilt of part or the whole tree.

Plantation management: any injury should be avoided, pruning carried out in dry season with eventually a treatment of the cut with Bordeaux mixture or carbendazim. No treatments are possible if plants are infected. Infected parts of the plant have to be cut back or the whole plant needs to be eradicated.

Varieties: use of some resistant varieties

4.12 BLACK ROOT ROT *(ROSELLINIA BUNODES*, *ROSELLINIA PEPO)*

This rot is distributed in different parts of the world and on a variety of crops. The fungus causes an infection of the root system, causing dying of part of the plants or the whole plant. Infected plant residues in the soil serve as the inoculum, and are sometimes difficult to eliminate.

Infected plants have to be totally eliminated and the place may be treated with a copper fungicide. It is not recommended to use a soil fumigant, in order not to destroy beneficial microorganisms. With the application of some of these microorganisms, some of which are commercially available, the natural control can be augmented.

5. NEMATODES

Nematodes affect agricultural land worldwide and are some of the most damaging pests of tropical, sub-tropical and temperate agriculture. They can cause serious yield losses in crops such as citrus, potatoes, banana, rice, pineapple, coffee, peanuts, sugar cane, and tobacco. Nematodes damage crops by direct feeding, transmitting viruses and facilitating bacterial and fungal infections.

They are very common organisms in the soil, but only a few cause damages to crops of commercial importance. As soil living organism their control is very difficult and, if not specific, causes a high environmental impact. Nematodes are a typical problem of monocultural, very intensive crops with inadequate management of the soil fertility (low organic matter, destruction of soil organisms through pesticides, humidity and temperature imbalances).

A wide range of parasitic nematodes has been found on coffee plants. The most significant problems arise due to root-knot nematodes (*Meloidogyne spp.*). In coffee *Meloidogyne* and *Pratylenchus* are the most potentially damaging. Some very aggressive species or strains of Meloidogyne are known from Central America, especially Guatemala and El Salvador.

Control strategies for different crops often combine crop rotation, nematicides application and the use of resistant varieties. However, these conventional approaches are becoming increasingly unsatisfying. Crop rotation is of limited value for controlling nematodes with a wide host range and is impractical in perennial crops or for specialist growers. Intensive farming methods rely heavily on the use of chemical control, but this is causing concern as nematicides are amongst the most toxic and environmentally damaging of all crop protection agents. As a result, resistant plants are likely to become increasingly important in the battle to reduce crop losses to plant parasitic nematodes.

Resistant plants: As Robusta is more resistant, a strategy is to use grafted plants, Arabica varieties on Robusta rootstock. This is a recommended control strategy in India to avoid the application of nematicides in the soil. Equally, in Central America considerable effort is put into getting resistant plants (the Arabica on the variety Nemaya, released very recently). But the rootstock of Robusta is not always well adapted to the high altitudes where coffee is often cultivated. The various cultivated varieties show differences in their susceptibility, but it seems, that this may change from one country to the other.

Plantation management: Experiences (pers. com., Ing. Llobet) of Costa Rica, a country known for their long and intensive use of nematicides, show, that the most important strategy in the management of nematodes lies in maintaining a high organic matter. The use of organic manure and mulching improves soil structure and provides microorganisms that suppress soil borne diseases and pests. A good humidity balance, shade management and plant pruning, that avoid too high yields per plant, and may stress it, improve plant defences. In some cases, organic products (like Sincosin) may be applied. To trigger maximum yields with high and costly inputs, may work for some years, but is in no way sustainable.

The use of antagonistic plants (*Tagetes, Crotalaria*) may be another tool to reduce high populations.

Planting material: As it is known that in the distribution of nematodes to new coffee plantations, nurseries are an important infection source, special care has to be given producing nematode free, highly vigorous seedlings. In order to reduce nematodes risk, it is advisable, not to interchange material with other farms.

Use of antagonistic microorganisms: Different antagonistic species or organisms, helping to prevent negative impacts, are known, some are commercially available (*Paecilomyces lilacinus*, *Beauveria bassiana, Metarrhizium anisopliae).* Moreover, growing interest exists in products to augment the vigour of plants and others able to induce resistance to different pest and disease problems. It is believed that the management of nematodes in future should be more concentrated in this field, utilizing at maximum the naturally occurring antagonistic properties of well-managed soils. Further investigation will be needed, but already a lot may be learned from organically managed farms.

Chemical control: All nematicides are belonging to the WHO I class. Common used substances are aldicarb, cadusafos, carbofuran, fenamiphos and terbufos. Methyl-bromide also was used for controlling nematodes. If and to what extend it is still applied, especially in nurseries, is not known. Its use belongs to an unacceptable practice for the code. All nematicides fall under the red criterion and should be substituted with an alternative control strategy.

6. WEEDS

Weeds are in all agricultural systems a problem farmers have to deal with. On the one hand, they compete with the crop, and may also serve as retreat for pests and diseases. On the other hand, they help to protect the soil from erosion, increase the diversity of the plantations, and thus the chances for natural enemies.

A successful weed management tends to eliminate the damaging effect of the weeds and uses the beneficial ones. Principal methods for weed control are as follows:

In established coffee plantations, weed control methods are depending mainly on the availability and costs of labour force. The majority of small coffee holdings adopt manual and cultivation methods of weed control. But, if financial conditions allow, also chemical weed control is used.

Weed control is normally very time consuming. But experiments in Central America (mainly Nicaragua) showed, that the time and money input can be reduced, combining selective weed control with cover crops, mulch and shade management. Selective weed control is a combination of eliminating aggressive weeds by chemicals and manually. The cover crop may result of the local flora or is planted like *Arachis pintoi*. Most commonly used herbicides for selective application are glyphosate or paraquat. The main obstacle of the system is a still intensive work initially (about 2 to 3 years) and some knowledge of the farmers. This system is likewise applicable by bigger holdings.

Weed control in large plantations is normally also a combination of manual, mechanical and chemical control, but with the chemical as the more important one. The herbicides used are 2,4-D, glyphosate or paraquat, and some pre-emergence herbicides like acetochlor, alachlor, oxyfluorfen or simazine (see also Tab. 8). Part of the pre-emergent herbicides is listed in the red criterion because of there carcinogenicity. In well-established plantations, working with mulch as soil cover, there is normally no need for herbicides.

The situation is different in establishing plantations, above all in sun-grown coffee or if shade trees are still not developed. The crop itself is more sensitive to the competition and can still not suppress weeds. Depending on the type of weed flora, there are generally some recommendations which of the herbicides are most effective.

As a rule for the 4C, as far as possible, weed densities should be controlled with cover crops. Hand weeding should be employed as far as labour force is available and the costs are reasonable. This strategy may be complemented by an herbicide of low acute toxicity and with a low leachability to avoid groundwater contamination.

7. NURSERIES

Whether a farmer starts of with a highly vigorous plant, free from any disease and pest, and with a high potential of resistance to pest and diseases, depends mostly on the nursery management.

Until now, the base of what we are calling vigorous and resistant, is not totally understood, but there is sufficient knowledge that a plant, grown from the beginning in an environment with lot of beneficial antagonists, mycorrhizas and most probable some kind of hormonal agents, has the best chances to develop the desired properties.

In a sustainable system, the nurseries should be the first place where all highly toxic chemicals, and especially the soil fumigants are to be eliminated. Reason for this is not only the hazard for human beings and the environment but also the quality of the planting material. The higher the quality of the planting material the less chemicals and other control measures will be needed in the entire crop management.

The first step in nurseries is to ensure that the soil is free of potential diseases and pests. The alternative to soil is a substrate free production system, applied in a few cases, for example in Brazil. This, however, is very cost intensive at the beginning.

Under the more conventional system, a variety of methods for soil sterilisation are used:

Steaming or application of hot water: This is a method known since a very long time; the disadvantage is that a high energy input is needed.

Solarization: Solarization is a method of hydrothermal disinfection. This is done by covering moist soil with transparent polythene sheet and exposing it to direct sunlight during the hottest period of the year. This is a method very easily applicable also by small farmers.

Benefits of solarization

- Control of fungal pathogens like *Pythium, Phytophthora, Fusarium, Rhizoctonia*
- Control of nematodes: Population reduction of nematodes like *Meloidogyne, Heterodera, Xiphinema*, etc. has been achieved by solarization
- Control of weeds: A number of commonly occurring weeds particularly annuals can be effectively controlled by solarization
- Plant growth response: Increased growth response is observed in plants cultivated in solarized soil.

Chemical control: Methyl bromide, disulfoton, dazomet, pencycuron, tolclofos-methyl, iprodione, thiabendazole.

Biological agents: *Trichoderma* spp., *Bacillus subtilis*

The small coffee plants in the nurseries need some shade and a good water and fertilization management. One of the typical diseases in nurseries is damping-off *(Rhizoctonia solani)* often a sign of a bad drainage system. In some cases pesticides like pencycuron may be applied. If there is a heavy attack from *Cercospora* Bordeaux mixture is a low toxic solution.

OUTLOOK

In terms of protection for coffee plants against pests and diseases, pesticides are currently one of the most important methods for farmers to avoid significant losses. In some areas, the coffee crop would not even grow without them. The use of these inputs was supported or subsidized by governments. For many farmers it proved to be an economically attractive solution.

In the meantime, negative impacts of some of the pesticides have become an important issue. The costs of these external effects are paid by society and/or indirectly by some members with severe health problems.

One of the main considerations in plant protection should be the cost, including the external costs related to the measure. The farmer will always prefer the method, which he knows best, which is the most effective, the easiest to apply and the cheapest to get. More and more, he also has to take into account that the method he will use must be accepted by the market of his product.

In this paper, costs of pest management strategies have not been analysed. A general assessment is not feasible at this stage. The situation in each country and at each farmer level varies, and thus the potential crop damage and the control cost are quite different. A study of the actual situation of the different countries is far beyond the scope of this paper. Moreover, a comparison between the "toxic" and the less hazardous production systems is no longer relevant, if the market refuses to accept and buy coffee from systems using highly toxic products.

Likewise, management plans are impossible to be defined when farmers are left out. Management plans are to be developed with them, based on the principle laid down in the code matrix. It has to be evaluated at which point it is necessary that they start to improve their system.

At this stage, some observations are made, which have to be considered so that the 4C principle concerning pesticides can be fulfilled:

- In most cases a viable and safer alternative to hazardous pesticides already exists.
- Most probably, their implementation will be more expensive at the beginning. The change from weed control by using paraquat and hand weeding to one, which is based on a selective weed control, requires one-time investments for the cover crop and involves intensive training of the farmers.
- The alternative to hazardous pesticides is normally a combination of different methods. A high infestation level by a pest or disease is more difficult to control in cases where plantations have been neglected for some time.
- Some of the alternative substances following a chemical-for-chemical replacement strategy may not be successful to control the same spectrum of pests or diseases with the same efficiency as some alternative substances are more specific.

This paper classifies registered pesticides according to their toxicological properties in red, yellow and green. These colours correspond to an unwanted, tolerated and accepted practice for coffee on its way to sustainability. In the common understanding of a "traffic-light" system, it goes from red, yellow to green. In terms of plant protection management, the concept should aim to adopt all methods to prevent plant protection problems. Otherwise passing from the red criterion to sustainable production will be difficult as there are rarely simple solutions for the control of pests and diseases in a sustainable way. In the first place, the aim would be to grow a healthy crop that can tolerate pest and disease pressure. This depends on the following contributing factors:

- Adequate area for coffee production
- Variety and density adapted to the location
- Plant management (pruning)
- Soil management and fertilization
- Regulation of climatic conditions with shade trees. Sun coffee gives higher yields, but needs much more external inputs. It is prone to Leaf Rust or weeds and has a shorter life span.
- No overexploitation of the coffee trees.

These principles for good crop management apply in the same way to smallholders and to medium-sized or large holdings. In the management of diseases and pests different programmes have to be applied, as small farmer are more likely to be able to carry out labour intensive methods, whereas for big holdings a biological programme is more adequate.

Actions needed to get there

Farmers may need incentives in order to change the whole management concept of the crop. As farmers in the coffee growing countries are usually not very concerned about their health, their safety, their environment, or that of their workers, they need an incentive to change their production system, as long as the pesticides in question are on the market.

At the farmer level, pilot programmes are necessary to show the feasibility of an alternative management strategy. They would serve as examples for others and would be centres where new production methodologies are tested so that the most effective control measure for the area is found. In most countries, organic coffee farms can provide already some useful information about effective measures. These might provide also insights into further research and development needs.

At national and international level it has to be guaranteed that researchers and research institutions are able to continue their research programmes related to plant breeding and resistant varieties and that they focus their efforts on biological control systems.

Regional programmes for Integrated Pest Management (like CAPPS) may be supported. This will facilitate the orientation of national policies toward sustainable pest management practices.

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Commissioned by:

Federal Ministry
for Economic Cooperation
and Development