

Production of Traditional Leafy Vegetables and Spice Crops Under Nature-Positive and Agroecological Practices in Kenya: Pest and Disease Management

Noah Adamtey, Edwin Mwangi Nderitu, Jemutai Kibet, and Nancy Munyoki

December 2025



The authors

Noah Adamtey, Senior Researcher, Resource Recovery and Agri-food System, International Water Management Institute (IWMI), Accra, Ghana
Edwin Mwangi Nderitu, Consultant, Nairobi, Kenya
Jemutai Kibet, Independent Consultant, Nairobi, Kenya
Nancy Munyoki, Independent Consultant, Nairobi, Kenya

Acknowledgment

This work was carried out under the CGIAR Multifunctional Landscapes Program, CGIAR Sustainable Farming Program, and Biodiversity for Resilient Ecosystems in Agricultural Landscapes (B-REAL) project. The authors are grateful for the support of the CGIAR Trust Fund contributors (<https://www.cgiar.org/funders/>). CGIAR is a global research partnership for a food-secure future dedicated to transforming food, land, and water systems in a climate crisis.

CGIAR Multifunctional Landscapes Program

Multifunctional Landscapes is a CGIAR Science Program that aims to enhance the resilience, productivity, and sustainability of agricultural landscapes by integrating diverse land uses, ecosystem services, and livelihood strategies. The initiative supports evidence-based policies and innovations that balance food production with climate adaptation, biodiversity conservation, and social inclusion. By working with local communities, governments, and partners, it promotes landscape-level approaches to managing natural resources for long-term ecological and economic benefits. Learn more here: <https://www.cgiar.org/initiative/multifunctional-landscapes>

CGIAR Sustainable Farming Program

The CGIAR Sustainable Farming Science Program will address key challenges in agrifood systems by fostering efficient production of nutritious foods and safeguarding the environment to create fair employment opportunities, as we simultaneously tackle climate change, soil degradation, pests, diseases, and desertification.

Citation

Adamtey, N.; Nderitu, E. M.; Kibet, J.; Munyoki, N. 2025. *Production of traditional leafy vegetables and spice crops under nature-positive and agroecological practices in Kenya: pest and disease management*. Colombo, Sri Lanka: International Water Management Institute (IWMI). CGIAR Multifunctional Landscapes Program; CGIAR Sustainable Farming Program. 56p.

Copyright © 2025, International Water Management Institute (IWMI). All rights reserved. IWMI encourages the use of its material provided that the organization is acknowledged and kept informed in all such instances.

Front cover photo: Close-up of red chili peppers on table (*photo*: Freepik)

Back cover photo: Bollworm on an onion (*photo*: Freepik)

Disclaimer

This publication has been prepared as an output of the CGIAR Multifunctional Landscapes Program and the CGIAR Sustainable Farming Program and has not been independently peer reviewed. Responsibility for opinions expressed, and any possible errors lies with the authors and not the institutions involved.

Prefix

Target groups

The manual is designed to serve as a field guide for stakeholders involved in the production and protection of traditional leafy vegetables under nature-positive and agroecological agricultural practices. It is intended for smallholder farmers and kitchen garden growers, extension officers and community trainers, agricultural researchers and students and development practitioners, farmer-based organisations, and non-governmental organisations.

Aim and Objective

The manual provides farmers, trainers, and agricultural stakeholders with reliable, practical, and locally relevant knowledge on nature-positive agricultural methods and practices for identifying and managing major pests and diseases affecting traditional leafy vegetables and spice crops. It specifically aims to raise awareness of pests and diseases that impact common traditional leafy vegetables and spice crops, along with their symptoms. It encourages sustainable management practices by emphasising effective nature-positive approaches, including cultural, biological, and biopesticide (home-made botanicals) control methods that are affordable and eco-friendly. Finally, the manual supports the transfer of knowledge for use by extension officers, trainers, and community facilitators in farmers' training on eco-friendly pest management strategies adaptable to local farming practices.

Content

The manual offers an overview of specific pests and diseases affecting traditional leafy vegetables and spice crops grown in Western Kenya, particularly in Kisumu County. It includes details on their identification, symptoms, and potential damage. The manual discusses targeted management strategies, highlighting and exemplifying scientifically validated, nature-positive agricultural and agroecological practices, such as cultural, biological, and chemical methods (biopesticides) used to control major pests. It concludes with illustrations of all plants containing pesticidal components, which can be utilised to produce homemade botanical preparations.

Scope

The manual focuses on smallholder farmers, community trainers, extension officers, and institutions involved in the production of traditional leafy vegetables and spice crops under nature-positive agricultural management. It emphasizes environmentally friendly, accessible, and low-cost solutions that utilize locally available resources and practices, promoting sustainable pest and disease management to ensure food and nutritional security. The pest management experiences are drawn from a wide range of research conducted globally. Readers should see the manual as a collection of ideas and options for selection and adaptation in pest management for vegetable production. We hope the guide will encourage all stakeholders to test and adapt these pest management options to their local conditions, leading to the development of new, region-specific approaches and technologies that can be shared.

Organization

For ease of use, the manual is organised in the following sections:

1. Chapter 1: Introduction -Nature-positive agricultural and agroecological approaches for managing cropping systems
2. Chapter 2: Traditional vegetable and spice crops
3. Chapters 3–8: Pests, diseases, and management strategies for traditional vegetables
4. Chapters 9–12: Pests, diseases, and management strategies for spice crops

Content

Chapter 1: Nature-positive and agroecological approaches to pest and disease management in vegetable cropping systems	8
Chapter 2 : Traditional Vegetable and Scipy crops	10
Chapter 3: Amaranth	11
3.1 Overview	11
3.2 Major Pests and Diseases	11
3.3 Management Strategies	12
Chapter 4: Black Nightshade	14
4.1 Overview	14
4.2 Major Pests and Diseases	14
4.3 Management Strategies	15
Chapter 5: Spider plant	17
5.1 Overview	17
5.2 Major Pests and Diseases	17
5.3 Management Strategies	18
Chapter 6: Okra	20
6.1 Overview	20
6.2 Major Pests and Diseases	20
6.3 Management Strategies	22
Chapter 7. Kales	24
7.1 Overview	24
7.2 Major pests and diseases	24
7.3 Management Strategies	25
Chapter 8. Legumes	28
8.1 Overview	27
8.2 Major pests and diseases	28
8.3 Management Strategies	29
Chapter 9. Pepper (Capsicum)	31
9.1 Overview	31
9.2 Major pests and diseases	31

Chapter 10. Shallot	35
10.1 Overview	35
10.2 Major pests and diseases	35
10.3 Management Strategies	35
Chapter 11. Ginger	38
11.1 Overview	38
11.2 Major pests and diseases	38
11.3 Management Strategies	39
Chapter 12. Basil	40
12.1 Overview	40
12.2 Major pests and diseases	40
12.3 Major pests and diseases	41

List of Tables

Table 1: Summary of pests and diseases of Amaranthus and their control	13
Table 2. Summary of pests, and diseases of Black nightshade and their control	16
Table 3: Summary of pests and diseases of the Spider plant and their control	19
Table 4. Summary of pests and diseases of the Spider plant and their control	22
Table 5. Summary of pests and diseases of Kales and their control	26
Table 6: Summary of pests and diseases of Legumes and their control	30
Table 7. Summary of pests and diseases of the pepper and their control	34
Table 8. Summary of pests and diseases of the shallot plant and their control	37
Table 9. Summary of pests and diseases of the ginger plant and their control	39
Table 10. Summary of pests and diseases of the basil plant and their control	42

List of Figures

Figure 1: Aphid spp, Beet webworm and Amaranth stem weevils	11
Figure 2: Damping off, Blight and Bacterial leaf spot	12
Figure 3: Cotton (melon) aphid, Red spider mite, Flea beetle and Chilli thrips	14
Figure 4: Bacterial wilt, and Early blight	15
Figure 5: Aphids, Flea beetles and Spider mites	17
Figure 6: Thrips, Root-knot nematodes and Cutworms	18
Figure 7: Aphids, Whiteflies, Cutworms and Cucumber beetle	20
Figure 8: Cabbage looper, Thrips , Root knot nematode,Spider mites and Bollworm	21
Figure 9: Charcoal rot, Fusarium wilt, Powdery mildew, Southern blight, White, OELCV and BYMV	21
Figure 10: Beet armyworm larvae, Cabbage aphid, Cabbage looper, Cutworms, Flea beetles, Cross-striped cabbageworm, Thrips and Root-knot nematode	25
Figure 11: Alternaria leaf spot, Anthracnose, Damping off, Downy mildew and Black rot	25
Figure 12: Bean fly, Aphids (<i>A. fabae</i>), Thrips, Cutworm and Bean leaf beetle	28
Figure 13: Bean rust, Angular leaf spot, Anthracnose, Bacterial blight and Root rot (<i>Fusarium</i> sp.)	29
Figure 14: Thrips, Aphids, Fruit borer, Whiteflies, Spider mite and Root knot nematodes	32
Figure 15: Damping off/root rot, Powdery mildew and Bacterial wilt	32
Figure 16: Onion Thrips (<i>Thrips tabaci</i>), Cutworms (<i>Agrotis</i> spp.) and Onion Maggot (<i>Delia antiqua</i>)	35
Figure 17: Cutworms (<i>Agrotis</i> spp.), Purple blotch, Fusarium basal rot, Onion smut and Neck rot	36
Figure 18: Root knot nematode and Burrowing nematode	38
Figure 19: Bacterial wilt and Rhizome rot	39
Figure 20: Aphids, Looper, Cutworm and Flea beetle	40
Figure 21: Cercospora leaf spot, Downy mildew and Fusarium wilt	41

Chapter 1. Nature-positive and agroecological approaches for managing cropping systems

The need for the production system to meet the demands of a growing population and rising population, while also addressing the necessity of restoring the environment, rebuilding ecological processes, enhancing ecosystem services like nutrient cycling, improving and restoring soil health, and managing land, water, and other natural resources effectively, calls for the use of nature-positive agriculture and agroecological practices in crop production.

Nature-positive agriculture. An approach to farming that works with nature rather than against it. Its objective is to produce food while preserving biodiversity, ecosystems, and natural resources. To put it simply, it refers to farming practices that:

- Enhances biodiversity (plants, animals, and microorganisms)
- Biodiversity conservation: Protect farm biodiversity, plants, animals, and microorganisms, through landscape-level conservation, community seed banks, and seed-saving practices.
- Uses resources sustainably (soil, water, nutrients)
- Reduces negative impacts like pollution, habitat destruction, and greenhouse gas emissions
- Builds resilience to climate change and other shocks
- Supports ecosystem services such as pollination, soil fertility, and water regulation

It integrates scientific knowledge, technology, and traditional practices to create food systems that are productive, resilient, and environmentally friendly.

Agroecology is an approach to farming that applies ecological principles to the design and management of sustainable food systems. It integrates science, farming practices, and social equity to enhance nutrient cycling, soil health, biodiversity, resource efficiency, and resilience (Gliessman, 2015). Agroecology emphasizes working with natural processes such as nutrient cycling, biological pest control, and ecosystem diversity rather than relying heavily on external chemical inputs (FAO, 2018). It also promotes farmer knowledge, local innovation, and fair food systems.

Key practices include:

- **Soil health and nutrient cycling:** This includes composting, using organic fertilizers, applying biochar to improve soil carbon and nutrient retention, incorporating green manures and cover crops, and adopting conservation or reduced tillage.
- **Diversification of production:** Diversify through crop rotations, intercropping, agroforestry, tree integration on farms, mixed farming systems, and crop-livestock integration.
- **Water management:** Techniques include mulching to preserve soil moisture, small-scale rainwater harvesting and storage, efficient irrigation (such as drip systems), wetland restoration, and maintaining natural water flows.
- **Ecological pest and disease management:** Use botanical pesticides, biocontrol agents, habitat management to support natural enemies, and integrated pest management (IPM).
- **Circular and resource-efficient systems:** Close nutrient loops by integrating crops and livestock and recycle nutrients through manure management and composting.
- **Social and cultural dimensions:** Strengthen local innovations and farmer knowledge, encourage collaborative research and problem-solving, and promote community-based markets and short value chains.

Integrating the above practices into farming systems can reduce reliance on agrochemicals, manage pests and diseases, and build resilient, productive, and sustainable farms that safeguard nutrition and farmer livelihoods. For example, intercropping leafy vegetables with pest-repellent species, conserving natural enemies, and using organic soil amendments help reduce infestations while improving soil fertility and biodiversity (Salim et al., 2022). Crop rotation with different plant families breaks pest cycles, while proper spacing improves airflow and limits disease spread. Companion planting deters pests, and conserving habitats supports natural enemies such as predators and parasitoids which feed on pests. Biopesticides, biorational sprays made from plant extracts, are also used for pest suppression.



Chapter 2. Traditional Vegetable and Spice crops

The global recognition of Traditional Leafy Vegetables (TLVs) and spice crops has increased significantly, highlighting their vital roles in food security, nutrition, and rural economies (Bokelmann et al., 2022). Traditional leafy vegetables (TLVs) are plant species native to Africa, historically eaten by local communities and deeply embedded in indigenous food systems (Shackleton et al., 2009). These crops are ecologically resilient due to a long history of cultivation and domestication shaped by regional climate and soil conditions (Ambrose-Oji, 2009; Shackleton et al., 2009). Along with spice crops, they have important nutritional, ecological, and socio-economic value in many regions, especially in Africa and Asia, where they improve dietary diversity, food security, and smallholder livelihoods (Dube et al., 2017; Bokelmann et al., 2022; Ngidi, 2023). For smallholder farmers, particularly women, cultivating and selling TLVs and spice crops provides a reliable and substantial economic pathway for poverty alleviation (Onyango, 2015). TLVs are a rich source of micronutrients essential for fighting "hidden hunger," the deficiency of vitamins and minerals that are common in diets based mainly on staples (Lugumira et al., 2025; Borrelli & Ndakidemi, 2020). Spice crops also provide vital micronutrients and powerful phytochemicals with health benefits (Almodaifer et al., 2017). Spice crops are important for flavor and aroma, often grown alongside TLVs in smallholder farms (Peter, 2012).

Despite the resilience and adaptability of TLV and spice crops to local agro-ecological conditions, they face grave threats from pests and diseases, which jeopardize both yields and quality. Common pests, such as aphids, caterpillars, whiteflies, and leaf miners, as well as fungal, bacterial, and viral pathogens, frequently attack TLVs and spice crops at various growth stages. Since these crops are highly perishable, even brief infestations can lead to rapid deterioration, compromising both marketability and nutritional value. The economic impact of pest and disease pressures on TLVs and spice crops is substantial. Losses occur at both the farm and market levels: reduced yields, postharvest spoilage, and downgraded quality directly affect farmer incomes, while fluctuating supply leads to unstable prices for consumers. Smallholder farmers, who often lack access to affordable pesticides or suitable protective technologies, are disproportionately affected. At the same time, a heavy reliance on synthetic pesticides, when available, not only increases production costs but may also pose risks of chemical residues, resistance development, and environmental degradation, thereby undermining both human health and ecosystem stability (Zhou et al., 2025).

Chapters 3 to 8 of the manual cover the nature-positive and agroecological in managing pests and diseases in traditional leafy vegetable cropping systems. Chapters 9 to 12 cover the management of pests and diseases in spice cropping systems.

Chapter 3. Amaranth (*Amaranthus* spp)

3.1 Overview

Amaranthus is a diverse genus of fast-growing leafy and grain crops valued for their nutritional density, ecological adaptability, and cultural importance. Amaranthus belongs to the family Amaranthaceae and is native to tropical America and Africa. Three major species, *Amaranthus hypochondriacus*, *Amaranthus cruentus*, and *Amaranthus caudatus* are cultivated broadly as edible amaranths sp. These species are being grown for their edible grains, hence they are also called grain amaranths. *Amaranthus tricolor*, *Amaranthus lividus*, *Amaranthus blitum*, and *Amaranthus dubius* are cultivated as vegetable species for their leaves. The grain amaranths are rich in protein, essential amino acids, minerals, and antioxidants, while vegetable amaranths contribute substantially to micronutrient intake. Amaranthus species exhibit high water-use efficiency and tolerance to heat and marginal soils, making them important crops for climate-resilient food systems. Recent research highlights their roles in nutrition security, agroecological diversification, and sustainable intensification in smallholder systems (Teutonico & Knorr, 1985; Achigan-Dako et al., 2014; Rastogi & Shukla, 2013). This chapter discusses Nature-Positive Agricultural and Agroecological practices for managing pests and diseases in the Amaranth cropping system.



Amaranth plant (*photo*: Freepik)

3.2 Major Pests and Diseases

Major pests:

Aphid species such as *Myzus persicae* Sulzer: Sap-sucking insects which, through their feeding, cause leaf curling, yellowing, and can transmit viral diseases such as Potato leaf roll virus (PLRV), Potato virus Y (PVY), Cucumber mosaic virus (CMV), and Pepper vein mottle virus (PVMV). Beet webworm/ leaf webbers e.g. *Spoladea recurvalis* Fabricius. The larval stage of the moth causes damage by creating webs on the leaves while feeding within them. Amaranth stem weevils, *Hypolixus* sp. The weevils bore into stems, causing wilting and lodging, which can severely impact plant health.



Figure 1. Aphid spp, Beet webworm and Amaranth stem weevils (*photo*: Envato)

Major Diseases

Amaranthus is commonly affected by damping off, choanephora blight, and leaf spot. Damping off is a soil-borne fungal disease that affects the seeds and seedlings, making them decay in the soil before emergence or wilt and die after germination. Choanephora blight is a fungal disease that manifests as water-soaked lesions on the affected part before turning brown or black and becoming soft and mushy. Leaf spot is a leaf discolouring fungal, bacterial, or viral disease that causes the development of spots characterised by cell necrosis (death) at the centre.



Figure 2. Damping off, Blight and Bacterial leaf spot (photo: Freepik)

3.3 Management Strategies

A. Cultural practices:

For aphids, beet webworm and leaf webbers, intercrop amaranth with basil (*Ocimum gratissimum* L. and *Ocimum basilicum* L.). In all the above, pets destroy infested plant parts and remove weeds from the field. Ploughing and handpicking also expose and kill the pupae and caterpillars of the Beet webworm and leaf webbers.

B. Biological control:

For aphids conserve natural enemies and parasitoids like lady beetles, lace wings, syrphid/hover flies, and parasitic wasps. Beet webworm and leaf webbers are managed by conserving parasitoids such as *Apanteles*, *Bracon*, *Campoletis*, and *Trichogramma*. For stem weevils, use biologically active *Bacillus thuringiensis* and *entomopathogenic* fungus like *Metarhizium anisopliae*.

C. Chemical (biopesticide):

Aphids, Beet webworm, leaf webbers, and Amaranth stem weevil can be managed using plant extracts prepared from chilli, Mexican marigold, neem leaf and seed extracts and bark ash bioassays. Other biopesticides used include African soapberry, Tithonia leaves, stem and flower, cloves, onion or garlic, lemon grass, and tobacco extracts. See Annex 1 for details.

A summary of cultural, biological and biopesticides management strategies are as shown in Table 1.

Table 1. Summary of pests and diseases of Amaranthus and their control

Pest/ Disease	Symptoms	Cultural Control	Biological Control	Biopesticide Options
Aphids	Curled, yellow leaves; sticky honeydew; small, soft insects visible on stems/leaves.	Intercrop with Basil. Destroy Infested plant parts. Remove weeds.	Use natural enemies like lady beetles, lacewings, and parasitic wasps	Mexican flower, chilli, papaw leaf extracts
Beetworm	Leaves spun together with silk webbing; caterpillars chew large holes in leaves.	Destroy and remove infested plant parts. Ploughing and hand picking	Conserving parasitoids	Neem leaf & bark, tick-weed, spider plant extracts,
Leaf webbers	Leaves spun together with silk webbing; caterpillars chew large holes in leaves	Same as above	Conserving parasitoids. Metarhizium anisopliae	Neem leaf & bark, tick-weed, spider plant extracts,
Stem weevils	Wilting or breaking stems; swelling or lesions on the stem; grubs found feeding inside.	Same as above	<i>Bacillus thuringiensis</i> Metarhizium anisopliae	Neem leaf and bark, lemon grass, cloves, onion, tobacco & ginger extracts
Damping off	Seedlings collapse with a shriveled stem near soil line; seeds rot before emerging.	Use Certified Disease-Free Seeds; Avoid Over-watering; Plant on Raised Beds; Solarize Soil before planting; Avoid Dense Planting.	Antagonistic Fungi (like Trichoderma species); Beneficial Bacteria (e.g., <i>Bacillus subtilis</i>).	Moringa leaf extracts; Garlic and Mexican Marigold extracts.
Leaf spot	Small, circular to angular spots on leaves, often dark with a lighter center; spots may merge.	Crop Rotation; Use Disease-Free Seed; Avoid Overhead Watering; Remove infected plant debris; Ensure good air circulation.	Fungi like Trichoderma (applied to soil/foilage) to compete with pathogens.	Extracts of Neem or Garlic.
Blight	Large, irregular dark lesions on leaves and stems; rapid browning and dieback of foliage; entire plant may collapse.	Crop Rotation (3-4 years); Use Resistant Varieties (if available); Improve Drainage; Space Plants widely; Sanitize Tools frequently	Antagonistic Fungi and Bacteria applied as bioprotectants.	Neem Oil for some fungal controls.

Chapter 4. Black Nightshade (*Solanum nigrum*)

4.1 Overview

Black nightshade (*Solanum nigrum* complex) is a highly valued, intensely bitter traditional leafy green. The species complex is broad and includes several variants crucial to African diets. Common cultivated species include *Solanum scabrum* and *Solanum villosum*. However, production is often limited by a variety of pests and diseases. It holds significant importance in East and Southern Africa, where it is commonly known as “Managu” in Kenya. Nutritionally, the leaves are potent, being rich in Vitamins A and C, calcium, iron, and protein. However, traditional preparation is critical due to the presence of solanine and other glycoalkaloids. To manage bitterness and ensure palatability, the leaves are traditionally prepared by boiling them multiple times or by mixing them with milk or other, less bitter leafy greens. Once prepared, it serves as a staple relish consumed alongside primary starches such as ugali or any accompaniment. This chapter discusses Nature-Positive Agricultural and Agroecological practices for managing pests and diseases in the Black Nightshade cropping system.



4.2 Major Pests and Diseases

Major pests:

These include aphids, spider mites, flea beetles, and chilli thrips. Aphids damage crops by sucking sap from plant tissues, leading to leaf curling, yellowing, and stunted growth. Spider mites feed on the undersides of leaves, causing stippling, yellowing, and potential leaf drop. Severe infestations can reduce photosynthesis and overall plant vigor. Flea beetles damage plants by chewing on leaves, stems, and flowers. Heavy infestations can stress crops, resulting in stunted growth and, ultimately, plant death. Chilli thrips cause curled leaves, discoloured fruits, and stunted growth.



Figure 3. Cotton (melon) aphid, Red spider mite, Flea beetle and Chilli thrips (*photo*: Freepik)

Major diseases:

These include bacterial wilt and early blight.

Bacterial wilt is a soil-borne bacterium that infects the plant's vascular system, causing wilting, yellowing, and eventual plant death. It poses a significant threat to nightshade cultivation in Kenya. Early blight, a fungal disease affecting Solanaceae crops, causes dark lesions on leaves and stems, leading to defoliation and reduced yield.



Figure 4. Bacterial wilt, and Early blight (photo: Freepik)

4.3 Management Strategies

A. Cultural practices:

To control aphids and spider mites, use pest-tolerant plant species. Plant the crop at a spacing of 30 cm × 30 cm and apply organic cattle manure to enhance crop vigor. Intercrop with cowpea as a border crop and increase potassium application to boost plant tolerance. Flea beetles can be managed through handpicking and destroying the pests, intercropping with cowpea and groundnuts, crop rotation, and sprinkling wood ash on the leaves. Additional strategies include reduced tillage, wider spacing, and planting fava beans, onions, eggplant, barley, and wild mustard as border crops. Thrips are managed by ploughing and harrowing the field before planting to reduce subsequent attacks and by destroying pupae in the soil.

B. Biological control:

Aphids are managed by conserving natural enemies such as lady beetles, lacewings, and parasitic wasps. Spider mites are controlled using *entomopathogenic fungi* like *Beauveria bassiana* and *Metarhizium anisopliae*.

Flea beetles and thrips are managed with *entomopathogenic nematodes* from the families Steinernematidae and Heterorhabditidae, as well as *entomopathogenic fungi* like *Metarhizium*. Predatory spiders and ground beetles are also effective.

C. Chemical (biopesticides) control:

Aphids are managed using pyrethrum. Aphids and spider mites can also be controlled with extracts from onion leaves, flowers, and roots (mixed with a small amount of vegetable oil or liquid detergent), neem seed kernel, and pawpaw extract (See Annex 1 for details). Flea beetles are managed with neem seed kernel and tobacco extracts. Thrips are controlled using neem powder and neem seed kernel extract. Additionally, solar-treated urine and neem have been recommended. A summary of cultural, biological and biopesticides management strategies are as shown in Table 2.

Table 2. Summary of pests, and diseases of Black nightshade and their control

Pest/ Disease	Symptoms	Cultural Control	Biological Control	Biopesticide Options
Aphids	Leaf curling, yellowing	Use pest-tolerant varieties in cultivation Plant at a spacing of 30 cm × 30 cm. Border crop with cowpea	Use natural enemies like lady beetles, lacewings, and parasitic wasps	Garlic, onion, neem, chilli extract
Flea Beetles	Shothole damage on leaves	Hand picking, crop rotation, intercrop with legume, and ash application	Beauveria bassiana, Metarhizium anisopliae	Neem seed, wild marigold, tobacco extracts
Spider Mites	Stippling, webbing on leaves	Adequate watering, intercropping	Hirsutella thompsonii	Aloe, neem oil
Thrips	Leaf silvering and curling	Tillage	Metarhizium anisopliae	Neem powder, seed extracts, Urine and neem.
Bacterial wilt	Root galls, wilting	Solarisation, marigold intercrop	Pochonia chlamydosporia, Pasteuria spp.	Neem cake, ginger, sesame extract
Early bright	Seedling severed at soil line	Wood ash, flood irrigation	Predatory beetles, parasitic nematodes	Tobacco, wild marigold, neem

Chapter 5. Spider plant (*Cleome gynandra*)

5.1 Overview

The Spider Plant (*Cleome gynandra*) is one of the most important indigenous African vegetables (Merchant et al., 2023), locally known as Sagaa in parts of Kenya. Its resilience to drought and high market demand makes it an important crop for smallholder farmers. However, production is often limited by a variety of pests and diseases. From a nutritional standpoint, it is exceptionally valuable, being highly nutritious and particularly rich in Vitamin C, beta-carotene, and iron (Wakhanu et al., 2019; Tumwet et al., 2014), often showing superior micronutrient content compared to common introduced vegetables. Due to its strong taste, its preparation, similar to nightshade, requires prolonged boiling or mixing with ingredients like cream or milk to reduce its bitterness.



5.2 Major Pests and Diseases

Pests:

Aphids (e.g., *Myzus persicae*): Sap-sucking insects that cause leaf curling, yellowing, and stunted growth. Also transmit viral diseases. - Flea Beetles (e.g., *Phyllotreta* spp.): Create small, round holes (shot holing) in leaves, reducing photosynthetic capacity. - Spider Mites (*Tetranychus urticae*): Cause stippling, yellowing, and webbing on leaves; thrive in dry conditions. - Thrips (e.g., *Scirtothrips dorsalis*): Damage includes silverying of leaves and distortion of plant growth. - Root-Knot Nematodes (*Meloidogyne* spp.): Cause root galls, poor nutrient uptake, and wilting. - Cutworms (*Agrotis* spp.): Cut young seedlings at the base, leading to plant death.



Figure 5. Aphids, Flea beetles and Spider mites (*photo: Envato*)



Figure 6. Thrips, Root-knot nematodes and Cutworms (*photo: Envato*)

Diseases:

Root Rot: Triggered by waterlogging, leading to yellowing and decay of roots. Symptoms include yellowing leaves that turn brown and mushy, and wilting foliage. **Leaf Spot Diseases:** Caused by fungal or bacterial pathogens; visible as brown or black necrotic lesions on leaves.

5.3 Management Strategies

A. Cultural Practices

Intercrop with pest-repelling species like African basil and garlic. Ploughing and sanitation to reduce soil pest load. - Apply wood ash around the base of plants to deter cutworms. Maintain field hygiene and remove infected plant parts. Implement crop rotation with non-host species to reduce nematode buildup. In addition to adequate watering during the dry period to wash spider mites from leaves. Thrips is managed through mulching.

B. Biological Control

Conserve natural enemies such as lady beetles, lacewings, and parasitoid wasps (e.g., *Aphidius colemani*) to manage aphids and cutworms. Spider mites can be controlled using entomopathogenic microorganisms like *Bacillus* spp. and *Clostridium* spp. Thrips, aphids, and flea beetles are managed with entomopathogenic fungi such as *Beauveria bassiana* and *Metarhizium anisopliae*. For root-knot nematodes, apply nematode-trapping fungi such as *Pochonia chlamydosporia*.

C. Biopesticides

Use neem-based sprays and botanical extracts (e.g., chilli, garlic, ginger). - Prepare home-made botanical formulations from wild marigold, tobacco, and Mexican sunflower (See Annexe 1 for details).

A summary of cultural, biological and biopesticides management strategies are as shown in Table 3.

Table 3. Summary of pests and diseases of the Spider plant and their control

Pest/ Disease	Symptoms	Cultural Control	Biological Control	Biopesticide Options
Aphids	Leaf curling, yellowing	Basil intercrop, clean cultivation	<i>Aphidius</i> spp., lady beetles	Garlic, neem, chilli extract
Flea Beetles	Shothole damage on leaves	Crop rotation, ash application	<i>Beauveria bassiana</i> , <i>Metarhizium anisopliae</i>	Neem, wild marigold extract
Spider Mites	Stippling, webbing on leaves	Adequate watering, intercropping	<i>Hirsutella thompsonii</i>	Aloe, neem oil
Thrips	Leaf silvering and curling	Mulching, plant part removal	<i>Metarhizium anisopliae</i>	Lemon grass, marjoram extract
Root-Knot Nematodes	Root galls, wilting	Solarisation, marigold intercrop	<i>Pochonia chlamydosporia</i> , <i>Pasteuria</i> spp.	Neem cake, ginger, sesame extract
Cutworms	Seedling severed at soil line	Wood ash, flood irrigation	Predatory beetles, parasitic nematodes	Tobacco, wild marigold, neem

Chapter 6. Okra (*Abelmoschus esculentus*)

6.1 Overview

Okra (*Abelmoschus esculentus*) is an economically important vegetable utilized across West Africa and the Horn of Africa. Diverse cultivars are grown, often categorized by the color, pod length, and whether the pods are ridged or smooth. It is prized specifically for its edible green seed pods and its unique mucilaginous (slimy) texture, which acts as a natural thickener in traditional soups and stews. Okra is rich in dietary fiber, Vitamin C, and K. The characteristic mucilage is crucial in binding ingredients and providing viscosity in iconic dishes like okra soup or gumbo. Furthermore, studies suggest that okra preparations can bind bile acids, potentially offering cholesterol-lowering benefits. The pods can be consumed fresh, or they can be dried and powdered for later use. While local okra landraces show resilience to drought, pest pressure significantly limits productivity. This chapter discusses Nature-Positive Agricultural and Agroecological practices for managing pests and diseases in the Okra cropping system.



6.2 Major Pests and Diseases

Major pests:

The major pests affecting okra include aphids, armyworms, corn earworms, cucumber beetles, loopers, root-knot nematodes, and spider mites. Aphids (*Myzus persicae*, *Macrosiphum euphorbiae*) cause leaf distortion, yellowing, necrotic spots, stunted shoots, and promote sooty mold through honeydew secretion. Armyworms (*Spodoptera exigua*, *S. praefica*) skeletonize young leaves, create irregular holes, and leave cottony egg clusters and fruit wounds. Corn earworm (*Helicoverpa zea*) damages buds, flowers, leaves, and pods. Cucumber beetles (*Acalymma vittata*, *Diabrotica* spp.) feed on foliage and stems, stunt seedlings, transmit bacterial wilt, and scar fruits. Loopers (*Trichoplusia ni*) cause extensive leaf perforation. Thrips (melon thrips) lead to leaf distortion, silvery stippling, and black specks. Root-knot nematodes (*Meloidogyne* spp.) form root galls, reducing vigor and causing yellowing and wilting. Spider mites (*Tetranychus urticae*) produce yellow stippling, bronzing, and webbing on leaves).

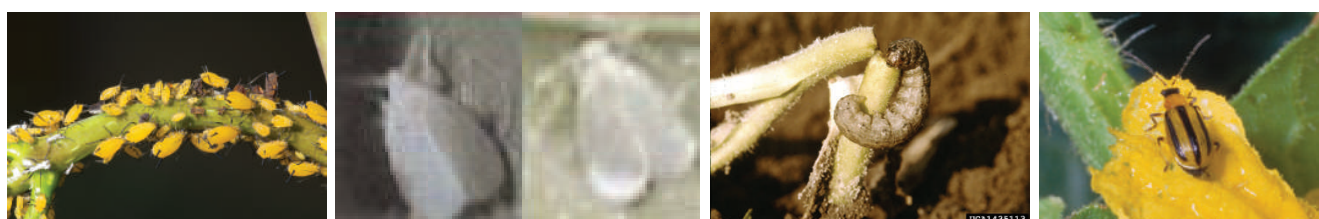


Figure 7. Aphids, Whiteflies, Cutworms and Cucumber beetle (photo: Freepik)



Figure 8. Cabbage looper, Thrips , Root knot nematode,Spider mites and Bollworm (*photo: Freepik*)

Major diseases:

Powdery mildew, Southern blight, White mold, Enation leaf curl disease, and Yellow vein mosaic are the major diseases of okra. Powdery mildew produces a white powdery growth on leaves that eventually covers the plant, causing leaf rolling and a scorched appearance, and thrives in warm, dry conditions with cool, dewy nights. Southern blight a soil-borne disease, leads to sudden wilting, yellowing foliage, stem browning, and fan-like mycelial mats under high temperature, humidity, and acidic soils. White mold also soil-borne, forms white fungal growth on flowers and cottony patches on water-soaked lesions of leaves, pods, and branches, which enlarge and become slimy, often killing branches or entire plants; it spreads through wind, contaminated irrigation water, or infected seed. Enation leaf curl disease (Okra enation leaf curl virus, OELCV), transmitted by whiteflies, causes small enations on leaf undersides that become rough and warty, reducing leaf size and twisting stems, branches, and petioles, resulting in thick, curled leaves and deformed fruits. Yellow vein mosaic disease (Bhendi yellow vein virus, BYVMV), also spread by whiteflies, produces alternating green and yellow patches, chlorotic veins that thicken over time, distorted stems and petioles, and small yellow-green fruits



Figure 9. Charcoal rot, Fusarium wilt, Powdery mildew, Southern blight, White, OELCV, BYVMV (*photo: Freepik*)

6.3 Management Strategies

A. Cultural practices:

To manage aphids, armyworms, and fruit borers, avoid planting okra near infested fields, maintain proper spacing, and control weeds. Handpick armyworm caterpillars and eggs and use shallow ploughing to expose caterpillars and pupae to predators. Plant maize or sorghum as borders or intercrops to act as trap crops and reduce entry of armyworms, whiteflies, beetles, and spider mites. Other intercrops such as cluster bean, ginger, marigold, sunflower, black gram, cowpea, red amaranth, Indian spinach, onion, garlic, mint, coriander, common bean, lettuce, and squash also help manage spider mites. Control cutworms by sprinkling wood ash around plants, deep ploughing to expose larvae, and using flood irrigation. Ploughing also helps reduce thrips. Manage root-knot nematodes by planting clean materials, practicing crop rotation and intercropping, and cleaning farm tools.

B. Biological control:

Aphids, cutworms, whiteflies, and cabbage loopers are managed by conserving parasitic wasps and predators such as flies, lacewings, ladybird beetles, flower flies, syrphid larvae, and hoverflies. Armyworms and fruit borers are controlled using parasitoids like *Trichogramma chilonis*. Thrips are managed with *Bacillus thuringiensis* and *Metarhizium anisopliae*. Root-knot nematodes are controlled with fungi culture such as *Trichoderma* spp., *Penicillium chrysogenum*, *Fusarium solani*, and *Fusarium oxysporum*. Spider mites are managed with entomopathogenic microbes like *Bacillus* spp. and *Clostridium* spp.

C. Chemical (biopesticides):

Aphids can be managed with plant-based extracts such as neem, garlic, lemongrass, chili, tobacco, marigold, and pawpaw, combined with detergent solutions or sun-fermented cattle urine. Armyworms, fruit borers, cutworms, whiteflies, and beetles can be controlled using neem-based products and extracts from turmeric, tobacco leaves, garlic, bitter apple, sour orange, onion, lemon eucalyptus, ginger, and neem. Thrips are managed with solar-treated animal urine and neem. Root-knot nematodes are controlled using sesame seed cake, castor bean, velvet bean, crotalaria, and neem extracts. Spider mites are managed with neem oil and neem seed kernel extract. A summary of cultural, biological and biopesticides management strategies are as shown in Table 4.

Table 4. Summary of pests and diseases of the Spider plant and their control

Pest/ Disease	Symptoms	Cultural Control	Biological Control	Biopesticide Options
Aphids	Leaf curling, yellowing, stunted growth	Use of sun-fermented cattle urine; detergent solution sprays	-	Extracts from neem, garlic, lemongrass, chili, tobacco, asafoetida, marigold, and pawpaw
Armyworms & Fruit Borers	Leaf damage, holes in leaves and fruits	-	-	Neem-based products; turmeric, tobacco leaf, garlic, bitter apple, sour orange, onion, lemon eucalyptus, ginger, and neem extracts
Cutworms, Whiteflies & Beetles	Seedling cutting, leaf yellowing, feeding damage	-	-	Neem-based botanicals and similar plant extracts as used for fruit borers

Thrips	Silvering of leaves, leaf distortion	Solar-treated animal urine	-	Neem extracts
Root-knot Nematodes	Root galling, stunted growth, poor vigour	Use of organic soil amendments such as sesame seed cake, castor bean, velvet bean, crotalaria	-	Neem extracts
Spider Mites	Leaf stippling, bronzing, webbing	-	-	Neem oil; neem seed kernel ex

Chapter 7. Kales (Brassica oleracea)

7.1 Overview

Kale (*Brassica oleracea* var. *acephala*) was introduced to East Africa but is now widely grown and considered a traditional food. Kales have become one of the most important leafy staples because they are hardy, fast-growing, and provide consistent yields, making them reliable for smallholder farming. They are an excellent source of Vitamins A, C, and K. Kale has high market demand and is a major source of income for small-holder farmers. They are a drought- and heat-tolerant crop, although they are vulnerable to major pests. This chapter discusses Nature-Positive Agricultural and Agroecological practices for managing pests and diseases in the Kales cropping system.



7.2 Major pests and diseases

Major pests:

These include beet armyworm, cabbage aphid, cabbage looper, cutworm, diamondback moth, flea beetles, thrips, and root-knot nematode.

Beet armyworm creates irregular holes in leaves; young larvae feed heavily, leaving foliage skeletonized, and cause shallow, dry wounds on fruits. Their eggs appear as whitish, cotton-like clusters on leaves.

Cabbage aphids stunt growth and can kill plants when infestations are severe. They are small, gray-green, soft-bodied insects with a white waxy coating, often hiding deep within shoots.

Cabbage loopers chew large holes in leaves, leading to significant leaf loss.

Cutworms attack seedlings and young transplants at night by cutting stems at the soil line and later making irregular holes in fruits.

Diamondback moth larvae initially feed between leaf surfaces, leaving small exit holes; older larvae create larger, irregular holes on leaf undersides. When disturbed, they drop on silk threads.

Flea beetles produce small pits and shot holes in young leaves, slowing growth and sometimes killing seedlings.

Large cabbage white and cross-striped cabbageworm larvae make ragged holes in leaves and leave green-brown droppings; they move more slowly than other caterpillars.

Thrips distort leaves, causing coarse stippling and a silvery appearance, leaving black fecal spots and transmitting plant viruses.

Root-knot nematodes cause stunted, uneven growth, swollen root galls, and wilting during hot, dry periods.



Figure 10. Beet armyworm larvae, Cabbage aphid, Cabbage looper, Cutworms, Flea beetles, Cross-striped cabbageworm, Thrips and Root-knot nematode (photo: Freepik)

Major diseases:

Alternaria leaf spot (Black spot, Gray spot): Causes small dark spots on leaves that turn brown or gray. Spots may be round or angular with dark edges, forming rings that later crack. Dark streaks can appear on stems and leaf stalks.

Anthracnose: Develops in warm, wet conditions. Starts as small gray or straw-colored spots that merge into large dead patches, causing yellowing and wilting. Spot centers may crack.

Damping-off: Kills seedlings soon after sprouting. Stems turn brown or black, become thin and twisted, and seedlings eventually collapse.

Downy mildew: Produces irregular yellow patches on leaves that turn light brown. A fluffy gray growth appears on the underside.

Black rot: Causes V-shaped brown spots on leaf edges, darkens stems, and may cause stem parts to fall off.



Figure 11. Alternaria leaf spot, Anthracnose, Damping off, Downy mildew and Black rot

7.3 Management Strategies

A. Cultural practices:

Cabbage aphids, green peach aphids, and cabbage looper are managed by improving soil organic matter to attract natural predators (ants, earwigs, beetles, spiders), removing weeds, using peel or straw mulches, intercropping with herbs (coriander, green onion, parsley, basil), crop rotation, early planting, healthy seedlings, trap crops, and integrating marigold–mustard in a push–pull system. Cabbage webworms, cutworms, and flea beetles are controlled through intercropping with citronella grass and basil, combined with natural sprays such as Bt and neem.

Leaf miner is managed through early ploughing, removing damaged leaves, pest-free seedlings, weed control, and crop rotation. Thrips are controlled by mulching with plant residues, removing infested leaves, and ploughing or harrowing seedbeds before transplanting to kill pupae.

Root-knot nematodes are managed through strict sanitation, cleaning tools, healthy seedlings, proper irrigation, uprooting infected roots and exposing them to sunlight, weed control, and adjusting planting time. Incorporate neem, sunn hemp, or brassicas as green manure.

Whiteflies are controlled by intercropping kales with coriander or marigold, rotating crops with onions, removing infested leaves, washing plants with water, and using row covers to prevent egg laying.

B. Biological control:

Biological control of major Kale pests involves a combination of entomopathogenic fungi, beneficial bacteria, and natural enemies.

Aphids (cabbage and green peach) & cabbage looper are controlled using *Trichoderma asperellum* combined with *Bacillus thuringiensis* or *Metarhizium anisopliae*, while conserving predators such as spiders, ladybugs, lacewings, syrphid fly larvae, and predatory bugs. Cabbage webworm: Managed with *Bacillus thuringiensis* plus pest-repellent intercrops like citronella grass and basil species. Beet armyworm is managed with *Bacillus thuringiensis* and entomopathogenic fungi. Diamondback moths, flea beetles, leaf miners are controlled by fungi (*Trichoderma asperellum*, *Metarhizium anisopliae*) and bacteria (*Bacillus subtilis*, *Bacillus thuringiensis*). Thrips is managed through predatory bugs, mites, and pathogens such as arbuscular mycorrhizal fungi, rhizobia, and *Metarhizium anisopliae*. Whiteflies are controlled by parasitoids (e.g., parasitic wasps), predators (ladybird beetles, lacewings, spiders), and fungi (*Metarhizium anisopliae*, *Beauveria bassiana*) alongside *Bacillus thuringiensis*. Root-knot nematodes are suppressed with nematode-trapping fungi like *Arthrobotrys* spp and *Monocrosporium* spp as well as compost prepared with neem seed and neem cake.

C. Chemical (Biopesticides control):

Kale pests are managed primarily with plant-based extracts:

Cabbage aphids: Garlic, chili, lantana, and neem extracts.

Green peach aphids: Tobacco, neem, river gum, and mahogany extracts.

Cabbage looper: *Trichoderma asperellum* combined with neem extract for young larvae and severe infestations.

Cutworms: Neem extract with pest-repellent intercrops such as citronella grass, sweet basil, and sacred basil.

Diamondback moth: Garlic, hot pepper, lantana, and neem extracts, plus Siam weed, node weed, wild chili, tobacco, African senna, poison nut, castor bean, and castor oil plant.

Cabbage webworm (including large white cabbage, cross-striped cabbage worm, beet armyworm): Garlic, chili, lantana, and neem extracts with intercrops of citronella grass and basils.

Flea beetles: *Bacillus thuringiensis* (Bt) and neem extract with pest-repellent intercrops.

Leaf miner: Neem-based products such as Nimbecidine, Achook, and Neemrok.

Whiteflies: Treat seedling roots with *Trichoderma asperellum* mycelia before transplanting, followed by neem extract sprays.

Root-knot nematodes: (See previous management strategies).

A summary of cultural, biological and biopesticides management strategies are as shown in Table 1.

Table 5. Summary of pests and diseases of Kales and their control

Pest/ Disease	Symptoms	Cultural Control	Biological Control	Biopesticide Options
Cabbage aphids	Curled, yellow leaves; sticky honeydew; small, soft insects visible.	Conserving natural predators Effective weed control. Early planting	Extracts from neem, garlic, lemongrass, chili, tobacco, asafetida, marigold, and pawpaw	Plant extract, Spray <i>Trichoderma asperellum</i> combined with <i>Bacillus thuringiensis</i> or <i>Metarhizium anisopliae</i>
Cutworm	Seedlings cut off at the base near the soil line; damage at night.	Neem extract Intercropping Crop rotation. Straw mulching Intercropping - Effective weed	-	Neem extract

Thrips	Silvery streaks or patches on leaves; tiny black specks of excrement; distorted growth	control. Ploughing Predatory bugs, mites	Metarhizium anisopliae	
Green peach aphids	Curled, yellow leaves; sticky honeydew; small, soft insects visible.	Intercropping	Parasitoids (parasitic wasps), Predators lady beetles, lacewings, and syrphid fly larvae, fungal diseases (<i>Entomophthora</i>)	Plant extract (see note) Trichoderma asperellum
Cabbage looper	Holes in leaves/ fruit; Frass (droppings); Feeding damage on foliage/stems.	Conserving natural enemies	Trichoderma asperellum	Neem-extract , Trichoderma asperellum Bacillus thuringiensis or Metarhizium anisopliae
Beet armyworm	Similar to those attacks of caterpillar on leaves and buds		Bacillus thuringiensis and entomopathogenic fungi	
Leaf miner	Winding, pale tunnels or "mines" visible within the leaf tissue.	Ploughing Effective weeding	Trichoderma asperellum, Metarhizium anisopliae	
Flea beetles	Tiny, irregular feeding holes ("shot holes") in leaves; jumping behavior when disturbed.	intercropping Neem extracts	Trichoderma asperellum, Metarhizium anisopliae	
White flies	Yellowing leaves; Sooty Mold on sticky residue; small, white insects cluster on leaf undersides.	Intercropping Predators	Parasitoids	Plant extract (see note) Metarhizium anisopliae Bacillus thuringiensis
Root-knot Nematodes	Galls/Knots or swellings on roots; stunted, yellowed plants; wilting despite water.	See other treatments	Nematode-Trapping; Arthrobotrys Parasitic Fungi; Paecilomyces (or Pochonia) and Verticillium. Parasitic Bacteria: Pasteuria penetrans. Plant Growth Promoting Rhizobacteria (PGPR): Bacteria; Pseudomonas and Bacillus species	Arthrobotrys spp and Monocrosporium spp

Chapter 8. Legumes (*Vigna* spp)

8.1 Overview

Cowpea (*Vigna unguiculata*) is an important indigenous African legume valued for its drought tolerance and nitrogen-fixing ability, making it vital for soil health and food security in the dry savannas of Sub-Saharan Africa. Its dried grains provide plant protein and B vitamins, while its tender leaves are widely used in traditional dishes. Similarly, French bean (*Phaseolus vulgaris*) is a major legume grown for fresh pods and dried seeds, serving as both a staple food and an export crop. Despite its adaptability and role in improving livelihoods in Eastern and Southern Africa, French bean production faces significant pest and disease challenges that require targeted management strategies. This chapter discusses Nature-Positive Agricultural and Agroecological practices for managing pests and diseases in the legume cropping system.



8.2 Major Pests and Diseases

Major pests:

Major pests include bean fly, aphids, bean leaf beetle and cutworm.

Bean fly: The larvae bore into seedlings, roots, and stems, causing patchy emergence, stunting, wilting, and ultimately plant death. Infestation is often linked to plant residues or heavy manure applications.

Aphids: These small insects suck sap, leading to stunted growth and are critical agents for transmitting viral diseases.

Bean leaf beetle: Adults chew holes in leaves and pods, resulting in defoliation and reduced yield.

Cutworm: The larval stages sever young seedlings at the base of the plant, causing immediate losses of crop.



Figure 12. Bean fly, Aphids (*A. fabae*), Thrips, Cutworm and Bean leaf beetle (*photo: Envato*)

Major diseases:

Bean rust, angular leaf spot, common bacterial blight and root rot.

Bean rust: Manifests as reddish-brown pustules on the leaves, ultimately leading to significant defoliation (leaf loss).

Angular leaf spot: Results in distinct angular, water-soaked lesions on the leaves, which causes the leaves to drop prematurely.

Common bacterial blight: Characterized by water-soaked spots that appear on both the leaves and pods, which then develop into necrotic (dead, dry) tissue.

Anthracnose: Forms characteristic dark, sunken lesions on the stems, leaves, and, most notably, the pods.

Root rot: It attacks the plant from below, leading to yellowing of the leaves, wilting, and decay of the roots, severely reducing the overall plant vigor.



Figure 13. Bean rust, Angular leaf spot, Anthracnose, Bacterial blight and Root rot (*Fusarium* sp.) (photo: Envato)

8.3 Major Pests and Diseases

A. Cultural practices

Field Enhancement: Ridging, hilling soil (earthing up), and applying fertilizer are used to boost plant vigor against the bean fly. **Planting Strategy:** Intercropping with cereals (like maize) or other plants (like eggplant/leeks), adjusting density and spacing, and early sowing are employed to deter bean fly, thrips, and aphids. **Hygiene and Removal:** Removing weeds, crop residues, and infected plants is crucial for controlling aphids, cutworms, thrips, and bean leaf beetle. **Tillage** helps manage cutworms. **Direct Control:** The bean leaf beetle is managed by handpicking, and damaged fields require reseeding/replanting after a cutworm attack.

B. Biological control

Bean Fly: Control is achieved using natural parasitic wasps that attack the pupal stage. Management also involves coating seeds with beneficial fungi and integrating the method with better soil fertility **management.** **Aphids:** This pest is managed primarily using various natural enemies. These include beneficial fungi, ladybird beetles (a type of beetle predator), and several types of parasitic wasps that target the aphids. **Bean Leaf Beetle:** Management utilizes extracts made from specific plants, such as smartweed, Lettuce-Leaf *Blumea*, and fish poison bean. **Cutworms:** Control involves a wide range of natural agents.

Microorganisms: Using specific types of beneficial bacteria, fungi, and nematodes that are antagonistic to the pest. **Predators and Parasitoids:** Control relies on various parasitic wasps, numerous types of predatory beetles (ground and rove beetles), ants, rodents, and spiders. **Thrips:** This pest is managed using a specific type of minute predatory bug as a natural enemy.

C. Chemical (biopesticide) control:

Aphids are controlled using mixtures of neem seed kernel, aloe, the crown flower, and other leaf extracts. In addition to cultivated tobacco, neem, garlic, eucalyptus, and mahogany. Bean leaf beetles are specifically managed using a simple aqueous extract from neem seeds. Thrips are managed with a mixture of neem, hot pepper, garlic, lantana, and wild marigold.

Bean fly and cutworms can be controlled using a 60-day biowash (liquid fertilizer) made from earthworm compost and plant extracts such as custard apple, devil's trumpet, Jatropha, neem, Parthenium, and Pongamia. The bean fly is also managed by applying dried leaves of fever nut or grey nickerbean.

Complex mixtures involving custard apple, red chilli, thorn apple, wormwood, and sweet basil are also used. Cutworms are managed using crude extracts from leaves and peels of ripe pomegranate fruits, or aqueous extracts from the leaves, roots, and fruits of the fever nut plant.

A summary of cultural, biological and biopesticides management strategies are as shown in Table 6.

Table 6. Summary of pests and diseases of Legumes and their control

Pest/ Disease	Symptoms	Cultural Control	Biological Control	Biopesticide Options
Bean Fly	Destroys seedlings (stunting, death).	Ridging/Hilling soil, early sowing, fertilizer use, intercropping (leeks/eggplant), mulching, removing infected plants.	Parasitic wasps and beneficial fungi (seed coating).	Earthworm biowash (custard apple, neem), fever nut or grey nickerbean leaves.
Aphids & Thrips	Sapsucking, disease spread, flower/pod deformities.	Intercropping (maize), adjusting spacing, removing weeds/residues, cereal borders.	Ladybird beetles, beneficial fungi, various parasitic wasps, and predatory bugs.	Extracts from neem, garlic, chilli/hot pepper, tobacco, and various plant mixtures.
Cutworms	Cuts seedlings at base (crop loss).	Tillage, weed removal, reseeding / replanting.	Predatory beetles / ants/spiders, parasitic wasps, beneficial bacteria, fungi, and nematodes.	Earthworm biowash, extracts from pomegranate and fever nut.
Bean Leaf Beetle	Holes in leaves/pods (defoliation).	Handpicking, removing weeds, companion planting.	Predatory bug.	Aqueous neem seed extract, or extracts from smartweed, fish poison bean, etc.

Chapter 9. Pepper (*Capsicum annuum*)

9.1 Overview

Both sweet bell peppers (*Capsicum annuum*) and hot chili peppers (*Capsicum frutescens*) are essential components of African cuisine. The genus *Capsicum* contributes varieties spanning the heat spectrum, including the fiercely hot pilipili (African Bird's Eye Chili) and the pungent Scotch Bonnet. Peppers are used in fresh, dried, or processed forms to impart intense heat and flavor. Studies confirm the significant nutritional and antioxidant potential of various African pepper varieties. Sweet bell peppers are typically incorporated into vegetable medleys. Peppers (*Capsicum annuum* and *C. frutescens*) are in constant high market demand as they are indispensable for imparting intense heat and flavor (e.g. Scotch Bonnet) and for use in vegetable medleys. While widely grown, open-field production is highly susceptible to a range of pests, diseases, and disorders, which can severely limit yield and quality, necessitating effective control measures throughout the growing cycle. This chapter discusses Nature-Positive Agricultural and Agroecological practices for managing pests and diseases in the pepper cropping system.



9.2 Major pests and diseases

Major pests:

These are aphids, thrips, fruit borers, white flies, spider mites, and Root-knot nematodes

Aphids damage plants by sucking sap, producing honeydew that coats plant surfaces, and transmitting viral diseases. They commonly infest young stems and flower buds.

Thrips feed on young leaves, flowers, and fruits, causing silvery leaf patches, dark faecal spots, leaf curling, wrinkling, and drying. Heavy infestation leads to distorted stems and fruits, stunted growth, and can transmit viruses such as tomato spotted wilt virus in peppers.

Fruit borers feed on flowers and fruits, causing flower bud abortion. Their larvae bore into fruits, creating entry points for secondary infections and accelerating fruit decay.

Whiteflies damage plants by sucking sap, causing chlorotic leaf spots, and excreting honeydew that promotes black sooty mould and reduces photosynthesis. They also transmit viral diseases such as chilli leaf curl.

Spider mites feed on plant sap, mainly from the underside of leaves. Severe infestations can spread across the entire plant, leading to leaf damage and defoliation.

Root-knot nematodes cause swollen, knotted roots that restrict water and nutrient uptake, leading to wilting. Severely infested roots rot, and plants may eventually die.



Figure 14. Thrips, Aphids, Fruit borer, Whiteflies, Spider mite and Root knot nematodes (*photo: Envato*)

Major diseases:

The major diseases are damping off, powdery mildew, and bacterial wilt. Damping-off and root rot cause seedlings to fail to emerge, collapse after emergence, or become stunted. Nursery beds show irregular patches. The soil-borne fungi involved vary by temperature: *Pythium* favours cooler conditions, while *Rhizoctonia solani* and *Fusarium* spp. thrive in warmer conditions.

Powdery mildew: White to grey powdery spots develop on upper leaf surfaces, spreading from older to younger leaves and causing leaf drop. It thrives in warm, humid, and dry conditions.

Bacterial wilt: Affected plants wilt suddenly without yellowing, appearing singly or in clusters. The disease spreads under warm, wet conditions.



Figure 15. Damping off/root rot, Powdery mildew and Bacterial wilt (*photo: Envato*)

A. Cultural practices:

Aphids can be managed by using resistant varieties, separating fields from infected crops, raising seedlings in protected environments, applying straw mulch, removing weeds, and using intercrops or barrier crops such as cassava, maize, sorghum, banana, sunflower, millet, legumes, and African marigold to limit aphid movement.

Spider mites can be controlled by keeping plants well-watered, washing mites off leaves, removing infested parts, ploughing, and intercropping with onion or garlic.

Fruit borers can be managed through resistant varieties, early planting, crop rotation, field sanitation, removal of nearby host plants (e.g., potato, tomato, eggplant), covering nursery beds with shade nets, removing infected shoots and fruits early, intercropping with coriander, and installing barriers to block moth movement.

Whiteflies: Managed through early planting, intercropping with rosemary, drip irrigation, organic mulching (compost, straw, bark, wood chips), spraying sour buttermilk or fermented cow milk, and foliar sprays of cow dung/urine.

Root-knot nematodes: Controlled by crop rotation, companion cropping with African marigold (*Tagetes* spp.), maintaining high soil organic matter, mulching with clove buds, and intercropping with cowpea.

B. Biological control:

Aphids are controlled using parasitoids, pathogens, and predators such as ladybird beetles, lacewings, and mirid bugs. Spider mites are controlled using pathogenic bacteria, fungi, and predators (see preceding chapters for details). Fruit borers are managed with *Bacillus thuringiensis* (Bt) bio-products, and *Trichogramma chilonis* (See preceding chapters for details on bio-products). Whiteflies and Root knot nematodes (see preceding chapters).

C. Chemical control:

Aphids (plant extract, see details in preceding chapters). Spider mites managed using Nimbecidine and plant extracts as described above. Fruit borers can be managed with extracts from turmeric rhizomes, tobacco leaves, garlic bulbs, bitter apple fruits and leaves, sour orange peels and seeds, onion bulbs, lemon eucalyptus leaves and seeds, ginger rhizomes, and neem leaves and seeds. Whiteflies are managed using mixtures of cow dung and urine with wood ash, soap, and water, plus foliar sprays of marigold, chilli, turmeric, neem formulations, milkweed, and garlic extracts. Root-knot nematodes are managed using plant extracts from pot marigold, neem, sweet wormwood, and castor seeds. A summary of cultural, biological and biopesticides management strategies are as shown in table 7.

Table 7. Summary of pests and diseases of the pepper and their control

Pest/ Disease	Symptoms	Cultural Control	Biological Control	Biopesticide Options
Aphids	Curled, yellow leaves; sticky honeydew; small, soft insects visible.	Use Resistant Varieties; Separate from infected crops; Remove Weeds; Use Rice Mulch; Intercrop with Marigold, Cassava, Grains, Vegetables.	Ladybird Beetles, Lacewings, Predatory Bugs; Various Parasitic Wasps ; Predatory Flies.	Aqueous extracts of Garlic, Hyptis Leaves, Neem Seed.
Spider Mites	Fine Webbing; tiny yellow/ white dots (stippling) on leaves; bronzing.	Ensure Adequate Watering; Rinse Mites off leaves; Plow fields; Intercrop with Garlic & Rosemary.	Predatory Mites (<i>Amblyseius</i> , <i>Neoseiulus</i> species); Predatory Beetles; Pathogenic Bacteria/Fungi (<i>Beauvaria</i> , <i>Lecanicillium</i> , <i>Metarhizium</i> species).	Neem Bio-products (oil, seed extracts); Extracts from Rough Cocklebur, Chamomile, Rosary Pea Seeds, Common Sage.
Fruit Borers	Holes/Tunnels in fruit/ shoots; Frass (droppings); fruit decay.	Resistant Varieties; Early Planting; Sanitation (remove host plants); Use Physical Barriers (shade nets, erection); Intercrop with Coriander.	<i>Bacillus thuringiensis</i> (Bt) bio-products; Various Parasitic Wasps (<i>Trichogramma chilonis</i> , <i>Chelonus</i> sp. species).	Extracts from Neem, Garlic, Turmeric, Tobacco, Papaya Leaves, Bitter Apple, Ginger; Use Wood Ash.

Whiteflies	Yellowing leaves; Sooty Mold on sticky residue; small, white insects cluster under leaves.	Early Planting; Use Drip Irrigation; Apply Organic Mulches; Intercrop with Rosemary.	Parasitic Wasps (<i>Encarsia</i> , <i>Eretmocerus species</i>); Coccinellid Beetles, Lacewings, Predatory Mites; Entomopathogenic Fungi (<i>Beauveria bassiana</i>).	Homemade sprays (Cow Dung/Urine/ Ash, Soap); Foliar sprays of Marigold, Chilli, Turmeric Roots, Milkweed, Neem/ Garlic extracts.
Root Knot Nematodes	Galls/Knots on roots; stunted, yellowed plants despite adequate care.	Crop Rotation; High Soil Organic Matter; Use Clove Bud Mulch; Companion plant with African Marigold & Cowpea.	Beneficial Soil Bacteria (<i>Pseudomonas</i> , <i>Bacillus species</i>) and Fungi (<i>Trichoderma</i> , <i>Paeclomyces species</i>) (often PGPR).	Extracts from Pot Marigold, Neem, Red Chilli, Ginger, Sweet Wormwood, Brassica species.

Chapter 10. Shallot (*Allium cepa*)

10.1 Overview

Shallot (*Allium cepa* var. *aggregatum*) is a popular, aromatic, and milder alternative to the common bulb onion across Africa. The term “shallot” often includes multiplier onions and small, pungent local onion landraces valued for their multiple, well-storing bulbs. It is a key ingredient in many African dishes, forming the base of traditional flavors. High demand persists due to its role as a reliable seasoning crop. Shallots are hardy and marketable because they produce small, storable bulbs. Pest and disease issues are similar to those of common onions, requiring control of soil-borne pathogens and onion thrips. This chapter discusses Nature-Positive Agricultural and Agroecological practices for managing pests and diseases in the Shallot cropping system.



10.2 Major pests and diseases

Major pests:

Onion thrips, cutworms and onion maggot

Onion crops are threatened by several pests: onion thrips suck sap from leaves, resulting in silver streaks and curling that reduce photosynthesis and stunt growth; while both cutworms and onion maggots attack the base of young seedlings, causing them to be cut off and leading to plant loss.



Figure 16. Onion Thrips (*Thrips tabaci*), Cutworms (*Agrotic* spp.) and Onion Maggot (*Delia antiqua*) (photo: Envato)

Major diseases:

Downy mildew, purple blotch, fusarium basal rot and neck rot

Downy mildew is a fungal disease that causes a purple-gray mold on the leaves, leading to wilting and eventual bulb rot. Purple blotch causes brown or purple lesions on the leaves, which reduces the plant's ability to photosynthesize. Fusarium basal rot is a fungal infection that leads to the yellowing of leaves

and the destructive rotting of onion bulbs. Onion smut results in dark streaks on the leaves and bulb deformation, which ultimately decreases the market value of the crop. Finally, neck rot is a fungal disease responsible for the rotting of onion bulbs specifically during storage.



Figure 17. Cutworms (*Agrotis* spp.), Purple blotch, Fusarium basal rot, Onion smut and Neck rot. (photo: Envato)

10.3 Management Strategies

A. Cultural practices

To control the onion maggot and cutworms, preventative soil and field cleaning are key: this involves early tillage and removing all weeds before planting, and practicing crop rotation and removing previous crop residues to disrupt the pests' environment. For onion maggots, it is also crucial to destroy affected plants and isolate new seedlings from older fields, often by delaying planting.

Managing onion thrips primarily relies on manipulating the plant environment. This is achieved through intercropping the onions with certain flowering and vegetable plants that act as traps (like carrots, cucumber, and carnation flowers). Other techniques include staggering planting times, using straw mulch, direct seed planting, and selecting resistant materials. Water and nutrition management is also important, requiring farmers to increase irrigation during dry periods and carefully adjust fertilizer application (either increasing nitrogen or reducing nitrogen and phosphorus, depending on the specific approach used). Finally, intercropping with pungent spices like dill, black pepper, red pepper, and ginger is an effective practice specifically used against the onion maggot.

B. Biological control

Onion thrips are managed by numerous natural predators, including various species of predatory mites, minute pirate bugs, and flower bugs, along with multiple types of predatory beetles, such as ladybird beetles and lacewing larvae. The larvae are also attacked by specialized parasitic wasps. Furthermore, the thrips are susceptible to control by numerous beneficial fungi that target all life stages, larvae, pupae, and adults. For cutworms, management combines microorganisms and larger predators. Control utilizes beneficial nematodes (microscopic worms) and various fungi that cause disease in the cutworms. Specialized bacteria are also applied. Natural enemies include different types of parasitic wasps and predators such as ants and various predatory beetles. Finally, the onion maggots are managed using beneficial nematodes, several types of specialized fungi, and predatory insects like ground beetles and rove beetles.

C. Chemical (biopesticide)

For onion thrips, management relies on the application of plant extracts from sources such as basil, neem, chilli, garlic, lemongrass, pyrethrum, and parthenium weed. Extracts from the violet tree, African soapberry, and tree tobacco are also utilized, alongside general neem-based bio-products. Cutworms are managed using a diverse array of plant extracts, often from herbs and aromatic plants. These include extracts from basil, garlic, mint, cumin, parsley, cucumber, lemon grass, and caraway. Further control is achieved using extracts from Egyptian horseweed, Persian lilac, Madagascar periwinkle, and wild mint. The onion maggot is managed using extracts from specific plants including neem, various types of custard apple (like African custard apple and soursop), and Jatropha. A summary of cultural, biological and biopesticides management strategies are as shown in Table 8.

Table 8. Summary of pests and diseases of the shallot plant and their control

Pest/ Disease	Symptoms	Cultural Control	Biological Control	Biopesticide Options
Onion Thrips	Suck sap, causing silver streaks, leaf curling, and stunted growth.	Intercropping (with flowers/vegetables), staggering planting, and straw mulch	Predatory mites, ladybird beetles, parasitic wasps, and beneficial fungi.	Extracts from neem, basil, chilli, garlic, and lemongrass.
Cutworms	Cut seedlings at the base, causing total plant loss.	Early tillage, weed removal, and planting resistant varieties	Predatory beetles/spiders, parasitic wasps, and beneficial nematodes/fungi /bacteria.	Extracts from basil, garlic, mint, cumin, and pomegranate.
Onion Maggots	Cut seedlings at the base, causing total plant loss.	Crop rotation, delaying planting, removing residues, and intercropping with pungent spices (dill, ginger).	Predatory ground beetles, beneficial nematodes, and specialized fungi.	Extracts from neem, custard apple, and Jatropha.

Chapter 11. Ginger (*Zingiber officinale*)

11.1 Overview

Ginger (*Zingiber officinale*) is a widely grown spice and medicinal crop valued for its aromatic, pungent rhizome. It is used fresh, dried, or powdered in cooking, in beverages, and in traditional remedies for ailments such as coughs and colds. Ginger thrives in tropical, high-rainfall areas and is resilient but vulnerable to rhizome rot and nematodes, requiring good drainage and phytosanitary practices. Demand remains high due to its culinary and medicinal importance. This chapter discusses Nature-Positive Agricultural and Agroecological practices for managing pests and diseases in the ginger cropping system.



11.2 Major pests and diseases

Major pests:

Root knot nematode and burrowing nematode

Root knot nematode: The leaves of the infected plant turn yellow, then, as the pathogen progresses, the plant wilts in hot weather. The roots of the plant show water-soaked lesions on roots. Burrowing nematode on the other hand, plant leaves turn yellow, with fewer shoots, and the rhizomes exhibit water-soaked lesions that turn brown as the disease progresses. This lesion merges and leads to rotting.



Figure 18. Root knot nematode and Burrowing nematode (*photo:* Envato)

Major diseases:

Bacterial wilt and rhizome rot

Bacterial wilt causes leaves to roll, curl ("green wilt"), yellow, and die, leading to stunted plants. Rhizome rot also causes leaf yellowing and stunting, but is specifically defined by the water-soaked internal decay of rhizomes and the discharge of discolored water with four distinct smells from the plant's conducting tissues.



Figure 19. Bacterial wilt and Rhizome rot (*photo: Envato*)

11.3 Management Strategies

A. Cultural practices

To manage root knot and burrowing nematodes, growers must prioritize strict hygiene and field rotation to stop the pests from spreading and to reduce their populations in the soil. Key preventive steps include planting only pest-free rhizomes, immediately uprooting and destroying any plants showing signs of infection, ensuring all farm tools are thoroughly cleaned after use, and applying only clean irrigation water. For effective soil treatment, farmers should implement crop rotation using crops that nematodes do not favor, such as cabbage, onion, maize, and sorghum. Finally, reducing nematode populations can be achieved by solarizing the field (heating the soil through ploughing and covering) and by applying green manure or mulching with materials such as *Gliricidia* leaves, Velvet bean, and Mexican sunflower.

B. Biological control

Root-knot and burrowing nematode management is achieved biologically through several beneficial microorganisms. These include various types of beneficial fungi and beneficial bacteria (See details for other sections above).

C. Chemical (biopesticide)

The management of root knot and burrowing nematodes involves applying botanical extracts to the root zone. This is achieved by drenching the area with neem plant extracts or a neem-based product, and by applying basil leaf extracts. A summary of cultural, biological and biopesticides management strategies are as shown in Table 9.

Table 9. Summary of pests and diseases of the ginger plant and their control

Pest/ Disease	Symptoms	Cultural Control	Biological Control	Biopesticide Options
Root Knot & Burrowing Nematodes	Root galls, stunted growth, and poor vigour.	Plant pest-free rhizomes, uproot and destroy plants, crop rotation, clean tools/water, solarize field, and use green manuring/mulch.	Use of beneficial fungi and beneficial bacteria.	Drenching the root zone with neem plant extracts or a neem-based product, and applying basil leaf extracts.

Chapter 12. Basil (*Ocimum basilicum*)

12.1 Overview

African Basil (*Ocimum basilicum*) is the most common type, widely used for cooking, traditional medicine, and cultural rituals. It has insect-repellent properties and growing market demand due to its short growth cycle (25–30 days). The crop is drought-sensitive and prone to fungal diseases and root rot if drainage is poor, requiring consistent moisture and good management. This chapter discusses Nature-Positive Agricultural and Agroecological practices for managing pests and diseases in the Basil cropping system.



12.2 Major pests and diseases

Major pests:

Aphids, cutworms and loopers, flea beetle

These pests primarily cause two types of damage: stunted growth and direct tissue loss. Aphids stunt plants and leave a sticky honeydew that fosters molds, hindering the plant's ability to use sunlight. Cutworms cause immediate plant death by cutting seedlings near the base. Other larvae, like loopers, strip the leaves, while the flea beetle creates a distinctive "shothole" appearance by chewing small holes in the foliage.



Figure 20. Aphids, Looper, Cutworm and Flea beetle (*photo*: Envato)

Major diseases:

Cercospora leaf spot, downy mildew, fusarium wilt

These three diseases primarily target the leaves, leading to wilting and plant death. Cercospora leaf spot is visible as dark, circular spots on the leaves that have lighter centers. Downy mildew causes the leaves to turn yellow, often starting from the center vein, and can be confirmed by the presence of gray, fuzzy growth on the underside, resulting in brown to black, angular patches. Finally, Fusarium wilt is the most severe, characterized by leaves that turn yellow and wilt, often showing brown streaks underneath, which ultimately leads to stunted growth and the death of the entire plant.



Figure 21. *Cercospora* leaf spot, Downy mildew and Fusarium wilt (photo: Envato)

12.3 Management Strategies

A. Cultural practices

Controlling aphids and the flea beetle involves maintaining a clean field environment. This is achieved through crop rotation, removing weeds (especially cruciferous weeds for aphids), and promptly destroying crop residues after harvest. For flea beetles, adequate tillage is used to expose their eggs, while covering young plants with fine mesh netting offers protection from aphids. Specific measures target the larval pests. Cutworms are managed by avoiding planting crops in areas with known outbreaks, regularly ploughing the field, and selecting resistant varieties. Loopers require active control measures like hand-picking and destroying the caterpillars, removing alternate host plants and infested plant parts, and using mass-trapping or sex pheromone traps to disrupt male moth mating. Planting mexican marigold can also be used as a trap crop for loopers.

Management focuses on field hygiene and strategic planting. For all pests, crop rotation and prompt destruction of crop residues are essential. Aphids and flea beetles are controlled by weed removal and can be physically excluded by covering young plants with mesh netting. Cutworms are managed by regular ploughing and planting resistant varieties in safe areas. Loopers require active removal by hand-picking caterpillars, removing infested parts, and using pheromone traps.

B. Biological control

Aphids are controlled by numerous agents. Key control relies on general predators such as ladybird beetles, lacewings, and various species of nabid and mirid bugs. Specific control is provided by a variety of parasitic wasps that attack the aphids. Control is also achieved using pathogens that cause disease in the pests. Cutworms are managed primarily with beneficial nematodes (microscopic worms) and larger predators. The most effective control involves using different groups of nematodes. Natural enemies also include various predatory beetles, wasps, and ant species. For loopers, control focuses on targeted parasitism and microbial agents. Management includes using wasps that parasitize the pest's eggs and larvae, as well as applying biopesticides based on bacteria known to cause disease in the larvae. Flea beetle is managed using a diverse mix of agents. Control relies on two main types of beneficial nematodes and various beneficial fungi that cause disease in the beetles. Also used are specialized parasitic wasps and general predators like spiders and ground beetles.

C. Chemical (biopesticide) control

A wide range of plant extracts is used, often derived from potent sources. Pungent and aromatic extracts like garlic, chilli/hot pepper, and cultivated tobacco are effective against all four pests. Bitter extracts from aloes, neem, mugwort, red bitter apple, and Chinaberry tree are key against aphids, cutworms, and loopers. Additionally, wild and Mexican marigold extracts are frequently used alone or in combination against aphids, cutworms, and loopers.

A summary of cultural, biological and biopesticides management strategies are as shown in Table 10.

Table 10. Summary of pests and diseases of the basil plant and their control

Pest/ Disease	Symptoms	Cultural Control	Biological Control	Biopesticide Options
Aphids	Stunted growth, honeydew production, and sooty mold (hinders photosynthesis).	Crop rotation, weed removal, residue destruction, and covering young plants with mesh.	Ladybird beetles, lacewings, predatory bugs, and parasitic wasps.	Extracts from garlic, chilli, tobacco, aloes, mugwort, and marigold.
Cutworms	Cut seedlings at the base, resulting in heavy plant loss.	Avoid high-infestation areas, regular ploughing, and planting resistant varieties.	Predatory beetles /ants, parasitic wasps, and beneficial nematodes, fungi, and bacteria.	Extracts from rosary pea, onion, chilli, tobacco, aloes, and mugwort.
Loopers	Early stages feed on terminal clusters; later stages skeletonize leaves.	Hand-picking caterpillars, removing host plants, crop rotation, and pheromone traps.	Wasp parasitoids (egg and larval) and bacterial biopesticides.	Extracts from rosary pea, chilli, tobacco, Peruvian pepper, and Mexican marigold.
Flea Beetle	Feeding causes small holes in leaves, giving a characteristic "shothole" appearance.	Crop rotation, clean cultivation (weed removal), tillage to expose eggs, and residue destruction.	Beneficial nematodes, specialized fungi, parasitic wasps, and spiders/ground beetles.	Extracts from alligator pepper, garlic, chilli, neem, tobacco, and ginger.

References

- Abang, M. M.; Kihurani, A. W.; Srinivasan, R. 2012. Managing diseases and pests of indigenous vegetables for GAP compliance in sub-Saharan Africa. *Scripta Horticulturae*, 15, 191-232.
- Abate, T.; Ampofo, J. K. O. 1996. Insect pests of beans in Africa: their ecology and management. *Annual review of entomology*, 41(1), 45-73. <https://doi.org/10.1146/annurev.en.41.010196.000401>
- Abhishek, T. S.; Dwivedi, S. 2021. Review on integrated management of brinjal shoots and fruit borer, *Leucinodes orbonalis* (Guenee). *Journal of Entomology and Zoology studies*, 9(1), 181-189. <https://doi.org/10.22271/j.ento.2021.v9.i1c.8143>
- Abteu, A.; Niassy, S.; Affognon, H.; Subramanian, S.; Kreiter, S.; Garzia, G. T.; Martin, T. 2016. Farmers' knowledge and perception of grain legume pests and their management in the Eastern province of Kenya. *Crop Protection*, 87, 90-97. <https://doi.org/10.1016/j.cropro.2016.04.024>
- Abteu, A.; Subramanian, S.; Cheseto, X.; Kreiter, S.; Tropea Garzia, G.; Martin, T. 2015. Repellency of plant extracts against the legume flower thrips *Megalurothrips sjostedti* (Thysanoptera: Thripidae). *Insects*, 6(3), 608-625. <https://doi.org/10.3390/insects6030608>
- Abubakar, M.; Koul, B.; Chandrashekar, K.; Raut, A.; adav, D. 2022. Whitefly (*Bemisia tabaci*) management (WFM) strategies for sustainable agriculture: A review. *Agriculture*, 12(9), 1317.
- Achigan-Dako, E. G.; Sogbohossou, O. E.; Maundu, P. 2014. Current knowledge on *Amaranthus* spp.: Research avenues for improved nutritional value and crop resilience. *Food Security*, 6(1), 109-122.
- Adelakun, O.; Ade-Omowaye, B.; Adeyemi, I.; Van de Venter, M. 2012. Mineral composition and the functional attributes of Nigerian okra seed (*Abelmoschus esculentus* Moench) flour. *Food Research International*, 47(2), 348-352.
- Aderolu, I. A.; Omooloye, A. A.; Okelana, F. A. 2013. Occurrence, Abundance and Control of the Major Insect Pests Associated with Amaranths in Ibadan, Nigeria. *Entomol Ornithol Herpetol* 2: 112. <http://dx.doi.org/10.4172/2161-0983.1000111>
- Adeyemo, A. E.; Omoba, O. S.; Olagunju, A. I.; Josiah, S. S. 2022. Assessment of nutritional values, phytochemical content, and antioxidant properties of shallot (*Allium Ascalonicum* L.) leaf and bulb. *SSRN Electronic Journal*. <https://doi.org/10.2139/ssrn.4065617>
- Akama, C. K.; Amiteye, S.; Appiah, A. S.; Kpentey, P. B.; Appiah, R.; Kutufam, J. T.; Amenorpe, G. 2023. Assessment of different rates of neem extracts as bio-pesticide for the control of insect vectors and associated viral diseases in okra. *African Journal of Agricultural Research*, 19(4), 364-373. <https://doi.org/10.5897/AJAR2022.16192>
- Ali, W. M.; Abdel-Mageed, M. A.; Hegazy, M. G. A.; Abou-Shlell, M. K.; Sultan, S. M.; Salama, E. A.; Yousef, A. F. 2023. Biocontrol agent of root-knot nematode *Meloidogyne javanica* and root-rot fungi, *Fusarium solani* in okra morphological, anatomical characteristics and productivity under greenhouse conditions. *Scientific Reports*, 13(1), 11103. <https://doi.org/10.1038/s41598-023-37837-z>
- Ambrose-Oji, B. (2009). Urban Food Systems and African Indigenous Vegetables: Defining the Spaces and Places for African Indigenous Vegetables in Urban and Peri-Urban Agriculture. In C. M. Shackleton, M. W. Pasquini, A. W. Drescher (Eds.), *African Indigenous Vegetables in Urban Agriculture* (pp.1-34). London: Earthscan.
- Anyanga, M. O.; Farman, D. I.; Ssemakula, G. N.; Mwangi, R. O.; Stevenson, P. C. 2021. Effects of hydroxycinnamic acid esters on sweetpotato weevil feeding and oviposition and interactions with *Bacillus thuringiensis* proteins. *Journal of Pest Science*, 94(3), 783-794. <https://doi.org/10.1007/s10340-020-01297-5>
- Arivudainambi, S.; Selvamuthukumar, T.; Baskaran, P. 2010. Efficacy of herbal extracts in management of amaranth leaf caterpillar. *International journal of vegetable science*, 16(2), 167-173. <https://doi.org/10.1080/19315260903375046>

- Ashilenje, D. S.; Omunyin, M. E.; Okalebo, J. R. 2011. Influence of potassium on aphid incidence and yield of vegetable African nightshades (*Solanum* L. section *Solanum*). *Annals of Biological Research*, 2(3), 317-326.
- Bandara, K. A. N. P.; Kumar, V.; Ninkovic, V.; Ahmed, E.; Pettersson, J.; Glinwood, R. 2009. Can leek interfere with bean plant-bean fly interaction? Test of ecological pest management in mixed cropping. *Journal of Economic Entomology*, 102(3), 999-1008.
- Besufkad, A.; Hinsermu, M.; Legesse, W. B.; Roothaert, R. 2025. Validation of Bio-Pesticides for the Pests of Kale (*Brassica oleracea* L. var. *acephala*.) in Ethiopia. Conference Paper.
- Boateng, F., Amiteye, S., Appiah, A. S., Marri, D., Offei, B. K., Ofori, S. E. K., Amoatey, H. (2019). Insect Pest Diversity and Damage Assessment in Field Grown Okra (*Abelmoschus esculentus* (L.) Moench) in the Coastal Savannah Agro-ecological Zone of Ghana. *J. Agric. Ecol. Res. Int*, 18(4), 1-10. <http://dx.doi.org/10.9734/JAERI/2019/v18i430066>
- Boivin, G.; Hance, T.; Brodeur, J. 2012. Aphid parasitoids in biological control. *Canadian J. Plant Sci.* 92, 1-12. doi: 10.4141/cjps2011-045
- Bokelmann, W.; Huyskens-Keil, S.; Ferenczi Z.; Stöber, S. 2022. The Role of Indigenous Vegetables to Improve Food and Nutrition Security: Experiences from the Project HORTINLEA in Kenya (2014–2018). *Front. Sustain. Food Syst.* 6:806420. doi: 10.3389/fsufs.2022.806420
- Borrelli, N.; Ndakidemi, P. 2020. Small farmers for a food system transition: evidence from Kenya and Tanzania. *Ledizioni*.
- Carnot, A. C.; Alvarest, T. T. E.; Justin, O.; Zachée, A.; Fabrice, M. T. 2017. Effect of culture density of black nightshade (*Solanum nigrum*) on the insect infestation. *Plant*, 5, 19-26. <https://doi.org/10.11648/j.plant.s.2017050501.13>
- Chandrashekharaiyah, M.; Sannaveerappanavar, V. T. 2013. Biological activity of select plant and indigenous extracts against diamondback moth, *Plutella xylostella* (L.)(Lepidoptera: Plutellidae) and cowpea aphid, *Aphis craccivora* Koch (Hemiptera: Aphididae). *Current Biotica*, 7(3): 134-144.
- Chouikhi, S.; Assadi, B. H.; Lebdi, K. G.; Belkadhi, M. S. 2022. Efficacy of the entomopathogenic fungus, *Beauveria bassiana* and *Lecanicillium muscarium* against two main pests, *Bemisia tabaci* (Genn.) and *Tetranychus urticae* (Koch), under geothermal greenhouses of Southern Tunisia. *Egyptian Journal of Biological Pest Control*, 32(1), 125.
- Cividanes, F. J.; Silva, K. P. D.; Martins, I. C. F.; Cividanes, T. M. D. S. 2020. Phytophagous insects and natural enemies in kale under organic and chemical fertilizers. *Arquivos do Instituto Biológico*, 87, e0902018. <https://doi.org/10.1590/1808-1657000902018>
- Collange, B.; Navarrete, M.; Peyre, G.; Mateille, T.; Tchamitchian, M. 2011. Root-knot nematode (*Meloidogyne*) management in vegetable crop production: The challenge of an agronomic system analysis. *Crop protection*, 30(10), 1251-1262. <https://doi.org/10.1016/j.cropro.2011.04.016>
- Currah, L. (2002). Onions in the tropics: Cultivars and country reports. *Allium crop science: recent Shackleton advances*, 379-407.
- da Silva, V. F.; dos Santos, A.; Silveira, L. C. P.; Tomazella, V. B.; Ferraz, R. M. 2022. Push-pull cropping system reduces pests and promotes the abundance and richness of natural enemies in brassica vegetable crops. *Biological Control*, 166, 104832. <https://doi.org/10.1016/j.biocontrol.2021.104832>
- de Araújo Hendges, A. R. A.; da Silva Melo, J. W.; de Almeida Guimaraes, M.; da Silva Rabelo, J. 2018. Intercropping kale with culinary herbs alters arthropod diversity and hinders population growth in aphids. *Hortscience*, 53(1), 44-48. <https://doi.org/10.21273/HORTSCI12010-17>
- Dekebo, A. 2022. Major Pests and Pest Management Strategies in the Sweet Pepper (*Capsicum annum*). In *Capsicum-Current Trends and Perspectives*. IntechOpen.

- Devi, G. 2020. Management of cutworm by entomopathogenic nematodes-a review. *Int J Curr Microbiol Appl Sci*, 9(6), 2520-2526. <https://doi.org/10.20546/ijcmas.2020.906.306>
- Djiwanti, S. R.; Kammenga, J. E.; Murk, A. J. 2009. Nematicidal activity of plant extracts against the root-knot nematode, *Meloidogyne incognita*. *Open Natural Products Journal*, 2, 77-85. <http://dx.doi.org/10.2174/1874848100902010077>
- Dohroo, N. P.; Gupta, M. 2025. Effect of bioagents on management of rhizome diseases, plant growth parameters and nematode population in ginger. *Agricultural Science Digest*, 34(1), 41-44. <https://doi.org/10.5958/j.0976-0547.34.1.008>
- Dube, P.; Ihle, R.; Heijman, W. J. M.; Ochieng, J. 2017. The Potential of Traditional Leafy Vegetables for Improving Food Security in Africa. In Erokhin, V. (ed): *Establishing Food Security and Alternatives to International Trade in Emerging Economies* (pp.220-243). IGI Global DOI: 10.4018/978-1-5225-2733-6.ch011
- Dubey, V. K.; Sahoo, S. K.; Sujatha, B.; Chowdhury, S. 2023. Integrated pest management strategies for okra, *Abelmoschus esculentus* (L.) Moench. *AgriCos e-Newsletter*, 4(1), Article 12. (PDF) https://www.researchgate.net/publication/367219138_Integrated_Pest_Management_Strategies_for_Okra_Abelmoschus_esculentus_L_Moench
- Ekoja, E. E.; Kumaga, P. H.; Abah, D. 2022. Flea beetle infestation and control strategies as perceived by farmers of Malvaceae crops in Benue State, Nigeria. *Australian Journal of Science and Technology*, 6(2), 78-85.
- Emam, S. S. 2022. Biological and Biochemical effects of pomegranate peels and leaves crude extracts on the Black cutworm larvae. *International Journal of Scientific Research and Sustainable Development*, 5(2), 199-210.
- FAO. 2018. *The 10 Elements of Agroecology: Guiding the Transition to Sustainable Food and Agricultural Systems*. Food and Agriculture Organization of the United Nations.
- FAO. 2022. *FAO's Plant Production and Protection Division*. Rome. <https://doi.org/10.4060/cc2447en>
- Farhana, F.; Latif, M. A.; Ali, M. 2021. Evaluation of the efficacy of chemical insecticides and biopesticides against flea beetle in cabbage (*Brassica Oleracea* var. *Capitata*). *Asian Plant Res J*, 7(4), 1-10. <https://doi.org/10.9734/APRJ/2021/v7i430159>
- Fortier, A. M.; Brodeur, L.; Fournier, F. 2024. *Delia antiqua* Meigen, Onion Maggot/Mouche de l'oignon (Diptera: Anthomyiidae). In *Biological Control Programmes in Canada, 2013-2023* (pp. 201-211). GB: CABI. <https://doi.org/10.1079/9781800623279.0021>
- Gagnon, A. È.; Fortier, A. M.; Audette, C. 2024. Biological Control and Habitat Management for the Control of Onion Thrips, *Thrips tabaci* Lindeman (Thysanoptera: Thripidae), in Onion Production in Quebec, Canada. *Insects*, 15(4), 232. <https://doi.org/10.3390/insects15040232>
- Gahatraj, S. 2019. Integrated management of green peach aphid *Myzus persicae* Sulzer (Hemiptera: Aphididae). *International Journal of Entomology Research*, 4(2), 42-45.
- Gemedé, H. F. 2015. Nutritional quality and health benefits of "Okra" (*Abelmoschus esculentus*): A review. *International Journal of Nutrition and Food Sciences*, 4(2), 208. <https://doi.org/10.11648/j.ijnfs.20150402.22>
- Gliessman, S. R. 2015. *Agroecology: The Ecology of Sustainable Food Systems* (3rd ed.). CRC Press.
- Gopalakrishnan, S.; Kumari, B. R.; Vijayabharathi, R.; Sathya, A.; Srinivas, V.; Rao, G. R. 2014. Efficacy of major plant extracts/molecules on field insect pests. In *Advances in plant biopesticides* (pp. 63-88). New Delhi: Springer India. https://doi.org/10.1007/978-81-322-2006-0_5
- Haile, G. A.; Tesfaye, D. 2024. Response of field pea (*Pisum sativum* L.) genotypes for grain yield in a multi-environment trial in southeastern Ethiopia. *Heliyon*, 10(15), e35233. <https://doi.org/10.1016/j.heliyon.2024.e35233>

- Hassan, D.; Rizk, M. A.; Sobhy, H. M.; Mikhail, W. Z.; Nada, M. S. 2017. Virulent entomopathogenic fungi against the two-spotted spider mite *Tetranychus urticae* and some associated predator mites as non-target organisms. *Egyptian Academic Journal of Biological Sciences. A, Entomology*, 10(6), 37-56. <https://doi.org/10.21608/eajb.2017.12124>
- Hassan, E. S. M.; El-Sheikh, M. F.; Hegazy, F. H.; Ali, F. A.; Mesbah, I. I. 2024. Efficacy of bioinsecticides, synthetic insecticides, macro and micronutrients for the management of onion thrips, *Thrips tabaci* in onion: A field trial. *Journal of Crop Health*, 76(4), 799-810. <http://dx.doi.org/10.21203/rs.3.rs-4223001/v1>
- Hervé, K.; Mariam, K.; Romaric, N. K. 2023. Local perceptions and endogenous knowledge of hoary basil (*Ocimum americanum* L.) in Burkina Faso. *Ethnobotany Research and Applications*, 26. <https://doi.org/10.32859/era.26.44.1-11>
- Hoarau, C.; Campbell, H.; Prince, G.; Chandler, D.; Pope, T. 2022. Biological control agents against the cabbage stem flea beetle in oilseed rape crops. *Biological Control*, 167, 104844. <https://doi.org/10.1016/j.biocontrol.2022.104844>
- Hooks, C. R.; Fereres, A. 2006. Protecting crops from non-persistently aphid-transmitted viruses: a review on the use of barrier plants as a management tool. *Virus research*, 120(1-2), 1-16. <https://doi.org/10.1016/j.virusres.2006.02.006>
- Horn, L. N.; Shimelis, H. 2020. Production constraints and breeding approaches for cowpea improvement for drought prone agro-ecologies in sub-Saharan Africa. *Annals of Agricultural Sciences*, 65(1), 83-91. <https://doi.org/10.1016/j.aosas.2020.03.002>
- Hussain, E. R.; Mudoi, S.; Hussain, S. A.; Hussain, A.; Saikia, R. 2025. Biological control of root-knot nematode, *Meloidogyne incognita* in chilli (*Capsicum annum* L.). *International Journal of Entomology Research*, 10(4), 54-59.
- Iglesias, L.; Havey, M. J.; Nault, B. A. 2021. Management of onion thrips (*Thrips tabaci*) in organic onion production using multiple IPM tactics. *Insects*, 12(3), 207. <https://doi.org/10.3390/insects12030207>
- Inyang, U. E.; Emosairue, S. O. 2005. Laboratory assessment of the repellent and anti-feedant properties of aqueous extracts of 13 plants against the banana weevil *Cosmopolites sordidus* Germar (Coleoptera: Curculionidae). *Tropical and Subtropical Agroecosystems*, 5(1), 33-44.
- Jakubowska, M.; Dobosz, R.; Zawada, D.; Kowalska, J. 2022. A review of crop protection methods against the twospotted spider mite—*Tetranychus urticae* Koch (Acari: Tetranychidae)—with special reference to alternative methods. *Agriculture*, 12(7), 898. <https://doi.org/10.3390/agriculture12070898>
- Jan, Q.; Khan, I. A.; Al-Shuraym, L. A.; Alshehri, M. A.; Ahmed, N.; Saeed, M.; Sayed, S. 2022. Comparative conventional preventive strategies for insect pest of okra. *Saudi Journal of Biological Sciences*, 29(5), 3114-3121. <https://doi.org/10.1016/j.sjbs.2022.03.022>
- Jared, J. J.; Murungi, L. K.; Wesonga, J.; Torto, B. 2016. Steroidal glycoalkaloids: chemical defence of edible African nightshades against the tomato red spider mite, *Tetranychus evansi* (Acari: Tetranychidae). *Pest management science*, 72(4), 828-836. <https://doi.org/10.1002/ps.4100>
- Javed, M.; Majeed, M. Z.; Sufyan, M.; Ali, S.; Afzal, M. 2018. Field Efficacy of Selected Synthetic and Botanical Insecticides against Lepidopterous Borers, *Earias vittella* and *Helicoverpa armigera* (Lepidoptera: Noctuidae), on Okra (*Abelmoschus esculentus* (L.) Moench). *Pakistan journal of zoology*, 50(6). <http://dx.doi.org/10.17582/journal.pjz/2018.50.6.2019.2028>
- Joshi, M. J.; Verma, K. S.; Chandel, R. S. 2020. Feeding inhibition with bioformulations in cut worms *Agrotis ipsilon* (Hufnagel). *Indian Journal of Entomology*, 82(1), 134-138. <http://dx.doi.org/10.5958/0974-8172.2020.00030.9>
- Kahlon, T.; Chapman, M.; Smith, G. 2007. In vitro binding of bile acids by okra, beets, asparagus, eggplant, turnips, green beans, carrots, and cauliflower. *Food Chemistry*, 103(2), 676-680. <https://doi.org/10.1016/j.foodchem.2006.07.056>

- Kankam, F.; Sowley, E. N. K.; Mohammed, A. 2015. Management of root-knot nematode (*Meloidogyne* spp.) on okra (*Abelmoschus esculentus* (L.) Moench) with aqueous sesame seed extract. *International Journal of Agronomy and Agricultural Research*, 6(8), 24-31. <http://www.innspub.net/>
- Karungi, J.; Agamire, P.; Kovach, J.; Kyamanywa, S. 2010. Cover cropping and novel pesticide usage in the management of pests of hot pepper (*Capsicum chinense*). *International Journal of Tropical Insect Science*, 30(2), 84-92. <https://doi.org/10.1017/S1742758410000160>
- Kethran, M. R.; Sun, Y.; Khan, S.; Baloch, S.; Wu, L. L.; Yang Yang, T. T.; Bashir, W. 2014. Effect of different sowing dates on insect pest population of Chillies (*Capsicum annuum* L). *Journal of Biology, Agriculture and Health care*, 4(25), 196-214.
- Khaliq, A.; Khan, A. A.; Afzal, M.; Tahir, H. M.; Raza, A. M.; Khan, A. M. 2014. Field evaluation of selected botanicals and commercial synthetic insecticides against Thrips *tabaci* Lindeman (Thysanoptera: Thripidae) populations and predators in onion field plots. *Crop Protection*, 62, 10-15. <https://doi.org/10.1016/j.cropro.2014.03.019>
- Kianmatee, S.; Ranamukhaarachchi, S. L. 2007. Combining pest repellent plants and biopesticides for sustainable pest management in Chinese kale. *Journal of Asia-Pacific Entomology*, 10(1), 69-74. [https://doi.org/10.1016/S1226-8615\(08\)60333-7](https://doi.org/10.1016/S1226-8615(08)60333-7)
- Knodel, J. J.; Shrestha, G. 2018. Pulse crops: pest management of wireworms and cutworms in the Northern Great Plains of United States and Canada. *Annals of the Entomological Society of America*, 111(4), 195-204.
- Korir, V. J.; Sikuku, P. A.; Musyimi, D. M. 2021. Phytochemical analysis of Pyrethrum plant extract and its anti-aphid effect on African Nightshades (*Solanum scabrum* Mill). *EAS J Biotechnol Genet*, 3(1): 21-29. <https://doi.org/10.36349/easjbg.2021.v03i01.002>
- Kraft, K. H.; Brown, C. H.; Nabhan, G. P.; Luedeling, E. Luna Ruiz, J. D.; Coppens d'Eeckenbrugge, G.; Hijmans, R. J.; Gepts, P. 2014. Multiple lines of evidence for the origin of domesticated chili pepper, *Capsicum annuum*, in Mexico. *Proceedings of the National Academy of Sciences*, 111(17), 6165-6170. <https://doi.org/10.1073/pnas.1308933111>
- Krishna, R. A.; Bhaskar, H. 2016. Evaluation of selected acaropathogenic fungi, botanicals and new acaricide molecules against *Tetranychus urticae* Koch (Prostigmata: Tetranychidae) on okra. *Journal of tropical agriculture*, 54(1), 21-21. <https://jtropag.kau.in/index.php/ojs2/article/view/365>
- Kumar, D.; Kumari, P.; Kamboj, R.; Kumar, A.; Banakar, P.; Kumar, V. 2022. Entomopathogenic nematodes as potential and effective biocontrol agents against cutworms, *Agrotis* spp.: present and future scenario. *Egyptian Journal of Biological Pest Control*, 32(1), 42. <https://doi.org/10.1186/s41938-022-00543-5>
- Laizer, H. C.; Chacha, M. N.; Ndakidemi, P. A. 2019. Farmers' knowledge, perceptions and practices in managing weeds and insect pests of common bean in Northern Tanzania. *Sustainability*, 11(15), 4076. <https://doi.org/10.3390/su11154076>
- Latifian, M.; Rahnama, A. A.; Amani, M. 2014. The effects of cultural management on the Date spider mite (*Oligonychus afrasiaticus* McG) infestation. *International Journal of Farming and Allied Sciences*, 3(9), 1009-1014.
- Leach, A.; Reiners, S.; Nault, B. 2020. Challenges in integrated pest management: A case study of onion thrips and bacterial bulb rot in onion. *Crop Protection*, 133, 105123. <https://doi.org/10.1016/j.cropro.2020.105123>
- Li, X. W.; Lu, X. X.; Zhang, Z. J.; Huang, J.; Zhang, J. M.; Wang, L. K.; Lu, Y. B. 2021. Intercropping rosemary (*Rosmarinus officinalis*) with sweet pepper (*Capsicum annuum*) reduces major pest population densities without impacting natural enemy populations. *Insects*, 12(1), 74. <https://doi.org/10.3390/insects12010074>
- Li, Z.; Costamagna, A. C.; Beran, F.; You, M. 2024. Biology, ecology, and management of flea beetles in Brassica crops. *Annual Review of Entomology*, 69(1), 199-217.

Lugumira, R.; Tafiire, H. Vancoillie, F.; Ssepuyya, G.; Van Loey, A. 2025. Nutrient and phytochemical composition of nine African leafy vegetables: A comparative study. *Foods*, 14(8), 1304. <https://doi.org/10.3390/foods14081304>

Lunze, L. M. M.; Buruchara, R. A. M.; Lon, N. O. G.; Ngongo, M.; Rao, I. 2012. Integrated soil fertility management in bean-based cropping systems of eastern, central and Southern Africa. *Soil Fertility Improvement and Integrated Nutrient Management - A Global Perspective*. <https://doi.org/10.5772/29151>

Mahmood, K.; Eijaz, S.; Khan, M. A.; Alamgir, A.; Shaukat, S. S.; Mehmood, Z.; Sajjad, A. 2014. Effects of biopesticides against jassid [*amrasca devastans* (dist.)] and white fly [*Bemisia tabaci* (genn.)] on okra. *Int. J. Biol. Biotech*, 11(1), 161-165.

Makhubu, F. N.; Khosa, M. C.; McGaw, L. J. 2021. South African plants with nematicidal activity against root-knot nematodes: A review. *South African Journal of Botany*, 139, 183-191. <https://doi.org/10.1016/j.sajb.2021.02.010>

Merchant, E. V.; Odendo, M.; Maiyo, N.; Govindasamy, R.; Morin, X. K.; Simon, J. E.; Hoffman, D. J. 2023. An evaluation of nutrition, culinary, and production interventions using African Indigenous vegetables on nutrition security among smallholder farmers in western Kenya. *Frontiers in Nutrition*, 10. <https://doi.org/10.3389/fnut.2023.115442>

Mohapatra, S.; Padhi, J.; Singh, S. 2024. Enhancing yield and economic benefits through sustainable pest management in Okra cultivation. *Sci Rep* 14, 22220. <https://doi.org/10.1038/s41598-024-72997-6>

Moyo, S. M.; Kayitesi, E. 2022. African Nightshade (*Solanum nigrum* complex species). *Handbook of Phytonutrients in Indigenous Fruits and Vegetables*, 97-117. <https://doi.org/10.1079/9781789248067.0007>

Mpumi, N.; Machunda, R. S.; Mtei, K. M.; Ndakidemi, P. A. 2020. Selected insect pests of economic importance to Brassica oleracea, their control strategies and the potential threat to environmental pollution in Africa. *Sustainability*, 12(9), 3824. <https://doi.org/10.3390/su12093824>

Mukasa, D.; Olila, D.; Tinzaara, W.; Kagezi, G. H. 2008. Effects of Tithonia and Phytolacca extracts against the banana weevil, *Cosmopolites sordidus* (Germar) (Coleoptera: Curculionidae). *AJABS*, 3(1), 24-29.

Munyoki, N. M.; Muthomi, J.; Kilalo, D.; Bautze, D.; Kiboi, M.; Mwangi, E.; Cheseto, X. 2024. Scientific validation of plant extracts used by farmers in the management of bean flower thrips on French beans in Kenya. *Journal of Applied Entomology*, 148(10), 1235-1244. <https://doi.org/10.1111/jen.13342>

Mureithi, D. M. 2018. Characterization of key pests of amaranth and nightshades in Kenya and development of integrated pest management (IPM) strategies (Doctoral dissertation, Gottfried Wilhelm Leibniz Universität Hannover).

Murovhi, J.; Phophi, M. M.; Mafongoya, P. 2020. Efficacy of plant materials in controlling aphids on Okra (*Abelmoschus esculentus* L. Moench) in Limpopo Province of South Africa. *Agronomy*, 10(12), 1968. <https://doi.org/10.3390/agronomy10121968>

Murungi, L. K.; Salifu, D.; Masinde, P.; Wesonga, J.; Nyende, A.; Knapp, M. 2014. Effects of the invasive tomato red spider mite (Acari: Tetranychidae) on growth and leaf yield of African nightshades. *Crop protection*, 59, 57-62. <https://doi.org/10.1016/j.cropro.2014.02.001>

Muthama, E.; Dharani, N.; Namikoye, S.; Karanja, R. 2024. Impacts of selected climate smart agricultural practices on African Indigenous vegetables in Kenyan drylands. *African Phytosanitary Journal Volume 4 Issue 1*, 4(1), 66-85. <https://doi.org/10.52855/uwbw9156>

Muthusamy, B.; Arumugam, E.; Dhamodaran, K.; Thangarasu, M.; Kaliyamoorthy, K.; Kuppusamy, E. (2015). Bioefficacy of *Caesalpinia bonducella* extracts against tobacco cutworm, *Helicoverpa armigera* (Hub.) (Lepidoptera: Noctuidae). *Journal of Coastal Life Medicine*, 3(5), 382-388. <https://doi.org/10.12980/JCLM.3.2015JCLM-2014-0058>

- Mutune, B.; Ekesi, S.; Niassy, S.; Matiru, V.; Bii, C.; Maniania, N. K. 2016. Fungal endophytes as promising tools for the management of bean stem maggot *Ophiomyia phaseoli* on beans *Phaseolus vulgaris*. *Journal of pest science*, 89(4), 993-1001. <https://doi.org/10.1007/s10340-015-0725-4>
- Mwanauta, R.; Mtei, K.; Ndakidemi, P. 2015. Potential of controlling common bean insect pests (bean stem maggot (*Ophiomyia phaseoli*), *Ootheca* (*Ootheca bennigseni*) and Aphids (*Aphis fabae*)) using agronomic, biological and botanical practices in field. *Agricultural Sciences*, 6: 489-497. <http://dx.doi.org/10.4236/as.2015.65048>.
- Mworia, J. K. 2021. Major pests of African indigenous vegetables in Tanzania and the effects of plant nutrition on spider mite management (Doctoral dissertation, Universität Hannover).
- Nag, S.; Bhullar, M. B.; Kaur, P. 2020. Efficacy of biorationals against two-spotted spider mite, *Tetranychus urticae* Koch (Acari: Tetranychidae) infesting green pepper cultivated under protected conditions. *International Journal of Acarology*, 46(7), 489-495. <https://doi.org/10.1080/01647954.2020.1811762>
- Nampeera, E. L.; Nonnecke, G. R.; Blodgett, S. L.; Tusiime, S. M.; Masinde, D. M.; Wesonga, J. M.; ... Abukutsa-Onyango, M. O. 2019. Farmers' knowledge and practices in the management of insect pests of leafy amaranth in Kenya. *Journal of Integrated Pest Management*, 10(1), 31. <https://doi.org/10.1093/jipm/pmz029>
- Ngakou, A.; Tamò, M.; Parh, I. A.; Nwaga, D.; Ntonifor, N. N.; Korie, S.; Nebane, C. L. N. 2008. Management of cowpea flower thrips, *Megalurothrips sjostedti* (Thysanoptera, Thripidae), in Cameroon. *Crop Protection*, 27(3-5), 481-488. <https://doi.org/10.1016/j.cropro.2007.08.002>
- Ngidi, M.S.C. 2023. The Role of Traditional Leafy Vegetables on Household Food Security in Umdoni Municipality of the KwaZulu Natal Province, South Africa. *Foods* 12, 3918. <https://doi.org/10.3390/foods12213918>
- Ngigi, B.; Kibet, P.; Otipa, M. 2024. Leaf miners on kale – Kenya (*Liriomyza brassicae*) [Pest management decision guide: Green and yellow list]. PlantwisePlus Knowledge Bank; Kenya Agricultural and Livestock Research Organization (KALRO). <https://doi.org/10.1079/pwkb.20167800633>
- Ngurwe, J. K.; Wanjala, F. M.; Ochieno, D. M.; Kiptoo, G. J. 2018. Infestation and damage of black nightshade (*Solanum nigrum*) by black bean aphid (*Aphis fabae*) and red spider mite (*Tetranychus evansi*). *International Journal of Agronomy and Agricultural Research*, 13(5), 79-88.
- Nisha, M. S.; Raj, K. K.; Beula, R. S. 2024. Biorational Management of Root-knot Nematode (*Meloidogyne incognita*) in Ginger (*Zingiber officinale* Rosc.). *Indian Journal of Nematology*, 54(2), 249-259.
- Nkhata, W.; Shimelis, H.; Melis, R.; Chirwa, R.; Mzengeza, T. 2019. Breeding for bean fly resistance in common bean (*Phaseolus vulgaris* L.): a review. *Acta Agriculturae Scandinavica, Section B—Soil Plant Science*, 69(3), 275-285. <https://doi.org/10.1080/09064710.2018.1554747>
- Obeng-Ofori, D.; Sackey, J. 2003. Field evaluation of non-synthetic insecticides for the management of insect pests of okra *Abelmoschus esculentus* (L.) Moench in Ghana. *SINET: Ethiopian Journal of Science*, 26(2), 145-150. <https://doi.org/10.4314/sinet.v26i2.18210>
- Ochieng, J.; Schreinemachers, P.; Ogada, M.; Dinssa, F. F.; Barnos, W.; Mndiga, H. 2019. Adoption of improved amaranth varieties and good agricultural practices in East Africa. *Land use policy*, 83, 187-194. <https://doi.org/10.1016/j.landusepol.2019.02.002>
- Ochilo, W. N.; Nyamasyo, G. H.; Nderitu, J. H. 2013. Impact of soil fertility management practices on a major insect pest infestation and yield of beans (*Phaseolus Vulgaris* L.) in Taita District, Kenya. *African Journal of Food, Agriculture, Nutrition and Development*, 13(5), 8340-8350. <https://doi.org/10.18697/ajfand.60.12550>
- Odhav, B.; Beekrum, S.; Akula, U.; Baijnath, H. 2007. Preliminary assessment of nutritional value of traditional leafy vegetables in KwaZulu-Natal, South Africa. *Journal of Food Composition and Analysis*, 20(5), 430-435.

- Oforma, C.; Udourioh, G.; Ojinnaka, C. 2020. Characterisation of essential oils and fatty acids composition of stored ginger (*Zingiber officinale* Roscoe). *Journal of Applied Sciences and Environmental Management*, 23(12), 2231. <https://doi.org/10.4314/jasem.v23i12.22>
- Oke, O. A.; Odiyi, C. A.; Ofuya, T. I. 2015. Insects associated with underutilized crop: grain, leafy and ornamental amaranth in Ibadan, Nigeria. *Journal of Agriculture and Ecology Research International*, 2(2), 145-155. <https://doi.org/10.9734/JAERI/2015/14227>
- Onkendi, E. M.; Kariuki, G. M.; Marais, M.; Moleleki, L. N. 2014. The threat of root-knot nematodes (*Meloidogyne* spp.) in Africa: A review. *Plant pathology*, 63(4), 727-737.
- Orech, F. O.; Jensen, S.; Friis, H.; Estambale, B. 2011. Vitamin A content of traditional leafy vegetables consumed by the Luo people of western Kenya. *International Journal of Food Safety, Nutrition and Public Health*, 4(2/3/4), 237.
- Ouma, L. O.; Muthomi, J. W.; Kimenju, J. W.; Beesigamukama, D.; Subramanian, S.; Khamis, F. M.; Tanga, C. M. 2023. Occurrence and management of two emerging soil-dwelling pests ravaging cabbage and onions in Kenya. *Scientific Reports*, 13(1), 18975. <https://doi.org/10.1038/s41598-023-46190-0>
- Owade, J. O.; Abong', G. O.; Okoth, M. W.; Mwang'ombe, A. W. 2020. Trends and constraints in the production and utilization of cowpea leaves in the arid and semi-arid lands of Kenya. *Open Agriculture*, 5(1), 325-334. <https://doi.org/10.1515/opag-2020-0038>
- Pal, S.; Wahengbam, J.; Raut, A. M.; Banu, A. N. 2019. Eco-biology and management of onion thrips (*Thysanoptera: Thripidae*). *Journal of Entomological Research*, 43(3), 371-382. <https://doi.org/10.5958/0974-4576.2019.00066.5>
- Paul, T.; Sarkar, S. 2023. Effect of intercropping and few biorationals in eco-friendly management of major pest Okra. *The Pharma Innovation Journal*, 12(3), 2048-2053. <https://www.thepharmajournal.com/archives/2023/vol12issue3/PartY/12-3-382>
- Dittmar, P. J.; Dufault, N. S.; Desaegeer, J.; Qureshi, J.; Boyd, N. S.; Paret, M. L. 2024. Chapter 4. Integrated Pest Management. *Critical Issue: 1. Agricultural and Horticultural Enterprises* DOI:<https://doi.org/10.32473/edis-cv298-2023>
- Rastogi, A.; Shukla, S. 2013. Amaranth: A new millennium crop of nutraceutical values. *Critical Reviews in Food Science and Nutrition*, 53(2), 109-125.
- Rodingpuia, C.; Lalthanzara, H. 2021. An insight into black cutworm (*Agrotis ipsilon*): A glimpse on globally important crop pest. *Science vision*, 21(2), 36-42. <https://doi.org/10.33493/scivis.21.02.02>
- Saad, A. M.; Salem, H. M.; El-Tahan, A. M.; El-Saadony, M. T.; Alotaibi, S. S.; El-Shehawi, A. M.; Swelum, A. A. 2022. Biological control: An effective approach against nematodes using black pepper plants (*Piper nigrum* L.). *Saudi Journal of Biological Sciences*, 29(4), 2047-2055. <https://doi.org/10.1016/j.sjbs.2022.01.004>
- Sæthre, M.-G.; Godonou, I.; Hofsvang, T.; Tèpa-Yotto, G. T.; James, B. 2011. Aphids and their natural enemies in vegetable agroecosystems in Benin. *J. Int. J. Trop. Insect Sci.* 31, 103-117. doi: 10.1017/S1742758411000191
- Sahayaraj, K.; Sathyamoorthi, P. 2010. The toxicity and biological effect of *Petalium murex* L. extracts on the tobacco cutworm, *Spodoptera litura* (Fabr.) larvae. *Archives of phytopathology and plant protection*, 43(18), 1768-1780. <https://doi.org/10.1080/03235400902753626>
- Sakong, E.; Olspa, M.; Too, A.; Masinde, B.; Wamalwa, N.; Ringe, E. 2020. Root-knot nematode in Ginger – Kenya (*Meloidogyne* spp.): Pest management decision guide – Green and yellow list. *PlantwisePlus*, CABI. <https://www.plantwise.org>
- Salim M.; Aamir, M.; Amal, S.; Raihana, K.; Waseem, R.; Khursheed, D.; Samar, M.; Ahmad, B.; Nasir, N.; Nazir, Dr.; Zakir, A.; Tajamul, M.; May, M.; Rafiq, K. M.; Idrees, M.; Suhail, M. 2022. Role of Intercropping in Sustainable Insect-Pest Management: A Review. *International Journal of Environment and Climate Change*. 3390-3404. [10.9734/IJECC/2022/v12i111390](https://doi.org/10.9734/IJECC/2022/v12i111390).

- Sani, I.; Ismail, S. I.; Abdullah, S.; Jalinas, J.; Jamian, S.; Saad, N. 2020. A review of the biology and control of whitefly, *Bemisia tabaci* (Hemiptera: Aleyrodidae), with special reference to biological control using entomopathogenic fungi. *Insects*, 11(9), 619. <https://doi.org/10.3390/insects11090619>
- Seif, A. A.; Nyambo, B. 2017. Integrated pest management for Brassica production in East Africa. ICIPE Science Press. <http://34.250.91.188:8080/xmlui/handle/123456789/670>
- Seni, A. 2018. Insect pests of amaranthus and their management. *International Journal of Environment, Agriculture and Biotechnology*, 3(3), 1100-1103. <http://dx.doi.org/10.22161/ijeab/3.3.50>
- Shackleton, C. M.; Pasquini, M. W.; Drescher, A. W. 2009. African indigenous vegetables in urban agriculture. Routledge.
- Shai, K. N.; Chakale, M. V.; Materechera, S. A.; Amoo, S. O.; Aremu, A. O. 2024. Utilisation of botanicals for the management of pests and diseases affecting crops in sub-Saharan Africa: A review. *Journal of Natural Pesticide Research*, 7, 100066.
- Siddesha, M.; Patil, C. S.; Saindane, Y. S. 2019. Efficacy of insecticides and some biorationals against thrips and mites in/on Chilli (*Capsicum annum* L.). *Journal of Pharmacognosy and Phytochemistry*, 10(1): 1812-1816.
- Silva-Filho, R.; Santos, R. H. S.; Tavares, W. D. S.; Leite, G. L. D.; Wilcken, C. F.; Serrao, J. E.; Zanoncio, J. C. 2014. Rice-straw mulch reduces the green peach aphid, *Myzus persicae* (Hemiptera: Aphididae) populations on kale, *Brassica oleracea* var. *acephala* (Brassicaceae) plants. *PLoS One*, 9(4), e94174. <https://doi.org/10.1371/journal.pone.0094174>
- Silva-Filho, R.; Santos, R. H. S.; Tavares, W. D. S.; Leite, G. L. D.; Wilcken, C. F.; Serrao, J. E.; Zanoncio, J. C. 2014. Rice-straw mulch reduces the green peach aphid, *Myzus persicae* (Hemiptera: Aphididae) populations on kale, *Brassica oleracea* var. *acephala* (Brassicaceae) plants. *PLoS One*, 9(4), e94174. <https://doi.org/10.1371/journal.pone.0094174>
- Srinivasan, K.; Moorthy, P. K.; Raviprasad, T. N. 1994. African marigold as a trap crop for the management of the fruit borer *Helicoverpa armigera* on tomato. *International Journal of Pest Management*, 40(1), 56-63. <https://doi.org/10.1080/09670879409371854>
- Srinivasan, R. 2008. Integrated pest management for eggplant fruit and shoot borer (*Leucinodes orbonalis*) in South and Southeast Asia: past, present and future. *Journal of Biopesticides*, 1(2), 105-112.
- Srinivasan, R.; Sevgan, S.; Ekesi, S.; Tamò, M. 2019. Biopesticide based sustainable pest management for safer production of vegetable legumes and brassicas in Asia and Africa. *Pest management science*, 75(9), 2446-2454. <https://doi.org/10.1002/ps.5480>
- Stansly, P. A.; Castillo, J. A. 2009. Control of broad mites, spider mites, and whiteflies using predaceous mites in open-field pepper and eggplant. In *Proceedings of the Florida State Horticultural Society* (Vol. 122, pp. 253-257).
- Suganthy, M.; Rajamani, K.; Nalina, L.; Meena, B. 2015. Development of IPM module against major pests of black nightshade, *Solanum nigrum* L. In *III International Symposium on Underutilized Plant Species* 1241 (pp. 515-522). <https://doi.org/10.17660/ActaHortic.2019.1241.76>
- Sultana, M.; Shimizu, N.; Itoh, T.; Iwabuchi, K. 2025. Efficacy of bottle gourd (*Lagenaria siceraria*) leaf extract in protecting against cabbage looper (*Trichoplusia ni*) (Lepidoptera: Noctuidae) infestation. *Crop Health*, 3(1), 1-11. <https://doi.org/10.1007/s44297-025-00050-7>
- Teutonico, R. A.; Knorr, D. 1985. Amaranth: Composition, properties, and applications. *Food Technology*, 39(4), 49-60.
- Thiyagarajan, S. S.; Kuppusamy, H. 2014. Biological control of root knot nematodes in chillies through *Pseudomonas fluorescens*'s antagonistic mechanism. *Journal of Plant Sciences*, 2(5), 152-158. <http://dx.doi.org/10.11648/j.jps.20140205.12>
- Thomidis, T., Damos, P. (2024). Sustainable Management of *Tetranychus urticae* and *Trialeurodes vaporariorum* on Tomato and Cucumber Plants Using Rhamnolipids and Essential Oil-Based Biocontrol Agents. *Insects*, 15(9), 720. <https://doi.org/10.3390/insects15090720>

- Tumwet, T.; Kang'ethe, E.; Kogi-Makau, W.; Mwangi, A. 2014. Diversity and immune boosting claims of some African Indigenous leafy vegetables in western Kenya. *African Journal of Food, Agriculture, Nutrition and Development*, 14(61), 8529-8544. <https://doi.org/10.18697/ajfand.61.12945>
- Uburyo, I.; Isaziyibish, G. 2016. Bean Stem Maggot control (Uburyo isazi yibishyimbo irwanywa)–EU pesticides database.
- van den Berg, J. 2024. *Agrotis ipsilon* (black cutworm). CABI. <https://www.cabi.org/isc/datasheet/3801>
- Wakhanu, J.; Nyambaka, H.; Kimiywe, J.; Nawiri, M.; Thagana, W. M. 2019. Consumption of African Indigenous vegetables improves children's body fat free mass in Machakos County, Kenya. *Journal of Food Science and Engineering*, 9(8). <https://doi.org/10.17265/2159-5828/2019.08.002>
- Waweru, B. W.; Rukundo, P.; Kilalo, D. C.; Miano, D. W.; Kimenju, J. W. 2021. Effect of border crops and intercropping on aphid infestation and the associated viral diseases in hot pepper (*Capsicum* sp.). *Crop Protection*, 145, 105623. <https://doi.org/10.1016/j.cropro.2021.105623>
- Wu, S.; Tang, L.; Fang, F.; Li, D.; Yuan, X.; Lei, Z.; Gao, Y. 2018. Screening, efficacy and mechanisms of microbial control agents against sucking pest insects as thrips. *Advances in Insect Physiology*, 55, 199-217. <https://doi.org/10.1016/bs.aiip.2018.07.005>
- Yangchan, J.; Choudhary, K.; Kumari, R.; Kumari, P.; Kumar, S. 2022. Greasy cutworm (*Agrotis ipsilon*) and its biorational management strategies: a review. *Journal of Biological Control*, 36(23): 94-100. <https://doi.org/10.18311/jbc/2022/32256>
- Yarou, B. B.; Bokonon-Ganta, A. H.; Verheggen, F. J.; Lognay, G. C.; Francis, F. 2020. Aphid behavior on *Amaranthus hybridus* L. (Amaranthaceae) associated with *Ocimum* spp. (Lamiaceae) as repellent plants. *Agronomy*, 10(5), 736. <https://doi.org/10.3390/agronomy10050736>
- Yuan, B.; Byrnes, D.; Giurleo, D.; Villani, T.; Simon, J. E.; Wu, Q. 2018. Rapid screening of toxic glycoalkaloids and micronutrients in edible nightshades (*solanum* spp.). *Journal of Food and Drug Analysis*, 26(2), 751-760. <https://doi.org/10.1016/j.jfda.2017.10.005>
- Zhou, W.; Li, M.; Achal, V. 2025. A comprehensive review on environmental and human health impacts of chemical pesticide usage, *Emerging Contaminants*, 11: (1) doi.org/10.1016/j.emcon.2024.100410
- Zohoungbogbo, H. P.; Vihou, F.; Achigan-Dako, E. G.; Barchenger, D. W. 2024. Current knowledge and breeding strategies for management of aphid-transmitted viruses of pepper (*Capsicum* spp.) in Africa. *Frontiers in Plant Science*, 15, 1449889. <https://doi.org/10.3389/fpls.2024.1449889>



Young okra plant at farm field (*photo: freepik*)



Pest infected cabbage plant (*photo: freepik*)



Red and green chili peppers growing on a farm (photo: freepik)



CGIAR is a global research partnership for a food-secure future. CGIAR science is dedicated to transforming food, land, and water systems in a climate crisis. Its research is carried out by 13 CGIAR Centers/Alliances in close collaboration with hundreds of partners, including national and regional research institutes, civil society organizations, academia, development organizations and the private sector. www.cgiar.org

To learn more about this program, please visit: <https://www.cgiar.org/cgiar-research-portfolio-2025-2030/multifunctional-landscapes/>

Contact:

Noah Adamtey, Resource Recovery and Agri-food System, International Water Management Institute (IWMI), Accra, Ghana (n.adamtey@cgiar.org)



CGIAR

MULTIFUNCTIONAL
LANDSCAPES

SUSTAINABLE
FARMING

IWMI
International Water
Management Institute

In partnership with
Canada