



**Kenya BDS**

Kenya Business Development Services Program

Lower Kabete Rd/ Peponi Rd  
Junction, Westlands  
P.O. Box 1327, 00606 Sarit Centre  
Nairobi, Kenya  
Tel: 254 - 2- 3753318/19,  
Fax: 254 - 2- 3753320  
E-mail: info@kenyabds.com  
www.kenyabds.com

**USAID Kenya Business Development Services Program  
(Kenya BDS)**

**Contract No. 623-C-00-02-00105-00**

**Deloitte Touche Tohmatsu Emerging Markets, Ltd.**

**PESTICIDE EVALUATION REPORT AND SAFER USE ACTION PLAN (PERSUAP)  
FOR THE KENYA BUSINESS DEVELOPMENT SERVICES PROGRAM**

**By**

**Dr. Jim Findlay**

**August 2003**



A USAID Funded Activity Managed by Deloitte Emerging Markets

**Deloitte  
Touche  
Tohmatsu**

## TABLE OF CONTENTS.

ACRONYMS	2
TABLES	3
SUMMARY	4
1. PROJECT DESCRIPTION	5
2. PURPOSE AND SCOPE OF THE STUDY	5
3. BACKGROUND	5
4. PROGRAM PESTICIDE ACTIVITIES	8
4 (a) Reduce reliance on pesticides	8
4 (b) Protective clothing	8
4 (c) Spray equipment	9
4 (d) Labelling of pesticides	9
4 (e) Re-use of pesticide containers	10
4 (f) Pre-harvest intervals	10
4 (g) Common mistakes of handling of pesticides	11
4 (h) Avoid pesticide application by women	11
4 (i) Discourage the use of toxic products (Group I and II)	11
4 (j) Avoid pesticide use near dwellings	12
4 (k) Prevent or minimise ground and surface water contamination	12
4 (l) Monitoring of safe use practices and label recommendations	12
4 (m) Kenya's ability to regulate or control distribution, storage, use and disposal the pesticide	13
4 (n) Provisions for training of users and applicators	13
4 (o) Methodology to monitor the use and efficacy of the pesticide	13
PESTICIDE EVALUATION REPORT	13
5.1 Weed Control for all crops	13
5.2 Avocado Pests and Diseases	16
5.3 Mango Pests and Diseases	16
5.4 Passion Fruit Pests and Diseases	17
5.5 Pesticide Summary	18
6. Safer Use Action Plan	19
7. Practical guide to reducing pesticide use	20
8. References	21
9. Collaborators and persons contacted	23
10. Recommended distribution	27
Annex 1. Pest management method selection – a decision framework	28

Compiled by J.B.R.Findlay  
Agricultural Resource Consultants  
P.O.Box 3474, Parklands  
2121 South Africa.  
Tel. 27-11-486-2254  
Fax. 27-11-486-2274

## ACRONYMS

ABSF	African Biotechnology Stakeholders Forum
ACDI/VOCA	Agricultural Cooperative Development International / Volunteers in Overseas Cooperative Assistance
ADI	Acceptable Daily Intake
ADSP	Agribusiness Development Support Project
AAK	Agrochemicals Association of Kenya
COP	Chief of Party
CPC	Crop Protection Chemical
CS	Capsule Suspension
EA	Environmental Assessment
EAG	East African Growers Ltd.
EC	Emulsifiable Concentrate
EIA	Environmental Impact Assessment
EPC	Export Promotion Council
EU	European Union
FIPS	Farm Inputs Promotions Africa Ltd.
GAP	Good Agricultural Practice
GR	Granule
HCDA	Horticultural Crops Development Authority
IEE	Initial Environmental Evaluation
ICIPE	International Centre of Insect Physiology and Ecology
IIRR	International Institute of Rural Reconstruction
ICM	Integrated Crop Management
IPM	Integrated Pest Management
KARI	Kenya Agricultural Research Institute
KBDS	Kenya Business Development Services
KBS	Kenya Bureau of Standards
KEPHIS	Kenya Plant Health Inspection Services
KMDP	Kenya Maize Development Program
LC50	Lethal Concentration to kill 50% of a test sample (mg product/l water)
LD50	Lethal Dose to kill 50% of a test sample (mg product/kg body mass)
ME&NR	Ministry of Environment and Natural Resources
MEO	Monitoring and Evaluation Officer
MoARD	Ministry of Agriculture and Rural Development
MRL	Maximum Residue Level
NGO	Non Governmental Organisation
PBK	Pyrethrum Board of Kenya
PCPB	Pest Control Products Board
PERSUAP	Pesticide Evaluation Report and Safe Use Action Plan
PHI	Pre-Harvest Interval
PPM	Parts Per Million (equivalent to mg/kg or mg/l)
QPM	Quality Protein Maize
REDSO	Regional Economic Development Services Office
SANAS	South African National Accreditation System
SC	Suspension Concentrate
SSF	Small Scale Farmer
SUI	Safe Use Initiative
TOR	Terms of Reference
UK	United Kingdom
USAID	United States Agency for International Development
USEPA	United States Environmental Protection Agency
WG	Water Dispersible Granule
WP	Wettable Powder

## TABLES

TABLE 1 : Kenya Fruit Production in 2000.	Page 4
TABLE 2 : Insecticides for use on avocado, mango and passion fruit. (A = avocado; M = mango; PF = passion fruit)	Page 17
TABLE 3 : Fungicides for use on avocado, mango and passion fruit.	Page 17
TABLE 4 : Pesticide characteristics for use in the KBDS project on avocado, mango and passion fruit. (a) Fungicides (b) Insecticides	Page 27
TABLE 5 : Risk analysis of candidate crop protection chemicals for use on avocado, mango and passion fruit in Kenya. (a) Fungicides (b) Insecticides	Page 29

## **EXECUTIVE SUMMARY**

Strategic Objective # 7 of United States Agency for International Development has the objective to increase rural household incomes and employment in Kenya. The Kenya Business Development Services Program is focusing on the development of avocado, mango and passion fruit production by the small scale farmer sector to achieve this. The concept is to improve crop husbandry techniques to enable growers to produce export quality fruit. This will enable them to obtain a better price for their crop than that which they would get on the local market or from the processors.

There are many aspects to crop production of this nature. Farmers must be able to access quality rootstock and transplants that are disease free, they must have access to specialist advice as to growing and management requirements of the crop, they must be able to resource all inputs such as fertiliser, herbicides, fungicides and insecticides and they must be able to harvest and market a desirable product that the consumer wants.

This report covers an evaluation of the pest control aspects of the production of these three crops. Field visits were undertaken to experience the situation on the ground with the farmers and the support structure that they have. Discussions were also held with a processor and exporters. There are many small dealers and stockists in the villages who can supply the basic pesticide requirements needed. The government does have an extension service to provide information to farmers. However, it is not functioning for various reasons and there is no effective link between the researchers, resource people and the farmers. Most of the specialist growers producing avocado, mango and passion fruit rely on fruit packers and exporters for technical advice and recommendations. Other growers are making an effort to access their own sources for information on how best to produce a quality crop. Although the Kenya Agricultural Research Institute has a tropical and sub-tropical fruit section, there is only one researcher servicing the entire industry. This necessitates private organisations to employ and train crop specialists and advisers for their growers. There are a large variety of pesticide spray programs that are being recommended in the field.

In discussions with growers and advisers, the important insect pests and diseases were identified for each crop. At the same time the insecticides and fungicide spray programs being recommended were discussed. The farmers indicated that there were no major pest and disease problems associated with avocado. They select their best fruit for export and deliver it to the packhouse, where it is sorted again. The exporters complained that the growers did not treat their crops for anthracnose and this manifested itself after packing. The exporters assumed that all fruit had to be treated after harvest during the packing process to ensure a quality product. Farmers agreed that mango had a number of diseases (mainly powdery mildew) and pests (mainly weevil) that required treatment if quality was to be achieved. Pesticides are applied where fruit quality is desired. However, the spray programs were not always the most efficient. Passion fruit is easier to manage but does require a pesticide program. Both export mango and passion fruit required sorting and cleaning (to remove any pesticide residues) in the packhouse.

The Agrochemicals Association of Kenya have had a major "Safe Use Initiative" in training farmers in the responsible use of pesticides. The introduction of the implementation of EUREPGAP standards for export fruit into Europe (85% of Kenya fruit goes there) will result in dramatic changes in the style of farming in these rural communities. Pesticide use accountability and traceability will become mandatory for this market. It becomes vitally important that these farmers use acceptable and approved pesticides in a responsible manner. An analysis is done on the potential pest problems on these crops and the effective products that are available in Kenya.

Finally, a proposal is included on training that is recommended for extension staff, stockists and dealers and the farmers.

**PESTICIDE EVALUATION REPORT AND SAFER USE ACTION PLAN (PERSUAP)**  
**FOR THE KENYA BUSINESS DEVELOPMENT SERVICES PROGRAM.**

**Supported in Kenya by USAID / Kenya Strategic Objective 7**  
**Increased Rural Household Income**

**1. PROJECT DESCRIPTION**

Strategic Objective # 7 of the United States Agency for International Development (USAID) is to increase rural household incomes and employment, with a particular emphasis on the rural micro- and small-enterprise (MSE) sector. As part of this strategy, USAID has identified horticulture, maize and dairy as having strong potential for impact at the small scale farmer (SSF). As part of this portfolio, USAID will also support a business services development program to impact growth in other subsectors of high growth potential. The horticulture contract is yet to be awarded. However Deloitte Touche Tohmatsu Emerging Markets (DTT-EM) has been contracted to implement the Kenya Business Services Program (KBDS), the maize sub-sector contract has been awarded to ACDI / VOCA and the dairy sub-sector contract has been awarded to Land O'Lakes (LoL).

An analysis conducted on the Kenya Business Development Service Program (KBDS) under the directorship of the Chief of Party (CoP) of DDT-EM in December 2002 used criteria such as the size, potential for growth, and commercial business linkages in support of subsector selection. After a more detailed analysis, the decision was made to focus on the tree fruit sub-sector as the initial point of intervention, and target specifically the promotion of avocado, mango and passion fruit.

**2. PURPOSE AND SCOPE OF THE PERSUAP STUDY**

The Pesticide Evaluation Report and Safe Use Action Plan (PERSUAP) will enable SSF in Kenya, who produce avocado, mango and passion fruit for local consumption and export, to comply with the USAID pesticide procedures as in 22CFR216.3 (b). This will also guide the use of pesticides in an environmentally responsible manner by SSF as well as meet EUREPGAP international export requirements. This analysis will identify the same or similar products registered by the United States Environmental Protection Agency (USEPA) that are also registered and available for use in Kenya.

**3. BACKGROUND**

In 2001 the size of the horticultural produce market in Kenya was 237.300ha of which the fresh fruit crops are about 140.500ha (60.4% of the total) with a value of 19.1 billion Ksh, which includes an export value of 1.6 billion Ksh (Horticultural Export Markets for Kenya, draft report 2002). The total national fruit production value was 25.2 billion Ksh with an export value of 1.09 billion Ksh in 2002 (See table 1 below). The emphasis of the KBDS is clearly on introducing modern technology and developing the investment, growth and marketing systems of the chosen crops. This will also focus on good agricultural practices (GAP) for quality produce as well as responsible environmental protection according to accepted environmental impact assessment (EIA) standards.

Table 1 : Kenya Fruit Production in 2000. (Source HCDA)

<b>Crop</b>	<b>Planted Area ha</b>	<b>Production ton</b>	<b>Value million Ksh</b>	<b>Export volume - ton</b>	<b>Export value million Ksh</b>
<b>Avocado</b>	<b>4.119</b>	<b>52.027</b>	<b>626</b>	<b>10.716</b>	<b>608.9</b>
<b>Mango</b>	<b>15.027</b>	<b>112.608</b>	<b>5.309</b>	<b>2.687</b>	<b>118.3</b>
<b>Passion Fruit</b>	<b>2.743</b>	<b>22.300</b>	<b>558</b>	<b>830</b>	<b>67.9</b>
Macadamia nut	2.290	11.647	159	498	149.1
Melons	-	3.294	125	28	78.2
Pineapples	13.082	606.516	3.104	484	29.5
Papaya	6.336	62.664	779	7	18.6
Citrus	15.161	141.926	1.959	-	8.9
Strawberries	39	421	12	48	7.5

Apples	179	1.035	58	14	3.0
Guavas	385	2.505	128	-	-
Banana	74.308	1.027.768	12.046	26	2.6
Others	6.794	18.124	383	78	-
TOTAL	140.463	2.062.835	25.246	15.416	1.093.7

[decimal points have been rounded off]

SSF represent 80% of the growers of all fruits and vegetables with the balance being large scale producers of mainly flowers, vegetables and pineapples. Ninety percent of production is consumed locally with the remainder being exported. Of the exported produce in 2000, 85% went to France, Germany, Netherlands and the United Kingdom, all of which enforce EUREPGAP standards (see below).

Avocado are produced in the Kiambu – Machakos – Nairobi and Transzoia – Kitale areas; Mango are produced in the Kiambu – Machakos – Nairobi, Kilifi – Kwale (coast) and Taita Taveta areas; Passion fruit are produced in the Kiambu – Machakos – Nairobi and Taita Taveta areas. These areas are well known for their suitability for the production of these crops and none can be regarded as marginal.

Kenya has many organisations that are in support of promoting the development of the SSF to become more productive. Some example of these and the role they play are the Ministry of Agriculture and Rural Development (MoARD) [policies, GAP], Ministry of Environment and Natural Resource (MENR)[environmental and resource conservation], HCDA [organisational, advisory, licensing exporters, registration of nurseries, maintenance of export quality and standards], Kenya Plant Health Inspectorate Service (KEPHIS) [seed certification, plant quality control, breeding rights, import/export of produce, analytical services, genetically modified organism control], Fresh Produce Export Association of Kenya (FPEAK) [training, promoting, marketing, quality control], Kenya Agricultural Research Institute (KARI) [research on crops], the International Centre of Insect Physiology and Ecology (ICIPE) [pest research and control measures], Export Promotion Council (EPC) and Pest Control Products Board (PCPB) [licensing and registration of all pesticide related matters]. In addition, there is the Agrochemicals Association of Kenya (AAK) that has the manufacturers, crop protection chemicals (CPC) registration holders and distributors as members as well as many of the smaller, regional and village stockists / dealers as associate members. The AAK operates under a strict code of conduct to promote the responsible use of CPC and works in close liaison with the registrar at the PCPB. The AAK, through CropLife Africa Middle East, is affiliated to CropLife International, the global organisation covering all aspects of CPC.

The value of these crops for the SSF is in producing a high quality fruit that is sought after by the consumer who will pay a high price. It is in the interests of the farmer to have as high a percent as possible of his fruit classified as ‘export quality’ for maximum income (money) and minimum waste (fruit, time, labour, transport, etc). First grade produce will go for export (high value), second grade fruit will go for local consumption (medium value), third grade fruit will go to the lower end of the local consumption market or to processors (low value) and anything else will go to the processors (very low value). Since pesticides are an integral component of producing a first grade crop, the responsible use of pesticides becomes an important issue to ensure no pest or disease damage (blemish), no visible pesticide residues, no chemical residues in violation of the Maximum Residue Level (MRL) and correct pesticide management practices are implemented. A large percent of the three crops is grown without any pesticides and this could be termed as ‘organic fruit production’ but the quality is such that the majority will not be acceptable for first and second grade produce and are unlikely to maintain export quality.

Most SSF do a measure of fruit sorting prior to delivery to exporters as it is in their interest to get as high a price as possible. The exporters sort and grade all produce that they receive according to quality and size to ensure that they deliver a quality product to their overseas customers. When farmers fail to grade and sort their crop correctly, which is common despite training and education, the exporter has no choice but to offer lower prices. Processors also have the problem that delivered fruit can be dehydrated and pulp extraction is very low and thus juice yield is low.

Exporters need to be assured of a certain quantity of quality fruit. Exporters such as East African Growers Ltd. (EAG) and Sunripe, through its agent in Central Africa, Fresh Link Growers Ltd., have appointed graduate technical advisers to ensure that contracted SSF produce the desired quality. EAG have 5 graduate agronomists and 4 graduate extension officers (EO) to supervise their contracted out-growers. Each out-grower has a 1 acre block, which has its own individual record sheet, and the EAG staff prescribe the CPC and fertiliser programs. They also ensure that all necessary entries of activities on the block are recorded. SSF are encouraged to scout for pests to ensure correct

spraying and the avoidance of programmed spraying that may be excessive or against integrated pest management (IPM) principals. The EO will visit the SSF about twice a week during the season.

The exporters are moving towards having their own farming units to guarantee export quality fruit. EAG has 7 farms producing vegetables, avocado (50% bought in) and mango (currently 100% bought in) and passion fruit, which is currently being developed.

The main problems facing the SSF producers of avocado, mango and passion fruit are poor quality fruit, post harvest diseases and poor handling. When fruit is sorted by the exporters, the rejection rate is high and this creates extra expenses, which result in lower prices to the SSF. There are a number of ways, either as a single factor or a combination of factors, whereby the SSF can become more efficient and productive and minimise many of the problems. Aspects such as clean planting material free from diseases and pests, correct fertilizer requirements applied at the right time, pest scouting and the correct application of pesticides, orchard hygiene and others can contribute to an improvement in production. It is for these reasons that the exporters have their technical advisors in the field as well as to train the SSF on good crop husbandry principals. This evaluation will deal with the use of pesticides in these three crops.

#### 4. PROGRAM PESTICIDE ACTIVITIES

The three crops that have been selected for development under the KBDS have various diseases and pests that attack either the tree or vine and the fruit. In order to produce an export quality end product, all these crops do need pesticide applications to control these problems. However, it is important that effective pesticides are applied accurately at the correct growth-stage with minimum impact on non-target areas. The control and management of pests and diseases are discussed below.

There are other problem pests such as rodents and birds, which can do severe damage to crops on the land or in storage. Rodents and buck are known to eat the growth point and bark of the young transplants and it often necessary to protect them by having a plastic sleeve cover the stem or to erect a barrier around the transplant with plastic fertiliser bags. In-field control of rodents is best done by owls. However, use can also be made of wax blocks, which contain an anti-coagulant such as Storm Blocks (contains 50mg flocoumafen/kg; Reg. No. 0157) or Racumin Blocks (contains 375mg coumatetralyl/kg; Reg. No. 0208). Racumin Ready Bait (1g contains 0.4mg coumatetralyl + 0.1mg cholecalciferol) is used around buildings and sheltered hide-aways for rodent control. This will be a farm hygiene issue with EUREPGAP.

The exporters are making pesticide recommendations to their contracted growers. The products being used are all on the "Approved Pesticide List", which is continually reviewed and adjusted by importers and grower's representatives, and this also sets the MRL levels. This is coordinated in Kenya by FPEAK. The British Fresh Produce Association conducts an audit every 6 months by visiting the exporting organisations. Exporters keep records of the contracted SSF for this audit and are obliged to keep them for 2 years. No MRL testing is done locally although the KEPHIS laboratory is capable of doing the analyses. The KEPHIS staff are all graduate analytical chemists and the majority have undergone training at the FAO / International Atomic Energy Laboratory in Vienna, Austria, and some have done specialist courses in the UK. The KEPHIS laboratory is currently undergoing an assessment to obtain international accreditation by the South African National Accreditation System (SANAS). This laboratory also does analyses of pesticides (quality control, environmental, tissue). It is reported that the Kenya Bureau of Standards (KBS) and KARI are also capable of pesticide analyses, although it would appear KEPHIS is the organisation of choice.

Export crops are tested for MRLs at random by the receiving country and the UK and Germany are known to do this regularly. It is possible for exporters to request an analysis prior to shipment by sending a sample to the receiving authorities. This is done when MRLs change or a new product has been used by the growers.

Since these crops are targeted at the European Union (EU) export market, it is appropriate to give some detail of the EUREPGAP requirements. EUREPGAP is an organisation called The Global Partnership for Safe and Sustainable Agriculture and it produces various guidelines or protocols as to the requirements of agricultural crop production where the product will be exported to the EU. Kenyan SSF wishing to export their crop to the EU will be compelled to follow the "EUREPGAP Protocol for Fresh Fruit and Vegetables", which came into effect in September 2001. The concept is based on Good Agricultural Practice (GAP), which incorporates Integrated Pest Management (IPM) and Integrated Crop Management (ICM). All growers should be able to demonstrate their commitment to (a)



maintaining consumer confidence in food quality and safety; (b) minimising detriment impact on the environment, whilst conserving nature and wildlife; (c) reducing the use of agrochemicals; (d) improving efficiency of natural resource use; and (e) ensuring a responsible attitude towards worker health and safety. A major issue associated with this concept is the traceability of produce in that all export consignments must have documentation that will identify the source of the fruit. Some of the issues that need to be addressed under this protocol are

- Detailed record keeping of all aspects of the crop production.
- Origin of all nursery stock
- Record of pesticides applied to nursery stock.
- Site history and site management
- Risk assessment that the site is suitable for agriculture
- Soil management.
- Fertiliser use and justification, application, storage.
- Crop protection – IPM implemented, choice of chemicals and justification.
- Quantities and types of pesticides applied.
- Safety training, protective clothing use.
- Spray equipment.
- Pesticide storage, empty containers, etc.
- MRLs and PHI.
- Farm hygiene.
- Waste and pollution management.
- Worker health, safety and welfare.
- Audit

There are many details to this. EUREPGAP does not expect all these issues to be implemented immediately (there are priorities) but growers must work towards implementing GAP. Specialist courses are held by EUREPGAP accredited training organisations for growers as well as independent auditors, who verify that the producer has met the required standards as in the relevant protocol.

SSF intending to export their crop will have to improve on farm hygiene. There will need to be protected clean areas for sorting and packing fruit, running water and suitable ablution facilities. Other aspects such as keeping livestock away from the fruit packing area (flies), rodent control and general cleanliness will need to be addressed.

There are many variations of the pest and disease control programs being recommended by the various technical advisers used by the exporters. However, the basic programs are using the same or similar CPC against the same problem. Understanding the pest biology and timing the application of CPC to prevent damage is a basic requirement of all programs being used by SSF.

#### 4 (a) Avocado, mango and passion fruit - reduced reliance on pesticides

These are potentially high value crops when export quality fruit is produced. Due to the demands of the consumer, this can seldom be achieved without the use of crop protection chemicals (CPC) such as fungicides and insecticides. However, it is in the interests of the producer (SSF) to avoid unnecessary sprays to reduce production costs. By scouting for pests on a regular basis (daily or 3 times a week) and correct timing of CPC application according to label recommendations, the SSF can produce an export quality fruit. A course on pest scouting techniques and the determining of pest economic threshold levels is available in Kenya.

There is an initiative to introduce a form of biological control using baits and traps to reduce pest populations but this is still in the process of being refined (see Para. 7 below).

Conclusion – to produce fruit efficiently and raise the yields and quality, pesticides are necessary at this stage. The choice of pest control method and products available should not present a high risk to humans, animals and the environment if used according to label recommendations. As the KBDS proceeds, new advances in pest control should be introduced as they become available to reduce pesticide usage.

#### 4. (b) Protective clothing : either often not effective or not worn

All farmers interviewed are aware of the need for wearing protective clothing – respirator or face mask, overall, rubber gloves and boots – but not one uses any of these items. It would appear that this is the reality throughout the farming areas. The reasons given are cost and non-availability. Some farmers admitted that they used their

old or dirty clothes as they “did not matter” or they will be washed soon. The Safer Use Initiative (SUI) programme has reached many farmers (600.000 have done the basic Safe Use Course) and some improvements in pesticide handling are noticeable but this education must be taken to a much higher level. When spraying trees, there is always a high chance of off-target spray drift as well as operator exposure.

Farmers do not appear to understand the potential hazard of spraying pesticides without protective clothing. When farmers have sprayed pesticides wearing only shorts and a shirt (no footwear, leg protection, gloves etc.), they know of no-one who has been poisoned, had skin or eye irritation or any other health problem. If there is no direct hazard, why worry?

There was one case of paraquat burn on a person’s leg. Paraquat is potentially dangerous when it is being used by uneducated and largely illiterate people, who show little respect for a potentially dangerous compound through ignorance (toxicity, irritation).

Conclusion – there is an awareness regarding protective clothing but it is not regarded as essential. Farmers are not aware of the potential hazards when spraying pesticides. Further education on protective clothing is necessary. In a program such as KBDS, it is important to use / recommend products that are going to have a minimal chance of being a hazard when used by farmers under these conditions.

#### 4. (c) Spray equipment : either inappropriate or in poor condition

Not all farmers have their own knapsack sprayers. Those seen were not well maintained (nozzles worn and dirty; in-line filters were not cleaned after use). Sprayers that are not thoroughly cleaned after use will have residues of the compound sprayed in the system and it is these residues that can lead to unwanted repercussions in the future.

At present, knapsack sprayers are the only available application equipment. There are few motorised mistblowers for use on tree crops such as avocado and mango. A hand operated knapsack sprayer is not adequate for complete spray cover of large bearing avocado and mango trees. The KBDS will need to address the availability of motorised equipment for the SSF with large trees (over 4m high). There are no stockists of spare nozzles or nozzles other than those that are delivered with the equipment. Application equipment is basic and adequate for small trees. As farmers develop their knowledge of pesticide application, dealers are in a position to stock alternative equipment.

Although part of the SUI, farmer training in the care and maintenance of spray equipment needs to be emphasised.

There is an opportunity for someone to start a contract spraying business in many of these communities. This can be used as an opportunity to train individuals to provide a high quality service in spraying, pest management systems (scouting, IPM) and be an example as to what safe and responsible use of pesticides entails.

There are reports of farmers having a single knapsack to spray both acaricides on cattle as well as pesticides on their crops. Inefficient or no cleaning leads to pesticide residues being sprayed onto cattle, which has resulted in temporary blindness of some animals and mortality in an other case.

A critical aspect of spraying pesticides is to have water of an acceptable quality. A number of water sources used by farmers as well as tap water in Eldoret and Nakuru were sampled and analysed. All were found to be acceptable for agricultural spraying purposes except for a pH of 8.0, which is high for some acidic formulations. In such a case the use of a buffering agent or a water acidifier can be considered if results of pesticide use are not acceptable. [The only outlet found that had suitable products to correct water quality problems was Hygrotech.] The water pH ranged from 6.8 to 8.0 and the hardness from 0 to 35.6 mg CaCO<sub>3</sub>/l. However, it must be borne in mind that these samples were taken during the rain season and the quality of water at the start of the crop planting period could be different and of a lower quality.

Conclusion – Cleaning and maintenance of spray equipment by farmers is negligible. This leads to unnecessary residues and contamination. Lack of knowledge on equipment is also very evident. Any training needs to focus

on this aspect to avoid contamination. There is an opportunity to encourage and train contract spray teams, which will help reduce mis-use.

#### 4. (d) Poor labelling of pesticides

The PCPB ensures that all labels comply with minimum requirements before a registration certificate is granted to an applicant. It is mandatory that any product offered for sale has a clean and clear approved label attached. It is the responsibility of the registration holder to ensure that all products supplied to distribution agents are correctly labelled.

There are certain products available in village crop protection product dealer's shops that do not appear to have correct labels and others that do not have registration numbers. Examples of this are (i) Deraphon P 1% Dust (1% w/w permethrin) for stalkborer control in maize made by Dera Chemical Industries; (ii) "Nova Maize Stalkborer Dust" (0.5% w/w pyrethrum) made by Nova. There are others. The authorities seem to be aware that adulterated and unregistered products are available in the market place but would appear to slow in reacting.

It is compulsory for each registered product to display the registration number. However, the PCPB insists on having a printed copy of the label and this is always prepared before registration is granted. Therefore the registration number is not known at the time of printing. Due to many products not displaying a registration number, it is difficult to know whether a product is in actual fact approved.

The PCPB last issued a list of registered pesticides in July 1998. There have been many pesticides registered in the interim. This lack of any reference as to the choice and legitimacy of products does not always allow for the correct decisions to be made.

##### Packaging

**Plastic Bottles** – The majority of products are packed in various sizes of these. Due to them being well-made and strong, they are not always destroyed by farmers (See 4.e below). The majority, but not all, have a tamper-proof seal. Labels are easily attached to plastic and there were no cases seen of unlabelled products. The bulk packaging of bottles is in cardboard boxes or shrink wrapped for transport. Apart from a few instances where the packaging had been negligently handled, all packaging was in good condition.

**Glass Bottles** – Some liquid products are packed in glass, which can easily break if mis-handled. Glass bottles should be avoided for pesticide packaging and this can be addressed through the AAK.

**Plastic Bags** – The majority of products packed in plastic bags supplied by international companies, are strong and robust. Many are also laminated plastic and aluminium, which ensures extra strength. However, there were many products packed in bags made of thin plastic, which is obviously not robust enough for use in this market. Many of these bags were found with small holes and resulting leakage. This is obviously an exposure hazard to humans and animals as well as a source of contamination of everything nearby.

**Single Dose Packs** – Certain products are packed in sachets designed so that the content of one sachet is the correct dosage in one knapsack sprayer of water (e.g. Roundup<sup>®</sup> Max herbicide). Another option is to formulate pesticides in a large tablet, packed in a blister pack, where a single tablet is dissolved in water in a single knapsack sprayer full of water (e.g. Decis<sup>®</sup> Tab). This type of packaging greatly reduces the chance of accidental exposure or contamination as well as ensuring the correct dosage rate.

**Conclusion** – labels contain sufficient information for the safe use of the product. Farmers seldom read use instructions and work on other people's recommendations. Single dose packaging for a knapsack should be encouraged. Glass packaging should be avoided.

#### 4. (e) Avoid re-use of pesticide containers

Farmers are aware that pesticide containers must not be re-used. Smaller ones (250ml and less) are generally discarded. Larger plastic pesticide containers (5l and more) are sought after for water and milk containers. There is a belief that if these containers are thoroughly washed out, there is no problem. There were some farmers who do not re-use the plastic containers and either burn them or perforate them and drop them in the pit latrine.

Conclusion - As with protective clothing, farmers are aware of a potential problem but do not regard it in a serious light. There are no associated obvious dangers in doing what they are doing. The SUI should re-emphasise this.

#### 4. (f) Emphasise pre-harvest intervals

Due to these fruit being targeted at the export market, pre-harvest intervals (PHI) are a very important aspect to ensure that there are no reasons for the crop to be rejected. Each CPC will be required to have data illustrating degradation after being applied as recommended to the crop before a registration is granted by the PCPB. The PHI is to ensure that no potentially hazardous CPC residues remain on the produce destined for human (or animal) consumption. Although there is no monitoring of CPC residues done locally, the UK and Germany are known to take random samples for testing. If unacceptable residues are found, the entire shipment is condemned at the exporter's cost. The exporter must ensure that the crop is free of CPC residues before dispatch and for this reason there is a very thorough washing process prior to packing.

This is not an important issue for produce sold on the local market nor is it an issue with the fruit processors. This concept may not be fully understood by SSF.

#### 4. (g) Common mistakes of unsafe storage, transport and handling of pesticides

Of the many dealers and stockists visited, not one is storing pesticides in an acceptable manner apart from Hygrotech in Nakuru. The majority are neat and clean but there are simple errors that can easily be corrected.

- (i) Stockists / Dealers : Shops do not have fire-fighting equipment; Insecticides are stored on shelves above feed additives; Powders are below liquids; Herbicides are stored above or next to seed; Seed is often displayed outside the shop in sunlight; Pesticides are stored next to animal health injectibles; Ventilation is often poor; Group I (red coded) products should be kept away from all other products at all times (locked up with a register?); Products in plastic bags were often leaking due to a perforation (plastic is too thin for robust handling); Absorbent material (saw dust, old newspaper) for accidental spillage was limited to the larger wholesalers (2); A bulk store visited in Eldoret can only be described as a "shambles". The best shop visited was Hygrotech in Nakuru.
- (ii) On Farm : Almost all farmers appreciated the fact that pesticides must be stored in a lockable cupboard or room. However, animal health products were stored in the same small cupboard as potentially hazardous pesticides. There is generally a poor understanding of the characteristics of CPC and animal health products. What makes a product relatively safe or hazardous?
- (iii) Decanting : A few cases of pesticides being decanted were observed. This leads to unlabelled or badly labelled containers with unknown pesticides inside. This can be exceptionally dangerous, especially with children and their natural inquisitiveness. Decanting of all pesticides must be prohibited by law and implementation of stockist and user education.
- (iv) Comment : The above problem areas are largely due to ignorance. When these issues were discussed with the stockists and farmers, all accepted and understood that there was a potential problem that was easily solved in most cases. Many farmers do not have sufficient space to improve on existing storage.
- (v) Post-spray re-entry intervals : In the interests of reducing human exposure to pesticides, certain countries have introduced restrictions on re-entry intervals after spraying a pesticide on a crop. These are for persons not wearing protective clothing as required by the product sprayed. Group IV (green) products have a re-entry interval restriction until the spray deposit is dry; Group III (blue) products have a re-entry interval restriction of 12 hours; Group II (yellow) products have a re-entry interval restriction of 24 to 48 hours; Group I (red) products have a re-entry interval restriction of 48 to 72 hours.

Conclusion – continued education is needed both for stockists and farmers. AAK member's sales representatives can play a role in helping to upgrade the standards in rural community CPC shops.

#### 4. (h) Avoid pesticide application by women and children

Pesticide application appears to be regarded as a man's work on the farm. However, there are many women that are farming and they may have to apply pesticides out of necessity. This can be reduced but it is unlikely to be eliminated. There is the option of hiring contract sprayers to apply pesticides as necessary, which would appear to be used by some female farmers.

Children are often used for manual labour on a farm. When relatively light work is required such as the application of fertiliser topdressing or a powder / granule stalk borer treatment on maize, children seem to be used fairly often. An instance of stalkborer treatment to maize was observed where children (about 8-10 years old) were applying dust by hand without gloves or any other protective clothing. This is an education issue.

4. (i) Discourage the use of toxic products (Group I and II)

The exporting companies have technical advisers in the field to help the SSF with the correct application and use of CPC. They encourage scouting for pests as well as the timely application of corrective or preventative measures. Exporters and AAK companies have their recommended spray programs for each crop and these take the residue factor into consideration. Since all fruit can be tested for residues and whether they are within acceptable MRLs, it is not in the interests of the producer nor the exporter to use CPC that are not approved.

Growers want to have good quality fruit. However, if it is discovered that they are using CPC that are not on the approved list, no exporter will handle their produce for fear of rejected fruit and the costs and penalties involved.

Fruit on the local market or that offered for processing is unlikely to have been treated with CPC as the farmer will probably not recover his costs. However, caution must be exercised in that if a farmer has used excessive quantities of CPC and he knows that his crop will be rejected, he will offer it on the local market to recoup his costs.

Many of the effective CPC used for quality fruit production are in Groups I and II. However, when used as recommended on the labels, there should be little concern as to potential hazards.

4. (j) Avoid pesticide use near dwellings

The average small-holding in Kenya is below 1.5ha in size. This requires the farmer to use every available portion of his land to produce enough food for his household (food security), both a staple food crop and alternates, and to produce a surplus for sale. In such a situation there is always the possibility of a pest or disease outbreak on the crop(s) nearest the dwelling that will require a corrective pesticide treatment. However, farmers are familiar with the general pest threats in their area and should be encouraged to plant crops, which have few or no disease and/or insect pest threats, close to their dwelling.

Should there be a pest outbreak in the crop(s) near or adjacent to the dwelling, a suitable registered pesticide should be applied in strict accordance with the label recommendations. These recommendations have been widely tested as a requirement for registration. The government registration authorities have evaluated the supporting data and come to the conclusion that the product can be used with minimum hazard potential when used correctly. All pesticide users must read the label of the product they intend using before actual use to ensure correct and safe application.

When CPC are applied to tree crops, there is always a chance of pesticide spray drift onto non-target areas. It is important that the person applying the product ensures that the wind does not carry the spray drift towards the dwelling, animals and food or feed. Water sources must also be protected from contamination.

4. (k) Prevent or minimise ground and surface water contamination

This is an aspect that must be emphasised with all training – do not spray pesticides over any water body. (There are exceptions such as the use of Roundup to control aquatic weeds, which will not result in detrimental water contamination.) In addition, CPC should not be sprayed where there is a chance of severe soil erosion by water run-off. Crops should not be planted within 5m of a water source. Eroded areas must be rehabilitated with a vegetation ground cover and stone/grass barriers. Conservation or no tillage systems encourage the retention of organic matter on the soil surface, which will adsorb certain spray deposits but will also prevent physical movement of possible contaminated soil into surface water sources. Rows of tree crops should be planted along the contour with grass in between the rows to prevent erosion on slopes.

Cleaning of spray equipment must be done in such a manner that rinsate does not contaminate any water source, grazing or crops. A disposal pit (1.0m square and 1.0m deep) with straw and lime can be used whereby the formulation ingredients and active will be adsorbed onto these materials. When the straw dries out after the rinsate has dissipated, it can be burnt.

Conclusion – awareness must be created that farmers must protect all water sources from contamination.

#### 4. (l) Monitoring of safe use practices and label recommendations

The Pest Control Products Board has 7 inspectors who are responsible for ensuring that premises and products resorting under this legislation comply with all requirements, including safe use and label recommendations. It is clear from the very limited survey done for KBDS that these inspectors are ineffective in enforcing legislation or educating the majority of stockists. The majority of those selling products controlled by the PCPB are not licensed and do not have basic qualifications to deal in pesticides.

The SUI organised by the AAK plays a vitally important role in upgrading the level of awareness in the rural communities. However, there is much ignorance at the level where farmers purchase pesticides. Clearly, an education programme targeting legitimate licensed and other dealers is necessary.

All KBDS field staff must attend the SUI pesticide courses and be in a position to “inspect” and rectify any unsafe practices that they observe in the field.

The KBDS must ensure that all farmers on the project attend a SUI training course and it will be advisable to include the local stockists that these farmers support. The majority of “problems” in the safety of pesticide use in rural communities is due to ignorance.

At the same time, it is important to educate the farmers and stockists on IPM and particularly on pest scouting. The majority of commercial farmers scout their lands for pests on a weekly basis. This enables them to control pests in an efficient and effective manner and avoid wastage and unnecessary costs.

When KBDS personnel visit cooperating farmers and stockists there must be a check run on what the farmer has done, is doing and planning to do with pesticides on the farm. These farmers will be used to educate their neighbours and expand SUI principles.

#### 4. (m) Kenya’s ability to regulate or control distribution, storage, use and disposal the pesticide

The PCPB has inspectors to enforce the acts and regulations pertaining to pesticide distribution, storage, use and disposal. This covers all aspects of responsible use of pesticides. However, there are many examples of unregistered products and unqualified stockists in the marketplace. The inspectors are not having a significant impact on safe use of pesticides. The AAK is aware of this and is putting a code of conduct for stockists in place as well as conducting numerous training courses to improve the safe use of pesticides. Of the 15 small stockists visited, only 6 were registered with the PCPB.

#### 4. (n) Provisions for training of users and applicators

The SUI has definitely had a positive impact in the field. Farmers and contract applicators need a refresher course on good spraying practices as most farmers have attended a course and have some knowledge about correct spraying but are not implementing many of the principals. See paragraph 6 below.

#### 4.(o) Methodology to monitor the use and efficacy of the pesticide

The KBDS field staff must continually monitor the performance of all pesticides used in the program to promote the safer and more responsible use. The principals of EUREPGAP should serve as the model to be followed.

### 5. PESTICIDE EVALUATION REPORT

## 5.1 Weed Control For All Tree Crops

With the establishment of new plantings, it is advisable to kill all potentially competing weeds within 1.0m of the planting hole. Weeds should be sprayed with Roundup® SL (contains 360g glyphosate per litre; PCPB registration number 0006) or Roundup® Max (contains 680g glyphosate per kg, GR; PCPB registration number 0273) when they are growing vigorously (see below). When the weeds are dead, make the planting hole and transplant the seedling. Avoid excessive soil disturbance as that will bring new weed seeds to the surface. After transplanting, a mulch on the soil surface around the tree will smother any weeds as well as conserve moisture.

5.1.a **Roundup® 360 SL post-emerge herbicide** (contains 360g glyphosate per litre, SL)

5.1.b The USEPA registration Status  
Registered for use in the USA; EPA III.

5.1.c The Kenya registration Status  
Registered for use in Kenya; PCPB (R) 0006; registered by Monsanto Kenya Ltd.

5.1.d The basis for selection of the requested pesticide  
This is the most common and widely used herbicide formulation in the world. It is packed in plastic bottles (½, 1 and 5 litre). It is used in a diluted form and is recommended generally as a 2.0% solution for annual weed control and 3.0% for perennial weed control. It will be used in the KDS to control all existing weeds before planting the crop. It is widely available to the small scale farmer.

Since glyphosate is off patent, there are a number of alternate formulations registered and available in Kenya. However, the technical support knowledge of many of the organisations selling these products is often lacking. Sales are generally based on price and not technical quality. Reducing or changing the surfactant system in the formulation, which lowers the efficacy and reliability of the product under stress conditions, achieves price reduction.

5.1.e The extent to which the proposed pesticide is compatible with an integrated pest management system  
Roundup 360 SL has little or no effect on living organisms other than plants. It will have no effect on beneficial insects such as predators and parasites of pests or the honey bee, *Apis mellifera* (the oral and contact 48 hour LD50 is greater than 100µg per bee). It will have no effect on plant pathogens. It will have no effect on the performance of insecticides or fungicides.

5.1 f Proposed method(s) of application, availability of equipment and safety of equipment  
Roundup 360 SL will be diluted in water and can be applied by knapsack sprayer, mounted boom sprayers, aircraft and wipe-type applicators. The most common application method in the KBDS will be by knapsack and this equipment is readily available. Types of knapsacks available in the Kenyan market are Cooper Pegler CP15 (cost 6.650 – 7.000/-), Jacto, Hardi, Osatu (cost 4.500 – 6.000/-) and there are others. Knapsack sprayers are widely used by SSF and large commercial farmers throughout the world and have proven to be effective and safe when used correctly. The mechanism is relatively simple and is not likely to cause any operator injury when used as recommended.  
There is a possibility of spare parts not being available for repairs at present. However, as more farmers use knapsack sprayers, the suppliers seem willing to stock maintenance items (diaphragms, washers, nozzles, filters and other parts).

5.1.g Potential acute or long-term human or environmental hazards and measures to reduce any hazards

### Humans

The formulation concentrate is unlikely to have any adverse effects on humans. Should there be accidental eye or skin contact, eyes should be flushed with water for at least 15 minutes and skin should be washed with soap and water. If ingested, the mouth should be washed out with water and then drink water.

The acute oral LD50 (rat) is > 5.000 mg/kg; the acute dermal LD50 (rabbit) is > 5.000 mg/kg. It is not mutagenic. Carcinogenicity – mouse, oral 24 months – the NOEL is > 30.000 mg/kg diet. It is not considered to have an effect on reproduction, fertility and teratogenicity.

The World Health Organisation classification of pesticides in drinking water regards glyphosate as the only pesticide where there is no restriction in glyphosate levels as under normal conditions glyphosate is unlikely to be hazardous to humans.

#### Environment

Glyphosate is widely used for terrestrial and aquatic weed control. Once it is sprayed onto the target plants it is absorbed and metabolised in the plant tissue. Any compound landing on soil will be absorbed by clay particles and broken down by soil micro-organisms into nitrates, phosphates, water and CO<sub>2</sub>. Under Kenyan climatic and soil conditions, residues of glyphosate are unlikely to be detectable in the soil after 72 hours. Acute toxicity to rainbow trout (*Oncorhynchus mykiss*) in a static system for 96 hours – LC<sub>50</sub> is 20 mg/l; Acute toxicity to the water flea (*Daphnia magna*) in a static system for 48 hours – EC<sub>50</sub> is 42 mg/l; Acute oral toxicity to bobwhite quail (*Colinus virginianus*) LD<sub>50</sub> is 1.651 mg/kg; Acute toxicity to the earthworm (*Eisenia foetida*) over 14 days in soil the LC<sub>50</sub> is > 1.250 mg/kg.

It is regarded as non-toxic to beneficial arthropods, micro-organisms, birds and fish.

Glyphosate is regarded as biodegradable and does not bioaccumulate.

#### 5.1 h The effectiveness of the pesticide for the proposed use

The common weeds observed in the crop growing areas are annuals such as *Amaranthus*, *Bidens*, *Commelina*, *Datura*, *Digitaria*, *Eleusine*, *Galinsoga*, *Physalis*, *Tagetes* and others. The major perennial weeds observed are *Cynodon*, *Cyperus* and *Pennisetum*. When sprayed as recommended, Roundup 360 SL will control these species and many more.

#### 5.1.i Compatibility with target and non-target ecosystems

Roundup 360 SL is a foliar applied systemic herbicide and it will kill or cause severe injury to any plant that it contacts. It is therefore important not to spray non-target areas. Apart from killing target plants, glyphosate will not have a significant impact on fauna and flora and will decompose relatively rapidly. Roundup is a water-based formulation with a tallow-amine surfactant. Both the active ingredient and surfactant will decompose rapidly after being applied and, under Kenya conditions, biologically active residues are unlikely to persist for longer than 3 days in soils over 5% clay.

#### 5.1.j The conditions for the use of the pesticide (climate, flora, fauna, geography, hydrology, soils)

Target plants must not be covered in a layer of dust nor suffering from stress (drought, waterlogging, cold, heat). Target weeds should be growing vigorously. The younger the target plants are, the more sensitive they are and the less Roundup 360 SL is required to kill them. There should be a 4 to 6 hour rain-free period after spraying to allow the plants to absorb the active ingredient. Soil type has no effect on the performance of Roundup 360 SL. Some plant species are tolerant to glyphosate due to their physiology but these are unlikely to occur in maize lands.

Roundup is adsorbed into clay colloids in the soil, where it is broken down into naturally occurring products (water, nitrates, phosphates, CO<sub>2</sub>) by micro-organisms in a short period. [Warm, moist conditions result in high numbers of micro-organisms in the soil and thus a rapid degradation.]

#### 5.1 k Both pesticide and other alternative control methods and their efficacy

Hand weeding and hand hoeing are the most common weeding practices in tree and vine crops. It is possible to control weeds with these methods but farmers generally wait until the weeds are 20cm high by which time they have had a very detrimental effect on the crop. Due to limited labour availability, farmers can control weeds on a limited scale with hand labour. Hand weeding is clearly not effective as weeds are a major problem of crop farmers.

Alternate herbicides are (i) paraquat is hazardous and potentially dangerous in an environment where many are illiterate; it is a scorching agent and does not kill weed roots; it is ineffective on perennial weeds; it can cause damage to maize if applied incorrectly; (ii) diuron is a residual broadleaf weed herbicide and will have little or no effect on grass weeds; it can be used in established avocado and mango crops but must not be used on young transplants; (iii) Basta<sup>®</sup> (glyphosate ammonium) is registered but has a smaller weed spectrum that it is efficacious against and is not readily available in the stockists shops; (iv) Touchdown<sup>®</sup> (glyphosate from the trimethyl sulfonium salt) is more toxic (Group II) than Roundup, is not as efficacious and not readily available.



Mowing of grass between the planting rows is advisable. The soil can not be left bare due to the possibility of soil erosion. If grass is allowed to become too prolific, it will remove moisture and nutrients from the soil. However, long grass becomes a fire hazard in the dry season and it is far easier to control a fire in short grass than it is in long grass. Fire is a major threat to tree crop production.

Farm hygiene by preventing weeds from flowering and shedding seeds will go a long way towards reducing weed pressure. Adopting a no-till system and using a mulch on the soil surface will suppress weed development.

Clearly, the weed control in the KBDS must utilise herbicides combined with hand weeding, suppression of weeds by a mulch, shade out weeds and the prevention of weed seed development on headlands, roadsides, farm yards – a multifaceted control programme.

## 5.2 Avocado Pests and Diseases

Avocado rootstock and grafted transplants are obtained from the prison's and KARI nurseries (60 – 80 Ksh per tree). The assumption is that these have been inspected by KEPHIS and are free of disease. Fuerte and Haas are the most common cultivars planted.

Anthracoze and fruit and leaf spot are the major problems in avocado. Certain growers maintain that there are no insect pests of any significance although fruit fly may occasionally be a problem. Once the trees start flowering, copper oxychloride should be sprayed at 14 day intervals with a total of 5 to 8 sprays depending on climatic conditions being conducive to the diseases. Copper hydroxide can be applied as a pre-harvest treatment for these two diseases. Spraying of large trees requires a motorised knapsack or mistblower since a hand operated one will not generate adequate droplet coverage of the tree and the crop.

No use is made of plant growth regulators (uniconazole) to increase flowering and fruit set and limit vegetative growth. There is no information on the possibility of nematodes being a problem.

The following are the diseases and pests that are a problem in Kenya and the common name of the product that will control them. Details of each product are given below. The species names listed are not positively confirmed in Kenya but are probable due to them being regarded as wide-spread avocado diseases. The two most important pests or diseases are indicated as (1) and (2).

<u>Disease</u>		<u>Active Ingredient(s)</u>
Anthracnose (2)	<i>Colletotrichum gloeosporioides</i>	benomyl; copper compounds; propineb
Anthracnose (post harvest)		thiabendazole
Fruit & Leaf Spots (1)	<i>Pseudocercospora purpurea</i>	benomyl; copper compounds
Root & Trunk Rot	<i>Phytophthora cinnamomi</i>	fostyl-Al; phosphorus acid
Sooty blotch	<i>Stomiopeltis citri</i>	benomyl; copper compounds
Post harvest decay	<i>Dothiorella</i> spp. <i>Pestalotiopsis</i> spp. <i>Phomopsis</i> spp. <i>Thyronectria pseudotricha</i>	thiabendazole; Sporekill
<u>Pest</u>		
Fruit flies	<i>Ceratitus</i> spp.	fenthion; malathion; protein hydrosilate
Green stink bug	<i>Hemiptera</i> spp.	deltamethrin; azadirachtin; beta-cyfluthrin
Loopers		<i>Bacillus thuringiensis</i>
Mites	<i>Polyphagotarsonemus</i> spp.	amitraz; bifenthrin; pyrethrin; sulfur
Scale – heart shaped	<i>Protospulvinaria pyriformis</i>	buprofezin; malathion;
soft brown	<i>Coccus hesperidum</i>	pyrethrin
Thrips	<i>Thripidae</i> spp.	deltamethrin; pyrethrin

## 5.3 Mango Pests and Diseases

The major mango cultivars for export are Tommy Atkins, Van Dyke and Apple with Sabine, Kent, Ngowe and Maya being less sought after. Sabine is sought after for juice. Rootstock is Zabri (a South African cultivar grown for atcha) or Ukgambani, which cost 200 Ksh each whereas a “roadside special” costs 60 Ksh with a 50% failure rate. A

specialist KEPHIS inspected nursery is needed for quality trees or growers must establish their own. When growers are pruning their trees, desired scions are collected from the better trees for grafting.

In June the trees are put under moisture stress to ensure an even flowering, which is induced with a foliar feed (500g urea / 100l water). When flowering is initiated, Cu oxychloride is sprayed for anthracnose control (250g / 100l water) and this is repeated at 10 – 14 day intervals. There are at least 3 sulphur sprays (250g / 100l water) and 1 benomyl spray (100g / 100l water) for powdery mildew. An additional mancozeb spray (200g / 100l water) can be included for powdery mildew. At the end of flowering, a bifenthrin (or fenthion or deltamethrin) treatment is necessary for mango weevil control (100ml / 100l water); this is repeated 21 days later. Fenthion is applied at pre-harvest for fruit fly control (125ml / 100l water); at least 1 but often 3 fruit fly treatments are necessary. When fenthion (and other insecticides) is sprayed for weevil control, an application must be made at bud break, flowering and when the fruit is 3cm long. Use is also made of fruit fly bait consisting of an attractant, methyl eugenol, and fenthion (2 parts to 1). After harvest, a hot water treatment at 45°C for 5 minutes is adequate for anthracnose, fruit spot and fruit fly control.

White mussel scale is only a problem on apple mangoes.

Spraying must be done with a high pressure tractor mounted unit with hoses so that all sides of the trees can be sprayed. Knapsack sprayers can be used on small trees but bigger mature mango trees are unlikely to have a complete cover spray deposit from this type of equipment. This can be a limitation for SSF. Each bearing tree requires at least 2.0l of spray solution for adequate droplet cover.

Orchard hygiene in that all fallen fruit are collected from under the trees and covered with soil in a compost pit, can help reduce pest infections.

The following are the diseases and pests that are a problem in Kenya and the common name of the product that will control them. Details of each product are given below. The species names listed are not positively confirmed in Kenya but are probable due to them being regarded as wide-spread mango diseases.

<u>Disease</u>		<u>Active Ingredient(s)</u>
Anthracnose (2)	<i>Colletotrichum fructigenum</i>	benomyl; copper compounds; propineb
Anthracnose (post harvest)		thiabendazole
Blossom blight	<i>Dothiorella dominicana</i>	?
Blossom spot	<i>Altenaria alternata</i>	?
	<i>C. gloeosporioides</i>	
Powdery mildew (1)	<i>Oidium mangiferae</i>	benomyl; triadimefon; sulphur
Post harvest decay	<i>C. gloeosporioides</i>	thiabendazole; iprodione; hot water
	<i>Diplodia natalensis</i>	
	<i>Hendersonia creberrina</i>	
<u>Pests</u>		
Aphid	<i>Aphididae</i> spp.	?deltamethrin; dimethoate; pyrethrin
Bud mite	<i>Aceria mangiferae</i>	?bifenthrin; garlic extract
Fruit flies (2)	5 species	beta-cyfluthrin; fenthion
Mango gall fly	<i>Procontarinia matteiana</i>	not treated
Mango scale	<i>Aulacaspis tubercularis</i>	deltamethrin; pyrethrin
Mango weevil (1)	<i>Stemochetus mangiferae</i>	bifenthrin; fenthion; deltamethrin
Thrips	<i>Scirtothrips aurantii</i>	deltamethrin; pyrethrin

#### 5.4 Passion Fruit Pests and Diseases

The major diseases of passion fruit are leaf and fruit spot and *Fusarium* wilt. Fungicides that will control these diseases are copper oxychloride (3 – 4 sprays; 200g / 100l water) or sulphur. Sprays for thrips must be done at 6 week intervals and these treatments will also control aphids and leaf feeding insects.

Orchard hygiene by removing fallen diseased fruit will help to reduce the source of disease infestation. The aborted fruit should be buried and made into compost.

The following are the diseases and pests that are a problem in Kenya and the common name of the product that will control them. Details of each product are given elsewhere in this document. The species names listed are not

positively confirmed in Kenya but are probable due to them being regarded as wide-spread avocado diseases. The two most important pests or diseases are indicated as (1) and (2).

<u>Disease</u>		<u>Active ingredient</u>
Leaf or fruit spot (1)	<i>Alternaria alternata</i> <i>Septoria fructigena</i>	copper compounds
Wilt (2)	<i>Fusarium</i>	copper compounds benomyl
<u>Pests</u>		
Aphids	<i>Aphididae</i>	dimethoate; lambda-cyhalothrin; pyrethrin
Fruit flies	<i>Ceratitus</i> spp.	fenthion
Mealybug	<i>Paracoccus bumerae</i>	deltamethrin;
Scale – circular purple	<i>Chrysomphalus aonidum</i>	deltamethrin; pyrethrin
- soft	<i>Parasaissetia nigra</i>	deltamethrin
Stink bug	? <i>Nezera viridula</i>	dimethoate
Thrips (1)	<i>Thripidae</i>	deltamethrin; dimethoate; pyrethrin; lambda-cyhalothrin; azadirachtin

### 5.5 Pesticides Summary

It is important to read the label of the CPC before use. This will ensure the correct dosage and the correct timing or growth stage will be sprayed. Examples are (a) copper compounds should be sprayed before or at petal drop for anthracnose control in the crop as later than this will result in reduced control; (b) when washing fruit before packing, a fungicide should be included in the process to prevent post-harvest diseases developing while the fruit is in transit.

All products are registered by the USEPA (?malathion). All products are registered by the PCPB in Kenya.

Each of the crops has a spray program with a sequence of treatments to ensure that all pests and diseases are controlled. Each supplier of CPC and each exporter has a program of their chosen products to give a clean crop, which leads to a wide variety of possible products that can be used.

The following table indicates the common name of the pesticide, the formulation registered in Kenya, the WHO and EPA classification, the Pre-Harvest Interval (PHI) in days, the Acceptable Daily Intake (ADI) in mg per kg body weight, the Maximum Residue Level (MRL) permitted on the fruit at picking in mg per kg fruit. Unless it is specified, the value will be for all three of the crops.

**Table 2** : Insecticides for use on avocado, mango and passion fruit. (A = avocado; M = mango; PF = passion fruit)

<b>Active ingredient</b>	<b>Formulation</b>	<b>EPA</b>	<b>WHO</b>	<b>P.H.I. (days)</b>	<b>ADI (mg/kg)</b>	<b>MRL (mg/kg)</b>
amitraz	Mitac; 200g/l	III	III	(28?)	0.003	(0.2?)
azadirachtin	Achook;	IV	IV	0	-	-
<i>Bacillus thuringiensis</i>	Xen Tari;	III	III	0	0	0
beta-cyfluthrin	Bulldock; 25g/l, EC	II	II	7	0.1	?
bifenthrin	Brigade; 25g/l, EC	II	II	(60?)	0.02	(0.01?)
buprofezin	Applaud; 400g/l, SC	III	Table 5	160	0.01	0.05
deltamethrin	Decis; 25g/l, EC	II	II	7 (M),2 (PF)	0.01	0.05 (M)
dimethoate	Dimethoate; 400g/l, EC	II	II	15	0.002	?
fenthion	Lebaycid; 500g/l, EC	II	II	14	0.001	1.0
garlic extract	GC Mite; 40%	IV?	IV	0	-	-
Lambda-cyhalothrin	Karate; 17.5g/l, EC	II	II	(14?)	-	(0.2)

malathion	Malathion; 250g/kg	III	III	14 (A)	0.02	
pyrethrins	Pyerin; 75g/l EC	III	II	2	0.04	1.0

**Table 3 :** Fungicides for use on avocado, mango and passion fruit.  
(A = avocado; M = mango; PF = passion fruit); PoH = Post Harvest Treatment.

Active ingredient	Formulation	EPA	WHO	P.H.I. (days)	ADI (mg/kg)	MRL (mg/kg)
benomyl	Benlate; 500g/kg, WP	IV	III	30 (A), 14 (M, PF)	0.02	3.0 (A, PF), 5.0 (M)
Copper hydroxide	Kocide DF; 614g/kg	III	III	3 (A)	-	20.0 (A,M,PF)
Copper oxychloride	Many; 500g/kg, WP	III	III	3 (PF), 14 (A, M)	-	20.0
fostyl-Al	Aliette; 800g/kg, WP	III	Table 5	14	2.2	50.0
iprodione	Rovral; 500g/l, SC	IV	Table 5	PoH	0.3	-
phosphorous acid				100	2.2	50.0 (A)
Propineb	Anthracol; 700g/kg, WP	IV	Table 5	3	0.005	(3.0?)
Sulfur	Thiovit 80 WP; 800g/kg Cosavet and other similar products.	IV	Table 5	-	-	50.0 (A,M)
thiabendazole	Tecto; ?	III	Table 5	PoH	0.1	5.0 (A)
triadimefon	Bayleton; 250g/l, EC	III	III	28	0.03	0.05 (M)

Sporekill is known as a post harvest treatment but it is not listed under registered compounds.

## 6. SAFER USE ACTION PLAN

In 1995 a hospital survey on pesticide poisoning indicated that there were 140 serious poisonings of which 75% were attempted suicides. At the same time the government figures indicated that there were between 50 and 100 deaths related to pesticides. After the AAK awareness and training program, there are no serious cases of occupational pesticide poisonings although there are still some successful suicides ascribed to pesticides.

It is clear from interviews in the field that the SUI initiated by the AAK has created awareness of safe use when handling and using pesticides by stockists and farmers. However, there are still many issues that need to be improved upon to achieve responsible use of pesticides. Dealers and stockists in the towns and villages need to be trained in the safe storage of pesticides, pesticide recommendations and emergency procedures. EOs and those promoting the KBDS must undergo training on all aspects of pesticide safe use at all levels, which will enable them to correct and improve safer use in the community. Farmers and farmer groups must be systematically targeted and trained to be responsible in their use, storage and disposal of pesticides and their packaging. Previous initiatives have had a good success rate at creating safety when using CPC but this does need continued and increased effort. The objective must be to get all growers using pesticides in a manner acceptable to EUREPGAP standards.

The PCPB inspectors are not effective in implementing the legislation that ensures the standards of pesticide safe use. There is much ignorance amongst the stockists and dealers, which suggests an education program before implementing fines and punishment.

There is little or nothing in the way of emergency support services should there be an accidental pesticide poisoning or a major spillage due to a road accident. The registration holder is required by legislation to have a telephone contact number where information on emergency procedures can be obtained. The experience in trying to obtain information for this PERSUAP showed that it is very difficult to find the necessary qualified people in the various companies consulted and the information required is lacking. This

is a point that the AAK must address with its members. None of the stockists nor dealers knew that they could contact the medical faculty at the University of Nairobi for advice on pesticide poisoning or emergencies.

The PCPB does not insist on Material Safety Data Sheets (MSDS) being submitted to support a registration. Such a document contains all the relevant information regarding the product to deal with emergencies. When requested, most companies could not supply this document. It is proposed that awareness be created that the medical faculty at the University of Nairobi has an information centre to address this problem. Transport Emergency Cards (TREM cards) are not in use either.

The KBDS should target EOs, dealers, stockists and farmers in the major fruit growing areas where activities will be concentrated. AAK company representatives are accredited to be able to do their job in making CPC recommendations – they must be encouraged to carry their knowledge to the village stockists and dealers to improve their standards.

It is proposed that training should be done on three levels –

- (1) Extension Officers, pesticide company representatives and KBDS staff (2 week course);
- (2) Stockists and dealers (3 – 5 day course);
- (3) Farmers (1 – 2 day courses).

It is also recommended that KARI staff involved in pesticide evaluations, use and recommendations should be included with group 1.

By targeting group 2, a more responsible approach to safety in the field will be achieved as well as it will support the PCPB and recruit associate AAK members.

The AAK has initiated a country-wide “Responsible Use of Pesticides” training program. This was on the radio and covered 12 topics, each repeated three times, and was aimed at upgrading farmers knowledge, making farmers aware of producing quality produce and alerting exporters to adhere to EUREPGAP standards. This included a period for farmer questions to the advisory panel. It is advisable for KBDS to liaise with the AAK when formulating a final training program.

Since both avocado and mango are both large tree crops, it will be important to train SSF in the use of the correct spray equipment and in minimising the human and environmental hazards of this operation. Knapsacks with long lances (3m +) and motorised mist-blowers are the most likely equipment to be used and a level of contamination can be expected. This is a good opportunity for professional contract sprayers.

Dr. Jack Aston, Global Crop Care Consultants, has been conducting a range of courses for AAK members, commercial farmers and NGO sponsored projects. To date approximately 600.000 farmers have attended a one day course on “The Safe Use of Pesticides on the Farm”, which is given in English, Kiswahili or other local languages as needed. CropLife International has a series of courses and handbooks which are available through AAK, a founder member of CropLife Africa Middle East. Peter Mills is the CropLife training specialist for Eastern and Southern Africa. [He can be contacted through Les Hillowitz, Tel. 27-83-305-2700; P.O.Box 72127, Parkview, 2122 South Africa].

Proposed course for group 1 : The detailed CPC course over 2 weeks will include topics such as – CPC legislation, the registration process and requirements – label information – human health hazard and treatment – environmental contamination precautions – MSDS - types and characteristics of insecticides / fungicides / herbicides – spray equipment - application techniques (theory and practical) – safe handling, transport, storage of CPC – examples of pests and their control measures – IPM and ICM techniques – CPC disposal -

Proposed course for group 2 : All stockists and dealers are required by law to be registered and licensed or course qualified with the PCPB. There is an existing 3 day course specifically for stockists and dealers. This can be used for those stockists who have not done the course previously. There needs to be a one day refresher course for those that have done the course previously. As more SSF start using CPC, the stockists will be required to give a better service. They need more background information on legislation, registration requirements, safe and responsible use of CPC, application techniques,

Proposed course for group 3 (SSF) : There is a 1 day course on “Safe use of pesticides on the farm”. Additional 1 day courses need to be introduced to increase farmer CPC knowledge and skills such as – pesticide storage on the farm – spray operators safe use of pesticides – pest / disease scouting course (2-3 days plus practical) – pesticide skills for supervisors – This group must also be trained on EUREPGAP requirements if they are to export fruit.

Examples of course contents :

Detailed contents of the “Safe use of pesticides on the farm” – methods of personal contamination – factors which contribute to danger – understanding the product label and storage – use, care and maintenance of protective clothing – safe working practices when measuring, mixing and spraying pesticides in the field – protection of fellow workers, public and the environment – first aid measures.

Detailed contents of the “Crop scouting for pests and diseases on the farm” – identification of common pests and diseases – introduction to the life cycle of common pests and diseases – factors favouring infections and infestations – scouting procedures – estimation of the severity of infection – marking sites of infection – collection and presentation of samples for identification – preparation of a crop history – recording results of scouting.

Detailed contents of the “Pesticides store keeping on the farm” – Use, care and maintenance of protective clothing – safe working practices when handling pesticides – protection of self, fellow workers and the environment – understanding the product labels – practical store keeping – receiving products – issuing pesticides – checking the store – cleaning up leaks and spills – disposal of containers and out-of-date stock – record keeping.

Other topics are “Due diligence in food safety”, “Effective spraying on the farm”, “Supervision of safe and effective spraying on the farm”, “Transportation of pesticides on the farm” and others.

A Safer Use training program can be implemented throughout the year. However, it is during the crop growing season when many of the examples of pesticide use and mis-use can be illustrated in the field. However, this is also the busy time of the season for field workers. It is proposed that short courses (1 – 2 days) be held on-site in the field during the growing season and longer courses (3 – 10 days) be held during the quieter off-season periods.

Training must also focus on the requirements of EUREPGAP. This entails auditing and monitoring by trained individuals as to compliance to the principals by the farmer as well as the farmer’s obligation.

As part of the training and capacity building, one or two selected individuals should be sent on a study tour to visit commercial large scale growers in South Africa. This will give exposure to modern and efficient crop production systems that comply with EUREPGAP requirements.

## 7. PRACTICAL GUIDE TO REDUCING PESTICIDE USE

Rootstock and nursery treatments : It is essential that all nurseries supplying tree crops to commercial growers have a licence and are audited by KEPHIS on a regular basis. Strict sanitary precautions must be maintained when grafting scions to rootstock in order to prevent the transmission of virus and disease during the process. An infected plant will only become obvious after being planted for a number of years when the symptoms show. An infected plant will have to be rogued and replaced, which means the loss of the same number of years production. It is perhaps better to be over cautious when sterilising equipment to prevent transmission of infections when grafting.

Plan and implement an anti-resistance strategy : With the continued use of insecticides or fungicides of the same chemical group, there is a possibility that the target pests can develop resistance to the CPC and thereby become a major problem causing severe crop damage. It is a wise policy to implement a spray program policy with a variation in the pesticide chemical group to avoid the possibility of resistance or tolerance developing within the pest population. As an example for anthracnose control in avocado it is advisable to alternate benomyl and copper oxychloride in the spray program – two different compounds with two different modes of action against the disease.

Pest tolerant cultivars : Traditional crop breeding techniques select new cultivars for their resistance to various diseases and insect pests (host plant resistance). This is perhaps the most efficient method of preventing pest damage to crops. Many maize cultivars are resistant to diseases such as grey leaf spot. Plant breeders (both government and private) must be encouraged to select new lines to include such benefits.

Genetic modification (biotechnology) : This technology is specific and, as techniques and knowledge develop, it will become highly pest specific. The concept is to make a plant resistant to attack from a specific insect or group of insects (or diseases) by inserting a gene known to have that characteristic, into the host plant. The *Bt* gene makes maize resistant to Lepidoptera pest attack and thus it is no longer necessary to treat maize with an insecticide for stalk borer control. This is commercial in many countries and has greatly reduced the use of insecticides in maize. The most well-known maize with this technology is Yieldgard® maize by Monsanto. Similarly, cotton is resistant to bollworm attack in Bollgard® cotton and the reduction in insecticide use is dramatic, down from a maximum of 12 sprays to 1 or 2. Maize resistant to nematode attack as well as Coleoptera (beetle) is being developed for commercial release. This will result in a huge reduction in pesticide use in maize. Most research to date has been targeted at annual crops. However, there are initiatives to develop this technology in tree and vine crops.

There can be no doubt that the SSF will benefit greatly from this technology – the farmer will not need to apply insecticides to the transplant or seedling, nor to the soil for soil dwelling insects, nor for leaf chewing insect control and the post harvest diseases will also be controlled. The savings in tree crop spraying will be enormous – big trees require a high spray water volume for complete coverage but water costs time and money when it is to be collected and applied. The insertion of a gene(s) to make a crop resistant to fruit fly or powdery mildew, will save great amounts of money.

It is necessary for countries to have legislation in place to allow this technology to be introduced. Kenya does have proposed legislation being considered for ratification.

Biological control agents : Numerous efforts are being made to control pests with their natural enemies, either diseases, predators or parasites. This technology will not eliminate pests but will contribute to the reduction of potentially threatening pest populations. Research, breeding and monitoring of these agents requires very specialised knowledge and facilities. In Kenya, ICIPE is doing work on fruit fly control with pathogens (see below), maize stalk borer and bollworm control with parasites. By having this research capacity, other developments can be expected in the future.

ICIPE is researching biological control agents against fruit fly. There are 5 major species of fruit fly that attack fruit crops and 4 of them are indigenous to Africa. They are *Ceratitus cosyra*, *C. rosa*, *C. fasciventris*, *C. anunae* and a recent discovery, *Bactocera*. The latter is very likely indigenous. This makes biological control difficult as all 5 species must be brought under control. Although parasites are identified, they are not having a significant impact as all have developed with their hosts.

The sterile male release technique will be extremely difficult to implement against 5 species. Research is focusing on bait stations with a sex attractant for male flies and a food attractant for female flies. The bait contains either an insecticide or a pathogen, which is effective against all 5 species. Since all flies pupate in the soil, the use of a pathogen in the soil to kill the pupae is being investigated.

There is a private initiative, Dudutech, which is investigating the use of predatory mites for the control of pests in horticultural crops (flowers and vegetables).

The recognised leading countries in developing these technologies are the United States, Australia and South Africa. Kenya has formed an association with these countries to benefit in the long term.

Rootgard : This is microbiological product containing 14 species bacteria and Trichodema as well as 4 enzyme complexes. It is claimed to be completely safe for humans. Some of the claims made are that it solubilises phosphorous for better plant uptake, it fixes nitrogen, promotes plant growth and suppresses plant pathogens. It is recommended to apply Rootgard as a soil drench or through irrigation at the rate of 1.0kg / ha before the start of spring growth in tree crops.

Crop rotation : This is not a practical option for tree crops. However, trap or catch crops can be planted around orchards to attract potential pests away from the tree crops.

This is an important aspect of pest management in that diligent and programmed annual crop rotation can easily reduce pest populations, specifically soil dwelling insects and diseases. Some pests such as nematodes have a wide host plant range but there are nematodes, which are very specific in the choice of host plant. By rotating maize and dry beans (or other non-grass crop) the potential pest populations will be greatly reduced.

Intercropping is counter productive in a pest management programme and will ensure the survival of all pests of all inter-cropped crops. This will also make acceptable pest management and control very complicated. Intercropping should be discouraged.

Pest and disease scouting : Farmers must scout their crops at least once a week and observe/search for any pests and diseases. Farmers must be familiar with the biology of the pests on the crops planted so that they know where to search for the eggs and young growth stages before crop loss damage is significant. Use can be made of insect traps to record adult pest flight patterns. Records of scouting counts from each land and each crop must be kept so that pest population build-up can be monitored as well as the effect of any treatment applied to control the pest. KARI, EOs, technical advisers and commercial growers should develop the scouting methodology and interpretation.

Pest baiting stations : The concept is to have an attractant (pheromone or chemical) which will attract all mobile adult pests or only males or only females. The bait can contain an insecticide so that the pest comes into contact with it and subsequently dies before it can reproduce. Alternatively, the bait station is a trap which allows the pest in but not out. These are placed at strategic places in and around an orchard or crop. This has the advantage in that the insecticide is concentrated in a small area with very little chance of contamination of the environment. It also does away with the CPC, time and labour required to spray a crop.

Economic threshold pest and disease levels : Farmers must know how much damage a pest can cause to the crop before the yield is reduced and an economic loss is incurred. When a low population of a pest such as maize stalk borer is recorded, a corrective insecticide spray must be applied immediately before the young larvae can penetrate the crop. Maize can tolerate a relatively high aphid population before crop loss is realised and spraying becomes necessary. KARI, EOs, members of the AAK and commercial growers should compile recommendations for scouting pests in each major crop as well as determine the economic threshold levels. Certain scouting techniques and threshold levels have already been determined and are available in a training course (by Jack Ashton).

Crop nutrition : For plants to be vigorous and inherently resistant to light disease and pest pressure, they must be healthy and have adequate nutrition. The correct feeding or fertilising of a crop ensures an optimum yield, both quality and mass, and this is important if a farmer is aiming for the export market. Farmers must know the nutritional requirements of the crop, recognise any hunger signs and be able to correct any deficiencies. It is false economy to under fertilise and starve a crop.

Weed management : Uncontrolled weeds are one of the major growth limiting factor in SSF tree and vine production. Hand weeding is exceptionally time consuming and labour intensive if it is to achieve its aim of a weed-free crop. Herbicide use should be targeted at the perennial weeds that are the most problematic. Residual herbicides will also reduce the potential for weeds to shed seeds. However, cultural aspects such as having a mulch soil cover to inhibit weed seed germination, having an even and dense crop stand to shade out weeds, hand hoeing small weeds and preventing weeds from flowering by slashing, will all contribute to a reduction in weed pressure and thus herbicide use. Any weed on the farm must be prevented from flowering and shedding seeds to prevent a problem in the future.

Parasitic plants : Maize is the host to *Striga* species, which are root parasites. They can place the host plant under stress by competing for moisture and nutrients. *Striga* are very common in nitrogen deficient soils, a good indicator species, and can be easily suppressed by increasing the nitrogen fertilisation level. The fertiliser will benefit the crop as well. *Striga* is also sensitive to certain herbicides. Certain tree crops such as pecan nuts can be parasitised by mistletoe species, which are indigenous to parts of Africa. These should be cut out to avoid stress of the crop.



Rodent control : Crop production will always attract rodents, whether they eat the newly planted seed in the soil, eat the stored grain or eat the fruit on or off the trees. There are a number of commercially available baits (wax blocks, granules) that contain anti-coagulants. These must be placed strategically around the dwelling and storage areas, avoiding places where children and domestic animals can reach them. Storage places can also be rat-proofed with fairly inexpensive methods. However, owls remain the most efficient rodent control method around the farm. Unfortunately, in many African communities this predator is seen as the “the messenger of death” and it is ruthlessly pursued and exterminated. A ‘save the owls’ campaign will go along way to reducing rodent damage to crops.

## 8. REFERENCES

Anonymous (2003) – Integrated Pest Management. CropLife International. 27 pages.

Anonymous (2002) – Roundup® and Glyphosate. Monsanto Company, 18 pages.

Ashton, Jack; personal communication regarding “Safe use of pesticides”.

EUREPGAP Fresh Fruit and Vegetables Protocol (2001).

Grobler, Hermien, J.B.Vermeulen & Kathy van Zyl (2000). A guide to the use of herbicides. National Department of Agriculture, Republic of South Africa.

Horticultural Export Markets for Kenya Report; draft, 2002.

Kenya Business Development Services Program (KENYA BDS) Report; anonymous, undated.

Nel, Annette, Mareli Krause, Neervana Ramautar & Kathy van Zyl (1999). A Guide for the control of plant diseases. National Department of Agriculture, Republic of South Africa.

Nel, Annette, Mareli Krause & Neervana Ramautar (2002). A Guide for the control of plant pests. National Department of Agriculture, Republic of South Africa.

Thomson, W.T. (2000) – Agricultural Chemicals, Book IV – Fungicides.

Thomson, W.T. (2001) – Agricultural Chemicals, Book I – Insecticides.

Tomlin, C. (1994) – The Pesticide Manual; 10<sup>th</sup> Edition.

Ware, G.W. (2000) – The Pesticide Book; 5<sup>th</sup> Edition.

## 9. PERSONS CONTACTED

**Sandra Alai**, Registration Manager,  
Monsanto East Africa Inc., I&M Building, Ngong Road, Nairobi.  
Tel. 02-719-567

**Lincoln A. Asembo**, Western Region Sales & Marketing Manager,  
Bayer East Africa Ltd., Eldoret.  
Tel. 0722-761-134

**Dr. Jack Aston**,  
Global Crop Care Consultants,  
P.O.Box 60723, Nairobi.  
Tel. 02-43404                      Fax. 02-47279

**Enock Chikava**, Regional Manager,  
Monsanto Kenya Ltd.,

P.O.Box 47686,  
Nairobi.  
Tel. 02-719-567 Fax. 02-719-255

**Steve C. Collins**, Country Director and Chief of Party,  
ACDI – VOCA, Kenya Maize Development Program,  
209, Muthangari Drive, Westlands, Nairobi.  
Tel. 02-444-3254 Fax. 02-445-0785

**Amu Gadher**, Managing Director,  
Gadher Enterprises,  
P.O.Box 107, Kitale.  
Tel. & Fax. 0325-31625

**Julius Gatembo**,  
Juanco SPS Limited,  
Juanco Centre, Ngong Hills,  
P.O.Box 381, Karen, Nairobi.  
Tel. 0303-40206 / 41209 or 0722-827-987 Fax. 0303-40190

**Dr. Kenneth Kambona**, Crop Marketing Manager,  
Syngenta East Africa Ltd.,  
Mogadishu Road, Industrial Area, Nairobi.  
Tel. 02-532-750 or 552-515 or 0722-357-855 Fax. 02-532-753

**Mrs. Anne M. Kinyanjui**,  
District Horticultural Officer, Ministry of Agriculture,  
P.O.Box 68, Muranga.  
Tel. 060-30239

**Dr. Walter I. Knausenberger**, S.R.E.O.,  
U.S.Agency for International Development,  
P.O.Box 30261-00100, Nairobi.  
Tel. 2-862-400/2 Fax. 2-860-562

**David Knopp**, Chief of Party,  
Deloitte Touche Tohmatsu, Kenya Business Development Services Program,  
Lower Kabete Road, Westlands, Nairobi.  
Tel. 02-375-3318 Fax. 02-375-3320

**James N. Koome**, Managing Director,  
Just Juice Enterprises,  
P.O.Box 13588, Nairobi.  
Tel. 825-206 Fax. 825-209

**Dr. Slawomir A. Lux**, Principal Scientist,  
International Centre of Insect Physiology and Ecology,  
P.O. Box 30772, Nairobi.  
Tel. 860-110 or 861-168.

**Ms. Gladys N. Maina**, General Manager, Quality Assurance,  
Kenya Plant Health Inspectorate Services,  
Waiyaki Way, Nairobi.  
Tel. 02-444-0087 or 02-444-8663 Fax. 02-444-8940

**Lydia Mbevi**,  
ACDI / VOCA, Nairobi.  
Tel. 0722-720-615

**Peris Mongure**, Crop Specialist,  
Ministry of Agriculture,  
P.O. Box 95, Eldoret.  
Tel. 63861 or 0722-279-181

**F. N. Muchiri**, Senior Inspector,  
Pest Control Products Board,  
Waiyaki Way, Nairobi.  
Tel. 02-446-115 Fax. 02-449-072

**Mrs. Anne M. Mwaura**,  
District Crops Officer, Ministry of Agriculture,  
P.O.Box 68, Muranga.  
Tel. 060-30239

**Joseph Nzomo Mueke**, Managing Director,  
P.O.Box 4548, Kitale.  
Tel. 0325-30714

**John K. Mumu**, Inspector,  
Pest Control Products Board,  
Waiyaki Way, Nairobi.  
Tel. 02-446-115 Fax. 02-449-072

**Muli Musinga**, Business Development Specialist,  
Deloitte Touche Tohmatsu, Kenya Business Development Services Program,  
Lower Kabete Road, Westlands, Nairobi.  
Tel. 02-375-3318 Fax. 02-375-3320

**Dr. Maria Mutai**, Registration Manager,  
Bayer CropScience, Bayer East Africa Ltd.,  
Thika Road / Outering Road, Ruaraka, Nairobi.  
Tel. 020-860-667 or 020-803-346 Fax. 020-860-935 or 020-861-636  
[Previously the Registrar of Pesticides, Pesticides Control Board]

**Dr. Vasey Mwaja**, Technical and Marketing Manager,  
Bayer CropScience, Bayer East Africa Ltd.,  
Thika Road / Outering Road, Ruaraka, Nairobi.  
Tel. 020-860-667 or 020-803-346 Fax. 020-860-935 or 020-861-636

**[Dr. Vasey Mwaja**, Chairman,  
Agrochemicals Association of Kenya,  
Cooper Center Kabete, Kaptagat Road, off Waiyaki Way, Nairobi.  
Tel. 020-732-960 Fax. 020-581-1213]

**Dr. Rhonest Ntaya**, Head, KEPHIS Analytical Chemistry Laboratories,  
Kenya Plant Health Inspectorate Services,  
Waiyaki Way, Nairobi.  
Tel. 02-444-0087 or 02-444-8663 Fax. 02-444-8940

**Prof. James Ochanda**, Chairman,  
African Biotechnology Stakeholders Forum,  
Waiyaki Way, P.O.Box 66069-00800, Nairobi.  
Tel. 02-444-4558 Fax. 02-444-8762

**Lucas Ochieng**, Area Representative,  
Hygrotech East Africa Ltd.,

P.O.Box 13838, Nakuru.  
Tel. 037-212-184 or 0733-836-486

**Vallabhdad D. Patel**, Managing Director,  
Devji Meghji & Bros. Ltd.,  
P.O.Box 62, Ruiru.  
Tel. 02-352-151 Fax. 0151-54413

**Edward Sawe**, Area Representative,  
Bayer East Africa Ltd., Eldoret.  
Tel. 0722-626-309

**Dr. Paul Seward**, Managing Director,  
FIPS-Africa, Farm Input Promotions Africa Ltd.,  
No. 1 M'pulla House, Arboretum Drive, Nairobi.  
Tel. 020-273-0700 or 0722-220-110

**Mrs. Evelyn Shipala**, Programmes Manager,  
Pert Networks Ltd., (Enterprise Development Consultants)  
P.O. Box 7313, Eldoret.  
Tel. 62478 or 0722-292-782

**George Solomon**, Outgrowers Manager,  
East African Growers Ltd.,  
P.O.Box 49125-00100, Nairobi.  
Tel. 822-017 or 350-137 Fax. 822-155

**Samuel W. Theuri**, Technical Adviser,  
Fresh Link Growers,  
P.O.Box 1852, Karatina.  
Tel. 0171-72359

**Isaac Tongola**,  
Farm Input Promotions Africa Ltd., Eldoret.

**Mathew Kigotho Wachira**, Project Co-ordinator,  
Fresh Link Growers,  
P.O.Box 1852, Karatina.  
Tel. 0171-72359

#### Village Distribution Agents Interviewed

Bankview Pharmacy, Eldoret.

Eman Holdings, P.O.Box 1910, Nakuru.

Farmcare Agro Chemicals, Makutano Karaba. (licensed)

Gadher Enterprises Ltd., P.O.Box 107, Kitale. (licensed)

Hygrotech East Africa Ltd., P.O.Box 13838, Nakuru.  
[The best organised retail shop visited]

Kiungani.

Kimilili AgroVet, (Terese Nasimiyu Kabwu), P.O.Box 304, Soy.

Launch Agro-Vet, Muranga. (licensed)

Lessos Veterinary Supplier, P.O.Box 1080, Eldoret. (member AAK)

Menengai Agrovet, Nakuru.

Mwami Agrovet, Matunda. (licensed)

Progressive Farming Cooperative, Uasin Gishu District.

Sombe Agrovet, Soy. (licensed)

Ukulima Agrochem, P.O.Box 1716, Kitale.

#### 10. Recommended distribution

Annex 1. Pest management method selection – a decision framework

## ANNEX. 1

Due to incomplete registration details being available from PCPB, some products would appear to be registered but not recorded in the official list of registered products. These products are marked with an asterisk. The patent has expired on some of these products and alternate formulations are available.

It is accepted that during the registration process, all products have been reviewed for their toxicological characteristics such as mutagenicity, teratology, carcinogenicity and others. Due to the fact that a product has been registered implies that it has been approved for use as recommended on the label.

All crop protection chemicals should be applied according to label recommendations. Precautions included on the label should always be followed. However, mis-use and ignorance must be catered for.

**Table 4** : Pesticide characteristics for use in the KBDS project on avocado, mango and passion fruit.

The chemical class of the active ingredient is given in parenthesis.

The LD<sub>50</sub> is the acute oral for the rat for the active ingredient.

Crops are indicated as A = avocado, M = mango, PF = passion fruit.

Dosage rate per ha – a maximum of 1000l spray volume depending on tree size; spray for full droplet cover, to the point of run-off.

(a) Fungicides

Active Ingredient (a i.)	Trade name / Formulation	Kenya Reg.	EPA	a i. LD <sub>50</sub> (mg/kg)	Crop/Target Pest	Dosage/ha	Dosage/ 100l
benomyl (benzimidazole)	Benlate 50 WP; 500g/kg	0059	IV	> 10.000	A – anthracnose, fruit & leaf spot M – anthracnose, powdery mildew PF – leaf & fruit spot		20g
copper hydroxide (inorganic)	Kocide DF; 614g/kg	0263	III	890 – 1.120	A – anthracnose, fruit & leaf spot M – anthracnose PF – leaf & fruit spot, wilt	1.5 – 3.0kg	A - 150 – 250g M – 300 – 500g PF – 150 – 250g
copper oxychloride (inorganic)	Cobox 50 WP; 500g/kg Demildex and other similar products.	0025	III	700 - 800	A – anthracnose, fruit & leaf spot M – anthracnose PF – leaf & fruit spot, wilt	2.0kg	350g
fostyl-Al (alkyl phosphonate)	Aliette WP; 800g/kg	0125	III	5.800	A – root & trunk rot		375g?
iprodione	Rovral 250 Flo; 250g/l	0037	IV	> 2.000	M – post harvest decay	-	10.0ml (0.1-0.2%)

(dicarboximide)							
phosphorous acid		*	(IV)	3.000	A – root & trunk rot		
propineb (dithiocarbamate)	Antracol 70 WP; 700g/kg	0147	IV	> 5.000	A – anthracnose M - anthracnose	2.5kg	250g
sulfur	Thiovit 80 WP; 800g/kg Cosavet and other similar products.	0106	IV	Non toxic	M – powdery mildew	2.0 – 5.0kg	200 – 500g
thiabendazole (benzimidazole)	Tecto 41.8% FW; 450g/l	*	III	3.100	A – post harvest decay M – post harvest decay	-	250 – 275g (dip)
triadimefon (triazole)	Bayleton 25 WP; 250g/kg Bayleton 25 OEC; 250g/l	0219	III	1.000	M – powdery mildew	0.3 – 2.0kg 0.3l	30g 30ml

(b) Insecticides

Active ingredient (a.i)	Trade name / formulation	Kenya Reg.	EPA	a.i. LD <sub>50</sub> (mg/kg)	Crop/Target Pest	Dosage/ha	Dosage/ 100l
Amitraz (amidine)	Mitac 20EC; 200g/l	0017	III	600 - 800	A - mites		
Azadirachtin (plant extract)	Achook 0.15% EC	*	II/III	Non toxic	A – stink bugs PF - thrips	1.0 – 6.0l	80ml
<i>Bacillus thuringiensis</i>	Xen Tari; 3.0% Dipel 2X; 32k/mg	0262 0185	IV	Non toxic	A - loopers		
Beta-cyfluthrin (pyrethroid)	Bulldock 025 EC; 25g/l	0233	II	500 [form. 18.000]	A – stink bugs M – fruit fly	0.6l	75ml
Bifenthrin (pyrethroid)	Brigade 25 EC; 25g/l	0097	II	54.5 [form. 2.200]	A - mites M – weevil PF - thrips		
Buprofezin (thiadiazine)	Applaud 40 SC; 400g/l	0276	III	2.198	A - scale		40ml
Deltamethrin (pyrethroid)	Decis 2.5 EC; 25g/l Decis Tab; 0.5g/2g tablet	0023	II	135 – 5.000	A – stink bug, thrips M – scale, thrips, weevil PF – mealybug, scale, thrips	0.5l 20 tablets	50ml 5 tablets

Dimethoate (organophosphorus)		*	II	290 - 325	PF – mealybug, scale, thrips		
Fenthion (organophosphorus)	Lebaycid 500 EC; 500g/l	0065	II	250	A – fruit fly M – fruit fly, thrips, weevil PF – fruit fly Bait – fruit fly	0.9 – 1.25l	100 – 125ml  15ml / 20l
Garlic extract (plant extract)	GC Mite; 40%	?	(IV)	Non toxic	Mites on all crops	1.0l	150ml
Lambda-cyhalothrin (pyrethroid)	Karate 1.7 EC; 17.5g/l	0002	II	56 - 79	PF – aphids, thrips		(30ml?)
Malathion (organophosphorus)		*	II/III	1.375	A – flies, scale, thrips		
Pyrethrin (plant extract)	Pyerin 7.5EC	*	III	2.370	A – mites, scale, thrips M – aphid, scale, thrips PF – aphid, scale, thrips	1.0l	100ml
sulfur	Thiovit 80 WP; 800g/kg Cosavet and other similar products.	0106	(IV)	Non toxic	A - mites	2.0 – 5.0kg	200 – 500g

(c) Herbicide

Active ingredient (a i)	Trade name / formulation	Kenya Reg.	EPA	a i. LD <sub>50</sub> (mg/kg)	Crop/Target Pest	Dosage/ha	Dosage/ 100l
glyphosate	Roundup 360 SL; 360g/l	0006	III	4.320	Pre-plant Post-emerge; annuals & perennials	1.0 – 5.0l	1.5 – 3.0l

**Table 5 :** Risk analysis of candidate crop protection chemicals for use on avocado, mango and passion fruit in Kenya.

Aspects such as mutagenicity, carcinogenicity, teratogenicity, reproduction and other effects by the compound on toxicological issues have been addressed during the registration process and are not included here.

The following analysis is based on the product being used according to label directions. However, mis-use and the resulting potential hazard can be anticipated.

(a) Fungicides



Active Ingredient (a.i.)	Mammalian toxicity	Ecotoxicity	Non-target factors / hazards (degradation, water, soil, etc.)
benomyl (benzimidazole)	Relatively non-toxic. Excretion within 48 hours. Does not accumulate.	Non-toxic to birds and bees. Toxic to fish.	Converts rapidly to carbendazim; gradual decomposition over up to 6 months in soil and water.
copper hydroxide (inorganic)	Potential eye & skin irritant; Rapid excretion.	Non-toxic to birds and bees. Toxic to fish.	Strongly absorbed by soil.
copper oxychloride (inorganic)	Potential eye & skin irritant; Rapid excretion.	Non-toxic to birds and bees. Toxic to fish.	Corrosive to iron. Hard water reduces efficacy. Strongly absorbed by soil. Can be phytotoxic to copper sensitive crops.
fostyl-Al (alkyl phosphonate)	Relatively non-toxic. Non-irritant.	Non-toxic to birds, fish and bees. Systemic in the plant.	Degrades rapidly in soil and water. Incompatible with many other pesticides. Dilution water should be pH 6 and above.
iprodione (dicarboximide)	Formulation may be irritant; rapidly metabolised and excreted.	Toxic to fish. Do not graze the treated area.	Rapidly metabolised in soil.
phosphorous acid			
propineb (dithiocarbamate)	Non-irritant.	Non- toxic to birds & bees.	Do not spray in alkaline water. Rapid degradation in soil; not mobile in soil.
sulfur	Practically non-toxic. Can be irritating to eyes, skin & mucous membrane.	Non-toxic to birds, fish & bees.	Some crops are sensitive to sulfur. Do not mix with spray oils. No restriction on time of application.
thiabendazole (benzimidazole)	Some formulations may cause skin irritation. Hydrolysed and eliminated rapidly.	Low or not toxic to birds, fish & bees.	Used as a dip treatment. Do not dilute with alkaline water. Incompatible with copper fungicides. Used for roundworm control in humans & livestock.
triadimefon (triazole)	May cause eye & skin irritation. Readily excreted or metabolised.	Non-toxic to birds & bees. Toxic to fish.	Phytotoxic to some plants.

(b) Insecticides

Active ingredient (a.i)	Mammalian toxicity	Ecotoxicity	Non-target factors / hazards (degradation, water, soil, etc.)
amitraz	May cause eye & skin irritation.	Low toxicity to birds, bees & beneficial insects. Toxic to fish.	Has a contact and repellent action. Incompatible with alkaline compounds. Rapidly hydrolysed in water & degraded in soil. Avoid applying in cool, wet conditions. Used as an acaricide on livestock.

azadirachtin	A plant extract. Unlikely to be harmful.	Specific to insects.	Effective on larvae; has a repellent action. Apply immediately after mixing. Avoid alkaline conditions.
<i>Bacillus thuringiensis</i>	Not evidence of acute or chronic toxicity. No allergies recorded.	Non-toxic to birds, fish and bees.	Use immediately after mixing. Must be ingested by the target pest – ensure thorough coverage of target areas.
Beta-cyfluthrin (pyrethroid)	Slight eye irritation. Rapid excretion.	Toxic to fish, bees & beneficial insects.	Contact & stomach action on insects. Very low dosage rates are applied. Degradation is rapid in soil.
Bifenthrin (pyrethroid)	Skin & eye irritant.	Toxic to fish, bees & beneficial insects.	Contact & stomach action on insects & mites. Very low dosage rates are applied. Degradation is rapid in soil.
buprofezin	Skin irritant.	No effect on bees, parasitic and predatory insects.	Contact and growth regulatory effect on immature Coleoptera, Hemiptera, Acarina spp. Little or no effect on other insects. Remains active in water and soil for up to 30 days.
Deltamethrin (pyrethroid)	Slight eye irritant.	Toxic to fish & bees.	Active against a wide range of insects at very low active ingredient rates. Stable under normal conditions. Microbial degradation in soils within 2 weeks.
Dimethoate (organophosphorus)	Non-irritant.	Toxic to bees and beneficial insects.	Has contact, systemic & stomach activity. Phytotoxic to some crops. Use in the evening when bees are not active. Do not mix with alkaline or sulfur materials. Observe pre-harvest interval.
Fenthion (organophosphorus)	Non-irritant.	Toxic to aquatic life & bees.	Do not spray when bees are active. Controls insects and mites. Do not mix with alkaline materials. Degradation is rapid in the soil.
Lambda-cyhalothrin (pyrethroid)	Eye irritant. Rapid elimination.	Toxic to fish. Does not bio-accumulate.	Does not leach; degrades slowly in soil but little or no soil insecticidal activity. Dosage rates are very low per unit area.
Malathion (organophosphorus)		Toxic to fish & bees.	Controls leaf-feeding insects, mites and grain storage pests. Restricted in some countries. Incompatible with alkaline materials.
Pyrethrin (plant extract)	Skin & eye irritant. Possible allergy.	Very toxic to fish. Repellent to bees & toxic.	Has contact, stomach and fumigant action. Controls a wide range of pests as well as ticks.
sulfur	Practically non-toxic. Can be irritating to eyes, skin & mucous membrane.	Non-toxic to birds, fish & bees.	Some crops are sensitive to sulfur. Do not mix with spray oils. No restriction on time of application.

(c) Herbicide

Active Ingredient (a i.)	Mammalian toxicity	Ecotoxicity	Non-target factors / hazards (degradation, water, soil, etc.)
glyphosate	May cause skin & eye irritation to sensitive individuals	Rapidly excreted by animals, birds, fish, insects and micro-organisms – regarded as non-toxic. Recommended for weed control in sensitive environmental areas.	No or very little soil or residual activity. Do not spray with alkaline water. Requires 6 hours rainfree period after spraying. Rapidly degraded in the soil. Avoid off-target drift as it will kill or severely injure all plants. No surfactant required.