# INTEGRATED PEST MANAGEMENT FOR HAZELNUT CROPS

## A PRACTICAL HANDBOOK

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# INTRODUCTION

The hazelnut, like all crops, is vulnerable to a range of pests, parasites and illnesses. Crops may suffer from viruses, bacterial and fungal infections, nematodes, mites and insects – all of which can lead to smaller, lower-quality harvests. Pest control is a constant challenge for all farmers, from large commercial operations to small-scale producers. Invasive species and disease outbreaks can severely affect crop production, with new threats arising each season.

This document is a guide to Integrated Pest Management (IPM), an approach to controlling and reducing the economic impact of infestations. The IPM approach recommends against over-use of pesticides and encourages cultivators to monitor for the presence of pests on plants, suggesting chemical use only where a crop is threatened. This way, pests' natural predators are not harmed unless an infestation reaches a certain threshold, which reduces the risk of other outbreaks. Moreover, the IPM takes into account all the pest management approaches available, beyond pesticides, like: mechanical barriers (excluding nets), mass trapping with pheromone lures or attractants, use of resistant or tolerant cultivars, releases of natural enemies on the crop. In assisting farmers in being more careful about pesticide use, the approach also prevents the build-up of chemicals which may be dangerous to humans.

This handbook provides a visual guide to the most common threats to hazelnut crops in Abkhazia. It is intended to support farmers, government agencies, NGOs, and other agricultural actors in identifying pests and mitigating against their economic impact.

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# DISEASES

## VIRAL DISEASES

### THE APPLE MOSAIC VIRUS

The Apple Mosaic Virus, also known as ApMV, is a common viral disease, which is found wherever hazelnuts are cultivated. It may be transmitted through:

- grafting process
- pruning (infected tools being used on healthy trees)
- transplanting infected rooted suckers to have new trees
- wild grasses in the hazelnut orchard

ApMV does not spread through normal routes – such as insects, pollen or fruit. This makes controlling the disease easy.

The disease can be identified through a distinctive, yellow, mosaic marking on the leaves of infected crops (see Figure 1). ApMV does not typically pose a severe threat to infected crops, although productivity can be slightly reduced. Farmers that have identified the virus in their crops should isolate infected trees, paying special attention to the proximity of root systems and the presence of long, wild grasses in the area.

*Figure 1: Typical mosaic discoloration on leaves infected by Apple Mosaic Virus*
*Source: L. Bosco, DISAFA, University of Torino*

# BACTERIAL DISEASES

## BACTERIAL BLIGHT

Hazelnut blight is a common crop disease, which is present in all major centres of hazelnut production and is prevalent in countries bordering Turkey and Southern Russia. The disease is caused by bacteria, and poses a threat to both young and old plants.

*Figure 2: Typical spots induced by blight on the husk of hazelnuts*
*Source: EPPO Standards Diagnostic protocols for regulated pests*

### SYMPTOMS

Bacterial blight can be initially identified through the presence of small, spotted lesions across the plant's leaves and on the shells of its fruit, and from necrosis of emerging buds in late spring. In advanced stages, the disease can result in the formation of cankers – growing masses of dead tissue – across branches, trunk and suckers. These cankers may cause partial or total dieback of key parts of the plant, including twigs, branches, and in the most advanced cases, the trunk.

### DAMAGE

Whilst in rare cases bacterial blight can kill a plant, it is mainly a threat to production. If not properly controlled, it may spread quickly during late spring/early summer, particularly following a prolonged period of damp and humid weather. It typically colonises young buds, later progressing to leaves and involucres.

### CONTROL

- In a nursery environment, suckers may be transmission risk. Plants should be soaked at 42° C for 45 minutes.
- Copper-based products may be used to treat infections in mature groves. Treatment should be undertaken at minimum label dosage, and is most effective during the transition between spring and summer, and at leaf fall.
- Where infection is found, sites must be pruned and infection removed using tools disinfected with copper sulphate or 3% sodium hypochlorite.

# FUNGAL DISEASES

## GREY NECROSIS

Grey necrosis is a term applied to diseases affecting hazelnut fruit caused by a number of different fungi. Infections from such diseases are typically observed in the plant's fruit, but may also later effect flowers.

### SYMPTOMS AND DAMAGE

Grey necrosis can typically be first identified during fruit formation and is visible thereafter. It is characterised by the appearance of brown-grey spots, starting at the fruit's base before spreading to its tip (see Figure 3). Other signs of infection may include the wilting of young branches.

The infection can result in the complete destruction of a fruit as it succumbs to necrosis, and may also cause early drop. This form of fungal infection can be devastating, as infected plants may suffer from severe yield loss – up to 50% in particularly serious infections.

*Figure 3: Necrosis on a hazelnut caused by* a fungal infection
*Source: A. Belisario, CREA, Roma; Varvaro et al., 2011*

### CONTROL

- Grey necrosis can be prevented and controlled through intervention when fruits are beginning to form and grow.
- A combination of Boscalid and Pyraclostrobin can be used to prevent and treat infection, at a dose of 1 kg / ha, repeated every 15 days.
- Copper products are also effective against Grey Necrosis. Such products can be used starting from the end of flowering until the fruit growth phase, and again in late summer/autumn.

*Figure 4: wilting of a hazel branch from fungal infection*
*Source: A. Belisario, CREA, Roma; Varvaro et al., 2011*

## POWDERY MILDEW

Powdery Mildew is caused by a common fungus, and is well-known in the Black Sea region. Despite being widely recognized by farmers and easy to control, it is often left untreated. In recent years, however, a new, more dangerous form of the disease has been found in Abkhazia.
Farmers are advised to carefully monitor the spread of the fungus, and apply chemicals where necessary.

*Figure 5: Typical white spots on leaves caused by powdery mildew*
*Source: R. Botta, DISAFA, University of Torino*

## SYMPTOMS AND DAMAGE

The most common form of powdery mildew is familiar to most farmers, and appears on underside of leaves, usually in late season. The fungus may also appear in late spring, at which time it poses the strongest risk to plants, causing severe leaf fall.

The more dangerous, invasive form of the infection appears earlier in spring and poses a significantly greater risk to crops. Unlike the better-known variety, it may be visible on fruit as well as leaves. It is also distinct from its less virulent cousin in that the infection often covers both sides of a plant's leaves. In later stages of infection, small fungal bodies may be observed, which cause leaves to wither roll-up before falling to the ground. Similar symptoms are also observed on the plant's fruit.

*Figure 6: Nuts infected by powdery mildew*

## CONTROL

- The most common form of powdery mildew – which appears mainly on the underside of leaves – is easily controlled using products containing sulphur.
- Studies into the control of the more dangerous form of the fungus are still ongoing. Existing sulphur-based fungicides have been shown to limit the disease's spread, but not to prevent it completely. Sulphur-based fungicides should be applied once a month from late April until the first week before harvest.
- Sodium bicarbonate at 1.5% has been demonstrated to be a useful biocompatible fungicide for controlling powdery mildew on hazelnuts. Care should however be taken, as greater concentrations have been shown to cause damage to hazelnut leaves.

*Figure 7: The more virulent form of Powdery Mildew appearing on the top side of a hazelnut leaf*

# MITES AND INSECT PESTS

The hazelnut orchard is – generally speaking – a stable ecosystem, characterized by high levels of biodiversity. Numerous insects make their home in orchards, and whilst some may cause crop damage the majority are either harmless or actively useful to a hazelnut cultivator. Useful species may displace or consume other harmful species. The removal of a species may result in an explosion in secondary pests, such as aphids, spider mites, and scale insects – which are typically controlled by natural enemies.

Successful pest management must take the complex orchard ecosystem into account and take care to avoid damage to species that do not pose a risk to crops. If chemical intervention is required, producers must be highly selective in its selection and application, as broad-spectrum products can produce unexpected and harmful outcomes.

Chemical intervention should only be used where necessary, and only after a thorough assessment of the impact of a pest upon the crop. This process, termed monitoring, enables producers to manage risks and ensure that interventions are timely and appropriate.

This section contains detailed information on mites and insects that pose a threat to hazelnut crops in Abkhazia, with notes on each species' biological cycle, visible symptoms on crops, and strategies for monitoring and infestation management.

# MITES

## FILBERT BIG BUD MITE

The Filbert Big Bud Mite (FBBM) is a harmful pest found throughout hazelnut producing regions of the world. Two varieties of FBBM exist: the gall form and the vagrant form, both of which present a serious risk to the health of a crop, and must be carefully monitored and effectively managed.

The gall form is easily recognisable by the characteristic "galls" – misshapen hazel buds (see Figure 8) – which it causes during feeding. Galls (or "big buds") are formed by chemically induced distortions arising from a mite infestation, leading buds to become swollen, fleshy, deformed and pink.

The vagrant form does not cause big buds, but feeds on buds, catkins and on young fruit clusters, which can result in early fruit fall. The big buds produced by FBBM can also become home to other species of mites.

*Figure 8: Galls on a hazelnut plant*
*Source: DISAFA, Entomology, University of Torino*

### DESCRIPTION AND LIFE CYCLE

The adult FBBM is white, elongated, about 0.2-0.3 mm long, with two pairs of legs. The gall form has a simple life cycle with a single nymph form, which resembles the adult, while the vagrant form has a more complex life cycle, in which it undergoes two nymph forms.

There are typically at least six FBBM generations in a given year, with the species overwintering in the core tissue of swollen buds. In spring, nymphs leave their winter buds and spread to other buds where they feed, become adults, and mate (see Figure 9). FBBM migration lasts around 30-50 days, but consistently occurs throughout spring, usually around the appearance of a shoot's second or third leaf.

Migration typically takes place when day temperature exceeds 15-20°C and will not take place at lower temperatures. Egg production occurs from late February to mid-April, with the mite population peaking in March to early April.

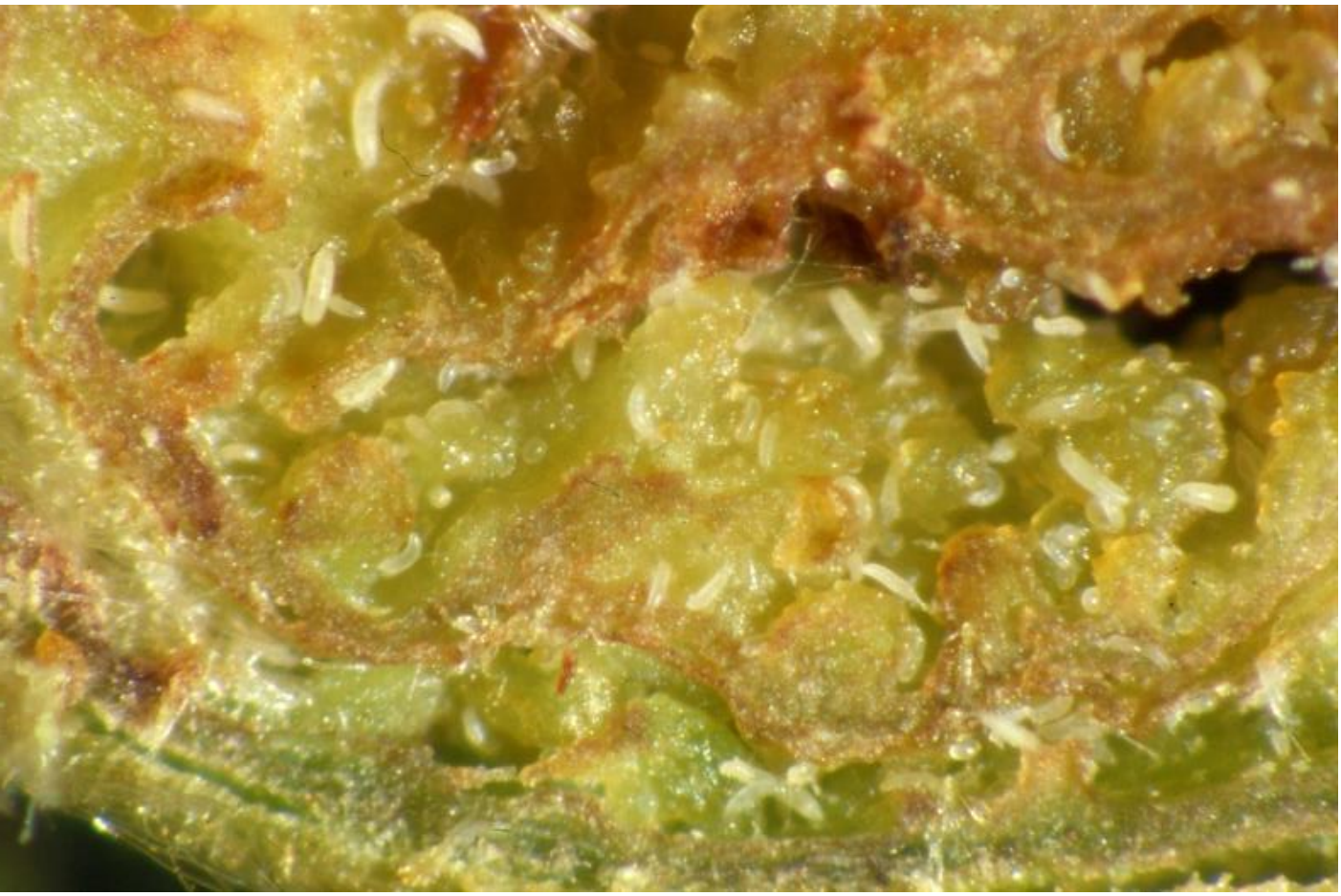

*Figure 9: Dense colonies inside buds infected by the FBBM*
*Source: DISAFA, Entomology, University of Torino*

## SYMPTOMS AND DAMAGE

An FBBM infestation can be a serious problem for hazelnut cultivators. Typical infestations can result in yield losses of up to 20%, however serious attacks have been recorded that have resulted in losses of up to 70%.

The FBBM feeds on the fluid content of plant cells, which causes serious swelling and tissue damage. An infestation whilst buds are growing can lead to weak and unhealthy shoots. Damaged male catkins can become stiff and brittle, producing little pollen, and weakened female buds may become infertile, preventing fruit formation. Damage may vary, dependent on the extent of the infestation, the susceptibility of the plant, and a range of environmental factors.

## MONITORING AND CONTROL

- Careful monitoring is essential to controlling FBBM infestation and should be carried out in late winter-early spring.
- Cultivators should perform visual inspection of 200 buds per orchard, or all buds on 4 branches of 10% of plans each hectare. If 15% of inspected buds show signs of galling, the economic threshold for treatment is reached and chemical application is recommended.
- The most effective time to undertake control measures is during the migration from infested to healthy buds. In Abkhazia, migration typically begins from late March to early April – although environmental factors may impact exact timing. Migration can be monitored by using sticky-tape to tap migrating mites, and a hand lens (5-10x magnification) to improve visibility.
- Sulphur products applied during the migration phase are usually effective. Two sulphur treatments with an 8-10-day interval period is recommended. An interval period is required although despite the lengthy 30-50-day migration period, recommended products act by contact and have short persistence.
- Interval periods are important to minimise damage to natural predators of the FBBM, such as the midges, wasps and most importantly predatory mites.

*Figure 10: An adult Brown Marmorated Stink Bug*
*Source: Pansa et al. 2013; DISAFA Entomology, University of Torino*

# INSECTS

## BROWN MARMORATED STINK BUG

The Brown Marmorated Stink Bug (BMSB) is a pest native to eastern Asia that has become an invasive harmful pest in North America, in Europe and recently in South Caucasus. The BMSB feeds on a wide variety of plant species and has caused widespread damage to crops in the region, including hazelnut.

### DESCRIPTION AND LIFE CYCLE

The adult BSMB is about 12-17 mm long, and is a brownish colour, with grey, off-white, black, copper, and bluish markings (see Figure 10). The BSMB can be easily distinguished from other stink bugs by the dual white bands that appear on its antennae, alternating bands on the edge of a specimen's abdomen, and by the dark bands which appear on its wing tips.

Eggs are barrel-shaped, white to pale green, and laid in clusters of around 28 elements (see Figure 11). Young nymphs display an orange abdomen with brown markings, while mature nymphs possess banded legs, and spines in front of eyes on shoulders (see Figure 12).

*Figure 11: Brown Marmorated Stink Bug eggs*
*Source: Pansa et al. 2013; DISAFA Entomology, University of Torino*

One or more generation of the BMSB can spawn within a given year, climatic conditions dependent – in Abkhazia around two to three generational cycles are typical. The BMSB overwinters in its adult form, and during the winter months can be found in large quantities in residential buildings. Its tendency to reside in human-occupied spaces constitutes a nuisance in addition to the threat the threat posed to agriculture. Although the BMSB does not bite or sting, it emits a pungent odour when disturbed.

In spring, adults migrate from their overwinter refuges to host plants, on which they feed and mate. In this period, the BMSB can travel long distances in search of a suitable host. When established, females typically begin to lay eggs during the May-early June period. A female can lay around 9-16 egg clusters – as many as 300 eggs – during a lifetime. Egg-laying usually peaks in June-July and ends in late August. From June to August, all stages are present on plants, with population peaking in August and September.

BMSB adults and nymphs may disperse widely and can fly or walk to infest new hosts throughout the fruiting period. The BSMB continually moves in search of fresh territory, with a distinct “edge effect” – whereby waves of infestation arrive in previously unaffected areas – often observed.

*Figure 12: A Brown Marmorated Stink Bug nymph*

## SYMPTOMS AND DAMAGE

Damage to crop is caused by the BMSB feeding on the leaves, fruit and seeds of its host plant. Both adults and nymphs feed on plant tissue and can even penetrate thick material, including hazelnut shells. The manner of their feeding causes the reaction of plants' enzymes, leading to damage like brown spots, surface depressions, and deformation.

Feeding impacts hazelnut development differently at different stages of growth. Feeding during shell expansion (May-early June) can lead to seed death and early nut drop. Feeding during kernel growth (mid-June-August) leads to a process known as "corking", which can be identified by whitish to black spots on a kernel's surface. Corking has a significant impact on nut quality, particularly where nuts are destined for industrial processes.

## MONITORING AND CONTROL

### Monitoring

Given the serious risk to crops posed by the BMSB, rigorous monitoring of crops is essential to ensuring plant safety. Two options for monitoring are advised, specifically plant beating and traps.

#### *Beating*

- Beating entails placing plastic sheets under monitored plants, before scouting branches to let insects drop for counting
- Plant beating should take place early in the morning (not after 7:00 AM) and should be repeated at regular intervals with gaps between intervals not exceeding two weeks.
- It is recommended that ten hazel plants per hectare should be beaten, with two insects per plant constituting an economic risk, necessitating chemical control.

#### *Traps*

Traps for BMSB are available in a range of formats, shapes and sizes, with the two primary varieties being black light and pheromone. Black light traps are non-specific to the BMSB and capture all flying insects active at night.

Pheromone traps have become the most popular approach for monitoring BMSB presence in hazelnut orchards, given their targeted approach and efficacy. They must however be utilised properly for maximum effect:

- Pheromone traps should be placed on an orchard's border as the pheromones used are extremely powerful and may attract large quantities of BMSB to the location of a device – only a fraction of which will become trapped.
- Traps are best placed between May and harvest time, and should be checked weekly throughout the season.
- In North America, thresholds have been developed at which a crop can be deemed at economic risk on the basis of pheromone trap monitoring. Should any one of the following conditions be met, chemical intervention is advised:
    - More than ten adult specimens are caught in a single trap in one week, over the course of a season.
    - More than five nymph specimens are caught in a single trap in one week, over the course of a season.
    - Nymphs' specimens are found over two consecutive weeks.

## Control

Chemical control of a BMSB infestation is difficult, with insecticides mostly effective on a particular stage (nymphs and adults) or on a particular generation of the pest (overwintering or summer generation). Overwintered populations are easiest to kill with insecticide application, once they colonize crops in spring, given the energy spent during dormancy.

Broad-spectrum insecticides have proven effective in controlling BMSB. This noted, such chemicals are only able to kill insects present in an orchard at the time of application, necessitating multiple applications throughout the season for the insects recolonizing the crop. This in turn may be harmful to insects and other animals which act as natural controls on BMSB populations. These predators are essential in combating the spread of the BMSB in the long term and in preventing outbreaks of secondary pests, such as aphids and spider mites.

### *Natural solutions*

Given the challenges to chemical-based solutions outlined above, researchers and governments have attempted to use natural predators to control BMSB populations. Parasitic wasps from a number of families have been shown to be effective in disrupting BMSB eggs, with the Japanese Samurai Wasp showing the most promise in the area of origin (Asia), and in some recent laboratory trials in USA and Europe.

The above notwithstanding, producers facing infestations must undertake immediate action to control damage to crops and halt the spread of an outbreak. Two approaches, which minimise the use of insecticides are recommended within the IPM approach: Integrated Pest Management-Crop Perimeter Restructuring (IPM-CPR) and Attract-and-kill (A&K).

### *Integrated Pest Management-Crop Perimeter Restructuring*

- IPM-CPR is based on the premise that control of the border of a plantation is the first line of defence against an infestation.
- Pesticide use is thus concentrated on the perimeter and first row of an orchard, with broader use only applied during the period in which crops are at risk of colonisation.

### *Attract and Kill*

- Attract and kill consists of baiting selected border row trees with both BMSB aggregation pheromone and MDT at high doses, which should be three to five times the dose used in traps for monitoring.
- These trees are then treated with effective insecticides.

*Figure 13: An adult Nut Weevil*
*Source: DISAFA Entomology, University of Torino*

## NUT WEEVIL

The Nut Weevil (*Curculio nucum*) is highly-specialised towards the hazelnut plant, and responsible for significant yield losses in crops globally.

### DESCRIPTION AND LIFE CYCLE

The adult is about 7-8 mm long and light brown-coloured (see Figure 13). The head ends with an elongated snout, which is long as the body in the female and shorter in the male. Its larvae are thick, curved, creamy white, with a light brown head and may reach 10-15 mm long at maturity (Figure 14).

*Figure 14: A mature larva dropping out from a nut*

The Nut Weevil has a much slower cycle than other major hazelnut pests. It typically completes one generation a year, but may remain dormant for up to three years, overwintering as mature larvae in the soil.

In spring, adults emerge from the ground and migrate to plants bearing pulpy and juicy fruit (such as cherries, peaches, and pears) where they start feeding. Then, in May-June, they move to hazelnut plants, where females lay eggs into the nut after boring a hole into the fruit with their snout.

Larvae develop within the nut, feeding on the kernel and completing development in around a month. When mature, the larvae create small, characteristic circular holes in the shell (see Figure 14), from which they leave the nuts and drop to the ground to shelter from winter temperatures before re-emerging as adults to begin the cycle again.

### SYMPTOMS AND DAMAGE

Damage from the Nut Weevil is caused predominately by the larvae that feed on the nut kernel, making nuts unusable and thus reducing the crop's yield. The extent to which yield is impacted by an infestation is often highly dependent on the variety of tree and thickness of shell. Feeding on young nuts, adults can cause an early drop, but rarely to an extent that provokes economic damage.

### MONITORING AND CONTROL

- Starting from mid-April until June, sampling is undertaken by beating the upper part of 6-10 plants on two adjacent rows (3-5 plants per row) onto a plastic sheet. This must be done early in the morning (not after 7:30 AM).
- For chemical control, a treatment with pyrethroids is applied at the economic threshold of two or three specimens per plant, and if necessary, repeated after two weeks.

## AMBROSIA BEETLES

A number of different species of ambrosia beetles can be found in hazelnut orchards. Due to distinct visual similarities in the damage caused to crops, varieties are often mutually confused. They are highly diverse in their diet, and can attack a range of fruit and forest trees.

*Figure 15: An adult Ambrosia Beetle*

### DESCRIPTION AND LIFE CYCLE

Adult Ambrosia Beetles are small, around 2-4 mm long, and are dark brown to black in colour coloured. Larvae lack legs and are a creamy colour. Ambrosia Beetles typically complete one generation per year, overwintering as adults in channels bored into trees – the primary mechanism through which damage is done to crops.

In spring, when temperatures reach around 18°C, females fly from their winter nests to reach other trees, where they bore through the wood, forming a characteristic network of canals 2 to 5 mm in diameter. After 10-15 days, females begin to lay eggs in the tree, with larvae emerging over the following 4-6 weeks, maturing within the host where they remain until the following spring.

### SYMPTOMS AND DAMAGE

Ambrosia beetles attack trees under conditions of stress, such as drought, waterlogged soil, and infection. Channels drilled by the pest obstruct sap flow, which can lead to the death of young trees, and a rapid decline of older crops may dry up suddenly after flowering. The Ambrosia Beetle may also transfer pathogens between plants.

*Figure 16: Channels bored by the Ambrosia Beetle*
*Source: DISAFA Entomology, University of Torino*

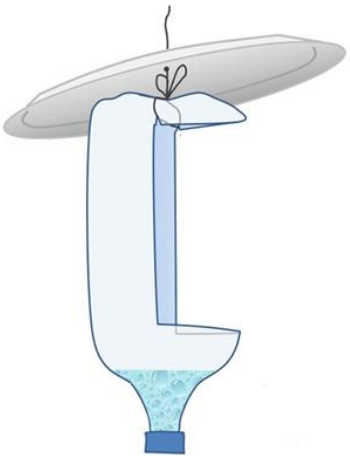

*Figure 17: A simple home-made trap*

### MONITORING AND CONTROL

The presence of Ambrosia Beetles in a tree may be detected by the presence of entrance holes (about 0.5-1 mm in diameter) on the branches.

In addition to visual inspection of crops, monitoring and control can be effectively undertaken using a simple trap made by cutting a large window into any two-litre plastic bottle filled with ethanol and water (1:1 ratio). The solution, which should be refilled every few days, both attracts pests, including the Ambrosia Beetle, and kills them. A plastic plate may be attached to the top of the trap to prevent rain from diluting the ethanol.

Besides monitoring tools, traps can be used for an active reduction of pests in the orchard (mass trapping strategy). For this purpose, the number of traps should be augmented by using 8-10 traps per hectare starting from March.

The best control strategy against this pest is to prevent stress by watering the trees deeply during dry spells and by a regular fertilization as recommended for the crop. In fact, in vigorous trees, the sap fills up the galleries and can impede the development of the eggs and the larvae.

## HAZELNUT AND WALNUT TWIG BORER

The Hazelnut and Walnut Twig Borer (HWTB) lives and reproduces on hazelnut, and more rarely on walnut, elder and willow.

### DESCRIPTION AND LIFE CYCLE

The adult is a long and slender insect, around 11-16 mm long and 2 mm wide, with a black body, long antennae and yellowish legs (see Figure 18). In larval form, it appears yellowish or light brown, with mature larvae reaching 20-25 mm in length. On hazelnut, HWTB completes one generation every 2-3 years, dependent on climate. After mating, females may lay eggs in the bark of a shoot, which appear as slits around 3-4 mm in diameter, 10-15 cm from a shoot's tip. The young larvae may bore channels in an affected plant, first around then perpendicular to a shoot, which may then dry out and break off. They continue to bore as they grow, and may cause significant damage to a plant in the process. In late autumn, larvae then hibernate until the following spring, when they continue boring into a plant. After their second winter, mature larvae pupate in late spring, with new adults emerging in May-June.

*Figure 18: A female Twig Borer*

## SYMPTOMS AND DAMAGE

Around the peak period in which adult Borers emerge, the ends of twigs may appear obviously dry, which often causes concern in producers. Borings within a plant may also be identified by swelling in branches, which can leave them dry and prone to breaking.

## MONITORING AND CONTROL

Despite alarming symptoms, the HWTB is rarely a serious threat to hazelnut orchards. This insect can be successfully controlled through pruning. In case of a serious infestation, twigs infested by HWTB must be removed, cutting 50 cm from tip, or 20-30 cm from where eggs are identified or the beginning of a dry portion. This process is best carried out in late summer-autumn after which infected branches should be carefully destroyed.

# SYMPTOMS AND INTERVENTIONS THROUGHOUT THE YEAR

## BUDDING AND FLOWERING

| Moment of intervention | | | |
|---|---|---|---|
| |  |  |  |
| | Winter buds<br>**Intervention recommended** | Male flowers<br>**Do not intervene** | Female flowers<br>**Do not intervene** |

| Pest / infection | Filbert Big Bud Mite (FBBM) |
|---|---|
| Monitoring and intervention criteria | Observation of 200 of buds per hectare, randomly on different plants, or observation of 4 branches on 20 plants.<br>Threshold: 10% (young plantations) 15-20% (productive plantations). |
| Notes | • One treatment in March-April after threshold exceeded<br>• Application should be done when mites are migrating to new buds (March-April): see below section |

# BREAKING OF BUDS

| | |
|---|---|
| **Moment of intervention** |  <br>Breaking of buds |

| **Pest / infection** | **Bacterial diseases** | |
|---|---|---|
| **Monitoring and intervention criteria** | Preventive intervention (basing on signs of disease in the previous season). | |
| **Effective products** | Copper | Mixture of Bordeaux or Liquid of Bordeaux (1% solution)<br>Kuproksat (50-60ml/10L of water) |
| **Notes** | One treatment at minimum label dosage. | |

| **Pest / infection** | **Ambrosia Beetle** |
|---|---|
| **Monitoring and intervention criteria** | Observation of the presence of entrance holes (0.5-2 mm diameter) on wood of the plant or presence in traps. |
| **Notes** | It is the right moment to deploy simple, home-made traps to monitor and kill Ambrosia Beetles. See page 24 of this document for more information. |

# THIRD LEAF

| | |
|---|---|
| **Moment of intervention** |  <br>Third Leaf |

| **Pest / infection** | **Filbert Big Bud Mite (FBBM) and Powdery Mildew** | |
|---|---|---|
| **Monitoring and intervention criteria** | One intervention is appropriate for both FBBM and Powdery Mildew.<br>For FBBM follow the threshold indicated for the monitoring in winter buds period (see above section). | |
| **Effective products** | Sulphur 80% Wettable Powder | Kumulus (40-80gr/10 L of water) or<br>Tiovit-Jet (50-60 gr/10 L of water) |
| | Sulphur Dust | 25-100 kg/ha |
| **Notes** | **FBBM**<br>• Application should be done when mites are migrating to new buds<br>• Monitor with magnifications lens (5-10×)<br><br>**Powdery Mildew**<br>• Remove infected shoots after treatment, ensure all leave that have fallen from the plant are burned | |

# FOURTH AND FIFTH LEAF

| | |
|---|---|
| **Moment of intervention** |  <br>Fourth and fifth leaf |

| **Pest / infection** | **Bacterial and Fungal diseases** | |
|---|---|---|
| **Monitoring and intervention criteria** | Observation of signs of disease. | |
| **Effective products** | Copper | Mixture of Bordeaux or Liquid of Bordeaux (1% solution)<br>Kuproksat (50-60ml/10L of water) |
| **Notes** | One treatment at minimum label dosage. | |

| **Pest / infection** | **Powdery Mildew** | |
|---|---|---|
| **Monitoring and intervention criteria** | Observation of white spots on leaves. | |
| **Effective products** | Sulphur 80% Wettable Powder | Kumulus (40-80gr/10 L of water) or<br>Tiovit-Jet (50-60 gr/10 L of water) |
| | Difenokonazol | Skor (2-15ml/10 L of water) |
| **Notes** | • Treatment can be repeated once a month until 1 week before harvest if needed<br>• Remove infected shoots after treatment, ensure all leave that have fallen from the plant are burned<br>• Sodium bicarbonate may be used as an organic treatment, however concentrations greater than 1.5% are toxic to plants | |

# FRUIT FORMATION

| | |
|---|---|
| **Moment of intervention** |  <br>Fruit formation |

| **Pest / infection** | **Bacterial and Fungal diseases** | |
|---|---|---|
| **Monitoring and intervention criteria** | Observation of signs of disease. | |
| **Effective products** | Copper | Mixture of Bordeaux or Liquid of Bordeaux (1% solution)<br>Kuproksat (50-60ml/10L of water) |
| **Notes** | • Treatment with copper at minimum label dosage<br>• Treatment can be repeated after 15 days but not more than 2 treatments per year<br>• Elimination of infected parts with pruning; disinfection of cuts and pruning tools with copper sulfate or sodium hypochlorite with 3% solution | |

# VISIBLE OVARY

| | |
|---|---|
| **Moment of intervention** |  <br>Visible Ovary |

| **Pest / infection** | **Nut Weevil and Brown Marmorated Stink Bug (BSMB)** | |
|---|---|---|
| **Monitoring and intervention criteria** | **Monitoring:**<br>Examination of 5-10 plants per field, beating branches onto a plastic sheet on the ground. To be conducted early in the morning.<br>**Threshold:**<br>2-3 NW or 2 BMSB per plant. One intervention for both pests. | |
| **Effective products** | Bifenthrin | Kliper (6ml/10L of water)<br>Talstar (1L/1ha)<br>Tsezar (0.6L/1ha)<br>Antikhrush (0.6L/1ha) |
| | Acetamiprid | Mospilan (5-6gr/10L of water) or<br>Alfa Amiprid (5-6gr/10L of water) |
| | Thiamethoxam | Medal, WG; Actara WG; Renova 25 WG |
| | Imidacloprid | Imidor Max, WG; Nuprid 600 SC; Sultan SL; Confidor Maxi, WG 70; Sidoprid 600 FS; Confidor SL 200; Resume WS; Gortca WS; Efdal Imidrid 70 WS; Confiprid, WDG; Imidagold 350 SC; Nuprid 200 SL; Gaucho FS 600; Midash WS; Imidor Max, WG |
| **Notes** | • One treatment after threshold exceeded<br>• Throughout all the season, not more than three treatments containing bifenthrin | |

# SEED GROWTH

| Moment of intervention |  Seed growth |
|---|---|

| Pest / infection | Nut Weevil and Brown Marmorated Stink Bug (BSMB) | |
|---|---|---|
| **Monitoring and intervention criteria** | **Monitoring:**<br>Examination of 5-10 plants per field, beating branches onto a plastic sheet on the ground. To be conducted early in the morning.<br>**Threshold:**<br>2-3 NW or 2 BMSB per plant. One intervention for both pests. | |
| **Effective products** | Bifenthrin | Kliper (6ml/10L of water)<br>Talstar (1L/1ha)<br>Tsezar (0.6L/1ha)<br>Antikhrush (0.6L/1ha) |
| | Acetamiprid | Mospilan (5-6gr/10 L of water) or<br>Alfa Amiprid (5-6gr/10 L of water) |
| | Thiamethoxam | Medal, WG; Actara WG; Renova 25 WG |
| | Imidacloprid | Imidor Max, WG; Nuprid 600 SC; Sultan SL; Confidor Maxi, WG 70; Sidoprid 600 FS; Confidor SL 200; Resume WS; Gortca WS; Efdal Imidrid 70 WS; Confiprid, WDG; Imidagold 350 SC; Nuprid 200 SL; Gaucho FS 600; Midash WS; Imidor Max, WG |
| **Notes** | • One treatment after threshold exceeded<br>• Throughout all the season, not more than three treatments containing bifenthrin<br>• For NW control, all early drop nuts should be collected and burned | |

# PRE-HARVEST NUTS

| Moment of intervention |  Pre-harvest nuts |
|---|---|

| Pest / infection | Brown Marmorated Stink Bug (BSMB) |
|---|---|
| Monitoring and intervention criteria | **Monitoring:**<br>Examination of 5-10 plants per field, beating branches onto a plastic sheet on the ground. To be conducted early in the morning.<br>**Threshold:**<br>Two BMSB per plant. |
| Notes | **Avoid chemical interventions, due to the pre-harvest interval.** |

| Pest / infection | Nut Weevil |
|---|---|
| Notes | • **Avoid chemical intervention**<br>• Identify, collect and destroy any nuts with small holes |

| Pest / infection | Powdery Mildew |
|---|---|
| Notes | • **Avoid chemical intervention**<br>• Collect and destroy any fallen leaves |

# LEAVES BEGIN TO FALL

| Moment of intervention |  Leaves begin to fall |
|---|---|

| Pest / infection | Hazel Wood Twig Borer (HWTB) |
|---|---|
| Monitoring and intervention criteria | **Monitoring:**<br>Twigs appear dried out. Larvae present inside wood. |
| Notes | **Avoid chemical intervention.**<br>Starting from late summer, remove infested twigs, cutting them 50 cm from the tip. Pruned wood should be burned. |

| Pest / infection | Powdery Mildew |
|---|---|
| Notes | • **Avoid chemical intervention**<br>• Collect and destroy any fallen leaves |

# LEAVES HALF-FALLEN

| Moment of intervention |  Leaves half-fallen |
|---|---|

| Pest / infection | Bacterial diseases | |
|---|---|---|
| Monitoring and intervention criteria | Observation of signs of disease. | |
| Effective products | Copper | Mixture of Bordeaux or Liquid of Bordeaux (1% solution)<br>Kuproksat (50-60ml/10L of water) |
| Notes | One treatment with copper at minimum label dosage | |

| Pest / infection | Powdery Mildew |
|---|---|
| Notes | • **Avoid chemical intervention**<br>• Collect and destroy any fallen leaves |

# LEAVES COMPLETELY FALLEN

| Moment of intervention |  Leaves completely-fallen |
|---|---|

| Pest / infection | Bacterial diseases | |
|---|---|---|
| **Monitoring and intervention criteria** | Observation of signs of disease. | |
| **Effective products** | Copper | Mixture of Bordeaux or Liquid of Bordeaux (1% solution)<br>Kuproksat (50-60ml/10L of water) |
| **Notes** | • One intervention at minimum label dosage<br>• Use no more than 6 kg of copper (active ingredient) per hectare per year | |

| **Pest / infection** | **Powdery Mildew** |
|---|---|
| **Notes** | • **Avoid chemical intervention**<br>• Collect and destroy any fallen leaves |

NOTES

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*Empowered lives.*
*Resilient nations.*