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TECHNICAL BROCHURE



WHITEFLY IDENTIFICATION AND INSPECTION BROCHURE

FOR INSPECTORS AND EXTENSION
WORKERS IN ACP COUNTRIES



COLEACP

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Figure 1: Jute (*Corchorus olitorius*) is a common leafy vegetable exported from the African Caribbean Pacific (ACP) countries to EU market and is normally intercepted for whiteflies. (Photo by V. Eziab, University of Ghana)..

Background

This Whitefly identification and inspection brochure for inspectors and extension workers in ACP countries is a part of a series of 4 brochures for whiteflies management:

1. Whitefly strategy management dossier for the control bodies
2. Whitefly inspection and identification brochure for inspectors and extension workers in ACP countries
3. Whitefly field management brochure for growers in Togo
4. Whitefly packhouse management brochure for packhouse managers in ACP countries

The ACP countries continue to receive increasing interceptions of whiteflies from commodities for export to the EU, especially, leafy vegetables. For instance, in 2020, 90 interceptions of whiteflies (mainly *B. tabaci*) on leafy vegetables (41), vegetables (33), edible/infusion flowers (15), leafy fruits (1). The breakdown includes Togo (46), Nigeria (12), Cameroon (8), Suriname (8), Sierra Leone (5), RDC (4), Kenya (3), Congo (1) and The Gambia (1). Considering the new EU regulation already in force, much stringent guidelines are needed to be followed, to ensure interceptions of harmful organisms (specifically whitefly, *Bemisia tabaci*) to not rise to alarming levels that may warrant a ban in any of the affected countries.

This whitefly identification and inspection brochure has been developed to assist inspectors and extension workers in the field and in the packhouse to properly detect, inspect and identify any whitefly species affecting the produces for export, to ensure that produces from the packhouse to the point of exit is free from whiteflies and any other quarantine pests to guarantee that no pest is present in plant commodities exported to the EU and other international markets.

Identity

- Synonyms: *Bemisia tabaci*, *Bemisia argentifolii*
- Common names: Sweet potato whitefly, Tobacco whitefly, Silverleaf whitefly, Poinsettia whitefly, B biotype
- Taxonomic classification
 - ↳ Kingdom: Animalia
 - ↳ Phylum: Arthropoda
 - ↳ Class: Insecta
 - ↳ Order: Hemiptera
 - ↳ Family: Aleyrodidae
 - ↳ Genus: *Bemisia*
 - ↳ Species: *Bemisia tabaci*

Major host plants

Bemisia tabaci is polyphagous, having a host range of over 600 different plant species, including herbaceous and woody plants. Common hosts include cotton, cassava, sweet potato, cucurbits, tomatoes, eggplant, peppers, lantana, roses, solidago, hibiscus, okra, leafy vegetables (e.g. Jute, Amaranthus) and tobacco.

Geographical distribution

Bemisia tabaci is widely distributed globally. However, certain areas within Europe are still free from *B. tabaci*, e.g., Finland, Sweden, Republic of Ireland and the UK (Fig. 2).

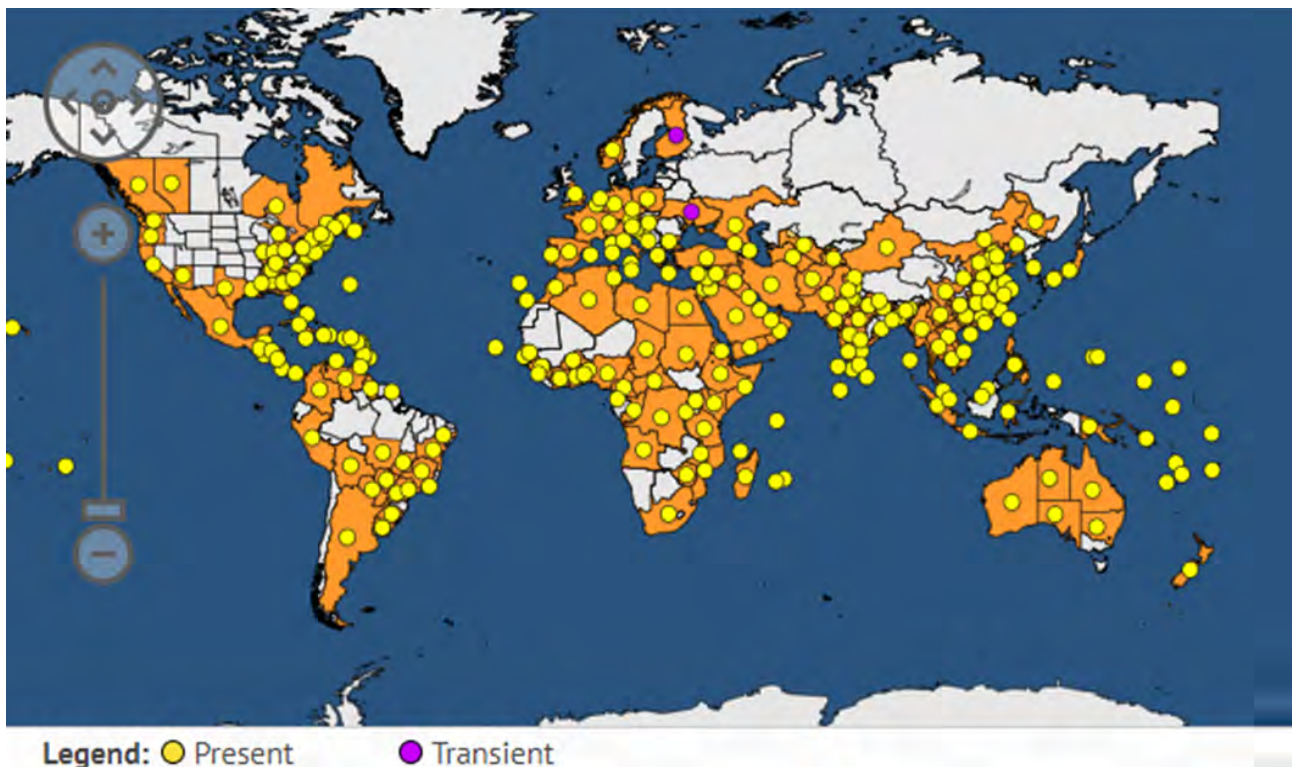


Figure 2: Distribution of *Bemisia Tabaci* in the world (EPPO, 2021)

Life cycle of whiteflies

Bemisia tabaci goes through six developmental stages, namely egg, first, second, third and fourth larval or nymphal stages and adult (Fig. 3). The duration of the egg to the adult stage depends on the climatic conditions and the host plant. For example, the duration of the egg-to-adult period of *B. tabaci* under laboratory conditions (25°C, 70 ± 10% RH, 14-hour photophase) was 19.8 days on collard, 21.2 days on soybean and 22.0 days on tomato (Takahashi *et al.* 2008).

Bemisia tabaci Stages - Characterization adopted

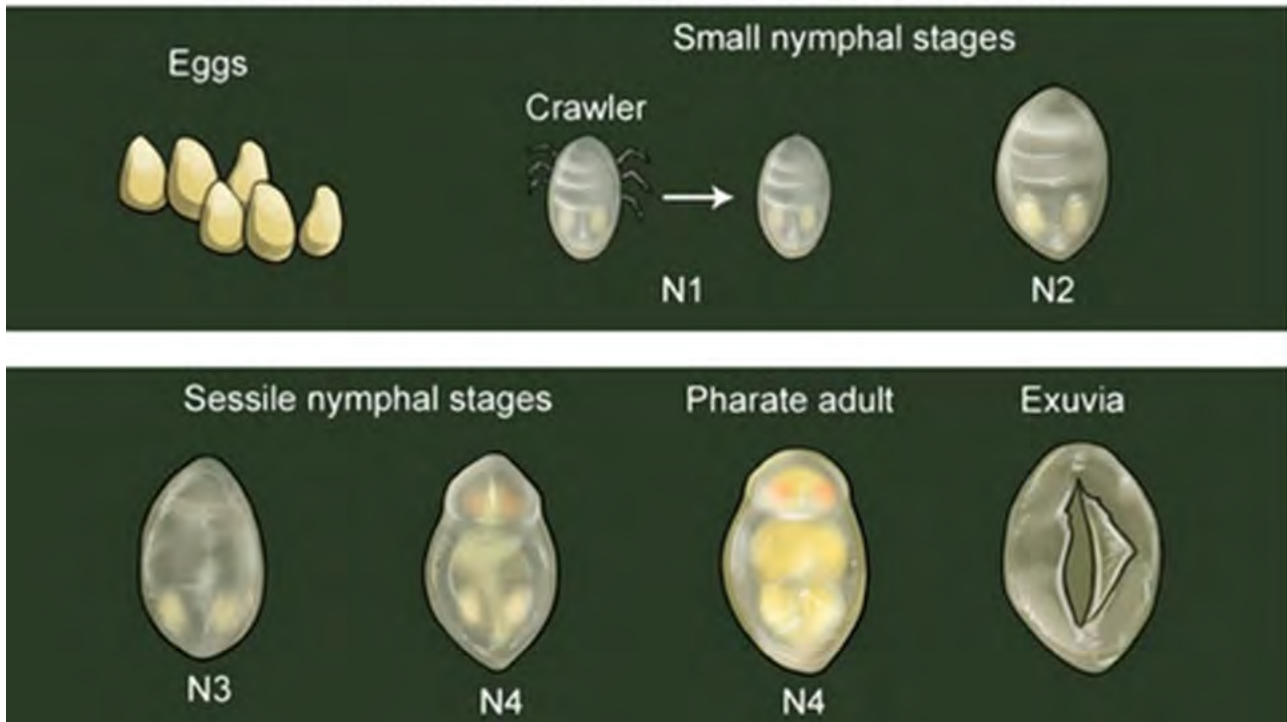


Figure 3: *Bemisia tabaci* developmental stages - illustration by Gabriella Czepak Caston. Adapted from Czepak et al. 2018.

Eggs:

Female whiteflies deposit pear-shaped eggs (Figs. 3-4) into the mesophyll or inner tissue of the leaf from the lower surface. Eggs are attached to the leaf by a stalk-like process. Eggs are white when first laid and become brown prior to hatching (Fig. 4). They are generally laid on the underside surface into the inner tissue of the younger upper leaves of the plant (Fig. 4). Females lay from 28-300 eggs depending on host and temperature.



Figure 4: Sweetpotato whitefly, *Bemisia tabaci* eggs laid in a circle with a 1st instar crawler in the middle and older nymphs nearby. Photo by Erfan Vafaie, Texas A&M AgriLife Extension.

Nymphs:

The first nymphal stage is called crawler (Figs. 3-5) and the last stage is often referred to as the pupa. After hatching the crawlers move a short distance and settle to feed. Once settled, the subsequent three nymphal stages are scale-like and sedentary. **Nymphs are creamy white to light green and oval in outline** (Figure 5b).

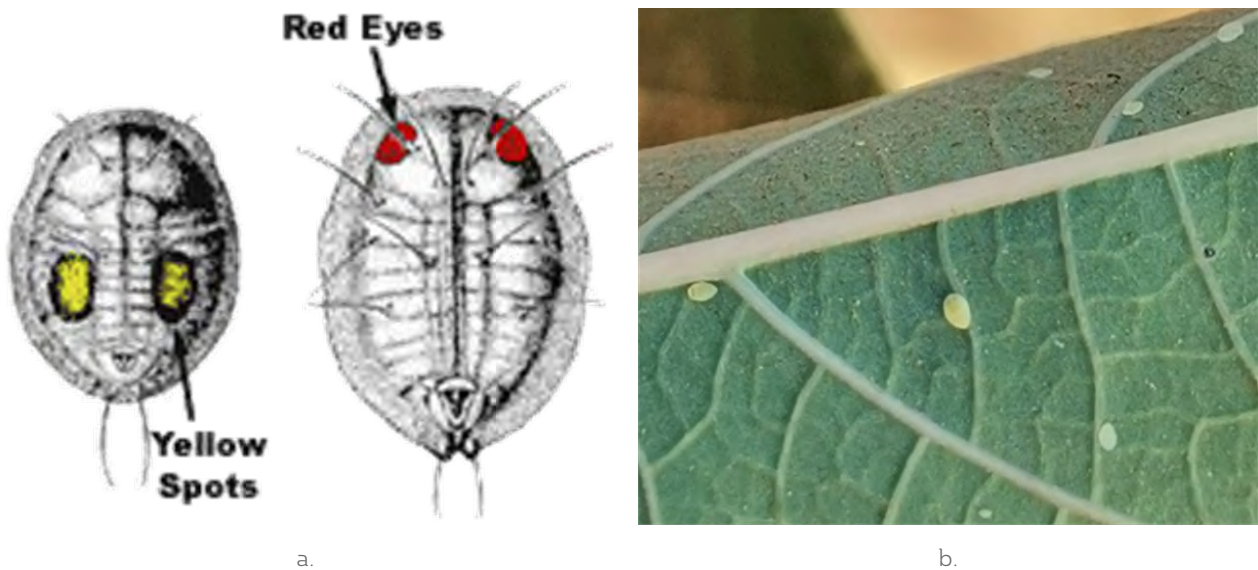


Figure 5: a. 3rd (left) & 4th (right) instar nymphs called crawlers. (Photo by Tong-Xian Liu).
 b. *Bemisia tabaci* nymphs on cassava leaf – Photo by KO Fening.

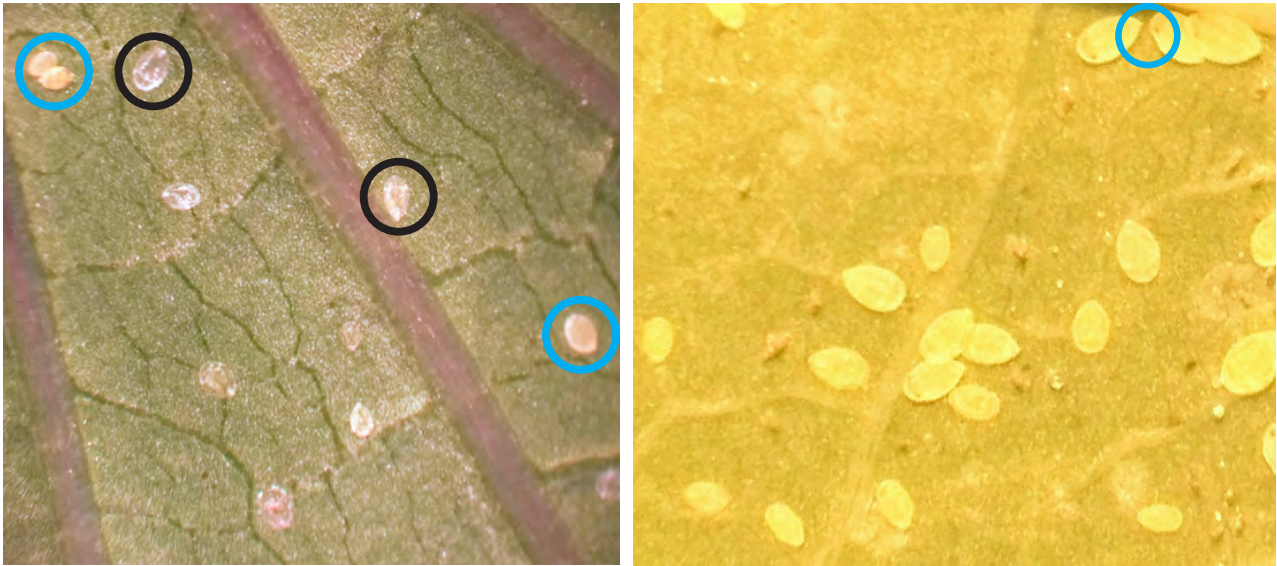


Figure 6: *Bemisia tabaci* nymphs (blue circle) and shed skin (exuvia) (black circle) on cassava and sweet potato, respectively as observed under the light microscope. Photos by KO Fening.

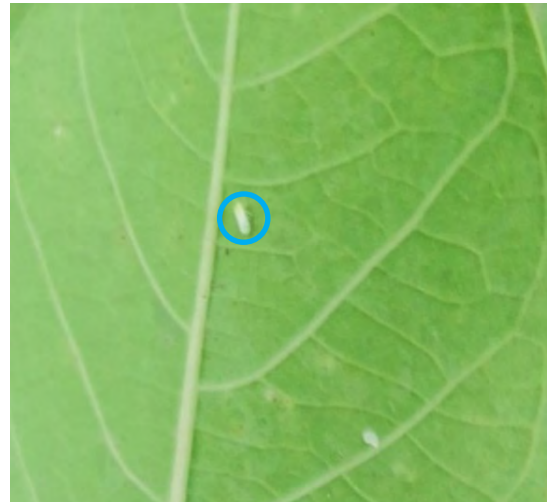
The eggs and early nymphal stages (1st and 2nd instars) might be difficult to observe with the naked eye, unless aided by a magnifying lens. Count large nymphs (3rd and 4th instars), those that are visible to the naked eye (Figs. 5-6). The 3rd & 4th instar nymphs appear as flattened, egg-shaped disks or 'scales' (Figs. 5-6). Although the 3rd & 4th instar nymphs should be visible to the naked eye, some of them may blend in with the leaf surface (Fig. 6). So, look for the two yellow spots on the 3rd and young 4th instars and the developing red «eye» spots on the matured or largest 4th instar (sometimes referred to as the pupae) (Fig. 5a).

Adults:

Adult sweet potato whiteflies are small, approximately 1mm in length, with a pale-yellow body and two pairs of white wings and covered with a white waxy powder (Fig. 7). At rest, wings are held in an inverted V position. Their compound eyes are red.



a.



b.

Figure 7: a. Adult *B. tabaci*- Photo from Public Domain - Released by the USDA-RS/original image by Stephen Ausmus.
b. Adult *B. tabaci* on cassava leaf- Photo by KO Fening

Avoid confusion of *Bemisia tabaci* with other whiteflies

The adult of the sweet potato whitefly (*Bemisia tabaci*) closely resembles the greenhouse whitefly (*Trialeurodes vaporariorum*) but is slightly smaller and yellow. More distinctively, the wings of *B. tabaci* are held vertical and parallel along the body compared to *Trialeurodes vaporariorum* where the wings are held horizontal along the body (Fig. 8).



Figure 8: Adults of the greenhouse whitefly, *Trialeurodes vaporariorum*. (Unlike, *B. tabaci*, the fourth-instar nymphs have very long waxy filaments and a marginal fringe). (see photo above). Photo ©University of California.

Symptoms of whitefly damage

Whiteflies use their stylets in sucking sap from the phloem of plant stems and leaves. High populations of whiteflies cause leaves to turn yellow, appear dry, distorted, discoloured, or fall off (Fig. 9). Whiteflies also excrete honeydew (sugary liquid). Leaves get sticky and covered with black sooty mould (Fig. 10) that grows on honeydew as a result. Honeydew attracts ants, which may interfere with the activities of natural enemies that control whiteflies and other pests.



Figure 9: Damage symptoms and adults of *B. tabaci* on cotton leaf.
Photo by David Riley, University of Georgia (CC BY)



Figure 10. Sooty mould on leaf. (Morningchores, 2021).



Figure 11: Damage symptoms and adults of *B. tabaci* on French bean leaf (Photo from A.M. Varela, *icipe*).

EU import action

The European Union (EU) has overhauled its plant health (phytosanitary) regulations. On 14 December 2019, the new Plant Health Regulation (EU) 2016/2031 came into operation bringing rigorous new rules to prevent the introduction and spread of pests and diseases into the EU. More details on specific pests and requirements are given in a new Implementing Regulation (EU) 2019/2072 issued on 28 November 2019 and amended by the Regulation (EU) 2021/759 issued on 7 May 2021. Whitefly species are found on a wide variety of host plants and can be a serious problem for crops causing direct damage as well as acting as a vector of plant viruses. Some species are listed under the EU regulations as quarantine pests including *Aleurocanthus citripardus*, *Aleurocanthus woglumi*, and *Bemisia tabaci* (non-European populations). Consignments of imported produce (leafy vegetables and ornamental plants) that are found to contain *B. tabaci* or other quarantine pest will be intercepted and detained at EU border controls. It is therefore essential to monitor and avoid their presence and all other harmful organisms in export crops. So far, the most important and commonly intercepted whitefly species in exported commodities from the ACP countries into the EU is *B. tabaci* (non-European populations).

Inspection

Farm level

It is important to monitor and inspect whiteflies population at the farm level for informed decision making on their management or to determine if management interventions were effective. Regular scouting and examination of crops will lead to early detection and timely management of whiteflies, their natural enemies (predators and parasitoid) and other pests.

The scouting could be done on the crop by:

- Looking at the underside of the leaves for the presence of the nymphs (Figs. 3-5) and adults (Fig. 7) whiteflies, *B. tabaci*, early in the morning (6-7am), where they are still inactive and easily noticeable. Note that the flying whiteflies are seen when the crop is disturbed. For early detection, scouting is done for adults and eggs that are usually found on young leaves (refer to Figs. 3-7)
- Counting the large nymphs (3rd and 4th instars), (Figs. 5-6) that are visible to the naked eye.
- Checking the presence of sooty mould and ants on host plants which are symptoms of the presence of the whiteflies (see section symptoms of whitefly damage) (Fig. 9-11).
- Using yellow sticky traps (Fig. 15) in the vicinity or crop canopy (1 trap per 100m²) (Wilen *et al.*, 2021).

Note during the inspection that:

- The eggs (Figs. 3-4) and early nymphal stages (1st and 2nd instars) (Figs. 5-6) might be difficult to observe with the naked eye, unless aided by a magnifying hand lens.
- The 3rd & 4th instar nymphs appear as flattened, egg-shaped disks or 'scales'. some of them may blend in with the leaf surface. So, look for the two yellow spots on the 3rd and young 4th instars and the developing red «eye» spots on the matured or largest 4th instar (sometimes referred to as the pupae).
- Adult whiteflies (Fig. 7) easily fly away when the leaf is disturbed, especially when there is sunshine.

Inspection tool recommended:

- Hand lens to examine leaves and other areas for better visibility of eggs and nymphal stages. A threshold of one (1) whitefly may warrant control measures due to its potential as a vector for the transmission of plant viruses.

Post-harvest monitoring and inspection at the farm

After the produce has been harvested from the farm, it should be taken to a holding area to screen out whiteflies from the produce entering the pack house.

In the holding area, a representative sample (minimum 2%) should be obtained and inspected for all the life stages (egg, nymphs, and adults) of whiteflies.

For inspection of whitefly eggs:

- Examine the underside of the younger leaves by using a hand lens of at least X10 magnification (Fig. 12) or head visors with different magnifying lenses to suit each need (Fig. 13).

For inspection of whitefly nymphs:

- Examine the underside of the older leaves by using a hand lens of similar magnification.

For inspection of the adult whiteflies:

- Hold the harvested produce with one hand and tap gently the foliage with the other hand to check for adult whiteflies. If adult whiteflies are present, they will fly out of the bunch.

Detail observations of the whitefly eggs and nymphs could be done under a light microscope (Fig. 14).



Figure 12: Using a table or hand magnifying lens in inspecting produce for the presence of quarantine pests. (Photo by KO Fening, University of Ghana) (see arrow).



Figure 13: Using the head visor, fitted with a magnifying lens, for inspecting the presence of quarantine pest in produce. (Photo by KO Fening, University of Ghana) (see arrow).



Figure 14: Detail inspection by the University of Ghana team for the developing stages of whiteflies and other pests on Jute under a light microscope. (Photo by V. Eziah, University of Ghana).

Produce infested with any of the life stages of whiteflies should be isolated from the pest free produce and destroyed appropriately or alternatively a postharvest treatment could be employed to dislodge and kill them. Furthermore, a follow-up in the field where the whitefly infested produce was harvested should be done and appropriate management measures taken to control the pest. Additionally, monitoring of whiteflies in the harvested produce is done by placing yellow sticky cards (Fig. 15) at strategic points in the holding area. The quality controller in the farm should check the yellow sticky card regularly or daily for presence of whiteflies. Observation of whiteflies on the yellow sticky traps is an indication that whiteflies maybe present in the harvested produce and the sample size for inspection should be increased.



Figure 15. Monitoring and mass trapping of whiteflies and other insects (e.g., thrips) in a greenhouse using yellow sticky traps (Photo from Russell IPM).

Inspection at the pack house

Inside the pack house, monitoring of whiteflies is done by placing yellow sticky cards (Fig. 15) in the pack house. The sticky cards should be placed at strategic points particularly near the entrance, near the windows and at different points inside the pack house. These cards should be examined regularly or daily for presence of whiteflies and replaced periodically (preferably weekly).

Other than monitoring, physical inspection of the harvested produce against whiteflies in the pack house should be done at three points:

1. Before grading (pre-grading): a representative sample (minimum 2%) should be taken and inspected for all the life stages of whiteflies.
2. During grading: when the produce is being graded, a quality controller should sample the produce being graded and inspect it for whitefly infestation
3. After grading (post-grading): after the produce has been graded and packed ready for dispatch from the pack house, a sample should be taken, inspected for presence of whiteflies. In all the three stages at the pack house, inspection procedure should be like that conducted at the produce holding area.

Produce infested with whiteflies should be isolated from the pest free produce and destroyed appropriately or alternatively use an appropriate postharvest treatment to dislodge and kill them. Some of the treatments that can be applied include:

- Cold storage
- Use of controlled atmosphere
- Washing, brushing, waxing, dipping, and heating.

Untreated infested produce should not be dispatched from the pack house to the market.

A follow-up in the field where the whitefly infested produce was harvested should also be done and appropriate management measures taken to control the pest.

Only produce inspected to be free from whiteflies and other quarantine pests should be sent from the pack house to the point of exit for final inspection before approval is granted for their export.

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