Action Plan for the control of the Oriental fruit fly

Bactrocera dorsalis (Hendel)

Compiled by:
Aruna Manrakhan (Citrus Research International),
Jan-Hendrik Venter (National Plant Protection Organisation of South Africa) and
Vaughan Hattingh (Citrus Research International)

agriculture,
forestry & fisheries

Department:
Agriculture, Forestry and Fisheries
REPUBLIC OF SOUTH AFRICA

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Table of contents

1. GENERAL INFORMATION 5

a. Action statement 5

b. Background information 5

(i) Origin & distribution 5

(ii) Host range 6

(iii) Demography 6

(iv) Attractants 6

2. SURVEY PROTOCOL 7

a. Detection survey 7

b. Delimiting survey 7

(c) Record keeping 8

(d) Monitoring survey 8

(e) Fruit survey 9

3. IDENTIFICATION 9

4. INFORMATION FLOW 9

a. Steering Committee (coordination, communication and decision making) 9

5. QUARANTINE 10

a. Determination of the quarantine area 10

b. Movement control. 10

c. Corrective and quarantine actions. 11

d. Awareness activities 11

e. Duration of quarantine 11

f. Areas under quarantine 11

6. ERADICATION PROCEDURES 12

a. Initiation 12

b. Eradication measures 12

i. Orchard and field sanitation 12

ii. Male annihilation Technique (MAT) 13

iii. Protein baiting 13

c. Sequence of events after a detection in a pest free area 14

d. Stock and materials required in preparedness of eradication 14

7. MANAGEMENT 15

8. ROLES AND RESPONSIBILITIES OF STAKEHOLDERS OR ROLE-PLAYERS 16
a. NPPOZA 16
b. Industry members participating in the BiSC 16
c. Universities 16
d. PDA and or Extension Services 16
e. Other research institution and commodity associations 17
f. Members of the public 17
g. Growers 17
9. IMPLEMENTATION PLAN SCHEDULE 17
The implementation plan schedule is depicted in the table below. 17
10. REFERENCES 19
Annexure 1: Traps and lures 24
Annexure 2: Surveillance protocol 25
Annexure 3: Phytosanitary measures for the control and management of Bactrocera dorsalis. 28
Annexure 4: Extensive host range of Bactrocera dorsalis. 42

1. GENERAL INFORMATION

a. Action statement

The action plan is a recommended response for survey, containment and eradication following a find of *Bactrocera dorsalis* in an area having an existing trapping network for exotic fruit flies. This plan also provides for options to control the fruit fly in areas where it is present. The action plan was developed for the South African *B. invadens* Steering Committee, to be convened under the auspices of the National Plant Protection Organisation (NPPOZA) of the South African Department of Agriculture, Forestry and Fisheries (DAFF). The action plan forms part of the South African Emergency Plant Pest Response Plan (SAEPPRP). However, this plan is available to any other SADC country (or the region) that may wish to make use of it. The action plan has been developed taking the principles of the International Plant Protection Convention (IPPC) and the relevant International Standards for Phytosanitary Measures (ISPM's) into consideration. Surveillance plays a crucial role in the implementation of this action plan. All official trapping records will be monitored and audited by the NPPOZA (DAFF). This action plan was previously developed for *Bactrocera invadens*. However, since *B. invadens* was synonymised with *B. dorsalis*, the action plan also changed to and action plan for *B. dorsalis*. The synonymisation of *B. invadens, B. philippinensis* and *B. papaya* with *B. dorsalis* took evidence of similarities in morphological characters, molecular structure, chemoecology and sexual compatibility between the four species as found in various research studies into consideration (Schutze et al. 2014a; Schutze et al. 2014b). The synonymisation lead to the distribution range of *B. dorsalis* to be much larger as well as the host range. More research data is available as well as pre- and post-harvest control measures. The common name for *B.dorsalis* is the Oriental fruitfly or (OFF).

b. Background information

(i) Origin and distribution

Bactrocera dorsalis originates from Asia and has invaded various parts of Africa. The fruit fly officially occurs in:

Asia: Bangladesh, Bhutan, Brunnei Darussalam, Cambodia, China, Christmas Islands,India, Laos, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam

Africa: Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Cape Verde, Central African Republic, Chad, Comoros, Congo, Democratic Republic of Congo, Equatorial Guinea, Ethiopia, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Ivory Coast, Kenya, Liberia, Madagascar, Malawi, Mali, Mauritania, Mayotte, Mozambique, Namibia*, Niger, Nigeria, Senegal, Sierra Leone, South Africa*, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia and Zimbabwe.

North America:

USA* - Hawaii

Oceania :

French Polynesia, Palau, Papua New Guinea

*Present only in specific areas in the country.

(ii) Host range

B. dorsalis is a polyphagous species and has to date been recorded from more than 200 host species belonging to more than 26 plant families. Pest compendia and pest action lists from various governments has listed hosts over many years. Many of the hosts listed cannot be confirmed to be hosts. However, the primary hosts of this pest remains to be mangoes and guavas. Additional to mangoes and guava the host listed in Regulation 110 of the Agricultural Pests Act, 1983 (Act No. 36 of 1983) must be inspected and regulated in the case of a *B. dorsalis* find and from areas where *B. dorsalis* is present. The host list presented in Annexure 4 is not exhaustive and can still be expanded.

(iii) Demography

The mean generation time for *B. dorsalis* in Africa was found to be 30.7 days at 28 ± 1º C. However, generation time is largely dependent on temperature. In order to determine phenological events in the field for monitoring and eradication purposes, it is important to determine the temperature-development rate of the pest. The developmental rates of *B. dorsalis* were determined at five constant temperatures of 15°C, 20°C, 25°C, 30°C and 35°C and a photoperiod of L12:D12.

The table below gives the published mean total developmental time of immature stages (egg to pupa) (days) obtained at varying constant temperatures for *B. dorsalis*.

TABLE 2 Mean total developmental time for immature stages of *B. dorsalis* (Rwomushana *et al*., 2008)

Temperature ºC	Mean total developmental time for immature stages , days
15	75.74
20	31.45
25	21.19
30	17.76

To predict the developmental rate of individual life stages, a temperature summation model can be used. This approach is based on the assumption that above some lower threshold for development, temperature-developmental rate relationships are linear and, therefore, a constant number of heat units, expressed as day-degrees above this threshold are needed to complete the development.

To calculate developmental times in fluctuating daily temperature regimes, the number of day-degrees per day can be determined by the formula $(T_{max} + T_{min})/2 - t$ with T_{max} being maximum temperature, T_{min} minimum temperature and t, the lower development threshold. The lower development threshold of *B. dorsalis* was found to be 8.8°C, 9.4°C and 8.7°C for the egg, larva and pupa.

(iv) Attractants

B. dorsalis responds to methyl eugenol which is a plant oil and attracts only males. Attractions of both sexes of the fly to protein hydrolysate and the 3-component (ammonium acetate, trimethylamine hydrochloride and putrecine) Biolure® Fruit Fly have also been reported.

2. SURVEY PROTOCOL

a. Detection survey

A regular surveillance programme throughout the year should be in place to detect any incursion of *B. dorsalis* and other exotic fruit flies in high risk areas which include points of entry such as border posts, sea ports and international airports as well as in production areas of known hosts and cities/towns/ villages close to the points of entry. Trapping with methyl eugenol and 3-component lure should be carried out to determine pest absence or presence. The official survey is carried out by DAFF with additional support from the relevant fruit industry bodies. DAFF may extend the surveillance to involve local and provincial departments of agriculture and other organs of state. This surveillance programme is supplemented with surveillance by each producer to demonstrate pest freedom in specified areas. Production Unit Surveillance (PUC surveys) may be audited by DAFF.

b. Delimiting survey

When one *B. dorsalis* is collected in a pest free area, a delimiting survey should be implemented immediately. This will include the placement of additional traps and fruit sampling as well as an increased trap inspection rate. The purpose of the delimiting survey is to asses if the detection represents an outbreak as described in ISPM. 26 (2006). Establishment of pest free areas for fruit flies (Tephritidae), and to determine the size of the affected area.

The area immediately surrounding the trap in which each *B. dorsalis* has been detected will form a core area of a 1 km x 1 km square grid. Methyl eugenol baited traps and Biolure® Fruit Fly (3-component lure) baited traps will each be placed at a density of 10 traps per km2 within the core area (Fig. 1 and Table 2). Moving outwards from the core area, there will be three surrounding zones of sizes 8, 16 and 24 km2. In each of the surrounding zones, the trapping density will be 2 methyl eugenol baited traps per km2. Additionally, radiating transects of about 100 km will be put into place from the third surrounding zone and will follow main road networks. Methyl Eugenol baited traps will be placed every 2 km for the first 10 km, every 5 km thereafter for the next 40 km and every 10 km for the 50 remaining km. Moreover, within 50 km radius of the core area, methyl eugenol baited traps will be placed in farms with orchards or fields containing host material. The density of traps in the farms will be determined by farm size, crops and extent of plantings. All traps will be serviced weekly, with core traps serviced daily for the first week. Traps will be maintained through three *B. dorsalis* generations (approximately 12 weeks) after the last fruit fly find.

If a fruit fly is found in an additional trap, a 1 km x 1km core area will be established around the fly find and traps will be placed at the same rate as mentioned above.
Trapping details are outlined in Annexure 2.

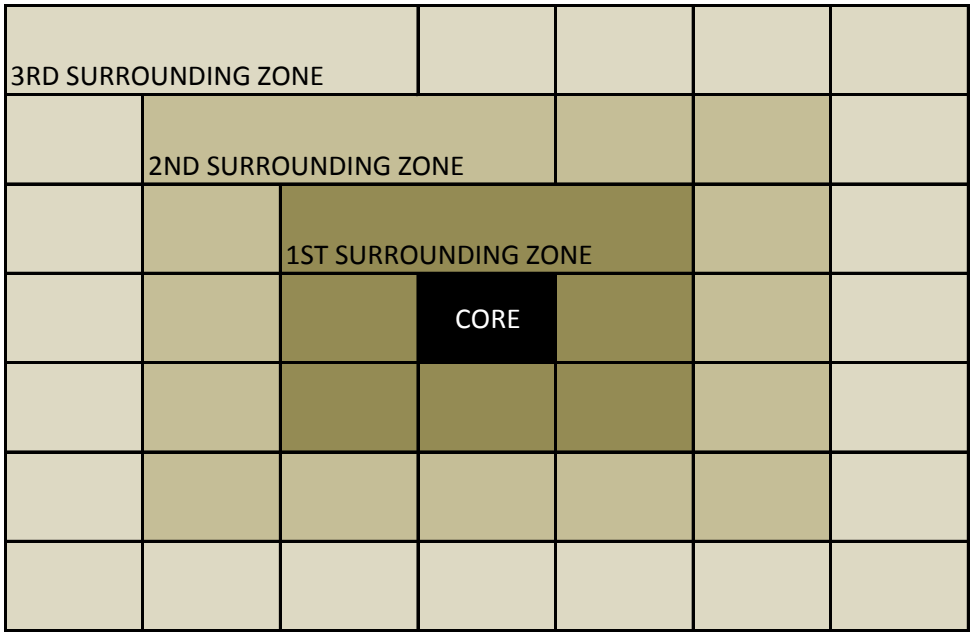


FIG. 1 Delimiting survey with single km^2 core area and three surrounding zones

TABLE 3: Trap density in core and surrounding zones

Zones	Area/km^2	Number of traps per km^2. Methyl Eugenol + Biolure 3C (Biolure 3 C only in core area)
Core	1	10+10
1st	8	2
2nd	16	2
3rd	24	2

(c) Record keeping

Record keeping is essential in a delimiting survey. The geographical coordinates of all traps should be taken and incorporated in a geographical information system. The location of traps should be geo-referenced with the use of global positioning system (GPS) equipment. Records of all trap inspections should be kept by the NPPO and should include trap number, date of servicing, outcome of servicing (catch/no catch), status of trap and replacement of trap in cases where it is gone or damaged, replacement of lure (yes/no).

(d) Monitoring survey

Trapping surveys for *B. dorsalis* will progress over time relative to changing status of the pest in the country. In Annexure 2, trap densities in different scenarios of *B. dorsalis* status are provided.

(e) Fruit survey

Host fruit from the survey or quarantine area should be surveyed, depending on host availability. Infested fruit will be collected and incubated for up to 6 weeks in sand in closed, aerated plastic containers in a facility within an affected area. Any pupae, third instar larvae or adult should be killed following emergence and preserved in alcohol or mounted for identification.

3. IDENTIFICATION

During detection and delimiting surveys, specimens should be collected and first screened by a local designated identifier. Any suspect specimen should be forwarded immediately to the local fruit fly expert in vials of at least 70% alcohol for confirmation.

If a positive ID is obtained from the local fruit fly expert, a Steering Committee should oversee the implementation of the quarantine, delimiting survey and eradication measures as described above. The effectiveness of the programme should be monitored periodically by the NPPO through review of documentation and procedures. All data must be captured in a database and the fruit fly numbers must be monitored in terms of fruit flies per trap per day (FTD) to measure the effectiveness of measures implemented.

For final confirmation of the fruit fly ID, the specimen should be sent to a fruit fly taxonomist. Care should be taken to ensure that reference samples are preserved in accordance with acceptable scientific procedures.

4. INFORMATION FLOW

a. Steering Committee (coordination, communication and decision making)

The SA *B. dorsalis* Steering Committee will oversee communication, co-ordination of actions and decision making in response to a *B. dorsalis* detection. Notifications to the international community will be done in consultation with this Steering Committee and in accordance with the requirements of the WTO SPS Agreement, the IPPC and relevant ISPMs, with which the national phytosanitary standard and operating procedures for pest reporting are aligned

The Steering Committee will consist of officials from the Department of Agriculture (representatives from each of the following: Directorate Plant Health, Directorate Inspection Services, Directorate Food Import and Export Standards) and representatives from each of the major affected industries (e.g. Citrus, deciduous fruits and sub-tropical fruits), a representative of fresh fruit exporters and a representative of fruit processors. The Steering Committee will be chaired by the Directorate Plant Health.

Members of the provincial department of agriculture affected or at high risk of being affected by the Invader fruit fly shall be co-opted if a need arise, to ensure thorough implementation and understanding of the control measures.

5. QUARANTINE

a. Determination of the quarantine area

Once a *B. dorsalis* specimen is caught in a trap in a previously pest free area and the identification is done with reasonable confidence by a competent entomologist, the area of the fruit fly detection is quarantined with immediate effect by means of an official order issued by DAFF to restrict movement of host material, in particular fruit listed above as *B. dorsalis* hosts, cannery waste and soil, through and out of the area to a pest free area .The initial minimum quarantine area will extend to a circular area of 5 km radius from the positive trapping point and must extend subsequently to each new fruit fly detection within the area. The delimiting survey will also be implemented immediately to determine the area of the infestation and therefore also any expansion of the initial quarantine area.

b. Movement control.

Removal of host material will be regulated in accordance with both relevant local legislation and international trade agreements and with assistance from local organs of state where necessary.

All growers (producers) and fruit sellers must comply with the conditions set by in an official order in terms of Section 7 of the Agricultural Pests Act, 1983, (Act No. 36 of 1983) and in terms of the control measures R110 to comply with a permit to remove fruit from an area. A permit may not be issued if the executive officer of the Act is not satisfied or convinced that the control measures used was effective to reduce the risk to a satisfactory level in order to prevent infested fruit to be removed from the affected area.

Regular fruit inspections will take place and larvae detected will be collected for identification. Larvae should be placed in sample bottles in ethanol (>70%). Fruit collected from reject bins at pack houses will be inspected. Fallen in orchards and fields will also be examined.

Areas where *B. dorsalis* is declared present will also be placed under quarantine. Such areas will be announced in the Government gazette and the removal of produce from such an area will be regulated by DAFF.

Road blocks should be implemented to regulate movement of fruits from the area. At any international point of entry or exit near a detection site, a mandatory check of passenger baggage should be implemented. The provincial and or local departments of agriculture from specific area should be involved with the arrangement and execution of road blocks on national roads.

All local growers, traders and hawkers in the area of the fruit fly detection, establishments within the area that handle fruits, cannery waste and soil, as well as the organs of state that would implement road blocks, should be notified of the threat posed by the fruit fly and actions that need to be taken through an activated emergency awareness programme.

c. Corrective and quarantine actions.

Corrective actions must be implemented when the status of a pest free area has been compromised or is in danger of being compromised. This may include phytosanitary measures to continuously lower the pest population in an area until it is no longer sustainable and the pest is eradicated from the area or to lower pest prevalence to an acceptable level.

Quarantine actions would be implemented to ensure safe removal of fruit from a quarantine area to a pest free area, moving consignments of host material should be covered with insect proof netting on its way to a juicing factory and each consignment should be accompanied by a removal permit issued by DAFF. These measures are extended to be implementable at the factory to prevent the potential further development of larvae in fruit especially in factory waste products.

Corrective measures as well as quarantine actions should be applied when the aim is to eradicate the pest from an infested area.

Annexure 3 provides basic phytosanitary measures (control measures) to be implemented to ensure compliance to quarantine measures and corrective actions.

d. Awareness activities

Awareness material should be kept ready to cater for different scenarios as well as different target audiences and in several local languages to ensure information flow and compliance with quarantine. It is important to observe all protocols before any activities can take place in especially rural villages (report to chiefs and local municipalities). A DAFF team together with local extension officers should engage with chiefs at tribal council meetings to present the whole *B.dorsalis* scenario and also make use of the opportunity to issue orders to the chiefs and municipal managers and also distribution of chemicals (Mat blocks & M3's) at these meetings.

e. Duration of quarantine

Quarantine in an area may be lifted after the pest has been declared eradicated or there has been no other *B. dorsalis* find for at least 3 generations (calculated from the local climate data, but at a minimum period of 12 weeks).

The quarantine period may be extended by DAFF depending on the prevailing weather conditions and the general level of compliance in relation to imposed phytosanitary conditions. Quarantine should be removed after the reinstatement of a pest free area (PFA).

f. Areas under quarantine

The NPPOZA may determine quarantine actions for the development and or maintenance of specific areas within its territory to contain, suppress or eradicate *B. dorsalis* other than a response to an incursion of a pest. Phytosanitary measures will be implemented to alter the existing status of this pest or to ensure the current status of the pest in the area.
These areas may include

- Pest free areas
- Pest free places of production
- Areas of low pest prevalence

- Buffer zones

Areas under quarantine may be natural owing to the pest not spreading into the area and as a result of geographical or biological barriers, or may be established through a dedicated control programme, which would include control measures.
Such areas must be defined and published in R110.

6. ERADICATION PROCEDURES

a. Initiation

Eradication of *B. dorsalis* should be initiated following the detection of a second *B. dorsalis* fruit fly in the delimiting survey area. The total area of coverage will depend on the extent of spread. For each *B. dorsalis* fruit fly find, the area under eradication will require to be according to a minimum standard of 25 km^2 surrounding the trap site. Duration of eradication measures should be planned for at least 2 generations of *B. dorsalis* (generation estimated based on local climatic conditions but generally should be estimated for about 8 weeks). Trapping to verify eradication should continue for at least one *B. dorsalis* generation (generally 4 weeks) after eradication measures have stopped (no more placement of fresh male annihilation blocks).

b. Eradication measures

This fruit fly should be controlled utilizing as many control techniques as possible to ensure eradication.

These include a combination of cultural and chemical control methods, which can be further supplemented with biological control and biotechnology.

Cultural control methods include orchard and field sanitation and removal of unwanted or uncontrolled host plants. Chemical control methods should make use of agricultural chemicals such as the placement of male annihilation blocks and the application of bait sprays.

i. Orchard and field sanitation

Sanitation is crucial not only at commercial production sites but also in surrounding areas such as at home gardens, subsistence, small scale or communal farms as well as at towns, villages and ports of entry in the quarantine area. Fruit stripping should be considered as a contributory measure to sanitation, where appropriate.

Removal of fallen fruit or fruit left over after harvest must be carried out on a weekly basis. Fruit and wet waste at processing, packing and shipping points throughout the distribution chain, must be collected and included in the sanitation program in affected areas.

Fruit removed should be buried at least 50cm deep and covered on a daily basis. The burial site should be located within the quarantine area. However, other methods of sanitation may be considered by the executive officer. Alternative methods of sanitation will only be approved if they deliver the same level of protection as fruit burying.

ii. Male annihilation Technique (MAT)

This will involve the distribution of square (5cm x 5 cm) 1.3 cm thick fibre-board/soft board blocks soaked in a mixture of methyl eugenol and malathion EC (500g/L) placed at a density of 400 per km^2, either nailed to poles or hung from trees (10 000 blocks per 25 km^2 fly-detection unit). MAT blocks can be procured from several suppliers in a pre-manufactured form. A single application of MAT blocks will cover a period of 8 weeks.

Male annihilation can also be carried out by applying STATIC Spinosad ME*.

STATIC Spinosad ME* may be applied as small, or large droplet spot applications to stakes, posts, fences, artificial targets, or non-edible border vegetation surrounding orchards or fields, or in urban areas. The product should be applied to application stations which are not readily accessible to the public. This would include telephone poles, light poles, fences, other inanimate objects out, non-crop tree trunks or limbs and non-edible foliage which are out of the general reach of children. STATIC Spinosad ME* should not be applied directly to fruit trees (Stems/trunks or any edible parts of plants or surfaces that might come into contact with edible plants or other edible produce).

Application techniques can range from application of dollops using a spatula or other spreading implement to mechanical or pneumatic meter-jet capable of delivering large droplets. Aerial applications are not permitted.

Application stations are created at intervals of 5 to 6m by applying 2 to 4ml of STATIC Spinosad ME* at every application station. Approximately 138 application stations are required per hectare. This will amount to approximately 250 to 500ml of STATIC Spinosad ME* used per ha as the number of application station can be reduced if more Static is applied per application site.

STATIC Spinosad ME* may be re-applied after 6 to 8 weeks if there are still *B. dorsalis* specimens detected in delimiting traps in the affected area.

iii. Protein baiting

Protein bait sprays should be carried out weekly. The toxicants that may be used in combination with the protein hydrolysate are malathion. GF-120 (containing spinosad) that includes the attractant is commercially available as the organically certified product GF120. (GF-120 should not be mixed with prot hydrolystate as it contains the attractant in the formulation).

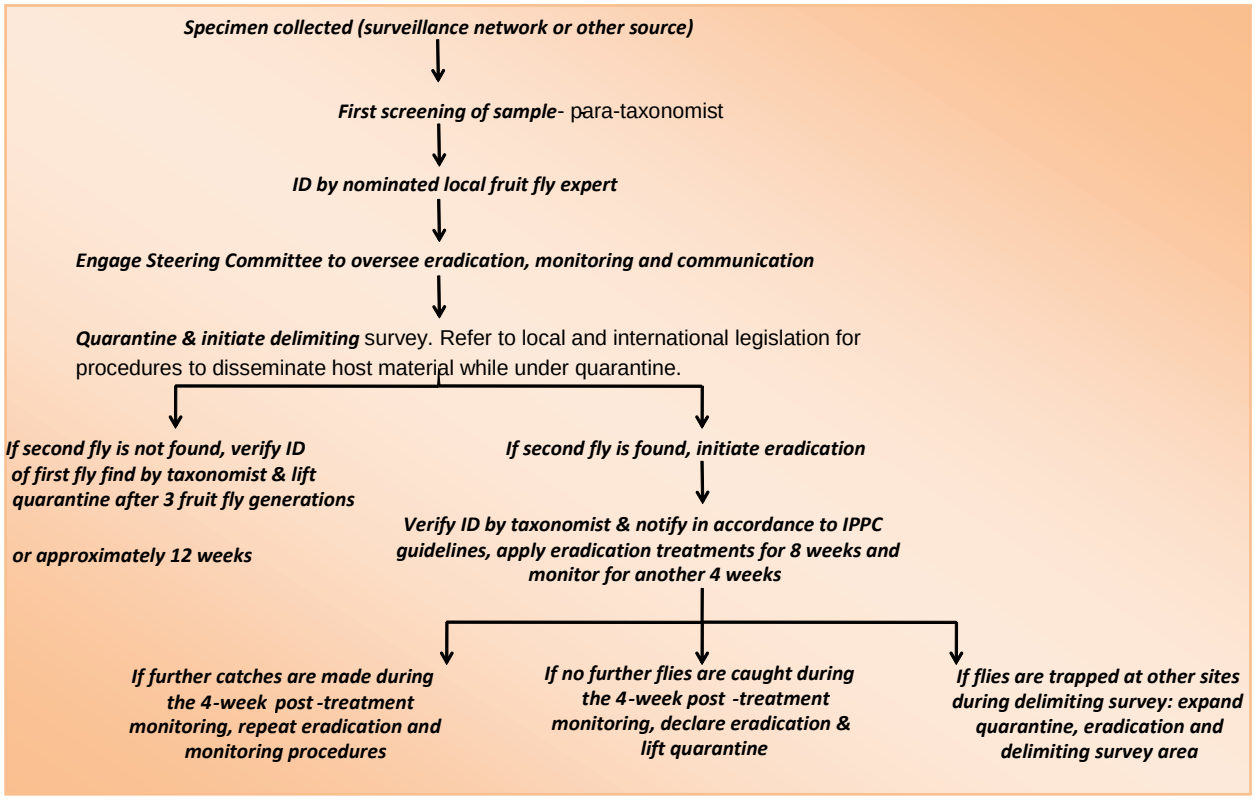
In production areas, aerial bait sprays will be the most viable and effective option. Protein hydrolysate (Hymlure 425 g/L) in combination with malathion UL (1130 g/L) is registered for aerial application as a bait using Hymlure 750 ml and malathion UL 250 ml/ha (75 + 25 L per km^2 and 1 875 + 625 L per 25 km^2). This amount will be required every week. Alternatively, GF 120 can now be used at 1 L per ha in a spray mix with 1-3 L of water (100 L per km^2 and 2500 L per 25 km^2). GF-120 is certified as an organic insecticide, with only a 1 day withholding period. Where possible, applications in an eradication programme should favour the use of GF120 when certified organic farms are treated.

If protein bait is applied from the ground, it should preferably be applied on host trees. The registered bait mixture is 400 ml Hymlure and 175 ml Malathion EC (500 g/l) in 100 L of water per ha (40 L + 17.5 L per km^2 and 1000 L + 437.5 L per 25 km^2) and for GF-120, the registered dilution

is 1-1.2 L in 4-29 L water which is then applied to every hectare (100 L in 2000 L per km^2 and 2500 L in 50 000 L per 25 km^2).

M3 fruit fly bait stations can also be used as a protein bait method. This is the most appropriate method in areas which include towns and villages and where bait spraying is not possible. M3 bait stations are deployed at a density of 300-400 units per ha depending on crop type. M3 bait stations should also be placed close to or at fruit and vegetable road stalls and open markets within affected areas.M3 bait stations must be replaced after 3- 4 months.

c. **Sequence of events after a detection in a pest free area**



d. Stock and materials required in preparedness of eradication

Materials should be kept at designated facilities in preparedness for a potential outbreak of *B. dorsalis* in new areas. The stock is essential to be able to initiate a delimiting survey and eradication

procedures without delay. In the event of an incursion and eradication actions being initiated, replacement of such stock must commence immediately. In the absence of an outbreak, stock of attractants and insecticides should be replaced every 2 years.

For eradication, the quantity of materials to be stockpiled in preparation will be based on units of one fly detection site and 2 months of eradication (which might be for 2 generations of *B. dorsalis* if temperature is at 28°C). The area of coverage around each fly detection site will be 25 km^2 as mentioned previously. The extent of stock piling (in multiples of single detection site units) is to be determined by the Steering Committee. The following will therefore be required per detection site (one unit):

i. 10, 000 fibre board blocks (5 cm x 5 cm x 1.3 cm)

ii. 150 L Methyl Eugenol

iii. 5000 L of UL Malathion

iv. 500 L of Malathion EC (500 g/L)

v. 15 000 L of HymLure

vi. 300 000 M3 bait stations

For delimiting , the amount of materials required would be based on one fly detection and 3 months of trapping. Four radiating transects will be calculated from the zone surrounding the core area. The minimum number of traps and lures for eradication must be stockpiled as followed.

i. 164 Bucket traps

ii. 522 Methyl Eugenol dispensers

iii. 30 Biolure 3C dispensers

iv. 552 DDVP strips

Note that trapping densities should increase from 2, to 3 to 5 ME traps per km^2 during eradication according to Annexure 2 in eradication areas adjacent to and subsequent to the outbreak area where the initial delimiting surveillance plan was implemented.

7. MANAGEMENT

Management actions may be necessary in areas where *B. dorsalis* are present to lower or suppress population numbers to such an extent to minimize natural dispersion and to increase crop productivity. It may furthermore, be crucial when eradication is not feasible in some areas due to high and continuous incursion pressure from the surrounding infested areas. These will be followed on a voluntary basis by producers except when such measures need to be imposed in order to remove host material from an area. A systems approach may need to be followed to obtain the best possible results with a combination of dependent and independent measures. Such measures may also be implemented already to ensure an appropriate level of protection to remove fruit from an area.

Management measures should be a combination of cultural and chemical control measures.

DAFF will ensure management measures are implemented in such areas after consultation with local producers industry members the local community. However basic phytosanitary measure could be followed as indicated in Annexure3 and in terms of R110 for removal control.

8. ROLES AND RESPONSIBILITIES OF STAKEHOLDERS OR ROLE-PLAYERS

a. NPPOZA

- lead the implementation of the contingency plan for the OFF
- provide resources in terms of human resource and funding for project needs
- Are responsible for official international & domestic reporting
- Are responsible for ensuring training and capacity building to all the participants. (training can be outsourced where possible)
- lead the coordination of the activities for this plan

b. Industry members participating in the BiSC

- The industry shall assist the NPPOZA in implementing the Contingency plan
- The industry shall assist the NPPOZA with human resource, technology and funding
- The industry shall assist in executing both the field surveys, laboratory tests and documentation.
- The industry shall assist in conducting the research

c. Universities

- University students may be lobbied to participate in the surveys and any other possible activity of the project as part of increasing the capacity.
- Universities may assist with development of technology, procedures or any innovative intervention in relation to this action plan.

d. PDA and or Extension Services

- PDA Coordinator shall represent the province in the BiSC if a need arise.
- The extension officers can assist in doing eradication and awareness on the ground
- The extension officers can assist in reporting suspected illegal movement of host fruit from quarantine areas to non quarantine areas.
- The extension staff shall assist in conducting roadblocks if a need arise.
- The extension staff can assist in monitoring the fruit fly damage on the ground (not necessarily OFF alone)
- PDA shall assist in assembling coordination structures with districts and local municipalities.
- PDAs, districts and local municipalities shall take full responsibility to manage the fruit fly in case it gets established (Working with PDAs from the initial stage is quite critical in building the capacity and preparation for handover in case the pest get established)

e. Other research institution and commodity associations

- Other research institutions like ARC shall assist in conducting research and co-opted to the BISC if a need arise
- Other commodity associations must inform the NPPOZA of any visible damage by OFF and make inputs on possible control measures

f. Members of the public

- Comply with R110
- Do sanitation in home gardens and or backyard fruit trees
- Comply with the national and import control measures for OFF
- Apply a registered chemical for chemical control but ensure male annihilation and bait application

g. Growers

- Comply with R110
- Growers should assist in reporting to the department any suspect of the disease
- Report illegal movement
- Help the department in implementing the survey and eradication
- Apply good agricultural practices or integrated pest management (sanitation, chemical control (MAT, BAT), prompt harvesting, comply to national movement control of host crops)
- Apply for removal control permits and implement the regulations

9. IMPLEMENTATION PLAN SCHEDULE

The implementation plan schedule is depicted in the table below.

Key Areas	Activity	Responsible unit	Period	Target provinces	Costs
Surveillance	Procurement of Surveillance buckets, lures Servicing of traps & reporting Fruit cutting Specimen collection & Lab tests	DAFF-Directorate: Plant Health (D: PH) Directorate: Inspection Services D: IS, D: PH & industry	When a need arise Regularly Regularly	All All	Determined by the extent of the area to be covered
Delimiting survey	Mapping Issuing of permits	D: IS & D: PH D: IS	When a need arise	Affected areas in any of the	Transport and accommodation

				affected province	costs involved
Eradication	• Procurement of MAT Blocks, M3 bait stations and spraying chemicals • Coordination of teams for eradication • Distribution of chemicals • Compile a quarterly eradication report to guide the review of the impact	DAFF - D: PH PDAs/Farmers/villagers D: PH- EWS in collaboration with the province, districts and local municipalities D: PH -EWS	When a need arise When a need arise When a need arise Quarterly	Affected areas in any of the affected province	Accommodation costs determined by number of official and size of the area involved Costs for eradication material depends on the size of the affected areas
Awareness	• Sending notification to mangers in the PDA, districts and local municipalities • Distribution of leaflets • Issuing of the media release • Facilitate the staging of press conference • Facilitate the use of various media houses • Compile a quarterly report for quarterly review	D: FIES - PHP	When a need arise Regularly If a need arise If a need arise If a need arise Quarterly		Costs determined by the number of
Roadblocks	Facilitate the staging of	NPPOZA	When a need	Affected areas in	

	the roadblock (engage municipality traffic department, engage other department such as police, Roadblock alert	D: FIES – PHP	arise When a need arise	any of the affected province	
Financial management	Budget and expenditure review of the Bi activities (monitor the expenses and tabulated the future budget)	NPPOZA, PDAs & BiSC	Regularly	All	
Stakeholder engagements	• Organise meetings with the affected provinces, Schools, Traditional leaders • Reporting on the stakeholder engaged	NPPOZA, PDAs, Districts, lLocal municipalities, industry	When a need arise	All	
Legislation review and update	• Update and review of the R110 of the Agricultural Pests Act of 1983	D: PH –PNS	When a need arise	ALL/affected areas	Accommodation and transportation fees during consultation may be incurred
Monitoring and evaluation	• Progress review and recommendation	BiSC, NPPOZA directorates	Regularly	All	

10. REFERENCES

Aluja, M. & Mangan, R.L. (2008) Fruit fly (Diptera: Tephritidae) host status determination: Critical conceptual and methodological considerations. *Annual Review of Entomology* 53: 449-472.

CABI. 2015. Invasive Species Compendium. http://www.cabi.org/isc/datasheet/17685. Date of Access: 3 February 2016.

Cantrell, B., Chadwick, B. & Cahill, A. (2002) Fruit fly fighters: eradication of the papaya fruit fly. Series: SCARM Report No. 81. Commonwealth of Australia and each of its States and Territories. CSIRO Publishing, Collingwood, Australia.

CDFA. 1996. Exotic Fruit Fly Regulatory Response Manual. California Department of Food and Agriculture. Plant Health and Pest Prevention Services. Pest Exclusion Branch. https://www.cdfa.ca.gov/plant/pe/EFFRRM/. Date of Access: 12 February 2016.

Clift, A.D., Meats, A. & Gleeson, P. J. (1998) A dispersal model for papaya fruit fly Bactrocera papaya Drew and Hancock and its application to treatment priorities in an eradication protocol. In: Pest management- future challenges, Vol. 2. Ed by Zalucki MP, Drew RAI, White G, 6th Australasian Applied Entomology Research Conference, Brisbane, 27-31

Correia, A.R.I., Rego, J.M. & Olmi, M. (2008) A pest of significant economic importance detected for the first time in Mozambique: *Bactrocera invadens* Drew, Tsuruta & White (Diptera: Tephritidae: Dacinae). *Bollettino di Zoologia Agraria e di Bachicoltura* 40: 9-13.

De Graaf, J. (2010) Host Status of Avocado ('Hass') to *Ceratitis capitata*, *Ceratitis rosa*, and *Ceratitis cosyra* (Diptera: Tephritidae) in South Africa. *Journal of Economic Entomology* 102: 1448-1459.

De Meyer, M., Mohamed, S. & White, I.M. (2012) *Invasive fruit fly pests in Africa*. http://www.africamuseum.be/fruitfly/AfroAsia.htm. Date of access: 18 September 2013.

Drew, R.A.I., Tsuruta, K. & White, I.M. (2005) A new species of pest fruit fly (Diptera: Tephritidae: Dacinae) from Sri Lanka and Africa. African Entomology 13, 149-150

Ekesi, S. & Billah, M.K. (2006) *A Field Guide to the management of economically important Tephritid fruit flies in Africa*. ICIPE Science Press Nairobi, Kenya. 206 pp.

Ekesi, S. Nderitu P.W. & Rwomushana I. (2006) Field infestation, life history and demographic parameters of the fruit fly *Bactrocera invadens* (Diptera: Tephritidae) in Africa. Bulletin of Entomological Research 96: 379-386

European and Meditteranean Plant Protection Organisation (2008) *Bactrocera invadens* (Diptera: Tephritidae) A new fruit fly species. EPPO alert list

FAO (1998) International standards for phytosanitary measures ISPM No.8 Determination of pest status in an area, Secretariat of the International Plant Protection convention

FAO (2002) International standards for phytosanitary measures ISPM No.17 Pest reporting, Secretariat of the International Plant Protection convention

FAO (2006) International standards for phytosanitary measures ISPM No.26 Establishment of pest free areas for fruit flies (Tephritidae), Secretariat of the International Plant Protection convention

Fay, H.A., Drew, R.A.I &Lloyd, A.C. (1997) The eradication program for Papaya fruit flies (Bactrocera papayae Drew & Hancock) in North Queensland. In: Management of fruit flies in the Pacific. A regional symposium Ed by Allwood AJ &Drew RAI, ACIAR, Nadi, Fiji, 259-261

Fletcher, B.S. (1989) Temperature-development rate relationships of the immature stages and adults of tephritid fruit flies. In: Fruit flies: their biology, natural enemies and control Vol 3A Ed by Robinson A.S. & Hooper C., Amsterdam, Elsevier

Goergen, G., Vayssières, J.F., Gnanvossou, D., & Tindo, M. (2011) *Bactrocera invadens* (Diptera: Tephritidae), A new invasive fruit fly pest for the Afrotropical region: Host plant range and distribution in West and Central Africa. *Environmental entomology* 40: 844-854.

Grout, TG. Daneel, J.H., Mohamed, S.A., Ekesi, S. Nderitu, P.W., Stephen, P.R & Hattingh, V. (2011) Cold susceptibility and disinfestation of *Bactrocera invadens* (Diptera: Tephritidae) in oranges. *Journal of Economic Entomology* 104:1180-1188.

Hallman, G.J., Myers, S.W., Jessup, A.J. & Islam, A. (2011) Comparison of in vitro heat and cold tolerances of the new invasive *Bactrocera invadens* (Diptera: Tephritidae) with three known tephritids. *Journal of Economic Entomology* 104: 21-25.

IAEA (2000). Action Plan, peach fruit fly, *Bactrocera zonata* (Saunders)

Lux, S.A., Copeland, R.S., White, I.M., Manrakhan, A. & Billah, M.K. (2003) A new invasive fruit fly species from the *Bactrocera dorsalis* (Hendel) group detected in East Africa. Insect Science and its Applications 23(4):355-361

Manrakhan, A., Hattingh, V., Venter, J-H. & Holtzhausen, M. (2011) Eradication of *Bactrocera invadens* (Diptera: Tephritidae) in Limpopo Province, South Africa. *African Entomology* 19: 650–659.

Meats, A., Fay, H.A.C. & Drew, R.A.I. (2008) Distribution and eradication of an exotic tephritid fruit fly in Australia: relevance of invasion theory. Journal of Applied Entomology 132:406-411

Messenger, P.S. & Flitters, N.E. (1954) Bioclimatic studies of three species of fruit flies in Hawaii. Journal of Economic Entomology 47(5):756-765

Mwatawala, M.W., De Meyer M., Makundi, R.H. & Maerere, A.P. (2006) Seasonality and host utilization of the invasive fruit fly *Bactrocera invadens* (Dipt. Tephritidae) in central Tanzania. Journal of Applied Entomology 130(9-10): 530-537

Mwatawala, M.W., De Meyer M., Makundi, R.H. & Maerere, A.P. (2006) Biodiversity of fruit flies (Diptera: Tephritidae) in orchards in different agro-ecological zones of the Morogoro region, Tanzania. Fruits 61:321-332

Mwatawala, M. W., De Meyer, M., Makundi, R. H., & Maerere, A. P. (2009) Host range and distribution of fruit-infesting pestiferous fruit flies (Diptera, Tephritidae) in selected areas of Central Tanzania. *Bulletin of Entomological Research* 10: 1-13.

North American Plant Protection Organization (2007) *Bactrocera invadens* Drew, Tsuruta & White Phytosanitary alert system. www.pestalert.org

Rwomushana, I., Ekesi, S., Ogol, C. K. P. O., Gordon, I. (2008) Effect of temperature on development and survival of immature stages of *Bactrocera invadens* (Diptera: Tephritidae) Journal of Applied Entomology.doi:10.1111/j.1439-0418.2008.01318.x

Schutze M.K. et al. (2014a) Synonymization of key pest species within the *Bactrocera dorsalis* species complex (Diptera: Tephritidae): taxonomic changes based on a review of 20 years of integrative morphological, molecular, cytogenetic, behavioural and chemoecological data Systematic Entomology:n/a-n/a doi:10.1111/syen.12113

Schutze M.K. et al. (2014b) One and the same: integrative taxonomic evidence that *Bactrocera invadens* (Diptera: Tephritidae) is the same species as the Oriental fruit fly *Bactrocera dorsalis* Systematic Entomology doi:10.1111/syen.12114

USDA. 2015. Bactrocera dorsalis, Oriental Fruit Fly Host List. United States Department of Agriculture Animal and Plant Health Inspection Service. https://www.aphis.usda.gov/aphis/ourfocus/planthealth/plant-pest-and-disease-programs/pests-and-diseases/fruit-flies. Date of Access: 12 February 2016.

Vargas, R., Walsh, W.A., Kanehisa D., Stark, J.D. & Nishida, T. (2000) Comparative demography of three Hawaiian fruit flies (Diptera: Tephritidae) at alternating temperatures. Annals of the Entomological Society of America 93(1):75-81

Vayssieres, J.F., Goergen, G., Lokossou, O., Dossa, P. & Akponon, C. (2005) A new *Bactrocera* species in Benin among mango fruit fly (Diptera: Tephritidae) species. Fruits (60):371-377

Vayssières, J., Korie. S. & Ayegnon, D. (2009) Correlation of fruit fly (Diptera Tephritidae) infestation of major mango cultivars in Borgou (Benin) with abiotic and biotic factors and assessment of damage. Crop Protection 28: 477–488.

Vayssières, J-F., Sinzogan, A., Korie, S., Ouagoussounon, I. & Thomas-Odjo, A. (2009) Effectiveness of Spinosad Bait Sprays (GF-120) in controlling mango-infesting fruit flies (Diptera: Tephritidae) in Benin. *Journal of Economic Entomology* 102:515-521.

Ware, A.B., Du Toit, C.L.N., Mohamed, S.A., Nderitu, P.W. & Ekesi, S. (2012) Cold tolerance and disinfestation of *Bactrocera invadens* (Diptera: Tephritidae) in 'Hass' Avocado. *Journal of. Economic. Entomology* 105: 1963-1970

Ye, H, Liu, J.H. (2005) Population dynamics of the Oriental fruit fly, *Bactrocera dorsalis* (Diptera : Tephritidae) in the Kunming area, southwestern China. *Insect Science* 12: 387–392.

Annexures

Annexure 1: Traps and lures

Methyl Eugenol baited trap

The locally available Morocco trap, Lynfield trap, Chempac Bucket trap and McPhail trap can be used. The Methyl Eugenol dispenser should be suspended/placed inside the trap. A 1 cm x 1 cm Dichlorvos DDVP block should also be placed at the bottom of the trap to kill any attracted flies.

Biolure® Fruit Fly 3-component baited trap

The locally available Chempac Bucket trap or the less conspicuous Moroccan type trap (in areas more prone to trap theft) can be used. Biolure 3-component consists of Ammonium Acetate, Trimethylamine and Putrescine commercially available in the form of membrane dispensers. These dispensers should be stripped open and placed at the bottom of the trap (avoid sticking the dispenser to the trap since flies can be trapped on the sticky materials) and a 1 cm x 1 cm Dichlorvos block should also be placed at the bottom of the trap to kill any attracted flies.

Trap handling and placement

Maximum precaution is required to avoid contamination on the outside of the trap. A wire should be used to suspend the trap on a tree. The trap should be placed at 1,5 m above ground, preferably on a host tree. The wire should be coated with a sticky material (e.g. Stickem, Tanglefoot) or grease to avoid entry of ants. Foliage touching the trap should also be removed to prevent entry of ants. For both attractants mentioned above and insecticides, a period of 6 weeks is optimum before replacement.

The trap should be placed preferably in a secure location (e.g. back garden, hotel compound) following arrangements with the owner. Good public relations are important. The trap should be labelled and fitted with other labels indicating the presence of an insecticide. Once the trap is placed, the co-ordinates of the trap must be taken and details of its location (e.g., province, town, habitat type).

Trap servicing

A fine hairbrush should be used to collect specimens from the trap. Separate hairbrushes should be used for Biolure baited and Methyl Eugenol baited traps in order to avoid contamination between trap types. The specimens should be collected into a vial that is properly labelled with a pencil and preserved in 70% alcohol before shipping for screening/identification.

During rebaiting, old attractants, insecticides and packaging materials must be collected and disposed of in bins far away from the trapping site. Dates of rebaiting should be noted.

Annexure 2: Surveillance protocol

This annex describes how trapping surveys for *Bactrocera dorsalis* will progress over time relative to changing status of the pest in the country. Information provided has been based on existing fruit fly trapping guidelines (IAEA 2003, FAO 2008).

2.1 Trap densities

Different trap densities will apply to the following scenarios of *B. dorsalis* status. Table 3 presents the changes in trap densities following incursion of the pest.

a. Detection or exclusion surveillance (*B. dorsalis* not in the country). The pest population is absent from the country. Surveillance is carried out for detecting entry of the pest and ongoing verification of country pest freedom. Trapping will be conducted at selected sites in identified risky areas. Sites will include points of entry, production, road transects and urban areas. Trap density will vary according to sites with 3-12/km2 traps at points of entry, 1-2 traps / km2 in selected production sites (farms), one trap every 10km on selected road transects and 1-5 traps/km2 in selected towns or areas in towns. Methyl Eugenol baited traps will be used in all sites. At points of entry and in towns, traps baited with Biolure 3 component will also be set. When the two attractants are used, different attractants will be combined to reach the total number.

b. Monitoring survey to determine eradication of incursion (*B. dorsalis* only in part of the country as a point incursion that is under quarantine and subject to eradication). When one *B. dorsalis* is detected in an area, a delimiting survey will be implemented immediately to determine the extent of spread and should be continued for three generations after the first interception (approximately 12 weeks). Eradication will be conducted if there is a second fly find within the outbreak area during the 12 week period. The frequency of road transects will be increased or new ones be implemented. Transects will follow main road networks. Trapping to verify eradication in the outbreak area will continue for one generation (4 weeks) after eradication measures have stopped. The detection area will be quarantined until the pest has been declared eradicated or there is no other fly find for 3 generations (12 weeks). Following lifting of quarantine restrictions, surveillance similar to (A) will be resumed in the affected area. Surveillance similar to (A) will be ongoing in other non-affected areas. During the process of delimitation and eradication new risk areas may be identified and the composition of the survey in (A) might change, focusing in new areas.

c. Monitoring survey for eradication of an established but localised population (*B. dorsalis* is established in a small part of the country and subject to containment and eradication). The pest population is present in a small part of the country and is subject to eradication. Surveys

are required to monitor progress of the control measures in the affected area. The latter will be subject to quarantine restrictions until eradication is confirmed to prevent spread of pest throughout the country. Radiating transects of about 100 km with decreasing trap intervals from eradication area will be set and will follow main road networks. Surveillance activities similar to (A) will be ongoing in non-affected parts of the country.

d. Monitoring survey of an established population in part of the country no longer subject to containment but suppression continues. The pest population is established in part of the country and no longer subject to containment. In part of the country, where the pest is present, monitoring will be carried out to determine pest population level and efficacy of control. In the other parts of the country, surveys to determine pest free areas will be implemented. Trap densities will be the same as in (A) for all site types except production areas where trap density will be per unit km2 instead of per farm. All production areas in the designated pest free area will be included in the survey.

2.2 Trapping records

All trapping records must be kept and made available to the NPPO of the importing country on request. The following information must be included: trap location, plant where trap is placed, trap and attractant type, date trap is set, servicing and inspection dates and target fly catches. Flies catches should be expressed as flies per trap per day (FTD) which is the average number of flies of the target fly (*B. dorsalis*) captured per trap per day during a specified period in which the trap was exposed in the field.

FTD of an area at any specified time is obtained by dividing the total number of target flies captured by the product of the total number of inspected traps in the area and the average number of days that the traps were exposed.

FTD = F/ T x D

Where,

F= total number of flies

T= number of inspected traps

D = average number of days traps were exposed in the field.

2.3 Supervision activities

The NPPOZA should regularly assess the quality of the materials used, servicing, placement, sample collection and dispatch , identification and reviewing the effectiveness of the use of these materials and trapping procedures.

Trap densities under different scenarios following *B. dorsalis* incursions in the country. Methyl Eugenol will be used as attractant in all surveys. Biolure 3 component will also be used in delimiting surveys (B) in the core outbreak area. When two attractants are used, different attractants can be combined to reach the total number as indicated below.

<table>
<tr><td rowspan="3">Areas</td><td colspan="5">Trap density per km^2 under different scenarios</td></tr>
<tr><td>B. Eradication of incursion</td><td colspan="2">C. Eradication of established population</td><td colspan="2">D. Establishment of pest in part of country (Monitoring)</td></tr>
<tr><td>Outbreak area</td><td>Eradication area</td><td>Delimiting survey in surrounding areas</td><td>Control areas (pest presence)</td><td>Pest free areas</td></tr>
<tr><td>Production</td><td rowspan="4">20 (10ME) (10Bio) in core area (1 km2) and 2 in each of three surrounding zones (8, 16 and 24 km2)2. Radiating transects of about 100 km with decreasing trap intervals from the third surrounding zone will be set. Traps will be placed every 2 km for the first 10 km, every 5 km for the next 40 km and every 10 km for the remaining 50 km.</td><td>3-5</td><td rowspan="4">Radiating transects of about 100 km with decreasing trap intervals from the border of eradication area will be set. Traps will be placed every 2 km for the first 10 km, every 5 km for the next 40 km and every 10 km for the remaining 50 km.</td><td>2-4</td><td>1</td></tr>
<tr><td>Marginal</td><td>3-5</td><td>1-2</td><td>1</td></tr>
<tr><td>Urban</td><td>3-5</td><td>0.25-0.5</td><td>1-5</td></tr>
<tr><td>Points of entry</td><td>3-5</td><td>0.25-0.5</td><td>3-12</td></tr>
</table>

1 Trap density could also be per town or point of entry instead of per km^2 depending on the total surface area of a point of entry or selected risk areas within bigger town or cities.

2 Trapping density could increase from 20-50 traps/km^2, especially in the core.

References

IAEA (2003). Trapping guidelines for area-wide fruit fly programmes. Joint FAO/IAEA Division, Vienna, Austria.

FAO (2008). Fruit fly trapping, Appendix 1 to ISPM No. 26 (Establishment of pest free areas for fruit flies (Tephritidae).

Annexure 3: Phytosanitary measures for the control and management of <u>Bactrocera dorsalis</u>.

Bactrocera dorsalis is controlled according to R110 of the Agricultural Pests Act, 1983 (Act No. 36 of 1983) or the APA. Basic phytosanitary measures must be implemented in affected areas as part of the eradication/control measures. Fruit movement out of *B. dorsalis* affected areas would only be allowed following implementation of the basic phytosanitary measures within the affected areas.

1. AREAS AND CONTROL

1.1 Areas where *B. dorsalis* is present

The pest name is removed from R110 of the APA as a prohibited insect for areas where *B. dorsalis* is present. Official, control remains, and movement control should be implemented when fruit is removed from an area where the pest is present to an area where it is absent or to an area under eradication. All other control actions to manage the pest are the producer's responsibility.

Any land user or person who intends to move host material of *B. dorsalis*, from an infested area into a pest free area must apply for a permit to do so. Inspection for the purpose of issuance of a removal permit is on request and payable according to prescribed tariffs (eg. R212 per 30 minutes or part thereof). Consignments may be inspected at production, packing or arrival points and may be rejected.
Removal permits requires phytosanitary conditions. The phytosanitary conditions will describe the actions to ensure a minimum probability of infestation before removal, during transport and packing as well as storage inside infested areas. It may also describe conditions to ensure traceability and due diligence with regard to road accidents involving fruit spillage, etc in pest free areas. The phytosanitary conditions will have to include as a minimum general requirement, an orchard or field sanitation programme, a programme to ensure male annihilation (application of MAT blocks) and a bait application programme. Land users must be aware that if they intent to sell their produce directly to a marketer, retailer group or a fresh produce market inside an infested area they still have to comply with pest suppression measures if the produce is anticipated to be moved by the marketer, retailer or any buyer from the fresh produce market to possible pest free areas. In practice it means that if the land user did not comply by applying pest suppression methods to lower his numbers the buyer would not be able to remove the produce from the market. It is therefore best for the land users to apply for removal permits. The producer/land user can procure registered agricultural chemicals to control OFF such as, MAT blocks, bait sprays and 3 bait stations to keep the fruit fly numbers under control to avoid infestation of fruit and fruit production losses.

Monitoring surveillance would continue together with detection surveys for other exotic fruit flies such as *B. dorsalis, B. zonata,* and *B. latifrons* and *Zeugodacus cucurbitae* on a once a month surveillance action. Such an area may require a surrounding buffer zone with a low pest prevalence which would also be under official control.

1.2 Areas under eradication or suppression by means of official control

B. dorsalis is considered to be transient when there have been isolated incursions in previously pest free areas and phytosanitary measures are being implemented to prevent perpetuation of the pest in these areas. DAFF would support area wide control in these areas by providing agricultural chemicals should funding be available.

An official order according to Section 7 of the APA and to R110 must be issued to all land users within the affected areas. All users of land are liable to comply with the provisions of such an official order.

Eradication will take place according to section 10 of the Action plan.

1.3 Pest free areas(PFA): areas where *B. dorsalis* is absent

1.3.1 Maintenance of the PFA

Areas identified within the RSA where *B. dorsalis* is absent, according to the relevant International Standards for Phytosanitary Measures (ISPMs). In the PFAs, official control by DAFF will be initiated in case of pest incursions following the official *B. dorsalis* action plan. The producer would need to implement proper surveillance actions as well as maintain and make available proper records to verify it. The NPPOZA will audit the records by inspection, fruit cutting, and its own monitoring traps. If the area is considered to be a pest free place of production (PFPP), the NPPOZA will only monitor the surveillance records of the producer. All the other requirements for a PFPP for fruit flies and PFA according to the relevant ISPMs will still apply and be implemented by the NPPOZA. Changes would need to be made to R110 if new PFA are to be considered.

1.3.2 Buffer zones

When there are no obvious barriers that will prevent the pest dispersing further into pest free areas, a buffer zone must be developed. A buffer zone will be considered as an extended quarantine area. The nature of the control measures employed and the size of the buffer zone will depend upon the particular characteristics of each PFA as well as the area where the pest is present.

A buffer zone must be developed to separate a pest free area from an area where *B. dorsalis* is present. The size of the buffer zone may depend on the existing control measures practised in the infested area, the FTD numbers and the availability of host plants in the infested area, as well as the availability of host plants in the buffer zone.

The purpose of the buffer zone is to monitor natural dispersal from an area where *B. dorsalis* is present towards a pest free area. The buffer zone is therefore bordering an area where the pest is known to be present and does not necessarily border on a pest free area. This will allow for early response without jeopardizing the status of the pest free area. The buffer zone can be considered as either free from the pest or as an area of low pest prevalence.

Therefore control measures should be applied within a buffer zone to ensure the pest status of *B. dorsalis* in the buffer zone remains the same.

1.3.3 Areas of low pest prevalence

An area of low pest prevalence (ALPP) can be declared as a production area with low pest numbers as determined by the FTD values of the area and should be subject to control measures. In such a case the ALPP status aims to facilitate trade to specific trading partners or in terms of local removal of fruit. It can also be a buffer zone which aims to protect a PFA and will be subject to control measures. DAFF will determine which phytosanitary measures should be applicable to establish and to maintain an ALPP depending on the availability of host material, climatic conditions and terrain. However basic phytosanitary measures should be followed as indicated in the basic phytosanitary measures as discussed below.

2. BASIC PHYTOSANITARY MEASURES WITHIN A DECLARED QUARANTINE AREA AFTER DETECTION OF *BACTROCERA DORSALIS* OR WHERE THE PEST IS PRESENT TO FORM A SYSTEMS APPROACH

Basic phytosanitary measures should be followed within a declared quarantine area after the detection of *Bactrocera dorsalis* or in an area where the pest is present, to form a systems approach.

3. BASIC PHYTOSANITARY MEASURES IN AREAS WHERE SPECIMENS WERE DETECTED

A systems approach can be followed to control the fruit fly in all areas where specimens were detected to support the objectives of corrective as well as quarantine actions as it can be used very effectively to manage the risk of specific hosts against the introduction of fruit fly species into new areas. It should also be applicable to ensure proper mitigation for existing or future export programs. The use of a systems approach can provide additional assurance when used in combination with a post-harvest treatment, especially when population levels in a specific area are high. Post harvest treatments facilities may not be available at areas of infestation and the treatment should for instance be completed at a port of exit before export as for other fruit fly pests according to the exporting country's specifications.

3.1 General measures for a systems approach.

Pest surveillance forms the keystone of all management decisions during a systems approach. This should include fruit cutting surveys.

The surveillance results of a specific area from where fruit is destined to be removed from should determine the independent measures in the systems approach.

Existing IPM measures may form part of the normal production cycle and need to be encouraged as far as possible.

Timing of fruit harvesting may assist with the reduction of infested fruit of certain cultivars as the fruit may not be suitable for oviposition yet or is not yet recognised by female fruit flies as hosts. Fruit hosts such as some avocado cultivars may not be a good fruit fly host and is only susceptible to oviposition after the fruit has been harvested.

Dependent measures such as host fruit inspection is not a measure as such, but should be a prerequisite to verify other measures implemented before the removal of host material for *B. dorsalis* is allowed. Inspection forms an important checking mechanism for compliance purposes which can be implemented during fruit set, just before harvest and after harvest (before and after packing). It is, however, labour intensive and good statistical models need to be followed for sampling in terms of the consignment size.

Post-harvest treatments may be cold or hot treatment of fruit, fumigation or irradiation. These can effectively be implemented to mitigate the risk in export consignments. When used as a standalone measure, post-harvest treatments should require a high level of certainty that they will effectively mitigate the risk of fruit fly larvae to survive in fruit hosts. Probit 9 treatments dramatically reduce the infestation level of fruit flies in fruit but it does not provide complete protection, especially when infestation levels are high. Extensive temperature tolerance tests have been completed for *B. dorsalis* in Austria which indicated that the same post-harvest cold sterilisation as for *Ceratitis capitata* could be followed for Citrus and pome fruits.

Post-harvest treatments used in a systems approach can be an independent measure on host material from an area of low pest prevalence or when a poor host is treated.

Irradiation for fruit hosts such as mangoes has been developed for Tephritidae species and could effectively be used for disinfestations of *B. dorsalis*.

3.2 Basic phytosanitary measures

3.2.1 Surveillance.

Additional to the existing traps which form part of the national survey or the delimiting survey or PUC surveillance traps, new traps may be set out in an affected area and maintained and serviced when the removal of fruit is required or for eradication purposes. Depending on the area and circumstances these traps will be placed and serviced either by the producers themselves and/or by DAFF. Prior arrangements for each area must be made to coordinate the surveillance.

The official *Bactrocera dorsalis* trapping guideline must also be followed to place and service traps at all times.

Traps must be set out as follows:

- In each production area of host crops Methyl Eugenol (ME) baited traps should be set at a rate of 3-5 ME traps per km^2 for eradication;
- At all fruit sorting, treatment, sanitation and disposal areas, animal feeding areas, or composting sites, pack houses, produce reception areas, such as fresh produce markets or ports, traps must be set at a ratio of 2 ME traps and one to two Biolure® Fruit Fly traps;
- At all house gardens within the production area under quarantine, there should be at least 1 ME trap;
- At urban or small holder areas the same frequency and ratio as which is applied in production areas is used within the quarantine area in association with host plants, focusing on private gardens and also according to the procedure on road transects, but Biolure® Fruit Fly traps must be included;

- ❖ Traps should as far possible be placed on fruit bearing host trees according to the season such as citrus or guava, and secondly in host trees that are not yet bearing fruit, such as mango or marula, preferably in the shade;
- ❖ Traps should be placed in the immediately surrounding vegetation In areas where host material cannot support the placement of traps, for example vegetable crops such as tomatoes grown for processing, and pumpkins,;

All traps servicing data should be recorded (Date trap checked, trap number, replacement of attractant and insecticide, number of specimens caught and if there are no catches, this should be recorded as "0). Completed trapping records should be kept and supplied to DAFF (janhendrikv@daff.gov.za) at the end of the quarantine period of all traps serviced by producers. If there are any suspect specimens caught, the relevant surveillance co-ordinator should be contacted immediately for identification of specimen.

All traps service data originating from quarantine areas serviced by DAFF personnel must be provided to the national surveillance coordinator on a weekly basis.

On farm scouts can work together with inspectors to form teams from different producers to scout traps. These reports must be sent through to the NPPO on a weekly basis.

3.2.2 **Chemical control.**

Male Annihilation Technique (MAT) and Bait Application Technique (BAT) should be used. BAT can be applied as either ground –based sprays or aerial sprays, or M3 bait stations. The same agricultural chemicals as described in section … of the action plan should be used. Agricultural chemicals should be used as per recommendation and as registered for the relevant crops

Areas covered by MAT and BAT

- ❖ All fields and orchards producing host material in the quarantine area must have MAT blocks set out at a ratio of at least 400 per km^2 or 4 per hectare or according to the label requirements of a specific registered product;
- ❖ BAT may be carried out at each producing area, with either GF 120 or a mixture of HymLure and malathion, or supplemented by M3 bait stations;
- ❖ House gardens within farms should also be treated with MAT and BAT;
- ❖ Delivery points such as fresh produce markets(formal and informal) and fruit stalls in affected areas or fruit stall selling fruit from affected areas should be treated with MAT and BAT;
- ❖ MAT and BAT should also be applied to natural vegetation surrounding production areas.
- ❖ MAT and BAT may also be applied in urban areas such as villages, town and cities. MAT blocks can be applied at a ratio of 4 per ha or in street blocks at a ratio of one every 50m if access to host trees in private gardens are not obtained or

unfeasible. M3 bait stations can be applied at a ratio of one per tree in each street of each street block if access to host trees is not feasible or at a ratio of one per host tree if access to trees is available.

It may be useful to apply MAT and BAT to areas surrounding fields, such as surrounding tomatoes and peppers.

Surrounding areas may include:

- Wind breaks and possible surrounding and in field
- Wild host plants such as bugweed or marula trees in or next to fields;
- Support structures for bananas, Additional MAT blocks may be set out in and around the field;
- M3 Bait stations may be set out in and around the field additional to bait sprays.

Bait sprays may be used as preventative measures in affected areas to protect undeveloped fruit or fruit not yet suitable for oviposition by fruit flies.

3.2.3 Cultural control

3.2.3.1 Orchard and field sanitation.

Fruit sources and frequency of sanitation: As far possible, dropped fruit must be collected in fields and orchards and from other sources as part of the sanitation process. This should be done according to the following guidelines:

- Orchard and field sanitation must be carried out every week. Fruit left over on trees in orchards or fields after harvest as well as fruit found on the ground should be removed and disposed properly;
- This includes fruit from orchards and fields which is not intended to be utilised due to other reasons such as frost damage and fruit not harvested (left over) which needs to be stripped;
- Scouts or workers must work daily in the production area to achieve sanitation of the whole production area in orchards and fields within one week;
- Fruit from host plants in house gardens in the quarantine area should be stripped and disposed properly;
- Fruits and wet waste rejected or dropped at reception, processing, sorting, packing and shipping areas should be disposed of properly on a daily basis;
- Only dry waste from processing plants may be used for animal feed (peels from the juice factory and pips and peels from the tomato paste factory).

Procedures for fruit sanitation. Either of the following procedures can be applied. The procedures are listed in order of the level of security it would provide.

Fruit buried and covered. Preferably this should be undertaken at all times during eradication.

- Must be buried and covered with a top layer of soil or sieved compost from the previous season of at least 0.5 m or heaped on top of the soil and covered with a top layer of soil or sieved compost of at least 0.5 m;
- A trench can be dug and the waste fruit placed inside, which must be covered on a daily basis;
- No buried fruit may be uncovered for at least five weeks after being covered;
- All reception, processing, sorting, packing and shipping areas on concrete must be cleansed once a day with a detergent or chorine solution;
- All reception, processing, sorting, packing and shipping areas on soil must be drenched once a week with a suitable insecticide;
- All trucks must be cleaned with a detergent or sprayed with an insecticide before loading when intended to be moved out of the quarantine area, and after offloading.

Fruit sanitation with black plastic bags. Preferably this should be undertaken at all times during eradication

- Fruit collected as part of the sanitation program can be placed into plastic black bags and left in the sun at the end of each row;
- The same principle should also apply for fruit waste at hawker stands, fruit stalls small fresh produce markets and green grocer shop outlets;
- A date of waste collection must be indicated on the bag;
- After four weeks decomposing fruit inside bags can be removed and either be buried, shredded or used for composting.
- Plastic bags should be issued to all road stall vendors in affected areas to encourage all waste fruit to be placed and sealed off.

Fruit picked and placed at game feeding sites within quarantined areas. This could be undertaken during eradication but provide a lower level of assurance

This should only to be done to prevent game and other wild animals from feeding in orchards and fields. This is to prevent a further damaging situation of fruit and smaller pieces of fruit that is dropped everywhere throughout the orchard and away from the orchard, which would be unlikely to be picked up during normal orchard sanitation.

- The soil where the fruit is put must be covered with a net which does not have holes bigger than 1 mm in diameter. This is to allow larvae to move into the soil but to prevent adults to move back through the net. Parasites of larvae will be able to escape through the net;
- The edges of the net must be buried 30 mm deep into the soil;
- The net must be well secured to the ground with steel pegs to prevent it from lifting up;
- An area of at least 5m around the net must be drenched with a contact insecticide once a week;
- All the fruit dumped must be place on the net.

Shredding or mulching of fruit. Preferably this should not be undertaken during eradication.

- ❖ Fruit collected for sanitation can be shredded or mulched into a fine pulp;
- ❖ The pulp can be spread between rows and left into the sun to dry;
- ❖ The areas allocated for sun drying must be soil drenched with an appropriate insecticide before the fruit is shredded and spread on it and sprayed with a contact insecticide thereafter to increase effectiveness
- ❖ When heaped and covered with soil or compost, the area must be soil drenched with a suitable insecticide before the waste is placed on top of it. The top of the heap must be sprayed on a weekly basis along with an area of one meter surrounding the heap;
- ❖ Additionally a layer of lime can be added to cover the waste before it is covered by soil or sieved compost;
- ❖ When composting is done with proceed rests such as peels and pips from processing plants the compost heap must be turned on a weekly basis, and a soil drench applied with a suitable insecticide surrounding the heap (distance of approximately 1 metre);

Augmentation tents. This is effective at small production sites with low volumes of fruit.

- ❖ Fruit collected for sanitation can be placed in augmentation tents;
- ❖ These are tents with openings large enough for parasitoids to leave but too small for fruit fly adults to exit;
- ❖ Augmentation tents can be placed at each row or block or field.

3.2.3.2 Fruit bagging

Bagging of fruit is a labour intensive but effective measure to ensure that fruit is protected against fruit fly oviposition. Bags should be checked by DAFF and should be applied to all fruit. This is effective for smaller production units. All other fruit not to be harvested should be removed to avoid infested fruit to be mixed with protected fruit.

3.2.3.3 Fruit stripping and removal of neglected trees and orchards.

The removal of all fruit left after harvest and should be encouraged in affected areas. Such fruit should be treated according to section 3.1 under cultural methods. Fruit trees which are neglected, especially from old orchards and home gardens should be removed.

3.2.3.4 Soil drenching

Soil drenching is effective to eliminate larvae and pupae in the soil and litter surrounding fruit trees. This method should be carried out only with registered agricultural chemicals. It may be very effectively implemented in areas where there are no regular farming activities such as villages and towns, provided an environmentally suitable (safe) registered chemical is applied to avoid groundwater contamination. Soil drenching can also be implemented at reception, processing, sorting, packing and shipping areas of fruit originating from affected areas.

3.2.4 Harvesting methods.

Some fruit is not suitable for oviposition during earlier development phases of the fruit. This can be utilised with cultivars of some fruit which can be artificially ripened. Green bananas for instance have been found not to be a suitable host for *B. dorsalis*. The harvesting of tree ripe bananas should be discouraged. The planting of earlier ripening cultivars may also assist to reduce fruit fly numbers if fruit can be harvested before the natural rainfall season starts.

4. FRUIT INSPECTION

Regular fruit inspection by DAFF inspectors or farm workers relevant to the risk management stage (eradication or management) must be carried out at processing plants, pack houses, as well as any other sorting and grading areas within the affected area and where fruit is received, sorted, processed, handled or sold outside the area. This will include hawker stands and farm stalls.

In principle, inspections on site must be planned and worked out together with producers or pack house managers, processors, hawkers etc:

- Fruit cutting will be done on rejected fruit for fruit flies, namely at ambient temperature and in higher risk fruit such as sorted fruit in bulk bins rotten cracked or damaged fruit;
- Fruit cutting must also be done in orchards and fields especially on decaying fruit which might not have been collected during sanitation;
- Fruit found to be infested would be put into rearing cages after inspection;
- Fruit fly larvae should also be killed and sent for diagnostic analysis in Stellenbosch (PHDS) laboratories;
- Rearing cages must stay in the quarantine are in a secured place arranged with the local land users such as producers, research stations etc.

5. REMOVAL OF HOST MATERIAL FROM AN AFFECTED AREA:

A permit should be acquired for the removal of host material from:

- an affected area to a PFA
- a PFA through an affected area to a PFA
- an affected area to an ALPP
- an ALPP to a PFA
- an affected area under eradication but not yet eradicated to an PFA or ALPP
- within an area under eradication to another destination point within the same area under eradication

This includes fruit for small scale vendors (e.g bakkie trade), travellers, friends and family.

Host material that is moved from the affected area to a processing, or handling(packing house storage facility, inspection point) point in a pest free area will cause the destination point to be considered as a quarantine area..Such an area will have to implement waste removal and treatment protocols and traceability protocols in the case of packing houses to make sure fruit is not mixed with fruit fro the free area on the packing line.

Trucks and or cargo must be sealed in such a way that fruit cannot fall from the truck during transport.

Trucks must be sealed and covered in such a way that no adult fruit fly which may have entered the pack house and consignment during packing can escape during transport.

All trucks, bakkies and other modes of transport which moves fruit through, within and from a quarantine area will have to be covered in such a way that fruit flies cannot oviposit on the fruit and that fruit cannot fall off or could easily be removed by people or baboons.

5.1 Types of transport (in order of phytosanitary security)

- Container or sealed cooled trucks are the safest way of transport, (citrus export, pre-packed veggies to markets) followed by;
- Trucks with sides and cargo covered by plastic sheeting plus brown paper and nets and/or tarpaulin and cargo packed in boxes, followed by;
- Trucks with sides and cargo covered with tarpaulin with bulk cargo followed by;
- Flat bed trucks and trailers with side tarpaulin curtains and cargo packed in bins, crates or boxes followed by;
- Flat bed trucks with cargo in bins covered by nets or tarpaulin;

5.2 Packing or transporting containers

- All boxes and bulk bins used during transport must be packed in such a way that fruit will not fall off or out during transport;
- All boxes and bins must be in a condition that fruit cannot fall from it;
- Additionally, the bins should be lined with a material suitable to transport fruit and which will not allow the escape of any fruit fly larvae from it.

5.3 Delivery points

- All fruit destined for processing (juicing, canning, oils, sauce etc), packing inspection or storageis to be delivered to pre approved facilities;
- Host material may only be packed at pre approved packing facilities (for fresh produce market, retail outlets, pre-packed mini veggies etc).

5.4 Processing and stand over times

- ❖ Fruit from an affected area will be processed, packed or sorted after arriving at the sorting, packing or processing facility as a priority above fruit from non affected areas;
- ❖ Processing of fruit from affected areas should preferably processed or packed within 24 hours depending on the volumes.

6. POST HARVEST TREATMENTS (EXPORT PROGRAMS)

Oranges can effectively be treated against *B. dorsalis*. Orange fruit should be cold treated at a fruit pulp temperature which is maintained at 0.9°C (±0.5°C) or lower for 16 consecutive days.

No heat treatment schedule has been developed yet for the treatment of hosts such as mangoes and papaya although tolerance tests conducted in Vienna indicated that *B. dorsalis* is less tolerant to heat treatment than *C. capitata*.

Fumigation could be used for treatment against Mediterranean fruit fly in tomatoes and citrus (Refer to USDA treatment manual 2008- contact DAFF for details).

Irradiation for fruit hosts such as mangoes has been developed for Tephritidae species and could effectively be used for disinfestations of *B. dorsalis*. Generic dosages for fruit flies are described in ISPM No. 18 (2003), *Guidelines for the use of irradiation as a phytosanitary measure*. A dosage of 50-250Gy is recommended to prevent adult emergence from 3rd instar larvae. However, additional quality checks and protocols may still have to be developed to ensure an effective treatment and to ensure optimum dosages for many cultivars.

7. FARM SALES TO INFORMAL AND SMALL SCALE VENDORS OR FOR PRIVATE USE

- ❖ Producers and or land users must apply for a permit before they can sell fruit from affected areas to bakkies, small scale vendors and fruit stalls;
- ❖ Records should be kept of the volumes sold to each vendor;
- ❖ Each bakkie should have a food producers code;
- ❖ Only fruit without visible cuts blemishes ovipositing marks will be sold from the farm in affected areas ;
- ❖ Fruit sold from farms to bakkies and small scale vendors will be inspected by DAFF.

8. SMALL SCALE VENDORS AND FRUIT STALLS OF FRUIT ORIGINATING FROM A QUARANTINE AREA

- ❖ Fruit vendors selling fruit to the public within a quarantine area should have fruit covered in such a way to prevent fruit flies ovipositing on the fruit;
- ❖ Only fruit originating from producers with permits may be sold;
- ❖ The vendor should keep record of volumes of fruit sold and purchased from each producer.

References.

ARMSTRONG, J.W. 1991. Sharwill Avocado: Quarantine security against fruit fly (Diptera: Tephritidae) infestation in Hawaii. *Journal of Economic Entomology* 84:1398-1315.

DE GRAAF, J. 2010. Host Status of Avocado ('Hass') to *Ceratitis capitata*, *Ceratitis rosa,* and *Ceratitis cosyra* (Diptera: Tephritidae) in South Africa. *Journal of Economic Entomology* 102: 1448-1459.

DE MEYER, M., MOHAMED, S. & WHITE, I.M. 2012. *Invasive fruit fly pests in Africa*. http://www.africamuseum.be/fruitfly/AfroAsia.htm. Date of access: 18 Septmeber 2013.

EKESI, S. & BILLAH, M.K. 2006. *A Field Guide to the management of economically important Tephritid fruit flies in Africa*. ICIPE Science Press Nairobi, Kenya. 206 pp.

EKESI, S., NDERITU, P. W. & RWOMUSHANA, I. 2006. Field infestation, life history and demographic parameters of the fruit fly *Bactrocera dorsalis* (Diptera: Tephritidae) in Africa. *Bulletin of Entomological Research* 96: 379-386.

FAO. 2009. International Standards for Phytosanitary Measures 1-32. *Secretariat of the International Plant Protection Convention*, Rome FAO, Italy. https://www.ippc.int/servlet/BinaryDownloaderServlet/124047_2009_ISPMs_book_Engl.doc?filename=1187683730555_ISPMs_1to29_2009_En_with_convention.doc&refID=124047. Date of Access: 1 July 2011.

FAO. 2011. International Standards for Phytosanitary Measures No. 26 (2006) Appendix 1. *Secretariat of the International Plant Protection Convention*, Rome FAO, Italy. https://www.ippc.int/servlet/BinaryDownloaderServlet/124047_2009_ISPMs_book_Engl.doc?filename=1187683730555_ISPMs_1to29_2009_En_with_convention.doc&refID=124047. Date of Access: 1 July 2011.

FAO/IAEA. 2011. *Guidelines for implementing systems approaches for pest risk management of fruit flies.* Report and recommendations of the consultants group meeting organized by the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture, Vienna, Austria, June 7-11 2010. IAEA Vienna, Austria. http://www-naweb.iaea.org/nafa/ipc/public/IPC-systems-approach-2011.pdf. Date of Access: 25 August 2011.

FOLLETT, P.A. & VARGAS, R.I. 2010. A systems approach to mitigate oriental fruit fly risk in 'Sharwill' avocados exported from Hawaii. *Acta Horticulturae* 880: 439-445.

FOLLETT, P.A. & NEVEN, L.G. 2006. Current trends in quarantine entomology. *Annual Review of Entomology* 51: 359–385.

FRAMPTON, E.R. 2000. An overview of quarantine for fruit flies, *In*: Tan, K. H *ed.* Proceedings: Area-wide control of fruit flies and other insect pests. Joint proceedings of the international conference on area-wide control of insect pests, May 28-June 2, 1998 and the fifth international symposium on fruit flies of economic importance, June 1-5, 1998. pp 381-388. Penerbit Universiti Sains Malaysia, Penang, Malaysia.

GROUT, T.G., DANEEL, J.H., MOHAMED, S.A., EKESI, S., NDERITU, P.W., STEPHEN, P.R. & HATTINGH, V. 2011. Cold susceptibility and disinfestation of *Bactrocera dorsalis* (Diptera: Tephritidae) in oranges. *Journal of Economic Entomology* 104:1180-1188.

HALLMAN, G.J. 1999. Ionizing radiation quarantine treatments against tephritid fruit flies. *Postharvest Biology and Technology* 16: 93–106.

HALLMAN, G.J., MYERS, S.W., JESSUP, A.J. & ISLAM, A. 2011. Comparison of in vitro heat and cold tolerances of the new invasive *Bactrocera dorsalis* (Diptera: Tephritidae) with three known tephritids. *Journal of Economic Entomology* 104: 21-25.

HANNA, R. 2005. The Asian fruit fly *Bactrocera dorsalis* in West and Central Africa: distribution, host range and seasonal dynamics. http://esa.confex.com/esa/2005/techprogram/paper_23053.htm. Date of access: 12 December 2012.

JANG, E.B., & H.R. MOFFIT. 1994. Systems approaches to achieving quarantine security, pp. 224-237. *In* J. L. Sharp and H. J. Hallman *eds*. *Quarantine treatments for pests of food plants*. Westview Press, Boulder, CO.

JANG, E.B., MAU, R.F., VARGAS, R.I. & MCINNIS, D.O. 2006. Exporting fruit from low fruit fly prevalence zones with a multiple mitigation systems approach. *Food and Fertilizer Technology Centre Extension Bulletin* 584.

KLUNGNESS, L.M., JANG, E.B., MAU, R.F.L., VARGAS, R.I., SUGANO, J.S. & FUJITANI, E. 2005. New sanitation techniques for controlling Tephritid Fruit Flies (Diptera: Tephritidae) in Hawaii. *Journal of Applied Sciences and Environmental Management* 9: 5-15.

KWASI, W. 2008. Assessment of Fruit Fly Damage and Implications for the dissemination of management practices for mango production in the upper West region of Ghana. *Journal of Developments in Sustainable Agriculture* 3: 117-134.

LIEBHOLD, A. M. & TOBIN, P. C. 2008. Population ecology of insect invasions and their management. *Annual Review of Entomology* 53: 387-408.

MANGAN, R.L., FRAMPTON, E.R., THOMAS, D.B. & MORENO, D.S. 1997. Application of the maximum pest limit concept to quarantine security standards for the Mexican fruit fly (Diptera: Tephritidae). *Journal of Economic Entomology* 90:1433-1440.

MANRAKHAN, A., HATTINGH, V., VENTER, J-H. & HOLTZHAUSEN, M. 2011. Eradication of *Bactrocera dorsalis* (Diptera: Tephritidae) in Limpopo Province, South Africa. *African Entomology* 19: 650–659.

MWATAWALA, M. W., DE MEYER, M., MAKUNDI, R. H. & MAERERE, A. P. 2006. Biodiversity of fruit flies (Diptera: Tephritidae) in orchards in different agro-ecological zones of the Morogoro region, Tanzania. *Fruits* 61: 321-332.

MWATAWALA, M. W., DE MEYER, M., MAKUNDI, R. H. & MAERERE, A. P. 2006. Seasonality and host utilization of the invasive fruit fly, *Bactrocera dorsalis* (Dipt., Tephritidae) in central Tanzania. *Journal of Applied Entomology* 130: 530-537.

MWATAWALA, M. W., DE MEYER, M., MAKUNDI, R. H., & MAERERE, A. P. 2009. Host range and distribution of fruit-infesting pestiferous fruit flies (Diptera, Tephritidae) in selected areas of Central Tanzania. *Bulletin of Entomological Research* 10: 1-13.

NORTON, G.A. & MUMFORD, J.D. 1994. Descriptive techniques. pp 23-42, *In*: Norton, G. A. & Mumford, J.D. *eds*, *Decision tools for pest management*. CAB International, Wallingford, UK.

OGAUGWU, C., WILSON, D., COBBLAH, M., & ANNOH, C. 2012. Gamma radiation sterilization of *Bactrocera dorsalis* (Diptera: Tephritidae) from southern Ghana. *African Journal of Biotechnology*, 11: 11315-11320.

PINERO, J.C., MAU, R.F.L. & VARGAS, R.I. 2009. Managing oriental fruit fly, *Bactrocera dorsalis* (Diptera: Tephritidae), through spinosad-based protein bait sprays and sanitation in papaya orchards in Hawaii. *Journal of Economic Entomology* 102:1123–1132.

QUINLAN, M.M. 2002. Trends in phytosanitary standards: potential consequences on fruit fly control. *In* Barnes, B., *ed.* Proceedings of the 6th International Fruit fly Symposium. pp195-200. B Istec Scientific Publications Irene. South Africa.

QUINLAN, M.M. & IKIN, R. 2009. PRATIQUE. An EU framework 7 research project: enhancements of pest risk analysis techniques. Deliverable No. 4.2: *A review of the application of systems approach to risk management in plant health.* 69pp. Available at: https://secure.fera.defra.gov.uk/pratique/index.cfm. Date of access: 26 August 2011.

RWOMUSHANA, I., EKESI, S., OGOL, C.K.P.O., & GORDON, I. 2008. Effect of temperature on development and survival of immature stages of *Bactrocera dorsalis* (Diptera: Tephritidae). *Journal of Applied Entomology*, 132: 832-839.

USDA-APHIS. 2011. *Treatment manual*. United States Department of Agriculture, Animal and Plant Health Inspection Service Plant Protection and Quarantine http://www.aphis.usda.gov/import_export/plants/manuals/ports/downloads/treatment.pdf. Date of access: 19 July 2013.

VAYSSIÈRES, J., KORIE. S. & AYEGNON, D. 2009. Correlation of fruit fly (Diptera Tephritidae) infestation of major mango cultivars in Borgou (Benin) with abiotic and biotic factors and assessment of damage. Crop Protection 28: 477–488.

VAYSSIÈRES, J.-F., KORIE, S., COULIBALY, O., TEMPLE, L. & BOUEYI, S. 2008. The mango tree in northern Benin (1): cultivar inventory, yield assessment, early infested stages of mangoes and economic loss due to the fruit fly (Diptera: Tephritidae). *Fruits* 63: 335-348.

WARE, A.B., DU TOIT, C.L.N., MOHAMED, S.A., NDERITU, P.W. & EKASI, S. 2012. Cold tolerance and disinfestation of *Bactrocera dorsalis* (Diptera: Tephritidae) in 'Hass' Avocado. *Journal of. Economic. Entomology* 105: 1963-1970

Annexure 4: Extensive host range of Bactrocera dorsalis.

Scientific name	Plant Family	Common name	Host /Non Host	Condition if host is non host	Reference host	Reference Non host
Acca sellowiana	Myrtaceae	Guavasteen,	H		APHIS 2015	
Achra sapota	Sapotaceae	Sapodilla tree	H		N'Depo et al., 2010	
Adenanthera pavonina	Fabaceae	Red-bead tree	H		CABI 2016	
Adonidia merrillii	Arecaceae	Manila palm	H		APHIS 2015	
Aegle marmelos	Arecaceae	Baeltree	H		APHIS 2015	
Afzelia xylocarpa	Fabaceae	Doussie	H		CABI 2016	
Aglaia domestica	Meliaceae				CHINAJARIYAWONG et al 2000	
Alangium chinense	Alangiaceae	Begonialeaf alangium	H		CABI 2016	
Alangium griffithii	Alangiaceae		H		APHIS 2015	
Alangium salviifolium	Alangiaceae	Sage-leaf alangium	H		CABI 2016	
Alpinia mutica	Zingiberaceae	Small shell ginger	H		CABI 2016	
Anacardium occidentale	Anacardiaceae	Cashew	H		CABI 2016; De Meyer, 2014	
Ananas comosus	Bromeliaceae	Pine apple	H	?	APHIS 2015	
Annona ×atemoya	Annonaceae	Atemoya	H		APHIS 2015	
Annona cherimola	Annonaceae	Cherimoya	H		CABI 2016; Vargas et al 2010	
Annona diversifolia	Annonaceae	Ilama fruit	H		N'Depo et al., 2010	
Annona glabra	Annonaceae	Pond-apple	H		CABI 2016	
Annona macroprophyllata	Annonaceae	Llama	H		CABI 2016	
Annona montana	Annonaceae	Mountain soursop	H		CABI 2016; De Meyer, 2014	
Annona muricata	Annonaceae	Soursop	H		CABI 2016; Vargas et al, 2007	
Annona reticulata	Annonaceae	Custard apple	H		CABI 2016; Vargas et al, 2007	
Annona senegalensis	Annonaceae	Wild custard apple	H		CABI 2016; De Meyer et al, 2014	
Annona squamosa	Annonaceae	Sugar-apple	H		CABI 2016; De Meyer et al, 2014	
Antiaris toxicaria	Moraceae	Sackingtree	H		APHIS 2015	
Antidesma ghaesembilla	Euphorbiaceae	Black currant tree	H		CABI 2016	
Aporosa villosa	Euphorbiaceae	Ye-mein	H		CABI 2016	
Ardisia crenata	Primulaceae	Coral berry	H		CABI 2016	
Areca catechu	Arecaceae	Betelnut palm	H	?	CABI 2016	
Arenga engleri	Arecaceae	Formosan sugar palm	H		APHIS 2015	
Arenga pinnata	Arecaceae	Sugar palm	H		CABI 2016	

Arenga westerhoutii	Arecaceae		H		CABI 2016	
Artabotrys siamensis	Annonaceae		H		CABI 2016	
Artocarpus altilis	Moraceae	Breadfruit	H		CABI 2016; Clarke et al 2005	
Artocarpus chama	Moraceae	Chaplash	H		APHIS 2015	
Artocarpus elasticus	Moraceae	Terap	H		CABI 2016	
Artocarpus heterophyllus	Moraceae	Jackfruit	H		CABI 2016; Clarke et al 2005	
Artocarpus integer	Moraceae	Champedak	H		CABI 2016	
Artocarpus lacucha	Moraceae	Monkey jack	H		CABI 2016	
Artocarpus lanceifolius	Moraceae	Keledang	H		CABI 2016	
Artocarpus lanceolatus	Moraceae		H		CABI 2016	
Artocarpus nitidus	Moraceae		H		CABI 2016	
Artocarpus odoratissimus	Moraceae	Marang	H		CABI 2016	
Artocarpus rigidus	Moraceae	Monkey-jack	H		CABI 2016	
Artocarpus sericicarpus	Moraceae		H		CABI 2016	
Averrhoa bilimbi	Oxalidaceae	Blimbe	H		CABI 2016	
Averrhoa carambola	Oxalidaceae	Carambola	H		CABI 2016; Clarke et al 2005	
Azadirachta excelsa	Meliaceae		H		CABI 2016	
Baccaurea angulata	Euphorbiaceae	Red angled tampoi	H		APHIS 2015	
Baccaurea motleyana	Euphorbiaceae	Rambai	H		CABI 2016	
Baccaurea racemosa	Euphorbiaceae	Menteng	H		CABI 2016	
Baccaurea ramiflora	Euphorbiaceae	Burmese grape	H		CABI 2016	
Bactris gasipaes	Arecaceae	Peach palm	H		APHIS 2015	
Balakata baccata	Euphorbiaceae	Jiang guo wu jiu	H		CABI 2016	
Barringtonia edulis	Lecythidaceae	Cutnut	H		CABI 2016; Vargas et al, 2007	
Bischofia javanica	Phyllanthaceae	Java-cedar	H		APHIS 2015	
Blighia sapida	Sapindaceae	Akee apple	H		CABI 2016; De Meyer et al 2014	
Borassus flabellifer	Arecaceae	Toddy palm	H		CABI 2016	
Bouea macrophylla	Anacardiaceae		H		CABI 2016	
Bouea oppositifolia	Anacardiaceae	Plum mango	H		CABI 2016	
Breonia chinensis	Rubiaceae		H		CABI 2016	
Breynia racemosa	Euphorbiaceae		H		CABI 2016	
Breynia reclinata	Euphorbiaceae		H		APHIS 2015	
Bridelia stipularis	Euphorbiaceae	Lulalub	H		CABI 2016	
Brugmansia ×candida	Solanaceae	Angel's-trumpet	H		APHIS 2015	
Calophyllum inophyllum	Clusiaceae	Alexandrian laurel	H		CABI 2016; Vargas et al, 2007	
Callicarpa longifolia	Lamiaceae	Chukin	H		CABI 2016	
Cananga odorata	Annonaceae	Perfume tree	H		APHIS 2015; Vargas et al; 2007	
Canarium insulare	Burseraceae		H		APHIS 2015; Le Blanc et al 2012	

Capparis sepiaria	Capparaceae	Indian caper	H	?	CABI 2016	
Capparis tomentosa	Capparaceae	African caper	H	?	APHIS 2015	
Capsicum annuum	Solanaceae	Bell pepper	H		CABI 2016; Vargus et al 2007	
Capsicum chinense	Solanaceae	Bonnet pepper	H		APHIS 2015	
Capsicum frutescens abbreviatum	Solanaceae	Tobasco pepper	H		CABI 2016	
Capsicum frutescens var. grossum	Solanaceae	Pepper	H		CABI 2016	
Capsicum pubescens	Solanaceae	Apple chile	H		APHIS 2015	
Careya arborea	Lecythidaceae	Tummy wood	H		CABI 2016	
Careya sphaerica	Lecythidaceae	Kra doon	H		APHIS 2015	
Carica papaya	Caricaceae	Papaya	H/N H	possible non host due to ripening stage. Cugala (unpublished certain cultivars only	CABI 2016; Clarke et al 2005	Cugala (possible in press)
Carissa carandis	Apocynaceae	Carandas-plum	H		CABI 2016	
Carissa grandiflora	Apocynaceae	Natal Plum	H		CDFA 2013	
Carissa spinarum	Apocynaceae	Currentbush	H		CABI 2016	
Caryota mitis	Arecaceae	Burmese fishtail palm	H		CABI 2016	
Casimiroa edulis	Rutaceae	White sapote	H		CABI 2016	
Castanopsis	Fagaceae	Evergreen chinkapin	H		CABI 2016	
Celtis tetranda	Ulmaceae	Si rui po	H		CABI 2016	
Cereus aethiops	Cactaceae				APHIS 2015	
Cereus (=Hylocereus) coerulescens	Cactaceae		H		CABI 2016	
Cestrum latifolium	Solanaceae	Jasmin sauvage	H		APHIS 2015	
Cestrum nocturnum	Solanaceae	lady-of-the-night	H		APHIS 2015	
Chionanthus parkinsonii	Oleaceae		H		CABI 2016	
Chrysobalanus icaco	Chrysobalanaceae	Coco plum	H		APHIS 2015	
Chrysophyllum albidum	Sapotaceae	White star apple	H		APHIS 2015; De Meyer et al 2014	
Chrysophyllum cainito	Sapotaceae	Caimito	H		CABI 2016; De Meyer et al 2014	
Chrysophyllum oliviforme	Sapotaceae		H		CDFA 2013	
Chrysophyllum roxburghii	Sapotaceae	Athapala	H		APHIS 2015	
Chukrasia tabularis	Meliaceae	Burmese almondwood	H		APHIS 2015	
Cinnamomum yabunikkei	Lauraceae	Yabu-nikkei	H		APHIS 2015	
Cissus repens	Vitaceae		H		CABI 2016	
×Citrofortunella floridana	Rutaceae	Lime quat	H		APHIS 2015	
×Citrofortunella microcarpa	Rutaceae	Calamandarin	H		APHIS 2015	
Citrullus colocynthis	Cucurbitaceae	Colocynth	H		CABI 2016; De Meyer et al, 2014	

Citrullus lanatus	Cucurbitaceae	Watermelon	H		CABI 2016; De Meyer et al, 2014	
Citrus aurantiifolia	Rutaceae	Lime	H		CABI 2016; Le Blanc et al 2012	
Citrus aurantium	Rutaceae	Sour orange	H		CABI 2016	
Citrus clementina	Rutaceae	Clementine	H		APHIS 2015	
Citrus deliciosa	Rutaceae	Mandarin	H		APHIS 2016	
Citrus depressa	Rutaceae		H		APHIS 2017	
Citrus grandis	Rutaceae	Pomelo	H		Mwatawala et al., 2009	
Citrus hystrix	Rutaceae	Mauritius bitter orange	H		CABI 2016	
Citrus jambhiri	Rutaceae	Rough lemon	H		CABI 2016	
Citrus keraji	Rutaceae	Kabuchi	H		APHIS 2015	
Citrus latifolia	Rutaceae	Tahiti lime	H		CABI 2016; Vargas et al 2007	
Citrus limetta	Rutaceae	Sweet lime	H		APHIS 2015	
Citrus limetioides	Rutaceae		H		CDFA 2013	
Citrus limon	Rutaceae	Lemon	H		CABI 2016; Vargas et al 2010	
Citrus limonia	Rutaceae	Rangpur lime	H		APHIS 2015	
Citrus maxima	Rutaceae	Pummelo	H		APHIS 2015; Vargas et al 2007	
Citrus natsudaidai	Rutaceae	Daidai	H		CABI 2016	
Citrus nobilis	Rutaceae	King Orange	H		CABI 2016	
Citrus oto	Rutaceae		H		CABI 2016	
Citrus paradisi	Rutaceae	Grapefruit	H		CABI 2016; Vargas et al 2010	
Citrus reticulata	Rutaceae	Tangerine / mandarin	H		APHIS 2015; Vargas et al 2007	
Citrus reticulata X fortunella	Rutaceae		H		CABI 2016	
Citrus reticulata X C. sinensis	Rutaceae		H		CABI 2016	
Citrus reticulata var. Unshu	Rutaceae		H		CABI 2016	
Citrus sinensis	Rutaceae	Orange	H		CABI 2016; Vargas et al 2007	
Citrus swinglei	Rutaceae		H		CABI 2016	
Citrus tangelo	Rutaceae	Tangelo	H		APHIS 2015; De Meyer et al 2014	
Citrus trifoliata	Rutaceae				Le Blanc et al 2012	
Citrus unshiu	Rutaceae		H		APHIS 2015	
Citrus x microcarpa	Rutaceae				Le Blanc et al 2012	
Clausena lansium	Rutaceae	Wampi	H		CABI 2016	
Clusia rosea	Clusiaceae	Copey	H		APHIS 2015	
Coccinia grandis	Cucurbitaceae	Ivy gourd	H		CABI 2016	
Cocos nucifera	Arecaceae	Coconut	H	?	APHIS 2015	
Coccoloba uvifera	Polygonaceae		H		APHIS 2015	
Coffea arabica	Rubiaceae	Arabica coffee	H		CABI 2016; De Meyer et al 2014	
Coffea canephora	Rubiaceae	Rubusta coffee	H		CABI 2016; De Meyer et al 2014	
Cordia alba	Boraginaceae				CABI 2016	

Cordia dentata	Boraginaceae	English clammy berry	H		APHIS 2015	
Cordia sp. cf myxa	Boraginaceae		H		CABI 2016; De Meyer et al, 2014	
Cordyla pinnata	Fabaceae		H		CABI 2016; De Meyer et al, 2014	
Crinum asiaticum	Amryllidaceae	Grand crinum lily	H		CABI 2016	
Cucumis ficifolius	Cucurbitaceae		H		CABI 2016	
Cucumis figarei	Cucurbitaceae		H		Mwatawala et al., 2006	
Cucumis melo	Cucurbitaceae	Melon	H		CABI 2016; Clarke et al 2005	
Cucumis pepo	Cucurbitaceae	Guard	H		APHIS 2015; De Meyer et al 2014	
Cucumis sativus	Cucurbitaceae	Cucumber	H		CABI 2016; Clarke et al 2005	
Cucumis sp nr metuliferus	Cucurbitaceae		H		EPPO 2010	
Cucurbita maxima	Cucurbitaceae	Pumpkin	H		CABI 2016; De Meyer et al, 2014	
Cucurbita mixta	Cucurbitaceae		H		Vargas et al 2010	
Cucurbita pepo	Cucurbitaceae	Zucchini squash	H		CABI 2016	
Cydonia oblonga	Rosaceae		H		CDFA 2013	
Datura stramonium	Solanaceae	Common thorn-apple	H		APHIS 2015	
Desmos chinensis	Annonaceae	Jia ying zhua	H		CABI 2016	
Dillenia obovata	Dilleniaceae	Burma simpoh	H		CABI 2016	
Dimocarpus longan	Sapindaceae	Longan tree	H		CABI 2016; Clarke et al 2005	
Diospyros areolata	Ebenaceae		H		CABI 2016	
Diospyros blancoi	Ebenaceae	Mabolo	H		CABI 2016	
Diospyros castanea	Ebenaceae		H		CABI 2016	
Diospyros diepenhorstii	Ebenaceae	Kaya malam	H		CABI 2016	
Diospyros discolor	Ebenaceae		H		CDFA 2013	
Diospyros glandulosa	Ebenaceae	Mai kua thoun	H		APHIS 2015	
Diospyros japonica	Ebenaceae	Ryūkyū-mamegaki	H		APHIS 2015	
Diospyros kaki	Ebenaceae	Japanese persimmon	H		CABI 2016; Vargas et al 2010	
Diospyros malabarica	Ebenaceae	Indian persimmon	H		CABI 2016	
Diospyros mollis	Ebenaceae	Ma kluea	H		CABI 2016	
Diospyros montana	Ebenaceae	Mountain persimmon	H		APHIS 2015; De Meyer et al 2014	
Diospyros roxburghii	Ebenaceae		H		CABI 2016	
Diospyros sandwicensis	Ebenaceae	Elama	H		APHIS 2015	
Diospyros vera	Ebenaceae	Native persimmon	H		APHIS 2015	
Diplocyclos palmatus	Cucurbitaceae	Striped-cucumber	H		APHIS 2015	
Dovyalis hebecarpa	Flacourtiaceae	Ketembilla	H		CABI 2016	
Dracaena draco	Dracaenaceae	Dragon tree	H		APHIS 2015	
Dracaena steudneri	Agavaceae	Northern large leave dragon tree	H		CABI 2016; De Meyer et al, 2014	
Ehretia microphylla	Boraginaceae	Philippine tea	H		APHIS 2015	

Elaeocarpus hygrophilus	Elaeocarpaceae	Ma-kok-nam	H		CABI 2016	
Elaeocarpus madopetalus	Elaeocarpaceae		H		APHIS 2015	
Elaeocarpus serratus	Elaeocarpaceae	Ceylon olive	H		APHIS 2015	
Eriobotrya japonica	Rosaceae	Loquat	H		CABI 2016; Vargas et al 2010	
Erycibe subspicata	Convolvulaceae	Zhui xu ding gong teng	H		CABI 2016	
Eugenia brasiliensis	Myrtaceae	Brazil cherry	H		APHIS 2015	
Eugenia jambos =Syzigium jambos	Myrtaceae		H		CDFA 2013	
Eugenia megacarpa	Myrtaceae		H		APHIS 2015	
Eugenia malaccensis	Myrtaceae		H		CDFA 2013	
Eugenia palumbis	Myrtaceae		H		APHIS 2015	
Eugenia reinwardtiana	Myrtaceae		H		CABI 2016	
Eugenia uniflora	Myrtaceae	Surinam cherry	H		CABI 2016; Vargas et al 2010	
Euphoria longan	Sapindaceae		H		CDFA 2013	
Ehretia microphylla	Boraginaceae		h		CABI 2016	
Exalobus monopetalus	Annonaceae		H		APHIS 2015	
Excoecaria agallocha	Euphorbiaceae	Blind-your-eye mangrove	H	?	CABI 2016	
Fagraea ceilanica	Loganiaceae	Hui li	H		CABI 2016	
Feijoa sellowiana			H		CDFA 2013; Vargas et al 2010	
Fibraurea tinctoria	Menispermaceae	Sekunyit	H		CABI 2016	
Ficus auriculata	Moraceae	Roxburgh fig	H		CABI 2016	
Ficus benjamina	Moraceae	Weeping fig	H		CABI 2016	
Ficus carica	Moraceae	Common fig	H		APHIS 2015; Vargas et al 2010	
Ficus chartacea	Moraceae	Zhi ye rong	H		CABI 2016	
Ficus concatian	Moraceae		H		APHIS 2015	
Ficus eligodon	Moraceae		H		APHIS 2015	
Ficus erecta	Moraceae	Ai xiao tian xian guo	H		APHIS 2015	
Ficus fistulosa	Moraceae	Yellow stem fig	H		CABI 2016	
Ficus hirta	Moraceae	Cu ye rong	H		CABI 2016	
Ficus hispida	Moraceae	Hairy fig	H		CABI 2016	
Ficus microcarpa	Moraceae	Indian laurel tree	H		CABI 2016	
Ficus obpyramidiata	Moraceae		H		APHIS 2015	
Ficus cf ottoniifolia	Moraceae		H		CABI 2016; De Meyer et al, 2014	
Ficus pumila	Moraceae	Bi li	H		CABI 2016	
Ficus racemosa	Moraceae	Cluster tree	H		CABI 2016	
Ficus religiosa	Moraceae	Sacred fig tree	H		CABI 2016	
Ficus septica	Moraceae	Septic fig	H		APHIS 2015	
Ficus sycomorus	Moraceae	Sycamore fig	H		CABI 2016	

Ficus virgata	Moraceae	Dao rong	H		CABI 2016	
Flacourtia indica	Flacourtiaceae	Governor's plum	H		CABI 2016; De Meyer et al, 2014	
Flacourtia rukam	Flacourtiaceae	Rukam	H		CABI 2016	
Flueggea virosa	Phyllanthaceae	Common bushweed	H		CABI 2016	
Fortunella japonica	Rutaceae	Kumquat	H		CABI 2016	
Fortunella margarita	Rutaceae	Nagami kumquat	H		CABI 2016; De Meyer 2014	
Fortunella polyandra	Rutaceae	Malayan kumquat	H		APHIS 2015	
Fragraea berteriana var. sair	Rosaceae	Pua kenikeni	H		APHIS 2015; Vargas et al; 2007	
Fragaria ×ananassa	Rosaceae	Strawberry	H	?	APHIS 2015	
Fragaria chiloensis	Rosaceae	Strawberry	H	?	APHIS 2015	
Garcinia atroviridis	Clusiaceae	Gelugor	H	?	CABI 2016	
Garcinia cowa	Clusiaceae		H	?	CABI 2016	
Garcinia dioica	Clusiaceae		H	?	CABI 2016	
Garcinia dulcis	Clusiaceae		H	?	CABI 2016	
Garcinia griffithii	Clusiaceae		H	?	CABI 2016	
Garcinia hombroniana	Clusiaceae		H	?	CABI 2016	
Garcinia intermedia	Clusiaceae		H	?	CABI 2016	
Garcinia mangostana	Clusiaceae	Mangosteen	H	? Exocarp too thick	CABI 2016; Clarke et al 2005	
Garcinia mannii	Clusiaceae	Chewing stick	H	?	CABI 2016; De Meyer et al, 2014	
Garcinia parvifolia	Clusiaceae	Kandis	H	?	APHIS 2015	
Garcinia prainiana	Clusiaceae	Button mangosteen	H	?	CABI 2016	
Garcinia speciosa	Clusiaceae	Ma pong	H	?	CABI 2016	
Garcinia subelliptica	Clusiaceae		H	?	APHIS 2015	
Garcinia xanthochymus	Clusiaceae	Gourka	H	?	CABI 2016	
Garuga floribunda	Boraginaceae	Garuga	H		CABI 2016	
Glochidion littorale	Euphorbiaceae	Saka saka	H		CABI 2016	
Glycosmis pentaphylla	Rutaceae	Shan xiao ju	H		CABI 2016	
Gmelina elliptica	Lamiaceae	Badhara bush	H		CABI 2016	
Gmelina philippensis	Lamiaceae		H		CABI 2016	
Gossypium barbadense	Malvaceae	Egyptian cotton	H		APHIS 2015	
Gymnopetalum scabrum	Cucurbitaceae	Feng gua	H		CABI 2016	
Hanguana malayana	Hanguanaceae		H		CABI 2016	
Heynea trijuga	Meliaceae		H		CABI 2016	
Hylocereus undatus	Cactaceae	Dragon fruit	H		CABI 2016	
Holigarnakurzii	Anacardiaceae		H		CABI 2016	
Horsfieldia subglobosa	Myristicaceae		H		APHIS 2015	
Inocarpus fagifer	Fabaceae	Marrup	H		CABI 2016	
Irvingia gabonensis	Irvingiaceae	African wild mango	H		CABI 2016; De Meyer et al, 2014	

Irvingia malayana	Irvingiaceae	Kabok	H		CABI 2016	
Ixora javanica	Rubiaceae		H		CABI 2016	
Ixora macrothyrsa	Rubiaceae	Santan-pula	H		CABI 2016	
Juglans hindsii	Juglandaceae	California walnut	H		APHIS 2015	
Juglans nigra	Juglandaceae	Black walnut	H		APHIS 2015	
Juglans regia	Juglandaceae	English walnut	H		APHIS 2015	
Kedrostis leloja	Cucurbitaceae		H		APHIS 2015	
Knema globularia	Myristicaceae	Xiao ye hong guang shu	H		CABI 2016	
Lagenaria siceraria	Cucurbitaceae	Bottle gourd	H		CABI 2016; De Meyer et al, 2014	
***Landolphia* sp**	Apocynaceae		H		De Meyer et al 2014	
Lansium domesticum	Meliaceae	Langsat	H		CABI 2016	
Lansium parasiticum	Meliaceae	Sinpaju	H		APHIS 2015	
Lepisanthes alata	Sapindaceae		H		CABI 2016	
Lepisanthes fruticosa	Sapindaceae		H		CABI 2016	
Lepisanthes rubiginosa	Sapindaceae	Kelatiayu	H		CABI 2016	
Lepisanthes tetraphylla	Sapindaceae		H		CABI 2016	
Lindera oxyphylla	Lauraceae		H		APHIS 2015	
Litchi chinensis	Sapindaceae	Lichi	H		CABI 2016; Clarke et al 2005	
Litsea glutinosa	Lauraceae	Indian laurel	H		CABI 2016	
Litsea salicifolia	Lauraceae	Hei mu jiang zi	H		CABI 2016	
Luffa acutangula	Cucurbitaceae	Ribbed loofah	H		APHIS 2015	
Luffa aegyptiaca	Cucurbitaceae	Loofah	H		APHIS 2015	
Lycianthes biflora	Solanaceae	Hong si xian	H		APHIS 2015	
Machilus thunbergii	Lauraceae	Tabu	H		APHIS 2015	
Maclura cochinchinensis	Moraceae	Cockspurthorn	H		CABI 2016	
Maerua duchesnei	Capparaceae		H		CABI 2016; De Meyer et al, 2014	
Malpighia emarginata	Malpighiaceae	Barbados cherry	H		CABI 2016	
Malpighia glabra	Malpighiaceae	Acerola	H		CABI 2016	
Malpighia punicifolia	Malpighiaceae		H		CDFA 2013	
Malus domestica	Rosaceae	Apple	H		CABI 2016; Clarke et al 2005	
Malus sylvestris	Rosaceae	Acerola	H		APHIS 2015	
Mammea americana	Calophyllaceae		H		CDFA 2013	
Mammea siamensis	Calophyllaceae		H		APHIS 2015	
Mangifera caesia	Anacardiaceae	Binjai	H		CABI 2016	
Mangifera foetida	Anacardiaceae	Bachang	H		CABI 2016	
Mangifera griffithii	Anacardiaceae	Rawa	H		CABI 2016	
Mangifera indica	Anacardiaceae	Mango	H		CABI 2016; Clarke et al 2005	
Mangifera laurina	Anacardiaceae	Boa pow	H		CABI 2016;	

Mangifera longipetiolata	Anacardiaceae	Asam damaran	H		APHIS 2015	
Mangifera odorata	Anacardiaceae	Kurwini mango	H		CABI 2016	
Mangifera pajang	Anacardiaceae	Bambangan	H		APHIS 2015	
Manilkara jaimiqui	Sapotaceae	Wild sapodilla	H		CABI 2016	
Manilkara zapota	Sapotaceae	Bully tree	H		APHIS 2015; Clarke et al 2005	
Merremia vitifolia	Convolvulaceae	zhang ye yu huang cao	H		CABI 2016	
Microcos tomentosa	Tiliaceae		H		CABI 2016	
Mimusops elengi	Sapotaceae	Spanish cherry	H		CABI 2016	
Mitrephora maingayi	Annonaceae	Thabut-net	H		APHIS 2015	
Mitrephora teysmannii	Annonaceae		H		CABI 2016	
Momordica balsamina	Cucurbitaceae	Balsam apple	H		APHIS 2015; Vargas et al 2010	
Momordica charantia	Cucurbitaceae	Balsam pear	H		CABI 2016; De Meyer et al, 2014	
Momordica cochinchinensis	Cucurbitaceae		H		APHIS 2015	
Momordica cf trifoliata	Cucurbitaceae		H		EPPO 2010	
Morella rubra	Myricaceae	Chinese-arbutus	H		APHIS 2015	
Morinda citrifolia	Rubiaceae	Noni	H		CABI 2016	
Morinda coreia	Rubiaceae		H		CABI 2016	
Morinda umbellata	Rubiaceae		H		CABI 2016	
Morus alba	Moraceae	White mulberry	H		CABI 2016	
Morus nigra	Moraceae	Black mulberry	H		CABI 2016	
Muntingia calabura	Muntingiaceae	Jamaica cherry	H		APHIS 2015	
Murraya exotica	Rutaceae	Chinese-boxwood	H		APHIS 2015	
Murraya paniculata	Rutaceae	Orange jessamine	H		CABI 2016	
***Musa spp.* (AAA)**	Musaceae	Banana	H	Ripening phase	CABI 2016	Armstrong,2001; Cugala et al, 2014
Musa acuminata	Musaceae	Wild banana	H		CABI 2016; De Meyer 2014	
Musa balbisiana	Musaceae		H		CABI 2016	
Musa nana	Musaceae		H		CDFA 2013	
Musa troglodytarum	Musaceae	Fe'i banana	H		CABI 2016	
Musa x paradisiaca	Musaceae	Plantain	H		CABI 2016; De Meyer et al, 2014	
Musa troglodytarum	Musaceae				Le Blanc et al 2012	
Muntingia calabura	Elaeocarpaceae				CHINAJARIYAWONG et al 2000	
Myrciaria cauliflora	Myrtaceae	Jaboticaba	H		CABI 2016	
Myxopyrum smilacifolium	Oleaceae		H		CABI 2016	
Nauclea latifolia	Rubiaceae	Pin cushion tree	H		CABI 2016	
Nauclea orientalis	Rubiaceae	Canary wood	H		CABI 2016	
Neolamarckia cadamba	Rubiaceae	Burflower tree	H		APHIS 2015	
Neolitsea sericea	Lauraceae	Shirodamo	H		APHIS 2015	
Neonauclea purpurea	Rubiaceae		H		CABI 2016	

Nephelium cuspidatum Blume var. eriopetalum	Sapindaceae	Panungaian	H		APHIS 2015	
Nephelium lappaceum	Sapindaceae	Rambutan	H		CABI 2016; Clarke et al 2005	
Nestegis sandwicensis	Oleaceae	Olopua	H		APHIS 2015	
Ochreinauclea maingayi	Rubiaceae				CABI 2016	
Ochrosia mariannensis	Apocynaceae		H		APHIS 2015; Le Blanc et al 2012	
Olax scandens	Olacaceae	Dheniani	H		APHIS 2015	
Olea europaea	Oleaceae	Olive	H	?	APHIS 2015	
Opuntia megacantha,	Cactaceae		H		CDFA 2013	
Opuntia ficus indica	Cactaceae	prickly pear	H		APHIS 2015	
Palaquium maingayi	Sapotaceae	Nyatoh	H		CABI 2016	
Pandanus fragrans	Pandanaceae	Screw pine	H		APHIS 2015	
Pandanus odorifer	Pandanaceae	Pandanus	H		APHIS 2015	
Papilionanthe hookeriana	Orchidaceae		H		APHIS 2015	
Papilionanthe teres	Orchidaceae	Vanda orchids	H		APHIS 2015	
Parinari anamense	Chrysobalanaceae		H		CABI 2016	
Parkia speciosa	Fabaceae		H		CABI 2016	
Passiflora edulis	Passifloraceae	Passionfruit	H	? Thick exocarp	CABI 2016; Clarke et al 2005	
Passiflora foetida	Passifloraceae	Red fruit passion flower	H		CABI 2016	
Passiflora laurifolia	Passifloraceae		H		CABI 2016; Le Blanc et al 2012	
Passiflora ligularis	Passifloraceae		H		APHIS 2015	
Passiflora mollissima	Passifloraceae		H		APHIS 2015	
Passiflora quadrangularis	Passifloraceae	Giant granadilla	H		CABI 2016; Le Blanc et al 2012	
Passiflora suberosa	Passifloraceae	Corkystem passionflower	H		CABI 2016	
Pereskia grandifolia	Cactaceae		H		CABI 2016	
Persea ameriaca	Lauraceae	Avocado	NH	Harvest ripeness and encapsulation, Sharvill, Hass, Pinkerton and Fuerte	CABI 2016; Clarke et al 2005	Klungness and Follet, 2009; Ware et al 2016
Phaseolus vulgaris	Fabaceae	Common bean	H		CABI 2016	
Phoenix dactylifera	Arecaceae		H		APHIS 2015	
Phyllanthus acidus	Euphorbiaceae		H		APHIS 2015; Vargas et al; 2007	
Physalis angulata	Solanaceae	Cutleaf groundcherry	H		CABI 2016	
Planchonella	Sapotaceae		H		CABI 2016	
Planchonella duclitan	Sapotaceae		H		CABI 2016	
Polyalthea longifolia	Annonaceae		H		CABI 2016	
Polyalthia simiarum	Annonaceae		H		CABI 2016	
Pometia pinnata	Sapindaceae	Fijian longan	H		CABI 2016; Vargas et al 2007	

Poncirus trifoliata	Rutaceae	Trifoliate orange	H		CABI 2016; Vargas et al 2007	
Pouteria caimito	Sapotaceae		H		CABI 2016; Le Blanc et al 2012	
Pouteria campechiana	Sapotaceae	Canistel	H		CABI 2016; Vargas et al 2007	
Pouteria duklitan	Sapotaceae		H		Pacific Species 2000	
Pouteria sapote	Sapotaceae	Sapote	h		Clarke et al 2005	
Premna serratifolia	Lamiaceae		H		CABI 2016	
Prunus americana	Rosaceae		H		?	
Prunus armeniaca	Rosaceae	Apricot	H		CABI 2016	
Prunus avium	Rosaceae	Sweet cherry	H		CABI 2016; Clarke et al 2005	
Prunus cerasus	Rosaceae	Sour cherry	H		CABI 2016	
Prunus cerasifera	Rosaceae		H		APHIS 2015	
Prunus domestica	Rosaceae	Plum	H		CABI 2016; Clarke et al 2005	
Prunus ilicifolia	Rosaceae		H		APHIS 2015	
Prunus lusitanica	Rosaceae		H		CDFA 2013	
Prunus mume	Rosaceae	Japanese apricot tree	H		CABI 2016	
Prunus persica	Rosaceae	Peach	H		CABI 2016; Vargas et al 2010	
Prunus persica var. **Nectarina**	Rosaceae		H		CDFA 2013; Vargas et al 2010	
Prunus salicina	Rosaceae	Japanese plum	H		CABI 2016	
Psidium cattleianum	Myrtaceae	Strawberry guava	H		CABI 2016; Vargas et al, 2007	
Psidium guajava	Myrtaceae	Common guava	H		CABI 2016; Clarke et al 2005	
Psidium littorale	Myrtaceae	Strawberry guava	H		CDFA 2013; De Meyer et al 2014	
Punica granatum	Punicaceae	Pomegranate	H		CABI 2016; Vargas et al, 2007	
Pyrus communis	Rosaceae	European pear	H		CABI 2016	
Pyrus pyrifolia	Rosaceae	Oriental pear tree	H		CABI 2016	
Rhizophora	Rhizophoraceae	Mangrove	H		CABI 2016	
Rhodomyrtus tomentosa	Myrtaceae	Downy rose-myrtle	H		CABI 2016	
Richardella campechiana	Sapotaceae	Yello sapote	H		N'Depo et al., 2010	
Rollinia pulchrinervis	Annonaceae		H		CABI 2016; Le Blanc et al 2012	
Saba senegalensis	Apocynaceae		H		CABI 2016; De Meyer et al, 2014	
Sambucus javanica	Caprifoliaceae		H		CABI 2016	
Sandoricum koetjape	Meliaceae	Santol	H		CABI 2016	
Santalum album	Santalaceae		H		CDFA 2013	
Santalum panaiculatum	Santalaceae		H		APHIS 2015	
Sapium baccatum	Euphorbiaceae		H		CHINAJARIYAWONG et 2000	
Sarcocyphalus latyfolius	Rubiaceae	African peach	H		APHIS 2015	
Sauropus androgynus	Euphorbiaceae		H		CABI 2016	
Sclerocarya birrea	Anacardiaceae	Marula	H		CABI 2016; De Meyer et al, 2014	
Schoepfia fragrans	Olacaceae		H		CABI 2016	

Shirakiopsis indica	Euphorbiaceae		H		CABI 2016	
Solanum aculeatissimum	Solanaceae				APHIS 2015	
Solanum aethiopicum	Solanaceae	African scarlet eggplant	H		CABI 2016; De Meyer et al 2014	
Solanum americanum	Solanaceae		H		CABI 2016; Vargas et al 2010	
Solanum anguivi	Solanaceae	Forest bitter berry	H		CABI 2016; De Meyer et al 2014	
Solanum athiopicum	Solanaceae	Ethiopian eggplant	H		?	
Solanum capsicoides	Solanaceae	Cockroach berry	H		CABI 2016	
Solanum hazenii	Solanaceae		H		CABI 2016	
Solanum incanum	Solanaceae	Grey bitter-apple	H		CABI 2016; De Meyer et al 2014	
Solanum nigrum	Solanaceae	Black night shade	H		CABI 2016; De Meyer et al 2014	
Solanum lycopersicum	Solanaceae	Tomato	H		CABI 2016; Vargas et al 2007	
Solanum melongena	Solanaceae	Aubergine	H		CABI 2016; Clarke et al 2005	
Solanun muricatum	Solanaceae		H		APHIS 2015	
Solanum pseudocapsicum	Solanaceae		H		APHIS 2015	
Solanum rudepannum	Solanaceae		H		CABI 2016	
Solanum sodomeum	Solanaceae	Apple of Sodum	H		CABI 2016	
Solanum stramoniifolium	Solanaceae		H		CABI 2016	
Solanum torvum	Solanaceae	Turkey berry	H		CABI 2016	
Solanum trilobatum	Solanaceae		H		CABI 2016	
Sorindeia madagascariensis	Anacardiaceae		H		CABI 2016; De Meyer et al, 2014	
Spondias cytherea	Anacardiaceae		H		Mwatawala et al., 2006; Vergas et al 2007	
Spondias dulcis	Anacardiaceae	Sondriry	H		CABI 2016; Le Blanc et al 2012	
Spondias mombin	Anacardiaceae	Jew plum	H		CABI 2016; De Meyer et al, 2014	
Spondias pinnata	Anacardiaceae	Otaheite apple	H		CABI 2016	
Spondias purpurea	Anacardiaceae	Red mombin	H		CABI 2016	
Spondias tuberosa	Anacardiaceae		H		CDFA 2013	
Streblus asper	Moraceae	Tropical plum	H		CABI 2016	
Strychnos mellodora	Loganiaceae	Monkey orange	H		APHIS 2015; De Meyer et al 2014	
Syzygium aqueum	Myrtaceae	Watery rose-apple	H		CABI 2016	
Syzygium aromaticum	Myrtaceae	Clove	H		CABI 2016	
Syzygium borneense	Myrtaceae		H		CABI 2016	
Syzygium cumini	Myrtaceae	Jambolan	H		CABI 2016; De Meyer et al, 2014	
Syzygium formosanum	Myrtaceae		H		CABI 2016	
Syzygium grande	Myrtaceae	Sea apple	H		CABI 2016	
Syzygium jambos	Myrtaceae	Rose apple	H		CABI 2016; Vargas et al 2010	
Syzygium lineatum	Myrtaceae		H		CABI 2016	
Syzygium malaccense	Myrtaceae	Malay apple	H		CABI 2016; Vargas et al, 2007	
Syzygium megacarpum	Myrtaceae		H		CABI 2016	

Syzygium nervosum	Myrtaceae		H		CABI 2016	
Syzygium samarangense	Myrtaceae	Java apple	H		CABI 2016; De Meyer et al, 2014	
Terminalia arenicola	Combretaceae		H		CABI 2016	
Terminalia catappa	Combretaceae	Tropical almond	H		CABI 2016; De Meyer et al, 2014	
Terminalia chebula	Combretaceae		H		APHIS 2015	
Terminalia citrina	Combretaceae		H		CABI 2016; Vargas et al, 2007	
Theobroma cacao	Sterculiaceae	Cocoa	H		CABI 2016	
Thevetia peruviata	Apocynaceae	Lucky nut	H		CABI 2016; De Meyer et al, 2014	
Trichosanthes ovigera	Cucurbitaceae		H		CABI 2016	
Trichosanthes oxigera	Cucurbitaceae		h		Vijaysegaran 2001	
Triphasia trifolia)	Rutaceae	Limeberry	H		CABI 2016	
Uvaria cordata	Annonaceae		H		CABI 2016	
Uvaria grandiflora	Annonaceae				CABI 2016	
Veitchia merrillii	Arecaceae	Christmas palm	H		CABI 2016	
Vitis vinifera		Grape	H		APHIS 2015	
Vitellaria paradoxa	Sapotaceae	Sheanut	H		CABI 2016; De Meyer et al 2014	
Willughbeia edulis	Apocynaceae		H		CABI 2016	
Wilstromeia phyllyraefolia			H		APHIS 2015	
Xanthophyllum flavescens	Polygalaceae		H		CABI 2016	
Ximenia americana	Olacaceae	Hog plum	H		CABI 2016	
Zehneria wallichii	Cucurbitaceae		H		CABI 2016	
Ziziphus jujuba	Rhamnaceae	Common jujube	H		CABI 2016	
Ziziphus mauritiana	Rhamnaceae	Indian jujube	H		CABI 2016; De Meyer et al 2014	
Ziziphus nummularia	Rhamnaceae	Lotebush			CABI 2016	
Ziziphus oenoplia	Rhamnaceae	Lotebush	H		CABI 2016	
Ziziphus rotundifolia	Rhamnaceae		H		CHINAJARIYAWONG et al 2000	

References

http://www.spc.int/Pacifly/Species_profiles/B_philippinensis.htm

Armstrong, J.W. 2001. Quarantine Security of Bananas at Harvest Maturity Against Mediterranean and Oriental Fruit Flies (Diptera: Tephritidae) in Hawaii. Journal of Economic Entomology, 94(1):302-314.

CDFA) California Department of Food and Agriculture. 2001. *Exotic Fruit Fly Regulatory Response Manual*. Plant Health and Pest Prevention Services, Pest Exclusion Branch, United States Department of Agriculture, Animal and Plant Health Inspection Service, Plant Protection and Quarantine.

CHINAJARIYAWONG, A., CLARKE, A. R., JIRASURAT, M., KRITSANEEPIBOON, S., LAHEY, H. A., VIJAYSEGARAN, S. AND WALTER, G. H. 2000. Survey of Opiine parasitoids of fruit flies (Diptera:Tephritidae) in Thailand and Malaysia. The Raffles Bulletin of Zoology, 48 1: 71-101.

CLARKE, A. R. , ARMSTRONG, K. F. , CARMICHAEL, A. E. ,MILNE, J.R. , RODERICK, G. K. & YEATES, D. K. 2005 Invasive Phytophagous Pests Arising Through a Recent Tropical Evolutionary Raditation : The Bactrocera dorsalis complex of fruit flies . Annual Review of Entomology 50:293-319.

Cugala, D.; Ekesi, S.; Ambasse,
D.; Adamu, R.S.; Mohamed, S.A.
2014. Assessment of ripening
stages of Cavendish dwarf bananas

as host or non-host to Bactrocera invadens. Journal of Applied Entomology. 138: 449-457.
De Meyer, M. Mohamed, S. White, I.M. 2014. Invasive Fruit Fly Pests in Africa. http://www.africamuseum.be/fruitfly/AfroAsia.htm
Klungness, L.M., Vargas, R.I., Jang, E.B., Mau, R.F.L. and Kinney, K. 2009. Susceptibility of ripe avocado to invasive alien fruit flies (Tephritidae) on the island of Hawaii. Proc. Hawaii. Ent. Soc. 41: 1-13.
Susceptibility of ripe avocado to invasive alien fruit flies (Diptera: Tephritidae) on the island of Hawaii. Proc. Hawaiian Entomol. Soc. 41:1-13.
Leblanc, L. , Tora Vueti, E., Drew, R.A.I. and Allwood, A.J. 2012. Host Plant Records for Fruit Flies (Diptera: Tephritidae: Dacini) in the Pacific Islands. *In* Proceedings of the Hawaian Entomological Society.
VARGAS, R.I, PIÑERO, J. C, MAU, R.F.L., JANG, E B., KLUNGNESS, L.M., MCINNIS, D.O., HARRIS E.B., MCQUATE, G.T. BAUTISTA, R.C. & WONG, L. 2010. Area-wide suppression of the Mediterranean fruit fly, Ceratitis capitata, and the Oriental Fruit Fly, Bactrocera dorsalis, in Kamuela, Hawaii. Journal of Insect Science. 10: 1-17.
Ware, A.B., du Toit, C.L.N., Du Toit, E., Collins,R., Clowes,R., Ekesi,S. and Mohamed, S.A. 2016. Host suitability of three avocado cultivars (Persea americanaMiller: Lauraceae) to oriental fruit fly (Bactrocera (invadens)dorsalis (Hendel) (Diptera: Tephritidae)).Crop Protection. 90: 84-89
WHITE, I.M. & ELSON-HARRIS, M.M. 1994. Fruit Flies of Economic Significance: Their Identification and Bionomics. CAB International, Wallingford, UK.
USDA. 2015 . Bactrocera dorsalis, Oriental Fruit Fly Host List, https://www.aphis.usda.gov/plant_health/plant_pest.../off-hostlist.pdf