***Bactrocera invadens***

**Fruit fly of quarantine importance for Mauritius**

 **PREPAREDNESS & EMERGENCY ACTION PLAN**

**Entomology Division**

**in collaboration with**

**National Plant Protection Office**

**Agricultural Services**

**Ministry of Agro Industry & Food Security**

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**I. GENERAL INFORMATION**

**a. Action statement**

The action plan is a recommended response for survey, containment and eradication following a detection of *Bactrocera invadens* in Mauritius through the island wide existing fruit fly trapping network.

**b. Background information**

**(i) Origin & Distribution**

*Bactrocera invadens* originates from Asia and has invaded various parts of Africa. The fruit fly officially occurs in Sri Lanka, India and Bhutan. Since its first record in Africa in Kenya in 2003, since then it has spread to Uganda, Tanzania, Sudan, Democratic Republic of Congo, Congo, Nigeria, Angola, Sierra Leone, Senegal, Ghana, Togo, Niger, Ivory Coast, Mali, Guinea, Equatorial Guinea, Benin, Burkina Faso, Zambia, Mozambique (2007). This insect has now reached the Comoros Islands.

**(ii) Host Range**

*B. invadens* is a polyphagous species and has to date been recorded from 25 host species belonging to 13 plant families. The host list in the table below has been compiled from published scientific papers. These hosts should therefore be inspected and regulated in the case of a *B. invadens* find. The host list presented below is not exhaustive and can still expand.

Table 1. Host plants of B. invadens

|  |  |  |  |
| --- | --- | --- | --- |
| **Scientific name** | **Common name** | **Scientific name** | **Common name** |
| ***Mangifera indica*** | Mango | ***Carica papaya*** | Papaya |
| ***Anacardium occidentale***  | Cashew | ***Lycopersicon esculentum*** | Tomato |
| ***Sclerocarya birrea*** | Marula | ***Capsicum annuum*** | Bell pepper |
| ***Sorindeia madagascariensis*** | Sondriry | ***Capsicum frutescens*** | Chili pepper |
| ***Spondias cytherea*** | Jew plum | ***Psidium guajava*** | Common guava |
| ***Spondias mombin*** | Tropical plum | ***Syzygium malaccense*** | Malay apple |
| ***Citrus aurantium*** | Sour orange | ***Syzygium samarangense*** | Java apple  |
| ***Citrus sinensis*** | Orange | ***Annona cherimola*** | Cherimoya |
| ***Citrus limon*** | Lemon | ***Annona muricata*** | Soursop |
| ***Citrus reticulata*** | Tangerine / mandarin | ***Annona squamosa*** | Sugar-apple |
| ***Citrus paradisi*** | Grapefruit | ***Averrhoa carambola*** | Carambola |
| ***Fortunella japonica*** | Kumquat  | ***Terminalia catappa*** | Indian Almond |
| ***Musa spp.*** | Banana | ***Flacourtia indica*** | Governor’s plum |
| ***Musa x paradisiaca*** | Plantain | ***Cordia* spp*.*** | Grey leaved saucer berry |
| ***Prunus persica*** | Peach | ***Strychnos mellodora*** | Monkey orange |
| ***Eriobotrya japonica*** | Loquat | ***Dracaena steudneri*** |  |
| ***Diospyros kaki*** | Japanese persimmon | ***Irvinia gabonensis*** | African wild mango |
| ***Diospyros montana*** | Mountain persimmon | ***Ficus sycomorus*** | Wild fig |
| ***Citrullus lanatus*** | Watermelon | ***Blighia* sp.** |  |
| ***Cucumis sativus*** | Cucumber | ***Chrysophyllum albidum*** | White star-apple |
| ***Cucumis figarei*** | Hyena’s watermelon (direct translation ) | ***Vitellaria paradoxa*** | Sheanut |
| ***Cucurbita maxima*** | Pumpkin | ***Landolphia*sp.** |  |
| ***Cucumis pepo*** | Gourd | ***Maerua duchesnei*** |  |
| ***Persea americana*** | Avocado | ***Garcinia mannii*** | Chewing stick |

**(iii) Demography**

The mean generation time for *B. invadens* 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. invadens* 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. invadens*.

Table 2: Mean total developmental time for immature stages of *B. invadens* (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 (Tmax + Tmin)/2 –t with Tmax being maximum temperature, Tmin minimum temperature and t, the lower development threshold. The lower development threshold of *B. invadens* was found to be 8.8°C, 9.4°C and 8.7°C for the egg, larva and pupa.

**(iv) Attractants**

*B. invadens* responds to methyl eugenol which is a parapheromone and attracts only males. Attraction of both sexes of the fly to protein hydrolysate and the 3-component Biolure have also been reported.

# II. SURVEY PROTOCOL

**a. Surveillance**

A regular surveillance programme throughout the year should be in place to detect any incursion of *B. invadens* 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 Biolure (3-component) should be carried out to determine pest absence or presence.

**b. Delimiting survey**

When one *B. invadens* is collected in an area, a delimiting survey should be implemented immediately. The area immediately surrounding each fly find will be a core area of a 1 km x 1 km square grid. Methyl eugenol baited traps and Biolure (3-component) baited traps will each be placed at a density of 10 traps per km2 within the core area (Figure 1 & 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 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. invadens* generations (approx. 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 the annex

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 3rd SURROUNDING ZONE |  |  |  |  |
|  | 2nd  SURROUNDING ZONE |  |  |  |
|  |  | 1st SURROUNDING ZONE |  |  |
|  |  |  | CORE |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |

Figure 1. Delimiting survey with single km2 core area and three surrounding zones

Table 3: Trap density in core and surrounding zones

|  |  |  |
| --- | --- | --- |
| Zones  | Area/km2 | Number of traps per km2. Methyl Eugenol + Biolure 3C (Biolure 3 C only in core area)  |
| Core  | 1  | 10+10  |
| 1st  | 8  | 2  |
| 2nd  | 16  | 2  |
| 3rd  | 24  | 2  |

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).

**c. Fruit inspection**

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

**III. QUARANTINE**

Once a *B. invadens* sample is caught in a trap and the identification is done with reasonable confidence by a competent entomologist, the area of the fruit fly detection is quarantined with immediate effect to restrict movement of host material, in particular fruits listed above as *B. invadens* hosts, out of the area. The initial quarantine area will extend to a circular area of 5 km radius from the trapping point. 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.

Movement of host material will be regulated.

Road blocks should be implemented to regulate movement of fruits from the area.

All local growers in the area of the fruit fly detection, establishments within the area that handle fruits and vegetables should be notified of the threat posed by the fruit fly and actions that need to be taken.

An area may be removed from quarantine status after the pest has been declared eradicated or there has been no other *B. invadens* find for at least 3 generations (calculated from the local climate data, but generally around 12 weeks).

**IV. ERADICATION PROCEDURES**

Eradication of *B. invadens* should be initiated following the detection of a second *B. invadens* fruit fly in the delimiting survey area. The total area of coverage will depend on the extent of spread. For each *B. invadens* fruit fly find, the area under eradication will be 25 km2 surrounding the trap site. Duration of eradication measures should be planned for at least 2 generations of *B. invadens* (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. invadens* generation (generally 4 weeks) after eradication measures have stopped (no more bait spraying and placement of fresh male annihilation blocks).

A combination of ground applied male annihilation treatments and air/ground applied protein bait treatments (air/ground application in orchards and ground application in residential areas) should be carried out. Fruit stripping should be considered as a contributory measure, where appropriate.

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 ULV at a ratio 3: 1 for a minimum of 24 hours and placed at a density of 400 per km2, either nailed to poles or hung from trees (10 000 blocks per 25 km2 fly-detection unit). A single application of MAT blocks will cover a period of 8 weeks.

Protein baiting

Protein bait sprays should be carried out weekly. The toxicants that may be used in combination with the protein hydrolysate are malathion and spinosad. Spinosad in combination with an attractant is commercially available as the organically certified product GF120.

Protein hydrolysate (0.2%) in combination with malathion 57EC (0.07%) is applied from the ground preferably under the leaves of host trees as spot sprays of 40 ml (80 L protein hydrolysate + 28 L malathion 57EC per km2; 2000 L protein hydrolysate + 720 L malathion 57EC per 25 km2). Alternatively, GF 120 can be used at 1 L per ha in a spray mix with 1-3 L of water (100 L per km2 and 2500 L per 25 km2). Where possible, applications in an eradication programme should favour the use of GF120 in residential areas.

Supplemental eradication treatments

*Fruit stripping*. If fruit stripping is undertaken in the core area, stripped fruits should be placed in plastic bags, fumigated if possible and removed to a landfill site for burial under at least 1 m of fill. The burial site should be located within the quarantined area.

**V. IDENTIFICATION & INFORMATION FLOW**

**a. Identification**

During surveillance, specimens should be collected and first screened by a local designated identifier. Any suspect specimen should be forwarded immediately to the Entomology Division in vials of at least 70% alcohol for confirmation.

If a positive ID is obtained from the Entomology Division, 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 Entomology Division with the NPPO through review of documentation and procedures.

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.

**b. Steering Committee (coordination, communication and decision making)**

The *B. invadens* Steering Committee will oversee communication, co-ordination of actions and decision making in response to a *B. invadens* 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 Agricultural Services (Divisional Scientific Officers of the Entomology Division and NPPO), University of Mauritius, Agricultural Research & Extension Unit, Food and Agricultural Research Council, Ministry of Environment, Ministry of Health and Quality of Life, representatives of growers. The Steering Committee will be chaired by the Chief Agricultural Officer.

**VI. SEQUENCE OF EVENTS**

Specimen collected (surveillance network or other source)

First screening of sample and ID (Entomology Division)

Engage Steering Committee to oversee eradication, monitoring and communication

Quarantine & initiate delimiting survey

If second fly is found, initiate eradication

If second fly is not found, verify ID of first fly find by taxonomist & lift quarantine after 3 fruit fly generations or about 12 weeks

Verify ID by taxonomist & notify in accordance to IPPC guidelines, apply eradication treatments for 8 weeks and monitor for another 4 weeks

If further catches are made during the 4-week post treatment monitoring, repeat eradication and monitoring procedures

If no further flies are caught during the 4-week post treatment monitoring, declare eradication & lift quarantine

If flies are trapped at other sites

during delimiting survey: expand quarantine, eradication and delimiting survey area

**VII. STOCK OF MATERIALS, EQUIPMENT, PERSONEL REQUIRED IN PREPAREDNESS OF ERADICATION AND MONITORING**

Materials should be kept in a designated facility in preparedness for a potential outbreak of *B. invadens*. 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. invadens* if temperature is at 28°C). The area of coverage around each fly detection site will be 25 km2 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):

1. 10 000 fibre board blocks (5 cm x 5 cm x 1.2 cm)
2. 150 L Methyl Eugenol
3. 50 L of Malathion ULV
4. 450 L of Malathion 57EC
5. 10 000 L of Protein hydrolysate
6. 10 000 L of GF120

For monitoring, 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.

1. 200 one-L yellow traps with wicks
2. 20 Biolure 3C dispensers
3. 250 DDVP strips

Equipment and transport required for implementation of the eradication action plan include:

1. 25 knapsack sprayers (preferably CP15)
2. Protective equipment for 25 persons (25 half face respiratory masks, 3 full face mask respiratory masks, 50 pairs of rubber gloves, 25 pairs of woolen gloves)
3. 30 hammers
4. 50 kg of nails (one inch long)
5. 25 kg of galvanized wire
6. 10 ‘pinces’
7. Three 4 x 4 vans
8. Two 14-seater vans

25 trained sprayermen should be available for intervention.

**VIII. Cost of materials**

|  |  |  |  |
| --- | --- | --- | --- |
| **SN** | **Item** | **Quantity** | **Cost (Rs)** |
| 1 | Fibre board blocks | 10000 | 6000 |
| 2 | Methyl eugenol | 75 L | 450000 |
| 3 | Malathion ULV | 25 L | 17500 |
| 4 | Malathion 57EC | 450 L | 362250 |
| 5 | Protein Hydrolysate | 10000 L | 3000000 |
| 6 | GF120 | 10000 L | 5250000 |
| 7 | Yellow traps | 200 | 4000 |
| 8 | Biolure 3C dispensers | 20 | 6000 |
| 9 | DDVP strips  | 250 | 6250 |
| TOTAL | **9102000** |