

MANGO ORCHARD TECHNICAL SPECIFICATION

For

TREES OF HOPE PROJECT

{A Plan Vivo Payment for Ecosystem Services (PES) Project}

Clinton Development Initiative

Off Mphonongo Road

Plot No. 10/42

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SUMMARY

This technical specification has been developed for use by Trees of Hope Project, a Plan Vivo Payment for Ecosystem Services (PES) project involving rural communities participating in Malawi. Through the Plan Vivo system communities may be able to access carbon finance by land use change activities that involve afforestation and reforestation.

This technical specification sets out the methods that should be used to estimate the carbon benefits from planting and managing mango orchards on small holding farms in Malawi. It further details the management requirements for this system over a long period of time, and the indicators to be used for monitoring the delivery of the carbon benefit. The technical specification aims to summarise the best available evidence about the environmental benefits associated with the sustainable management of this land use system. Further information and research is welcome and will be incorporated periodically.

This land use system has been developed in consultation with communities and individual farmers in Neno and Dowa districts of Southern and Central Malawi respectively. Other valuable contributions to the development of this system have been received from Clinton Development Initiative (CDI), formerly Clinton Hunter Development Initiative (CHDI) staff, national and district government officials and forestry and agricultural extension workers. The inputs have been received through a structured process of meetings and interviews with these key stakeholders between September 2007 and October 2008.

The objective of the mango fruit orchard system is to provide an alternative / additional source of income from other agricultural activities. Additional benefits will include soil conservation through the 1m by 1m basins made around each tree which trap water allowing it more time to percolate into the soil as opposed to running off the surface causing soil erosion, and enhanced biodiversity through attracting and providing more suitable microenvironment for insects and other fauna. The carbon finance will make a critical difference in allowing for the implementation of this system by providing tree seedlings, increasing capacity in managing fruit orchards and putting in place

frequent monitoring to ensure compliance with the technical specification that will create the carbon sink.

The project in which this technical specification is part is being piloted in Neno and Dowa districts but during the scale up phase, the project will spread to other districts with similar agro ecological conditions like temperature regimes, rainfall pattern, edaphic (soil) factors as described in section 5.0 of the Project Design Document (PDD) and where the tree species to be used are known to traditionally grow and have positive impact on local livelihoods. Within the districts where this technical specification will be established, it is important to ensure that appropriate pockets of land are chosen for the system to avoid unintended negative impacts on the socio-economic and environmental well being of the communities. Table 1 below offers a guideline to the eligibility of different land types to establishment of mango orchards.

Table 1: Land type eligibility for mango orchard technical specification

Land type	Basic characteristics	Eligibility
Natural forest	<ul style="list-style-type: none"> ➤ Covered with trees (government controlled or under customary control). 	<ul style="list-style-type: none"> ➤ Not eligible as natural trees must not be cut in order to establish a mango orchard.
Cultivated land	<ul style="list-style-type: none"> ➤ Generally of high fertility production potential. ➤ Less prone to erosion. ➤ Slopes of not more than 12%. ➤ Grown to food crops annually for the household. 	<ul style="list-style-type: none"> ➤ Not eligible as this might lead to displacement of production of food crops.
Degraded land	<ul style="list-style-type: none"> ➤ Low soil fertility with low production potential. ➤ Shallow soils ➤ High soil erosion hazard. ➤ Rarely put to arable cropping. 	<ul style="list-style-type: none"> ➤ Eligible only in cases where the household has enough more productive land elsewhere for production of food crops for its food security.
Neglected land	<ul style="list-style-type: none"> ➤ Very low soil fertility and productive capacity. ➤ Shallow rocky soils with high erosion hazard. ➤ Abandoned for arable crop production. ➤ Slopes of over 12%. 	<ul style="list-style-type: none"> ➤ Eligible but any existing trees on site should only be planted around and not cut down.
Wetlands	<ul style="list-style-type: none"> ➤ Permanent wetness 	<ul style="list-style-type: none"> ➤ Not eligible

The mango orchard technical specification, like others in the project, can be established by individuals or communal groups. However, wherever this technical specification is established, farmers should demonstrate possession of sufficient land so that the establishment of the system does not negatively interfere with the household's food production system by taking land out of production of food crops.

The net carbon benefit of this system above the baseline (with 20% set aside as risk buffer) is calculated to be 22.68 tonnes of carbon per hectare as a long-term average over 50 years. This is equivalent to 83.16 tonnes of carbon dioxide per hectare.

ACKNOWLEDGEMENTS:

This work has been undertaken by Edinburgh Centre for Carbon Management (ECCM) for Trees of Hope Payment for Ecosystem Services (PES) of the Clinton Development Initiative (CDI), formerly Clinton Hunter Development Initiative (CHDI) in Malawi. It has only been possible because of the financial support received from the Hunter and Clinton Foundations. ECCM wish to acknowledge the contribution made by all the staff of CDI Malawi, and all the other stakeholders engaged during the participatory planning process used to design and collect data for this technical specification.

1.0 DESCRIPTION OF LAND USE SYSTEM

This system involves the planting of mango trees for commercial fruit production (as well as providing a source of additional nutrition to those households that use this system). The preferred varieties of mango for planting are Kent, Erwin, Zill, Keitt and Tommy Atkins because of their low fibre content, which would be preferred on the market.

1.1 Main tree species

Table 2: Main tree species for mango orchard technical specification

Botanical name	Common name (English)
<i>Mangifera indica</i>	Mango

2.0 ECOLOGY

2.1 Altitudinal range.

Mango will grow well from sea level up to 1,200 m above sea level, however, fruit production decreases at higher altitudes.

2.1 Climatic factors

Mango is tolerant of a wide range of conditions from hot and humid to cool and dry. However, the climatic conditions will determine whether mangoes can be grown commercially and which cultivars should be selected. The optimum temperature range is 12°C - 37°C. Mango has no frost tolerance. A distinct dry season (more than 3 months) is required to assist with fruit production. Low rainfall (<500 mm/yr) will restrict fruit yields whilst high rainfall (>2,000 mm/yr) can also impact negatively on yields as vigorous vegetative growth will replace reproductive growth.

2.2 Habitat requirements.

Mango trees are tolerant of both drought and occasional flooding. For good growth deep soils are required to accommodate the large root system which can extend up to 6 meters deep.

2.3 Growth habit.

Mango trees will grow up to 40m high with a broad spreading crown but many cultivars may be much smaller.

3.0 MANAGEMENT OBJECTIVES OF MANGO ORCHARD SYSTEM

The main management objectives of establishing mango orchards include:

- Commercial production of mango fruits with potential of value addition through processing in the medium to long term.
- Improvement of house hold's nutritional status trough consumption of mango fruit products.
- Production of fuelwood in form of off-cuts from pruning.
- Production of timber from mature trees at the end of rotation cycle.
- Mango trees will also be considered for hanging beehives for apiculture besides providing excellent nectar for the bees.

4.0 COSTS OF IMPLEMENTATION

4.1 Nursery cost

The activities and costs for establishing about 200 seedlings per hectare during the setting up of the nursery are:

- Preparation of media.
- Pricking out and selection/transfer.

- Watering and sanitation.
- Pest and disease control.
- Purchase of scions for grafting and mango stones for planting to establish rootstocks.
- Green house sheeting materials.
- Cost of one wheelbarrow, hoes, grafting knives and tapes, machete, green house sheets, poles and watering cans.

The total nursery cost is estimated at \$ 450.

4.2 Establishment cost

The activities in the establishment phase would include:

- Land preparation (clearing of weeds and other trash to allow easy pitting and basin preparation).
- Chaining/marketing.
- Pitting.
- Planting.

The total cost for this phase per hectare would be \$50.

4.3 Maintenance cost

Operations for year one would include grass slashing, spot weeding, firebreaks and uprooting shrubs. The cost per hectare will be \$40 while year two operations that include grass slashing, spot weeding, firebreaks maintenance, and uprooting shrubs will cost an estimated \$20. Operations for years 3, 4, and 5 that include fire protection and basic agronomy will cost \$20 per hectare / year while other costs would go to buying equipments such as one slasher, one hoe, one machete, a pair of boots, and one overall estimated at \$50. The full nursery cost profile is summarized in Table 3 below:

Table 3: Nursery, establishment and short-term maintenance cost profile for mango orchard technical specification.

Activity	Cost (per hectare for mango fruit orchard)
Nursery costs	\$450
Establishment	\$50
Maintenance year 1	\$40
Maintenance year 2	\$20
Maintenance year 3	\$20
Maintenance year 4	\$20
Maintenance year 5	\$20
Equipment cost	\$50
Total	\$670

5.0 POTENTIAL INCOME

There will be a total of about 204 mango fruit trees per hectare from a spacing of 7m by 7m. The average yield per hectare of a mango orchard would be 16000kgs with yield of 80kg per tree per year. For an estimated productive life of 10 years, a hectare of a mango orchard would cumulatively yield 160000kg and at an estimated price of MK100 per kg, the yield would have a value of MK16000000 over ten years. However, it should be noted that this is a conservative estimate since the productive life of mango orchards can exceed 20 years under good management and optimal climatic conditions.

6.0 MANAGEMENT OPERATIONS

6.1 Establishment

Minimal land preparation should be done at the site of planting to facilitate digging of holes and making of basins around the trees. Any existing trees on site should not be cut but only planted around and all plots showing wholesale clearing of vegetation are disqualified. Basins of 1m by 1m are created around each tree so that water is trapped and percolates into the soil instead of running off. Apply mulch in the basins to assist in moisture conservation and weed suppression but the mulch should stay clear of the root collar to reduce risk of termite attack. On sloppy planting sites, terracing should be done and mulch applied (staying clear of the root collar) to assist in soil water conservation. Well rotten manure should be applied into the pit. Trees should be planted in rows in holes dug 60cm wide and 60cm deep at least a month before planting. When digging the holes, put topsoil on one side of the hole and subsoil on the other side. At planting, topsoil should be put into the hole, first before subsoil. It is best to plant at the beginning of the wet season to minimize the requirement to water the seedlings. At planting, the following actions need to be considered:

- Water seedlings before planting to hold nursery soil together and to assist establishment in case it fails to rain on the day of planting.
- Plant at the beginning of the rainy season.
- Care should be taken handling plants not to cause damage to shoots, buds or bark.
- Only remove plastic from around root-ball at the time of planting. Care should be taken to remove all the plastic.
- Plant to depth of root collar (i.e., for bagged plants, to level of existing nursery soil). Never plant deeper than in nursery, leaving no roots exposed.
- Heel in the soil around the seedling to ensure good root-soil contact by removing air pockets.
- Clear all grass and weeds around each seedling to a minimum radius of 1m.
- Regular watering especially in the first year will help trees survive.

6.2 Maintenance

Particular attention should be paid to weeding and uprooting of competing shrubs where grafted mango has been planted. The orchard should also be protected from livestock browsing and bush fires. Recommended procedures, as stipulated in manuals like the “Horticulture Crop Production Recommendations” by W. S. Braunworth of 1992 and any other documents on pest and disease management and crop nutrition will be followed in management of the orchard. Some of the common pest and disease problems in mangoes and their management practices are presented in Annex 17.1.

6.3 Pruning and harvesting

Pruning of unwanted branches should be done carefully to leave smooth scars to minimise infection. This activity is necessary to allow better penetration of photosynthetic active radiation, vital for fruit set. As the orchard ages, its productivity will decrease hence pollarding should be considered or complete re-establishment at approximately 50 years.

7.0 DESCRIPTION OF THE ENVIRONMENTAL AND SOCIO-ECONOMIC BENEFITS.

The establishment of this land use system will bring about the following environmental and socio-economic benefits:

- Soil conservation - particularly the prevention of soil erosion associated with heavy rainfall events and siltation of water courses (climate change adaptation benefit) due to the 1 metre basins made around bases of trees that trap water and allowing it to percolate into the soil as opposed to running off the surface, causing soil erosion.
- Hydrological benefit – harvesting of incidental moisture and encouragement of water infiltration which will help to reduce flooding (climate change adaptation benefit) through

the percolating water which will aid in recharging ground water systems and helping to raise the water table.

- Biodiversity benefit – through the provision of wildlife habitat for a diverse plant and animal life through the micro-environment (below and above ground) created by the mango trees.
- Provision of potential bee keeping habitat as beehives could be hung in the trees.
- Shading for humans and livestock.
- Pruning material may be used as firewood.

8.0 DESCRIPTION OF ADDITIONALITY

A key factor is that the emissions reductions from a project activity or intervention should be additional – i.e. the intervention would not have occurred in the absence of the carbon-derived finance. Additionality, can be demonstrated through an analysis of the barriers to the implementation of activities in the absence of intervention. In this case, the barriers to the establishment of mango fruit orchards that are overcome through the project activity and receipt of carbon finance include:

- Community mobilisation and participation in planning processes.
- Awareness of climate change issues, carbon trading and role of mango orchards in climate change management and livelihood improvement leading to renewed efforts in tree planting.
- Building of technical competence in development of grafted mango seedlings and their subsequent field establishment and management vital for sustainability.
- Access to high value mango planting materials.
- Access to tools and other nursery materials including polythene tubes, watering cans, seed etc to enable seedling production.
- Training to enable long term sustainability of programme through participatory monitoring and evaluation.

As there are no formal means by which communities can access funding to cover these costs, the effect of Plan Vivo carbon finance is strongly additional.

9.0 LEAKAGE ASSESSMENT

Leakage is defined as unintended loss of carbon stocks outside the boundaries of a project resulting directly from the project activity. In the case of establishing mango orchards, this is most likely to occur where farmers are establishing trees on cultivated land (these fruit trees are not suitable to be grown in combination with other cultivated food crops). If this were to occur, it may result in displacement.

The Plan Vivo system requires that potential displacement of activities within the community should be considered and that activities should be planned to minimise the risk of any negative leakage. These actions should include:

- All farmers establishing mango orchards should be assessed individually to demonstrate that they retain sufficient land to provide food for their households.
- Signatories to Plan Vivo activities will be contractually obliged not to displace their farming or livestock activities as a result of tree planting.
- In many instances, it may be most appropriate to establish fruit orchards on degraded bush / scrub land which is not currently being used for producing other food crops. In this case any leakage resulting from displaced grazing or firewood collecting activities should also be assessed.
- A plan to monitor leakage on specific other woodland areas to ensure leakage is not occurring.
- Formation of community based ‘policing’ to ensure that leakage resulting from displaced activities does not occur.

Where communities have a satisfactory plan for managing leakage risk resulting from the establishment of fruit orchards, there should be no assumption of leakage.

10.0 PERMANENCE AND RISK MANAGEMENT

The project recognizes the importance of permanence of its activities (carbon stocks) so that they are not only initiated but also become embedded in the community and further realizes that risks exist that could threaten this intention. These risks have been foreseen and risk management measures put in place to minimize any effects. One of the threats to sustainability of project activities is the mere lack of sense of ownership of the project by the participating communities. To minimize this threat, the project has a deliberate policy of striving to involve the communities in all project processes coupled with free flow of updated program information through a rigorous participatory training program. The project attaches highest priority for registration to individuals and groups that show tendencies of self-selection. Other risks to permanence are also foreseen and are presented in Table 4 below along with their management measures.

Table 4: Risks to permanence, their levels and management.

Permanence risk	Level of risk	Management measure
Forest fires	High	<ul style="list-style-type: none"> ✚ Adoption of recommended fire protection measures including establishment of fire breaks around plantations and removing all weeds and dry trash from within the plantation. ✚ Civic education to communities and their leaders on the dangers of bush fires to the environment and livelihoods. ✚ Formation of community-based fire monitoring committees in the villages.
Pests and diseases (largely fungal infections and leaf-eaters and damping-off disease in the nursery). Termites in some sections cause damage soon after planting out.	Low	<ul style="list-style-type: none"> ✚ Selection of indigenous tree species which are hardy to most known pathological problems. ✚ Recommended pest and disease management silvicultural practices both in the nursery and in the field following an integrated approach to pest and disease management. ✚ Implement an effective pest and disease surveillance system led by Local Program Monitors (LPMs).
Drought	Medium	<ul style="list-style-type: none"> ✚ Early planting of strong healthy seedlings. ✚ Good silvicultural practices like deep pitting and use of organic manure that promote higher soil moisture retention. ✚ Promotion of irrigation where applicable.

Table 4: Risks to permanence, their levels and management (*continued*).

Permanence risk	Level of risk	Management measure
Livestock damage	Low	<ul style="list-style-type: none"> ✚ Education of communities on recommended livestock management practices like tethering and zero grazing during periods when trees are vulnerable to livestock damage. ✚ Placement of protective structures (normally thorny fences) around plantations or individual trees where feasible. ✚ Enforcement of community by-laws by traditional leaders that regulate movement of livestock in communities. ✚ In certain cases, establishment of tree species that are not vulnerable to livestock damage through browsing.
Overreliance on external support.	Low	<ul style="list-style-type: none"> ✚ Capacity building on all technical aspects of tree establishment and management including community based seedling production. ✚ Broadening income streams to producers over and above carbon finance. ✚ Encouraging communities to contribute all locally available materials and labour for tree seedling production, with the project only providing materials that are difficult to source at community level. The latter materials will later also be the responsibility of the communities through carbon finance.

Based on the risks outlined above, the project will withhold 20% of carbon services generated from sale to form a carbon buffer (reserve of unsold carbon).

11.0 BASELINE CARBON EMISSIONS

The ‘**baseline**’ refers to carbon sequestered and stored in any existing vegetation (excluding food crops) on a site at the time of planting. When calculating the number of Voluntary Emission Reductions (VER’s) that a farmer has generated, the baseline carbon stock is subtracted from the carbon sink achieved by the project activity. The procedure used to quantify the “baseline” carbon emissions that would be associated with land management expected in the absence of the establishment of fruit orchards is set out in ‘*Assessment of Net Carbon Benefit of CDI Land Use Activities*’ (Camco 2010). It is assumed that this system will be used on low-potential cultivated and neglected land with an estimated carbon baseline of 0.37 tonnes per hectare in the absence of project activities.

12.0 QUANTIFICATION OF THE CARBON SINK

The approach used for estimating the long-term carbon benefit of afforestation for Plan Vivo VERs is based on average net increase of carbon storage (sink) in biomass and forest products over a 50 year period relative to the baseline. The carbon sink is calculated through a three-staged approach as below:

- Calculate tree growth rates based on tree measurement data captured within the project area.
- The carbon uptake of each species was calculated using the CO2FIX-V3 model (Mohren et al 2004).
- These model outputs were then used to build the result for the technical specification based on the numbers of species in each system and the length of rotations.

The procedure used to calculate the potential carbon sink created by mango fruit orchards is set out in ‘Assesment of Net Carbon Benefit of CDI Land Use Activities’ (Camco 2011). The potential carbon sink created by this land use system (based on long term average carbon storage over 50 years) is calculated to be 28.72 tonnes of carbon per hectare.

13.0 BUFFER

Twenty percent (20%) of all VER’s generated by the project activities are maintained as a risk buffer. Records of all buffer stock should be maintained in the database. It has yet to be decided at what stage the right to trade these VER’s will return to the farmer.

14.0 CALCULATION OF CREDITS

For the purposes of quantifying Plan Vivo certificates (carbon offset), the net carbon benefit of each tree planting system in addition to the baseline has been calculated. In accordance with Plan Vivo standards (<http://www.planvivo.org/>) 20% of all the carbon offset (i.e. net carbon benefit) is set aside to be kept as a risk buffer (i.e. non tradable carbon asset). Records of all buffer stock should be maintained in the database. The net carbon benefit, buffer stock and tradable carbon offset (Plan Vivo certificates) generated by the mango fruit orchard land use system (technical specification) is presented in the table below:

Table 5: The net carbon benefit and tradable carbon offset for the mango fruit orchard land use system.

Technical Specification	Sink (tC/ha)	Baseline (tC/ha)	Net benefit (tC/ha)	Net benefit (tCO ₂ /ha)	Buffer (%)	Tradeable (tCO ₂ /ha)
Fruit orchard (Mango)	29	0.37	28.63	106	20%	85

The figure below shows the long-term average carbon sink over the simulation period (50 years).

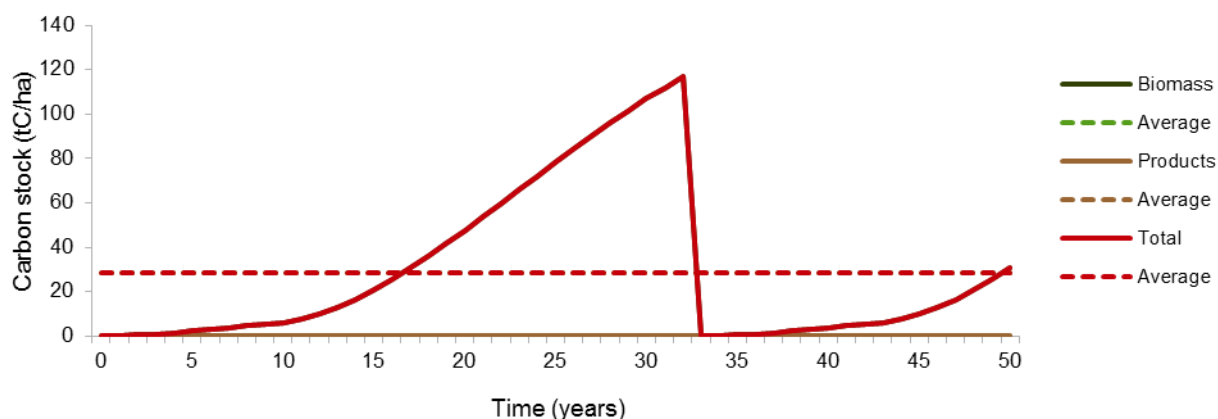


Figure 1: Mango fruit orchard technical specification carbon sequestration potential over 50 years.

15.0 MONITORING

Monitoring targets for the first 4 years are based on establishment whereby the whole plot must be established by the fourth year with at least 90% survival of trees. Thereafter monitoring targets are based on tree growth rates indicated by measurement of the Diameter at Breast Height (DBH). The expected DBH at the time of monitoring is based on a predicted mean annual diameter increment on which carbon sequestration estimates are based. Table 6 below shows the monitoring schedule (in years) and the corresponding key indicators or targets that are expected to be met by producers to warrant receipt of carbon finance upon selling their carbon credits.

Table 6: Monitoring milestones at different monitoring periods

Year	Monitoring Indicator
1	At least 50% plot established.
2	At least 75% plot established.
3	Whole plot established with 85% survival of trees.
4	Whole plot established with at least 90% survival of trees.
5	Average DBH not less than 4cm.
7	Average DBH not less than 8cm.
10	Average DBH not less than 15cm.

16.0 REFERENCES

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17.0 ANNEXES

17.1 Common pest and disease problems in Mangoes

Mangoes just like any other agricultural crop, is susceptible to pest and disease attack which affect productivity. Some of the common pests and diseases in mangoes are outlined below along with their recommended management practices (Guide to Agricultural Production and Natural Resources Management in Malawi):

17.3.1 Diseases

17.3.1.1 Anthracnose

- Caused by *Glomerella cingulata*.
- Causes discolouration of young leaves and premature ripening of fruits.
- Causes wilting and poor fruit set.
- Characterised by small, black sunken lesions on fruits.
- The lesions aggravate with wet weather, increasing in size, cracking the fruit and causing rotting.
- Tear staining may occur on fruit when spores are washed down from an infected twig or flower stalk.

17.3.1.1.1 Control of Anthracnose

- Spraying fungicides Captan, Dithane, Zineb and Maneb at 300g in 100 litres of water.
- Apply every three weeks after blossoming and later when the fruit has reached full development.
- Alternatively spray Benomyl (Benlate) 50WP at the rate of 15g in 10 litres of water.

17 3.1.2 Powdery mildew

- Caused by *Oidium mangifera* and attacks buds, flowers and young fruit.
- Leaves develop blotchy lesions and are malformed.
- Infected plant parts are covered in whitish powdery growth of the fungus hence the name.
- Cool weather aggravates the disease.
- Fruit set, size and quality are compromised.

17.3.1.2.1 Control of powdery mildew

- Spraying Benomyl (Benlate) 50 WP at the rate of 15g in 10 litres of water every two weeks.
- Maintain proper pruning of the trees to reduce build-up of humidity within the canopy.

17 3.2 Pests in mangoes

17.3.2.1 Weeds

- Keep the basins around the trees weed free and should be mulched to conserve moisture and suppress weeds.
- All the area outside the basins (within) the orchard and surrounding areas should be slashed and the grass kept short.

17.3.2.2 Mango stone weevil (*Sternochetus mangifera*)

- The larva enters the fruit during early stages of development.
- It leaves no external mark of entry with the fruit looking damage-free.
- Fruits fall prematurely from the tree and rot in transit, markets and storage.

17 3.2.2.1 Control of mango stone weevil

- Collect and burry all pre-maturely falling fruits as soon as they fall and should not be mixed with other fruit.

17.3.2.3 Mango fruit fly (*Ceratitis capitata*)

- Larvae bore into fruit making tunnels and bacteria take advantage and rot the fruit.
- Causes premature fruit fall.

17 3.2.3.1 Control of mango fruit fly

- All fallen fruits should be collected and buried as soon as they have fallen.
- Chemical control by spraying Fenthion (Labaycid) 50EC at a rate of 1ml in 2 litres of water.
- Sprays should start when the fruits have just formed.
- Harvest the fruit when physiologically mature and while still on the tree.