STDF | STANDARDS and TRADE DEVELOPMENT FACILITY

Code of Practice Interpretation Guide

Cambodia




Edited by: CABI, WASI and GDA

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Forward

Spices, including peppercorn, are associated with complex and diverse supply chains with products being sourced from a variety of businesses ranging from large-scale producers to small-scale farmers from around the world. Following harvest, the product will often pass through many intermediaries from farmer, collector, to middle-man before arrival at the processor/shipper. The aggregation and redistribution of these products at various stages along the supply chain contributes to a high food safety risk profile. Spices are vulnerable to a number of food safety risks: excessive pesticide residue levels; pathogen contamination (i.e. Salmonella); adulteration and substitute.

The code of practice interpretation guide outlines the principle for safety production of pepper corn. This guide is the result of collaborative efforts from stakeholders who has shared their valuable insights and expertise.

The primary goal of this guide is to enhance good practice for farmer and private sector involved in the production and processing of pepper corn. The guide provides principle and instruction on key procedure and good practice to improve productivity, safety and market access for smallholder pepper growers & processors and grower/processor groups by improving compliance with international food safety requirements in high value markets such as EU, USA and Japan, for production and to restore food manufacturing industry confidence in peppercorn sourced from the region.

It is our hope that this guide will serve as a useful resource for stakeholders to promote the uptake of the latest technologies, quality and safety measures, and sustainable practices in agriculture trade.

Disclaimer

This code of practice interpretation guide has been developed mostly based on general practice from regional code of practice, it has been piloted only in Memot with target farmer group. Therefore, it is essential that the user consult further information sources, standard and market requirement before making decisions on implementation for production intended for export. While every effort has been made to ensure the accuracy interpretation and in the text in this guide, it cannot be taken as an authoritative interpretation of National standard.

Acknowledgements

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We also wish to express our sincere gratitude to STDF/PG/619 Safer spices project: boosting food safety and market access for the peppercorn value chain in Viet Nam, Lao PDR and Cambodia for their support in collecting data and sharing insights into the challenges and opportunities in peppercorn production sectors.

Lastly, we extend our deepest appreciation to the leadership team and all the organizations and individuals who have supported and encouraged us throughout this journey. Your unwavering support and belief in the importance of effective communication and collaboration have been integral to the success of this project. We hope that this guide will serve as a valuable resource for all stakeholders involved in pepper corn value chain, and we look forward to continuing to collaborate and engage with you to achieve our common goals.

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1 Peppercorn production

1. Peppercorn Production	**1.1 Selection of planting material**	**1.1.1** Only use varieties with good resistance to pests and diseases. **1.1.2** This COP recommends that you only use cleaned planting material.
	1.2 Sourcing planting material	**1.2.1** If cuttings are outsourced, ensure nurseries follows Good Practices, and, ideally, are accredited.

1.1 Selection of planting material

Only varieties with good resistance to pests and disease should be used to ensure a healthy crop (COP 1.1.1) There are several different pepper varieties grown in Cambodia. Resistance to disease is region specific, and in extreme cases a variety may have excellent resistance to disease in one region, but poor resistance in another region. Selection of varieties should be made based on locality.

Important varieties in Cambodia include:

- **Kamchay**: There is not specific information about source of this variety. Kamchay has small leave, short node, and big seed
- **Lampong/Belangtoeng**: this variety originated from Indonesia. It has big leave, long node and pods, and small seed

You should use clean planting material (COP 1.1.2). This will reduce pest and disease pressure on the growing plant and lower the need for pesticide applications during peppercorn growth. You must only obtain planting material from sources that can guarantee that their material is clean and free of infection. Pepper disease can be spread through breeding.

If you cannot obtain cleaned planting material, you should only plant material sourced from virus-free vines.

You should try to adhere to the following guidelines when sourcing clean planting material:

- **Taking cuttings**: Shoots for rooting should be taken from pest and disease-free vines from disease-free gardens.

- **Type of shoots**: Base runner shoots or orthotropic, single-node cuttings with one leaf from orthotropic shoots may be used for initial rooting.
- **Rooting**: Cuttings should be rooted in nursery beds or propagated by other appropriate methods before transfer to the field.
- **Rooting mixture**: Soil, sand, and organic matter should be mixed to form the rooting mixture. Adopt suitable procedures to ensure that the rooting mixture is free of pathogens, at least by soil solarization.
- **Nursery sheds**: Rooting should be done in nursery sheds to protect against sun and rain and provide adequate humidity.
- **Nursery hygiene and maintenance**: Nurseries should be disease and pest-free. Constant monitoring and inspection should be carried out including inspection of root systems. Disease-infected or pest-infested cuttings should be removed and destroyed. After removing the affected cuttings and pests, appropriate treatment should be applied to prevent further spread. Nurseries and surrounding areas should be weed-free. Regular watering is required to ensure that adequate soil moisture is maintained in nursery mixtures.
- **Transfer to the field**: Rooted single-node orthotropic shoot should have 5-7 nodes at time of field planting. Hardening plant should be done by gradual exposure to sunlight.

Tips on planting cuttings

Shoot cuttings

- Gently detach the pepper and position it in the center of the opening.
- Angle the pot slightly, ensuring the pepper sprout faces towards the support, with the surface of the potting soil even with the ground. Avoid the practice of "digging a deep hole only to plant in dry conditions."
- Backfill with soil, using your hands to firm the soil around the pot. When using living stakes, consider adding temporary supports to facilitate climbing.
- Construct a drainage basin around the plant from the beginning.

Stem Cuttings: Place the cuttings facing the topsoil 450 towards the pillar, fill 3 segments, leave 2 segments on the ground, compact the soil around the cuttings.

1.2 Sourcing planting material

If cuttings are outsourced, ensure nurseries follows Good Practices, and, ideally, are accredited (COP1.2.1)

2 Establishing a new orchard

2. Establishing a New Orchard	**2.1 Site selection**	**2.1.1** When selecting a site for pepper, you should consider the growing conditions for pepper
	2.2 Prior use of land for new orchard	**2.2.1** Land previously planted with cocoa or rubber should be avoided, as some of these areas may be infected with Fomes spp. Fusarium spp. or Phythopthora sp. **2.2.2** Avoid land where the adjacent plots have been intensively cultivated with high use of agricultural chemicals as there may be leaching of chemicals into the soil through water runoff. **2.2.3** If land under 2.2.1 or 2.2.2 must be used, the plot should be kept fallow or planted with suitable annual crops for a period of up to 2 years. Cover crops may be planted and ploughed back to increase organic matter and beneficial microbial activities.
	2.3 Site drainage	**2.3.1** Pepper gardens must have a suitable drainage system.
	2.4. Shade and wind management	**2.4.1** Orchards must have adequate wind and shade protection.

2.1 Site selection

When selecting a site for pepper, you should consider the growing conditions for pepper (COP 1.1.1). You can grow pepper on many types of soil such as basalt red soil, alluvial soil, sandstone soil, etc. But do not grow pepper on alkaline soil or saline soil, sandy soil, or infertile soil. The land for pepper cultivation should be cultivated to a depth between 75 and 100 cm with a groundwater level of more than 2m deep. The deeper the groundwater, the more effective the conditions for pepper growth.

The mechanical components of the soil usually require a clay or sandy loam soil of light or medium level, rich in humus, with a pH of 4.5 - 6.5. The soil should be porous, have a high aeration and good drainage. You should avoid soil that waterlogs in the rainy season and

only soil that retains moisture for pepper must be selected. The upper cultivation layer of the soil must be rich in organic matter and have a slope less than 25 degrees. This is because the roots of pepper plants absorb nutrients from the shallow surface.

You can create individual terraces for each vine, but you must ensure that the terraces slope inwards. Soil for growing pepper must be treated so that it is free of pathogens and moulds. Soil must be rich in nutrients that can support plants with the nutrients they need to grow and develop at their best.

Additionally, beyond the soil requirements for planting, it's essential to consider the broader environmental conditions necessary for the optimal growth of pepper plants. These include:

- **Temperature Requirements**: Pepper plants thrive in temperate climates, with an ideal temperature range of 20 to 30 degrees Celsius. It is critical to ensure that temperatures do not fall below 10 degrees Celsius or rise above 40 degrees Celsius to prevent adverse effects on the plants' health and productivity.
- **Humidity Levels**: The atmospheric humidity plays a vital role in the growth cycle of pepper plants. During the dry season, a humidity level of around 63% is preferable, whereas, in the rainy season, a much higher humidity level of approximately 98% is beneficial for the plants.
- **Rainfall conditions:** Pepper should be planted in areas that receive at least 1,750mm of rainfall annually. Pepper cultivation is best under rainfall of 2,000-3,000mm. A clear dry season is advantageous for flower induction. Where there is a prolonged dry period, irrigation may be required**.**

2.2 Prior use of land for new orchard

Land that was previously cultivated with cocoa or rubber crops should be avoided for pepper planting due to the potential presence of pathogens such as Fomes spp., Fusarium spp., and Phytophthora spp. (COP 2.2.1). These pathogens can adversely affect the health and yield of pepper plants.

Pepper holdings should be located on suitable land, taking into consideration the previous land use, adjacent land use and accessibility. Land adjacent to the pepper holding should be free from pests and diseases. (COP 2.2.2).

Where such land must be used, keep the land fallow or plant suitable annual crops for a reasonable period. Cover crops may be planted and ploughed back to increase organic matter and beneficial microbial activities. It will also require specific treatment procedures before planting pepper to mitigate the risk of disease transmission (COP 2.2.3).

Cover crops should be planted in the inter-spaces between pepper vines to reduce soil erosion and to improve the physical, chemical and biological properties of the soil.

The type of cover crop to be planted is dependent on the terrain and soil conditions. Recommended cover crops include:

- Arachis pintoi
- Centrosema pubescens
- Calapogonium muconoides

Fodder crops and other economic crops that can provide soil cover are also recommended.

The recommended treatment process involves several steps:

- **Ploughing**: Turn over the soil thoroughly to expose any buried pathogens to the surface, where they are less likely to survive.
- **Root Collection**: Manually collect and remove old roots and plant debris from the soil, as these can harbor pathogens.
- **Burning Debris**: Safely burn the collected plant material to eliminate any remaining pathogens effectively.

To further rejuvenate the soil and restore nitrogen levels, it's advisable to plant two to three

successive crops of leguminous green manure. Legumes enrich the soil by fixing atmospheric nitrogen, improving soil fertility, and structure for the subsequent pepper crops.

Additionally, incorporating fungicide treatments is crucial to protect the newly planted pepper crops from existing soil-borne diseases. This integrated approach ensures the land is properly prepared, minimizing disease risk and promoting healthy growth and productivity of pepper plants.

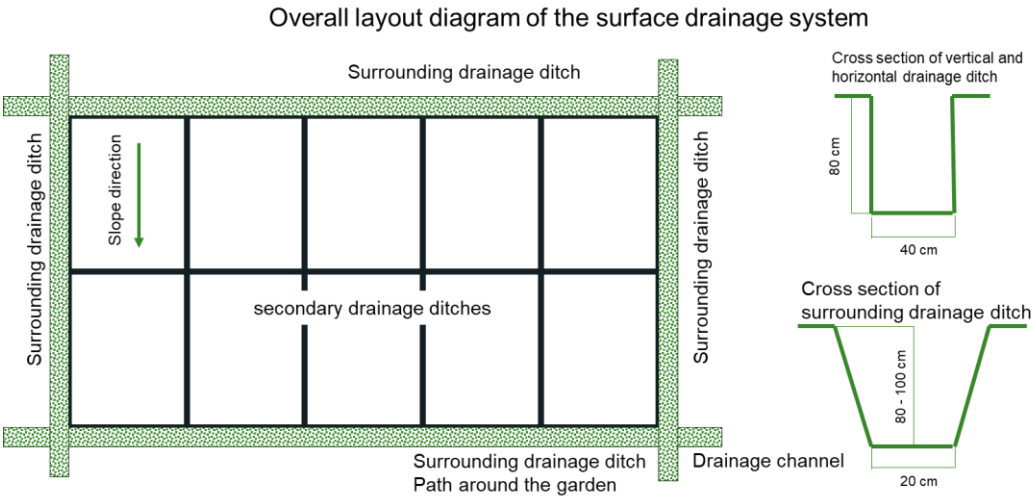
2.3 Site drainage

Pepper gardens require an efficient drainage system to thrive, especially during the rainy season when excess water needs to be directed away from the orchard to prevent waterlogging at the base of the pepper plants (COP 2.3.1).

Steps for Preparing an Effective Drainage System:

- **Sub-Ditch Construction:** Begin by preparing a sub-ditch for drainage. These trenches should be 30-40 cm wide and 25-30 cm deep. For every 2-3 rows of pepper plants, dig a trench positioned centrally between the rows to avoid damaging the roots of the pepper plants.
- **Main Ditch Construction:** In addition to sub-ditches, a main ditch is required. This ditch should run perpendicular to the sub-ditches and can be located at the garden's end or encircle the perimeter. The dimensions of the main ditch should be approximately 50-60 cm in width and depth, providing ample space for water flow.
- **Enhanced Drainage for Larger Gardens:** For pepper gardens that are particularly long and have a low slope, thereby requiring increased drainage capacity, it is advisable to dig an additional ditch in the center. This central trench should be dug after every 10 rows of pepper plants and run perpendicular to the sub-ditches, enhancing the garden's overall drainage efficiency.

Implementing this detailed drainage plan ensures that your pepper garden remains well-drained, protecting your plants from the detrimental effects of stagnant water and promoting healthy growth.



2.4 Shade and wind management

Orchards require effective windbreaks and shade to ensure optimal growth conditions for the plants (COP 2.4.1). Incorporating fruit trees like durian and avocado serves a dual purpose: they provide necessary wind protection and shade for the pepper plants, and they also offer an additional source of income.

Strategies for Wind and Shade Management

Wind Protection: To shield your orchard from prevailing winds, establish wind barriers in the direction most affected by wind. This can be achieved by planting trees in double rows. The spacing between these two rows should be 2 meters, with the barrier trees positioned 6-8 meters away from the pepper plants to prevent crowding and to ensure ample wind filtration without shading the pepper plants excessively.

Shade Provision for Pepper Orchards: In orchards where dead pillars (made of concrete or brick) are used, it becomes essential to introduce additional shade trees.

Live supports should be pruned as often as necessary. It is recommended that pruning of live supports be done before fertilizer application to maximize exposure to sunlight so as to encourage maximum uptake of nutrients.

A practical guideline is to plant a row of shade trees for every three rows of dead pillars, ensuring that the pepper plants receive adequate protection from direct sunlight while still benefiting from sufficient light penetration.

Recommended Tree Varieties

- **Windbreaks:** Cassia siamea, durian, and avocado trees are excellent choices for creating a dense barrier that can withstand strong winds.
- **General Shade:** Durian and avocado trees not only provide shade but also contribute to biodiversity and income diversification within the orchard.
- **Additional Shade:** River tamarind (Leucaena leucocephala) and Adenanthera pavonina can be planted to offer more targeted shade areas, especially where young pepper plants or sensitive areas of the orchard are located.

By carefully selecting and positioning these trees, orchard owners can create a conducive growing environment that balances the need for wind protection, shade, and productive land use.

3 Replanting an existing orchard

3 Replanting an Existing Orchard	**3.1 Soil infected by pests or of low quality.**	**3.1.1** Determine the pest status and soil quality before replanting and only plant if there is no risk of contamination.
	3.2 Soil rehabilitation requiring crop rotation	**3.2.1** If crop rotation is required, this should be 1-2 years before re-planting with pepper.

3.1 Soil infected by pests or of low quality.

Assessing the pest status and soil quality is crucial before replanting in an existing orchard, to ensure there's no risk of contamination (COP 3.1.1). Prior to reintroducing pepper plants into the orchard, a thorough examination of the soil for harmful nematodes and fungi, specifically within the top 0-50 cm layer, is necessary.

Soil sampling method for nematodes and fungi analysis

Soil samples should be collected from 5 plants per survey plot. At each plant take 100g of soil and 10 g of roots in the canopy area. Combine soil and root samples to get an average sample. Determine nematode population (individuals/100 g for soil samples, larvae/10g for root samples). Samples should be sent to an authorized lab for analysis.

The decision to replant should be based on the density of these pests:

Criteria for Immediate Replanting:

- The total number of parasitic nematodes in the soil must be below 100 individuals per 100 grams of soil, and in the roots, less than 150 individuals per 5 grams of roots.
- The density of Fusarium spp. and Rhizoctonia spp in the soil should be less than 10^3 cfu/g, with their occurrence in roots being less than 20%. There must be no historical incidents of Phytophthora spp. infection.

Conditions Necessitating Crop Rotation:

- If the soil contains more than 100 parasitic nematodes per 100 grams or the roots have

over 150 individuals per 5 grams of roots, crop rotation becomes essential.

- The necessity for crop rotation is also confirmed if the density of Fusarium spp. and Rhizoctonia spp in the soil exceeds 10^3 cfu/g, or their presence in roots is between 20-30%. The detection of Phytophthora spp. further emphasizes the need for this practice.
- By adhering to these guidelines, you can make informed decisions about replanting pepper crops, thereby ensuring the health and productivity of your plants.

3.2 Soil rehabilitation requiring crop rotation

To enrich and prepare the soil, planting legumes, maize, plants with yellow flower stalks, and chrysanthemums as rotational crops is highly recommended. These plants contribute to soil improvement by enhancing its structure, increasing nutrient content, and reducing pest populations.

Steps for Effective Crop Rotation and Soil Preparation:

- **Ploughing**: Begin by ploughing the land thoroughly, reaching a depth of 40-45 cm. This should be done twice, with each ploughing session directed horizontally and then vertically across the plot. This technique ensures that the soil is evenly turned and aerated, promoting better root penetration for the next crop.
- **Lime Application**: After the soil has dried from ploughing, evenly distribute 1-2 tons of lime powder per hectare over the land. Following the lime application, harrow the soil to a depth of 20-30 cm, again working horizontally and vertically across the plot. This step helps to adjust the soil pH, making it more suitable for the subsequent pepper plants by reducing acidity and improving nutrient availability.
- **Continuous Root Collection**: During both ploughing and harrowing, make an effort to collect and remove old roots and plant debris. This is crucial for minimizing the risk of disease and pest carryover to the next crop.

By following these procedures, you ensure that the soil is optimally prepared for replanting pepper, with improved fertility, structure, and a reduced presence of pests and diseases, laying a solid foundation for the success of your next crop.

4 Planting guidelines

4. Planting Guidelines	**4.1 Planting time**	**4.1.1** Pepper should be planted at the beginning of the rainy season, when it rains evenly, and the soil is moist enough for planting.
	4.2 Support selection	**4.2.1** This COP recommends the growing of pepper on live pillars as the preferred cultivation method, if not available, concrete or brick supports can be substituted. **4.2.2** Wooden poles are not permitted, unless sourced from a certified supplier who can prove the source and demonstrate that practices do not contribute to deforestation. **4.2.3** Guides for cultivation with live supports must be followed.
	4.3 Planting density	**4.3.1** Planting density must consider the type of pillar used and this COP requires that you follow national guidelines on planting density, detailed in the national interpretation guide, to ensure optimal growth and health of the plants.
	4.4 Planting pits/hole	**4.4.1** Soil and planting pits should be suitably prepared and treated, if necessary, before planting

4.1 Planting time

Pepper should be planted at the beginning of the rainy season, when it rains evenly, and the soil is moist enough for planting (COP 4.1.1)

For the different regions of Cambodia, but typically at the beginning of the rains, to ensure sufficient soil moisture for crop establishment.

4.2 Support selection

The growing of pepper on live pillars is the preferred cultivation method, if not available, concrete or brick supports can be substituted (4.2.1).

Utilizing live supports offers numerous benefits for Cambodian farmers, enhancing both the sustainability and efficiency of their agricultural practices.

Advantages of Live Supports:

- Cost-Effectiveness: Live supports require a lower initial investment compared to artificial structures.
- Productivity Regulation: They help in maintaining consistent fruiting patterns, avoiding the common issue of biennial bearing, and prolonging the productive lifespan of the plants.
- Microclimate Regulation: Live supports play a crucial role in modifying the microclimate around the plants, offering protection against extreme weather conditions such as droughts and storms.
- Timber Resource: These supports can also serve as a source of timber, providing additional economic value.
- Environmental Benefits: Live supports contribute to nitrogen fixation in the soil. Additionally, their branches and leaves can be utilized as green manure or livestock fodder, promoting a cycle of sustainability.

However, there are also considerations to keep in mind when opting for live supports:

- Growth Time: It may take 1-2 years for live supports to grow sufficiently strong to support climbing pepper plants.
- Maintenance Challenges: The rainy season demands frequent and potentially costly pruning to manage growth and prevent pest and disease infestations.
- Structural Limitations: Certain species, such as Ceiba pentandra, primarily develop horizontal roots without deep pile roots, compromising their stability in stormy conditions. Particularly for taller supports (6-8 m high), there is an increased risk of breakage.

By weighing these advantages against the potential drawbacks, farmers can make informed decisions about the use of live supports in their pepper cultivation practices, optimizing their agricultural outcomes while considering the environmental impact.

Wooden poles are not permitted, unless sourced from a certified supplier who can prove the source and demonstrate that practices do not contribute to deforestation (COP 4.2.2.).

The recommendations should be followed when cultivating live supports (COP 4.2.3):

Live support structures should have a minimum length of 2 meters and a diameter of at least 5 centimeters. To minimize the risk of pest and disease transmission among trees during peak peppercorn production, it is advisable to utilize a variety of tree species wherever feasible. Adequate water and nutrients must be provided to the trees to ensure successful crop establishment, and this preparation should occur prior to the planting of pepper vines.

It is essential to plant live support structures well in advance of introducing pepper vines to allow for proper establishment. These supports should be embedded into the soil to a depth of 30 centimeters. The spacing between the live support and the pepper plant is critical to avoid root competition, with the optimal distance varying based on the specific types of live support and pepper cutting employed, typically ranging from 10 to 60 centimeters.

Live pole species selection

In selecting suitable species for live supports, particular attention should be paid to local plant pests and the potential risk of infestation. Recommended species for live supports that are well-suited to local conditions include Cassia siamea, Leucaena leucocephala, Wrightia annamensis, Ceiba pentandra, and Oroxylum indicum, among others.

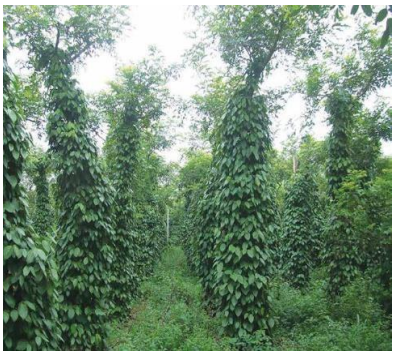
- Gyiricidia spp. (vegetatively propagated)
- Ailanthus malabarica (seed propagated)
- Grevillea robusta (seed propagated)
- Garuga pinnata (seed propagated)

Trees with economic value such as are coconut or jackfruit may also be used.

4.3 Planting density

Planting density must consider the type of pillar used and National guidelines on planting density should be followed.

- **Concrete pillars**: should have a diameter at the bottom edge of 15 cm, the top edge of the pillar should be 10 cm. Pillar height should be between 3.5- 4.0 m. Recommended planting distance when these pillars are used is: 2 x 2.5 m or 2.5 x 2.5 m, providing a density of between 1,600 and 2,000 pillars/ ha.



- **Living pillars**: Several different plants can be used as live pillars. Planting distance should be 2.5 x 2.5 m, giving a density of 1,600 pillars/ ha. If the living pillar is a black cycad, planting distance should be 3 x 3 m, giving a density of 1,100 pillars/ ha.
- **Combined planting**: Planting 1 - 2 rows of living pillars, alternating with 1 - 2 rows of dead pillars, planting distance should be 2.5 x 2.5 m, giving a density of 1,600 pillars/ ha.

4.4 Planting pits/hole

Soil and planting pits should be suitably prepared and treated, if necessary, before planting (COP 4.4.1). Rooted cuttings should be planted in prepared pits at the onset of the rainy season. Young vines should be tied loosely to the support and shaded with suitable plant material. Mounding should be carried out after planting, to prevent water stagnation and root exposure. In areas with low rainfall, or if there is absence of rain after planting, provide supplementary irrigation for the first 6 to 9 months. Where areas become water-logged after planting, provide adequate drainage.

5 Traceability and site identification

5. Traceability and Site Identification	**5.1 Orchard plan**	**5.1.1** The location of each orchard must be individually identified, and a plan of the orchard produced.
	5.2 Production unit identification	**5.2.1** Strict identification of the production block and use of identification codes must be followed.
	5.3 Record keeping	**5.3.1** Records of farm activities should be kept to ensure traceability and compliance, and available for audit when required.

5.1 Orchard plan

The location of each orchard must be individually identified, and a plan of the orchard produced (COP 5.1.1).

For effective traceability and management, it is essential to organize orchards into distinct blocks. The size of each block will depend on the total available land. An accurate and detailed orchard plan should be created, highlighting the location and dimensions of each production block. Additionally, this plan should include information on:

- Soil Types: Identifying different soil types helps in determining the most suitable crops for each block and in tailoring soil management practices.
- Water Sources: Documenting the locations of water sources and any natural watercourses ensures efficient water management and protection of water quality.
- Wildlife Corridors: Where applicable, mapping out wildlife corridors within or adjacent to the orchard helps in conserving biodiversity and managing wildlife interactions with the crops.
- Chemical and Fertilizer Storage Areas: Clearly marking these areas aids in managing and minimizing the risk of contamination.
- Waste Disposal Sites: Identifying these areas ensures proper waste management practices are followed, reducing environmental impact.

5.2 Production unit identification

Strict identification of the production block and use of identification codes must be followed (COP 5.2.1).

Each block must be distinctly identified using unique identification codes, a practice crucial for maintaining consistency and traceability, especially through activities such as planting, monitoring (scouting), pesticide application, and harvesting. It's imperative that the block references remain unchanged over time, even after replanting, to ensure uninterrupted traceability. These reference codes should be prominently used in all related documentation.

To facilitate identification within the orchard, each block should be clearly marked with its reference code, displayed on signboards made from durable, water-resistant material to ensure the information remains legible over time, even in adverse weather conditions.

Implementing such a system of block identification not only enhances the traceability of produce but also improves the overall efficiency of orchard management by ensuring that each area is easily and clearly identifiable for various agricultural activities.

5.3 Keeping records

Records of farm activities should be maintained to ensure traceability and compliance with guidelines, and available for auditing when required (COP 5.3.1).

The types of records that should be maintained include:

- Planting/propagation
- Input usage: Detailed records of all inputs used in the farming process, such as seeds, fertilizers, pesticides, and water usage, are required. This includes the type of input, quantities used, application dates, and areas of application.
- Environmental Management: Records of practices related to soil management, water use, and waste management, including efforts to minimize environmental impact.
- Harvest and post-harvest processes: Records of harvest dates, quantities harvested, and any treatments applied to the produce post-harvest. Also, handling and storage conditions to ensure product quality and safety.

Samples of record sheets are available in Annex 1.

6 Crop maintenance

6. Crop Maintenance	**6.1. Water management**	**6.1.1** With a single flowering season each year, pepper holdings do not require irrigation under normal conditions, except perhaps during the initial establishment period, in drought prone areas.
	6.2 Weed management	**6.2.1** Keep the orchard free from weeds and fallen leaves.
	6.3 Soil management	**6.3.1** Use organic manures in preference to fertilisers to maintain soil health overall in addition to providing value nutrients. **6.3.2** The addition of organic matter is encouraged when it will benefit the soil. **6.3.3** Use of untreated human sewage sludge is not permitted. Only well-composed farmyard manure can be used, which should only be applied to the land in the correct manner.
	6.4 Use of inorganic fertilisers	**6.4.1** Used correctly, inorganic fertilizers can be used to fertilize the soil to provide nutrients to plants through the roots. Recommendations on use of inorganic fertiliser must be followed. **6.4.2** Foliar fertilizer can be used for foliar spraying, containing one or more macronutrients, intermediates, micronutrients or adding growth stimulants. Use of foliar fertilizer should be restricted to times when there is a need to provide a quick supply of nutrients for plants, especially when the weather is unfavourable, during periods of nutritional crisis, and when the plant is under attack from pests and disease.

6.1 Water management

Pepper plants, with their single annual flowering season, typically do not require irrigation under normal circumstances, except during their initial establishment phase or within areas susceptible to drought (COP 6.1.1).

Ground and Soil Water Management: In dry areas, maximise water infiltration and minimise run-off by proper use. In areas where a pronounced dry season may occur, a source of water may be needed. Conservation measures include contour planting, contour bunding or terracing to prevent run-off on slopes over 10°. On level land, drainage channels of sufficient size should be dug where necessary to prevent water logging. Water may be required for production of planting materials, to facilitate establishment of young plants in the field and for spraying plant protection chemicals for control of pests and diseases. Water is also needed for processing pepper, particularly for white pepper production. If a river or a pond is available nearby, it can be a suitable water source; alternatively, a well may be dug to provide adequate water for on-farm activities. Rain water harvesting is also recommended.

Water Retention Capacity: Soil structure should be improved where possible to enhance the water retention capacity. Addition of organic matter in the form of mulches, composts, and green manure and planting suitable cover crops may be undertaken to improve soil structure, permeability and water retention.

Water Contamination: Ensure that water used on the farm is free from contamination and that production inputs, including waste or recycled products of organic, inorganic and synthetic nature do not contaminate water sources. Care should be taken to ensure that water used for irrigation (where needed) is free from unintentional contamination, particularly from pesticide residues and agro-industrial pollutants in surface water. Where agricultural chemicals and fertilisers are used, every effort must be made to deliver the required amount to the pepper plant without affecting water run-off from the holding. Where weeding is required, hand weeding should be adopted wherever possible, to avoid the use of chemical sprays that may be washed off into nearby water sources. Where white pepper production requires soaking green pepper in water for a few days, care must be taken to ensure that the waste water does not pollute water sources.

Monitor Crop and Soil Water Status: Adopt techniques to accurately schedule irrigation and adopt moisture conservation and water recycling measures where possible. A primary consideration for determining suitability of land for pepper production should be rainfall and water availability. In drier, marginal areas that have been planted with pepper, efforts to conserve water take on special significance. Clearing large tracts of land for pepper planting may have an undesirable impact on soil water status and care should be taken to preserve wind breaks and suitable shade, particularly in dry areas. Water saving measures, such as

drip irrigation and pitcher irrigation may be adopted especially during the establishment phase, where required.

A crucial aspect of pepper cultivation is allowing the plants to undergo a dry period lasting 30-45 days. This dry spell is necessary to halt vegetative growth, prompting the dormant buds to transform into flowering buds.

Post-harvest it's essential to restrict watering until the plants have fully transitioned into their flowering phase. The timing of irrigation, when deemed necessary, is critical for optimizing pepper growth and yield. Proper irrigation timing is pivotal for several reasons:

- **Late Watering**: Delays can adversely affect both the growth and yield of pepper plants, compromising overall productivity.
- **Early Watering**: Premature irrigation can lead to unfocused flowering, which impacts both yield and subsequent harvests. It also results in increased watering costs.

The need for and frequency of watering are contingent upon various factors, including the plant's growth stage, the season, and prevailing weather conditions. Indicators for the necessity of irrigation include:

- **Visible Plant Stress**: Symptoms such as yellowing leaves or wilting suggest the need for pre-harvest watering.
- **Extended Dry Seasons**: During particularly dry years, increased irrigation frequency may be necessary to sustain plant growth.

To precisely ascertain the optimal timing for watering pepper plants, the utilization of a soil moisture meter, as developed by the Western Highlands Agriculture and Forestry Science Institute, is advised. This tool aids in making informed decisions based on the soil's moisture content.

Soil sampling for moisture testing

Select five locations diagonally across the pepper garden. Take soil samples to a depth of 30cm within the edges of the canopy.

For the initial irrigation, aim for a soil moisture level of 28-29%. For subsequent waterings, adjust the moisture content to be 1-2% higher than the initial level. This strategy ensures the plants receive adequate hydration to support their development and productivity without the adverse effects of over- or under-watering.

Guidance for the amount of water to be used, and timing for irrigation, is provided below:

Soil type	Stage of growth	Amount (Litres/pillar)	Cycle
Basalt	New pepper cultivation	30 - 40	10 - 15
	Establishment phase	60 - 80	10 - 15
	Economic phase Pepper	100 - 120	20 - 25
Sandy	New pepper cultivation	20 - 30	7 - 10
	Establishment phase	40 - 50	7 - 10
	Economic phase Pepper	80 - 100	10 - 15

For optimal growth and health, newly planted pepper plants require consistent watering throughout the dry season, continuing until the onset of the rainy season. Should a prolonged drought occur during what is typically the rainy season, it is imperative to supplement with additional irrigation to support these young plants.

Mature pepper plants have specific irrigation needs tied to their growth cycle and environmental conditions. During the dry season, particularly when the plants are bearing fruit, adequate irrigation is crucial to support the development of the fruit. Additionally, at the start of the rainy season, if high temperatures and low humidity persist, mature pepper plants may require supplemental watering to mitigate the stress caused by these conditions.

Following the harvest, it's advisable to moderate watering. This reduced irrigation schedule is strategic, encouraging the plants to enter a phase of differentiation. By adjusting the watering practices according to the plant's life stage and the prevailing weather conditions, you ensure that the pepper plants receive the appropriate level of hydration needed to thrive and produce optimally.

Water management can be further enhanced through the adoption of the following practices

Intercropped with shade trees

Cover crop eg peanut

Use nets to cover pepper gardens

Allow weeds grow during dry season

6.2 Weed management

Weed management plays a crucial role in preventing the invasion and growth of weeds, which is most effective when conducted before the weeds flower. It is important to keep the orchard free from weeds and fallen leaves (COP 6.2.1). By employing integrated weed management strategies, the impact of weeds can be significantly mitigated.

Limited weeding by hand may be carried out when necessary, in the inter-spaces before the cover crop is fully established and at the base of the plant. Cover crops should not be allowed to grow excessively. Pruning of the leaves at the base of the plant to 30cm above the ground surface should be practiced.

Key Aspects of Weed Management

The primary goal of weed management is to control the invasion and proliferation of weeds through scientific methods, while also recognizing and leveraging the potential benefits of certain weeds. This approach supports the growth and development of pepper plants,

enhances productivity, and reduces cultivation costs. Moreover, it aids in the efficient care and harvesting of pepper plants, conserves soil health, and promotes the sustainable advancement of agriculture. Ultimately, effective weed management contributes to increased labour productivity.

Reducing weed density is essential to diminish competition for resources and, consequently, to improve the yield of pepper plants. Converting unwanted weed species into desirable ones can further optimize the agricultural ecosystem.

Weed control around the base of pepper plants should be meticulously scheduled to occur three times, specifically one month after the onset of the rainy season. This timing ensures that weed management efforts are both targeted and effective, providing an optimal environment for pepper cultivation.

Implementing these practices not only protects and enriches the agricultural land but also ensures the sustainable and profitable production of pepper, facilitating easier cultivation and harvesting processes.

Manual weeding techniques:

- For areas not near pepper plants, use a hoe to remove weeds effectively.
- Weeds growing near the pepper plants should be carefully pulled by hand to prevent damage to the pepper roots.
- Focus on clearing weeds within a 30-50cm radius around the pepper plant. Avoid weeding between the support pillars to prevent water overflow during rain, which can spread harmful fungi.

Weeding by machine:

- A mower or wire cutter can be employed to efficiently manage weed growth. This method is less labor-intensive and suitable for larger areas.
- Adjust the cutting height based on your preference: close to the ground or leaving a 5-7 cm grass stump.

Cultivation measures to limit weeds

Integrating cover crops and shade trees or using live pillars can naturally suppress weed growth. Cover crops like ghost peanut (Arachis pintoi) and stylo grass (Stylosanthes guianensis) not only inhibit weed proliferation but also contribute significantly to nitrogen

synthesis in the soil. Stylo grass can additionally serve as livestock fodder. In the dry season, mulching with straw or hay around the base of pepper plants helps retain moisture, extends the growth cycle, and reduces the need for irrigation. Ploughing and harrowing bury weed seeds deep in the soil, hindering their germination.

Before Soil Preparation, remove weeds from the garden, ensuring they are taken away and destroyed to prevent reseeding. Use well-rotted organic manure free from weed seeds to enrich the soil.

General maintenance

Adopt the following practice to maintain a healthier pepper orchard, reduce competition for nutrients, and ensure the vitality of your pepper plants.:

- prevent mature weeds from seeding to reduce future weed issues.
- Regularly sanitize gardening tools to prevent the spread of diseases and pests.
- Clean up the weeds before making the soil, take it out of the garden, burn it and destroy it. Use organic manure, manure) rotten, no weed seeds; and do not let old grass drop seeds.
- Sanitize work tools.

6.3 Soil management

The use of organic manures recommended in preference to inorganic fertilisers to maintain soil health overall in addition to providing value nutrients (COP 6.3.1).

Organic manure encompasses a variety of natural products derived from plant and animal sources. This group includes manure, green manure (includes the stems and leaves of plants such as weed anemones, windbreak tree remnants, legumes), compost, plant residues, microbial fertilizers, and ash, each offering unique benefits to soil and plants.

Before application, manure and green manure should undergo composting to enhance their efficacy and safety for soil addition. Utilizing microbial or bio-organic fertilizers involves a crucial consideration: the avoidance of pesticides and chemical fertilizers. These substances can detrimentally affect the beneficial microorganisms present in these organic fertilizers, thereby diminishing their effectiveness. Post-fertilization, it is essential to ensure that soil

moisture levels are conducive to the survival and proliferation of these microorganisms.

Benefits of Organic Fertilizers include:

- Nutrient Provision: They supply a wide range of nutrients essential for plant growth.
- Soil Fertility Enhancement: Organic fertilizers contribute to the long-term improvement of soil fertility, promoting a healthy growing environment.
- Microbial Support: These fertilizers improve the soil's microbial ecosystem, which is vital for nutrient cycling and disease suppression.
- Moisture Retention: They help in retaining soil moisture, reducing the need for frequent watering.
- Erosion Control: Organic matter increases soil structure, reducing erosion and nutrient washout.
- Synergistic Effects: When used in conjunction with chemical fertilizers, organic manures can increase the overall efficiency of nutrient uptake by plants.
- Water Use Efficiency: They enhance the soil's ability to hold water, leading to more efficient water use.
- Root Development: Organic fertilizers stimulate root growth, which is crucial for the absorption of nutrients and water, and they play a key role in the rejuvenation of pepper gardens.

Incorporating organic fertilizers into agricultural practices not only supports plant health and yield but also contributes to the sustainability of farming by enhancing soil health and reducing dependency on chemical inputs.

Organic fertilizers play a pivotal role in sustainable agriculture, enriching the soil with nutrients and improving its structure. Various types of organic fertilizers are available:

- Manure: This includes cattle and poultry manure, which is rich in nutrients and serves as a robust soil conditioner.
- Green Manure: Comprised of plant materials like the stems and leaves of weed anemones, remnants of windbreak trees, and legumes. These are turned into the soil to

decompose, thereby enhancing soil fertility and structure.

- Bio-Organic Fertilizer: These are sourced from organic materials that have been processed and fermented through an industrial process, involving the action of beneficial microorganisms. This type of fertilizer improves soil health by adding both nutrients and microbial life.
- Microbial Fertilizers: Characterized by their formulation from both raw materials and through industrial processes, these fertilizers contain live strains of beneficial microorganisms that remain active in the soil, promoting nutrient uptake and soil health.
- Vermicompost (Worm Microbiological Fertilizer): Produced through the breakdown of organic material by earthworms, vermicompost is rich in nutrients and beneficial soil microbes, making it an excellent organic fertilizer.
- Composted Organic Fertilizer: Derived from the composting of agricultural by-products, this type of fertilizer adds essential nutrients back to the soil and improves soil structure.
- Mineral Organic Fertilizer: This category includes organic or bio-organic fertilizers that are mixed with inorganic (mineral) fertilizers. It combines the benefits of both organic matter, which improves soil health and structure, and inorganic fertilizers, which provide specific nutrients in concentrated forms.

Each type of organic fertilizer offers unique benefits, including nutrient provision, soil structure improvement, and enhanced microbial activity. By selecting the appropriate type of organic fertilizer, farmers can support sustainable agricultural practices, leading to healthier soils and more productive crops.

Application of organic matter to soil

Incorporating organic matter into the soil is an essential practice for enhancing soil health and fertility. To ensure the effective use of organic fertilizers, it's important to adhere to the following guidelines.

By following these practices, you can maximize the benefits of organic manure, leading to improved soil structure, increased nutrient availability, and overall healthier plant growth.

- **For young vines**: For organic nutrition of pepper, adequate green manure in the form of loppings from pruning of live supports and farm manure should be applied to the young

vines in two applications before the rainy season. For young vines, 510 kg of organic manure may be applied in two or more applications, preferably at the onset of the rainy season. Wood ash may be added as a supplement for potassium and rock phosphate for phosphorous. Bio-fertilisers such as Azospirillum sp., Azotobacter sp. and PGPRs (Plant Growth Promoting Rhizobacteria) may also be used for better crop health.

- **For mature vines:** For organic nutrition of pepper, adequate green manure in the form of loppings from live supports, as well as other farm manure should be applied to the mature vines in two applications before the rainy season. For mature vines, 10-15 kg of organic manure may be applied in two or more applications, preferably at the onset of the rainy season. Wood ash may be added as a supplement for potassium and rock phosphate for phosphorous. Bio- fertilizers such as Azospirillum sp., Azotobacter sp. and PGPRs may also be used for better crop health.

Integrated nutrition

- **For young vines**: Adequate nutrition must be applied to young vines, based on the soil requirements, to ensure vegetative growth and plant health. Generally, during the first year of growth, 5 kg of organic matter may be applied to the vines. Bio-fertilisers such as Azospirillum sp., Azotobacter sp. and PGPRs may also be used for better crop health. At least a total of 300g/ year of inorganic fertilizer, such as 12:12:17 plus TE (Trace Elements) may be applied in 4 split applications of 30g, 60g, 90g, and 120g at 3-month intervals. This may vary from location to location.
- **For immature vines (bearing vines that are not fully grown):** Adequate nutrition must be applied to the immature vines, based on the soil requirements, to ensure vegetative growth, plant health and flower initiation. Generally, for immature vines, 5-10 kg of organic matter may be applied to the vines. Bio-fertilisers such as Azospirillum sp., Azotobacter sp. and PGPRs may also be used for better crop health. At least a total of 600g/ year of inorganic fertiliser, such as 12:12:17 plus TE, to be applied in 4 split applications of 150 g each at 3-month intervals. This may vary from location to location.
- **For mature vines (vines with stable yields):** Adequate nutrition must be applied to the mature vines, based on the soil requirement to ensure plant health and flower initiation. Generally, for mature vines, 10-15 kg of organic matter may be applied to the vines. Bio-

fertilisers such as Azospirillum sp., Azotobacter sp. and PGPRs may also be used for better crop health. At least a total of 1-1.5kg/ year of inorganic fertiliser. The inorganic fertiliser, such as 12:12:17 plus TE, should be applied in 4 split applications at 40%, 30%, 20%, and 10% at monthly interval upon the onset of the rainy season. This may vary from location to location.

Application Method:

- Create a trench around the perimeter of the canopy, ensuring it's 10-15 cm deep. This method targets the root zone directly, where the organic manure can have the most impact.
- Carefully distribute the organic manure within this trench, then backfill the trench with soil. Exercise caution during trench digging to avoid damaging the pepper plant roots, which are vital for the plant's nutrient uptake and stability.
- Applying organic manure directly to the root zone

Frequency of Application

Generally, organic manure should be applied once annually. The optimal timing is either at the onset or in the latter half of the rainy season when the soil moisture level is adequate for the manure to integrate well into the soil and be easily accessible to the plant roots.

In certain situations, such as when soil fertility is particularly low or if crop demands are high, a second application within the year may be beneficial to meet the nutritional needs of the plants.

Type of fertilizer (kg/pillar/year)	Year 1	Year 2 -3	Year 4 onwards
Manure, green manure	7 - 10	10 - 15	15 - 20
Bio-organic/ Micro-organic fertilizer	1 - 2	2 - 3	3 - 5

Use of untreated human sewage sludge is not permitted. Only well- composed farmyard manure can be used, which should only be applied to the land in the correct manner (COP 6.3.3).

In Vietnam, farmers use organic fertilizer made from fish waste, this could also be an option for some peppercorn producing areas in Cambodia, such as Kampot (see annex 2 for Factsheet).

6.4 Use of inorganic fertilizers

When utilized properly, inorganic fertilizers are highly effective in enriching the soil and delivering essential nutrients directly to plant roots. It's critical to apply the appropriate quantity of inorganic fertilizer to ensure optimal plant health and yield (COP 6.3.3).

For pepper cultivation, there is a wide array of inorganic fertilizers available. To ensure the precise application of nutrients, it is advisable to employ a calculation method that converts the nutrient content from pure fertilizer to its equivalent in a commercial product. This approach facilitates informed decisions on which fertilizers to purchase, thereby satisfying the specific nutritional requirements of your crop.

Information on symptoms of Nutrient deficiency can be found in Annex 3.

Single Fertilizers provide one primary macronutrient essential for plant growth:

- **Nitrogen Fertilizers**: Such as Urea and Ammonium Sulfate, are vital for vegetative growth.
- **Phosphate Fertilizers**: Including Fused Phosphate and Super Phosphate, essential for root development.
- **Potassium Fertilizers**: Like Potassium Chloride and Potassium Sulfate, vital for flower and fruit formation.

Mixed or Complex Fertilizers: These formulations offer a blend of two or more macronutrients, such as NPK (Nitrogen, Phosphorus, Potassium) or NPK+TE (NPK with Trace Elements), providing a balanced diet to support all stages of plant growth.

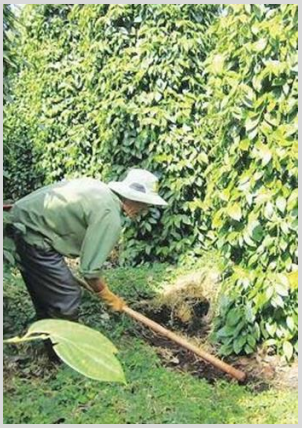
Foliar Fertilizers are liquid fertilizers contain NPK along with numerous micronutrients, designed for application directly onto the leaves for rapid absorption.

Fertilizer Application Guidelines

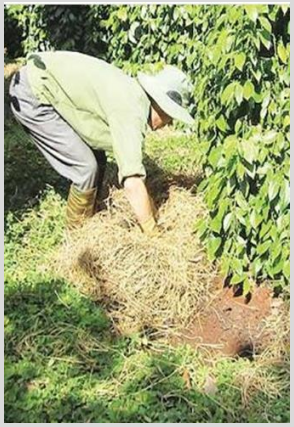
Ensure the soil is moist before adding inorganic fertilizer to facilitate nutrient absorption and prevent root damage.

Clear the area of leaves and plant debris prior to fertilizer application.

Distribute the fertilizer evenly around the edge of the plant canopy.



Lightly incorporate into the soil with minimal disturbance to avoid damaging the roots



Ideally cover with straw or hay if available.

Adhering to these guidelines ensures that your pepper plants receive the precise nutrients they need, promoting healthy growth and maximizing yield while minimizing environmental impact.

The total amount of inorganic fertilizer required for pepper are as follows:

Fertilizer type (kg/ha/Yr)	New Plantings	Year 2 - 3	Year 4 onwards
N	90 – 100	150 – 200	250 – 350
P_2O_5	50 – 60	80 – 100	150 – 200
K_2O	70 – 90	100 - 150	150 - 250

The suggested schedule of fertilizer application is presented below:

Stage	Application schedule
New Plantings	**Before planting**: apply phosphorus and manure 1 – 1.5 months apply 1/3 Nitrogen 2 – 3 month apply Potassium
Year 2 – 3	**First application**: All amounts of phosphate and manure are applied at the beginning of the rainy season. **Second application**: 1/3 protein + 1/3 potassium, 3-4 weeks after the first time **Third application**: 1/3 nitrogen + 1/3 potassium, applied in the middle of the rainy season. **Fourth application**: The remaining amount of fertilizer applied at the end of the rainy season.
Year 4 onwards	**First application**: 1/4 nitrogen + 1/4 potassium and all organic fertilizers, phosphate fertilizers about 10 days before the end of harvest. **Second application**: 1/4 nitrogen + 1/4 potassium, applied at the beginning of the rainy season. **Third application**: 1/4 nitrogen + 1/4 potassium, applied in the middle of the rainy season. **Fourth application**: The remaining amount of fertilizer applied at the end of the rainy season

Note: It is recommended to analyze the nutrient content of the soil before fertilizing to have a specific procedure for fertilizer

Lime is also important for improving acidity, providing Calcium and Magnesium. The annual application will depend on soil condition; a typical rate would be 500 – 1,000 kg/ha. Lime can be applied directly to the soil, or incorporated first into compost or manure.

Foliar Fertilizers

Foliar fertilizer can be used for foliar spraying, containing one or more macronutrients, intermediates, micronutrients or adding growth stimulants. Use of foliar fertilizer should be restricted to times when there is a need to provide a quick supply of nutrients for plants, especially when the weather is unfavorable, during periods of nutritional crisis, and pests and diseases (COP 6.3.3).

Use foliar fertilizers during the rainy season to support plant health. Use foliar fertilizers

supplemented with intermediate fertilizers (Ca, Mg...) and micronutrients (Zn, B...) for pepper to increase the rate of flowering and fruiting and reduce the drop rate.

Spray foliar fertilizer 2-3 times in the rainy season, spraying at the recommended concentration. Thoroughly spray the underside of the leaves and spray in cool weather without strong sunlight or heavy rain.

7 Pest and disease management

7. Pest and disease management	**7.1 Crop monitoring**	**7.1.1** Undertake regular inspection of the gardens to detect pests and diseases early and enable timely decision making.
	7.2 Pest management	**7.2.1** As a priority, integrated pest management practices should be adopted by applying the principles of prevention (adopt practices that will discourage pests and promote healthy plant growth), maintenance (adopt practices that will enhance natural control measures), and management (treat only when necessary, following sound decision-making tools)

7.1 Crop monitoring

It is important to undertake regular inspection of the gardens to detect pests and diseases early and enable timely decision making (COP 7.1.1).

Pest and disease management is a critical component of successful peppercorn cultivation, requiring diligent monitoring and strategic intervention to ensure the health and productivity of the crop. Pests such as the pepper weevil, root-knot nematodes, and various fungal diseases like Phytophthora foot rot can severely impact peppercorn plants if not adequately controlled. Constant surveillance is necessary to identify problems at an early stage and take immediate control where any incidence of disease or pest is noticed. Farmers should be trained to recognise disease symptoms and pest damage that affect pepper vines. Careful inspection of the vines should be done regularly. Where any incidence of disease or pest is noted, steps must be taken to treat and remove the affected part or vine.

The key feature of crop monitoring is accurate pest diagnosis. The key pests and diseases for peppercorn include:

- Quick Wilt (Phytophthora capsici): Characterized by yellowing leaves and rotten stems, prevalent in wet conditions.
- Slow Decline/Wilt: Caused by nematodes and fungal infections, leading to yellowing leaves and reduced plant vigor.

- Anthracnose Disease (Colletotrichum gloeosporioides): Causes yellow to black spots on leaves, thriving in moist conditions.
- Stunted Disease (Cucumber Mosaic Virus): Results in discolored, distorted leaves and stunted growth.
- Red Algae Disease (Cephaleuros virescens): Identified by velvety lesions on leaves and stems, exacerbated by high humidity.
- Mealybugs (Planococcus spp., etc.): Cause damage through feeding, leading to sooty mold and weakened plants.
- Stem Borer (Lophobaris piperis): Larvae bore into stems, causing significant damage to the plant structure.
- Beetles (Longitarsus nigripennis, etc.): Feed on leaves and stems, potentially transmitting viruses.

Regular Monitoring is important to ensure early detection and management. Weekly inspections is recommended.

7.2 Pest management

As a priority, integrated pest management practices should be adopted by applying the principles of prevention (adopt practices that will discourage pests and promote healthy plant growth), maintenance (adopt practices that will enhance natural control measures), and management (treat only when necessary, following sound decision-making tools) (COP 7.2.1). IPM involves a strategic combination of pest control techniques designed to maximize their benefits and minimize their drawbacks.

Prevention Measures

- Weed Control: Implement weed management to eliminate pest host plants, while acknowledging that certain weeds can benefit natural enemies, provide ground cover, and serve as mulching material. Aim to remove only weeds detrimental to your crops, carefully evaluating the potential benefits of retaining other varieties.
- Biodiversity Enhancement: Increase garden biodiversity to naturally disrupt pest pathways and foster the presence of beneficial organisms. This can be accomplished by planting beneficial species in non-cropping zones around or interspersed within the

garden, ensuring these do not compete with the main crop. Integrating peppercorn plants with other compatible crops can further diversify the ecosystem.

- Farm Hygiene: Disinfect tools after cutting infected plant parts before using them on healthy plants. Clean and disinfect farm tools moving from infected to clean areas. Limit gardener movement from diseased to healthy gardens to prevent disease spread. Farms should be regularly inspected, possible hazards stemming from farming practices were identified, emphasizing the need for preventive measures against re-infestation by pests through isolation from other pepper crops. To maintain hygiene and prevent contamination, workers involved in sorting and packing fruit are instructed to wash their hands with soap or detergent before handling the produce. Additionally, it's crucial to sort and package the fruit in clean and disinfected facilities, exclusively using new packaging materials for pepper fruits to avoid contamination. Employing clean (potable) water for washing is imperative to ensure food safety and minimize the risk of exposure to bacterial contaminants.
- Water Management: Implement effective drainage to prevent fungal disease spread through water.
- Nutrition Management: A healthy crop is the foundation of pest management, apply the correct fertilizer at the optimal time and dose to ensure the crop grows optimally.
- Resistant Varieties: Currently, no black pepper varieties are resistant to pests and diseases in Cambodia. Use disease-free seedlings and practice safe seedling treatment.
- Crop management: Implement pruning to ensure proper air circulation and light penetration. Consider intercropping with compatible plants for natural pest control (see Annex 4 for factsheet on intercropping).
- Diseased plants or affected portions of the plant should be removed from the holdings, and burned. Phytosanitary measures, such as physical removal of pests, affected plant parts, infected plants (virus-infected plants, severely disease-infected or pest-infested plants, including plants affected by Phytophthora sp. or slow decline/yellow wilt), should be undertaken. Implements used to remove the affected plants or plant parts should be cleaned or sterilized before use on other plants.
- Prophylactic measures must be taken for the plants surrounding the infected plant for diseases such as virus disease, foot rot, root rot, yellow wilt and slow decline. Steps

should be taken to prevent contamination of healthy holdings. Movement of workers in infected areas should be restricted. Fencing can be done to restrict movement into healthy holdings. Drains may be constructed to prevent disease spread between holdings and to prevent water stagnation. Farm implements used in one holding should not be used on other holdings.

Cultivation Practices

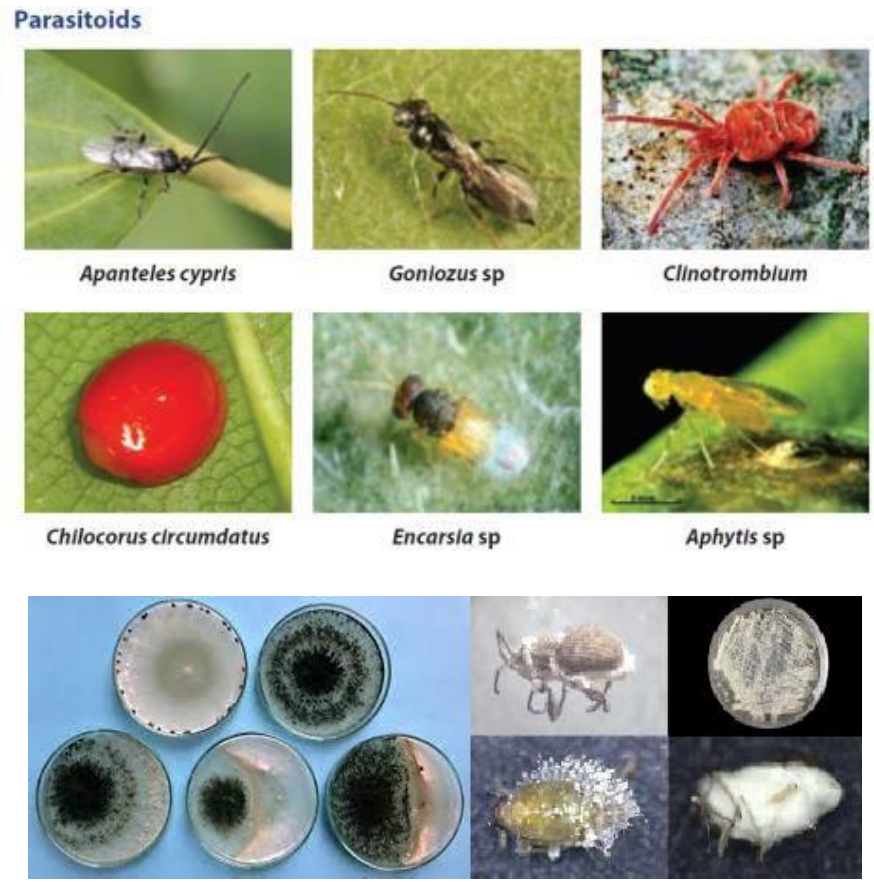
Adapt planting techniques to discourage pests, including crop rotation and plant spacing. Various cultural practices that are known to help in preventing and controlling pests and diseases should be implemented in all pepper holdings. Shade regulation should be done to allow optimal light penetration, with pruning of live support trees done regularly. Limited weeding by hand may be carried out when necessary, in the inter-spaces before the cover crop is fully established and at the base of the plant. Cover crops should not be allowed to grow excessively. Pruning of the leaves at the base of the plant to 30cm above the ground surface should be practiced. Provision and Cultivation measures

- Regular pruning from May to June is an important measure to limit beetle populations.
- Sanitize the field to remove beetles.
- Prune branches for live pillars.
- Regularly inspect black pepper garden.
- Catch and kill adults.
- Collect damaged parts, take them out of the garden and destroy. maintenance of drains should be undertaken when and where necessary.

Biological Control

Biological controls should be the first line of control for pests and diseases, when incidence is noticed and where an appropriate bio-control agent is available. Maintain an environment conducive to the proliferation of bio-control agents of pests and pathogens. Regular application of Trichoderma spp., Pochonia chlamydosporia, Pseudomonas fluorescens and other antagonistic microorganisms may be done. Recommended plant products and biocontrol agents for insect pests are: - Neem, tuba (Derris sp.), parasitoids, predators and entomo-pathogens.

Examples of Biologicals found in peppercorn gardens



Biological measures

- Use only on lightly damaged plants
- Beauvaria bassiana, Metarhizium Anisopliae and Spathious piperis are a biological control agent
- Hunting spiders help reduce beetle populations.
- Applying neem powder at the base will help kill the pupae.

Botanical Solutions:

Neem-Based Remedies: On-farm neem concoctions and commercially produced neem products provide effective pest control. Commercially standardized neem products generally yield more consistent and reliable outcomes compared to homemade mixtures.

Probiotic Disease Prevention:

- Utilize probiotics for preemptive disease control, incorporating:
- Trichoderma spp. for antagonizing harmful fungi.
- Streptomyces bacteria for a broad spectrum of disease resistance.
- Herbal extracts (excluding saponin) to deter larval pests.
- Alkaloids for managing root mealybugs.
- Metarhizium-based products for aphid management.

These biological agents can be seamlessly integrated into your fertilization regimen by applying the inoculum directly to the pepper root zone, followed by covering with soil to maintain adequate moisture levels, enhancing their efficacy.

Phytosanitary Protocols

Adhering to strict phytosanitary measures is crucial for maintaining plant health. This includes:

- The physical removal of pests and diseased plant parts, ensuring the elimination of virus-infected plants and those severely affected by diseases or pests, including those impacted by Phytophthora spp. or conditions like slow decline/yellow wilt.
- Sanitization of tools used in the removal process is imperative. Cleaning or sterilizing implements before they are used on other plants prevents the spread of pathogens.

By adopting these integrated biological control and phytosanitary strategies, you can sustainably protect your plants from pests and diseases, promoting a healthier, more productive garden.

Chemical control

Chemical control should be used as a last resort, and care should be taken to ensure that it

does not affect the environment and it does not leave any pesticide residue. Only treat when damage is more than 10%. Chemicals used should be compatible with biological control agents. Agrochemicals for control of pests and diseases may be used only when all other measures have been exhausted. Chemicals used should comply with permitted lists in the respective countries. Application of chemicals should follow recommended practices to ensure that the final product is free of residues, users are not affected by the chemicals and no environmental contamination takes place..

When turning to chemical interventions, adhere to the principle of the "Four Rights" for safe and effective pesticide application:

- Right Product: Choose pesticides with minimal environmental impact.
- Right Dosage: Apply the correct amount to minimize residue and environmental damage.
- Right Timing: Use pesticides at optimal times to maximize effectiveness and reduce harm.
- Right Method: Employ application techniques that ensure targeted delivery and minimize exposure.

Prioritize the well-being of workers and food safety by implementing stringent protective measures during pesticide use. Opt for pesticides that are eco-friendly, designed to break down rapidly in the environment, and leave minimal residues in agricultural produce. This approach not only safeguards environmental health but also ensures the safety and quality of food products.

Refer to specific pest management guides for specific pest problems in Annex 5.

8 Pesticide use

8. Pesticide use	8.1 Safe handling of pesticide	**8.1.1** Only pesticides specifically stated on the national Approved Pesticide List(s) may be used. **8.1.2** All pesticides must be used in a safe and correct manner as described in the national guide. **8.1.3** Do not arbitrarily mix different pesticides together. **8.1.4** Read the label carefully and understand what is in the bottle. **8.1.5** Only purchase pesticides that are still in their original container **8.1.6** Do not use the same pesticide all the time **8.1.7** No pesticides detailed in the Banned and/or Restricted Pesticide List may be held or used on a farm **8.1.8** Prior to spraying make sure all equipment is prepared and tested. **8.1.9** During and after spraying you must follow all guidelines.

8.1 Safe handling of pesticides

Only pesticides specifically stated on the national Approved Pesticide List(s) may be used (COP 8.1.1).

Only use pesticide products that are on the list of pesticide products allowed to be used in Cambodia, by the Ministry of Agriculture, Forestry and Fisheries is updated annually. The permitted pesticide list can be found at Plant Protection Sanitary and Phytosanitary Department. All pesticides must be used in a safe and correct manner (COP 8.1.2). You must use the 4 Principle approaches to correct use of pesticides, which has been adopted by Cambodia.

- **Right pesticides**: Choose the appropriate product for the pest and for use on pepper

making sure it is the correct agent for the target pest or disease. Check that it is the correct product by checking the package label. Use only containers with the original, intact, packaging label.

- **The correct dosage and concentration**: do not mix wasteful and toxic high concentrations, do not dilute too much as this will not kill pests and you will need to spray again. Mix the pesticides according to the instructions on the package of the pesticide.
- **At the right time**: Spray at the right time when the worms are young and easy to destroy. Spraying when newly infected will be easier to treat than when it is too severe.
- **The right way**: Handle pesticides at the location where pests and diseases appear and cause harm. When using pesticides, it is necessary to ensure the isolation time as recommended on the package to minimize pesticide residues on pepper.

NOTE: the use of botanical sprays should be treated with the same caution as pesticides, as some may be toxic to humans.

Treatment of pesticides directly into soil can prolong the withdrawal period, longer than written on the packaging. Therefore, if chemical pesticides are required to be applied to the soil to prevent pests and diseases, they should be handled at the beginning of the crop.

Do not arbitrarily mix different pesticides together (COP 8.1.3). When 2 or more pesticides are mixed this can increase the effectiveness against pests. But this practice can also reduce the effectiveness of pesticides or cause burning pf the leaves of plants, increase the chance of residues on the harvested product and can cause poisoning to you.

Read the label carefully and understand what is in the bottle (COP 8.1.4). When purchasing pesticides from a dealer, the bottle may contain 1-3 different pesticide active ingredients. You must read the bottle labels carefully to avoid spraying with active ingredients banned from use by importing countries (if any).

Only purchase pesticides that are still in their original container (COP 8.1.5). When purchasing and using pesticides, you must know what you are applying to your crops. If the product is not in the original containers, you cannot be sure that the contents are the same as declared on the label.

Do not use the same pesticide all the time (COP 8.1.6). On the same area of pepper cultivation, do not use the same pesticide continuously over many years. Changing

pesticides will prevent the phenomenon of pesticide resistance of the pest.

No pesticides detailed in the Banned and/or Restricted Pesticide List may be held or used on a farm (COP 8.1.7).

Prior to spraying make sure all equipment is prepared and tested (COP 8.1.8). Before spraying pesticide products, you must prepare the pesticide preparation equipment such as measuring tubes, scales, mixing buckets, stirring rods. Sprayers must have been tested, to ensure that they do not leak.

During and after spraying you must follow all guidelines (COP 8.1.9).

During spraying

- Make sure no pesticide comes into contact with your body;
- When spraying do not eat, smoke; do not let the pesticide to come into contact with your body, especially the eyes;
- Identify areas that have been sprayed and restrict access during the isolation period;
- Do not spray when the black pepper is prepared to harvest as this will not guarantee the isolation period.
- Do not spray against the wind, when too windy, it is about to rain, or too sunny.
- Apply pesticide at the right speed, in accordance with the amount of agent used;
- Ensure you have added the correct amount of water and pesticide for the desired concentration;
- Spraying should be done in the early morning or evening

After Spraying

- After spraying clothes and tools, must be washed and stored in a separate storage area.
- Do not pour excess pesticide, or spray rinse water into the domestic water supply or drains.
- Absolutely do not use bottles, packaging of used pesticides for any other purpose. They must be destroyed and buried far from domestic water sources and residential areas.

9 Harvesting

9. Harvesting	**9.1 Correct harvesting**	**9.1.1** Pepper fruit harvest time will be different for each type of product. Following harvesting guides according to type of peppercorn. **9.1.2** Pepper should be harvested by hand. **9.2.3** Spikes should be picked selectively. **9.1.4** Steps must be followed before harvesting pepper fruit **9.1.5** This COP encourages frequent harvesting of the pepper fruit during the harvest season **9.1.6** Precautions must be followed during the harvesting process

9.1 Correct harvesting

Pepper fruit harvest time will be different for each type of product (COP 9.1.1). Harvesting of pepper fruit should take place when:

- Black pepper - seeds are firm, the fruit turns yellow, and on each cluster there are 1-2 ripe yellow and red fruits
- White pepper - the cluster of fruits must be old, with scattered red ripe fruits
- Red pepper - fruit bunches are completely red. Ripe pepper fruits are kept intact when processing.

Black peppercorn

Harvest entire pepper bunches for optimal quality. The ideal moment for picking is when the bunch has matured, featuring fruit that has transitioned from green to yellow, indicating ripeness. Avoid harvesting green and immature bunches, with the exception of the final harvest of the season.

To ensure the integrity of each bunch, gently press and separate the fruit by hand, taking care not to damage the bunch or cause injuries to the stem nodes.

The time from flowering to harvest for pepper plants ranges between 6 to 8 months, influenced by both the variety of pepper and the prevailing climatic conditions. Consequently, the harvesting period can differ significantly across various regions.

Pepper should be harvested by hand (COP 9.1.2). Pepper should be harvested by hand and picked 2-3 times in a season, when fruit cluster turns green-yellow. Press each bunch of fruit separately by hand, do not pull the bunch of fruits, causing wounds in the nodes.

Spikes should be picked selectively (COP 9.1.3). Harvesting pepper often requires a large number of laborers, So farmers often harvest by the method of "rolling mats". It means that priority will be given to the first ripening plants and then the next ones until the end. Harvest when the pepper is 5-10% ripe on a bunch.

The following steps must be followed before harvesting pepper fruit (COP 9.1.4):

- Prepare equipment for harvesting - tarpaulin, bags, ladders, chairs, and machines chairs, and thresher.
- Inspect and clean the field in the area to be harvested.
- Care should be taken to remove any dead pepper shoots from the ground that have become rotten and mouldy.
- Spread a tarpaulin in the rows and around the pepper base to avoid berries dropping on the soil and becoming contaminated.

Frequent harvesting of pepper fruit is encouraged during the harvest season. Greater frequency of harvest during the season (2-3 times) will ensure that berries that are picked are more uniform. If picking is done only once or twice during the season, there will be greater likelihood of picking immature as well as over-ripe berries.

The following precautions must be followed during the harvesting process (COP 9.1.5):

- Berries that have fallen to the ground must be collected separately and not be mixed with pepper berries from the vines. The dropped berries should be processed separately for appropriate end uses.
- Harvested green pepper must be handled hygienically, collected, and transported in clean bags or baskets to where it is to be processed.
- Baskets or bags that have been used to hold agricultural chemicals must not be used for green pepper. Any container that is used should be cleaned thoroughly to ensure that it is free from any contaminants
- After picking pepper fruit, leaves and impurities must be picked up, packed into bags, and transported to the yard

Following the harvest of pepper, remove leaves and contaminants, then pack the pepper in bags for transport to the drying area. Berries are then manually detached from the spikes on a clean cement surface or using either a hand-operated or motorized thresher, ensuring the separation of stalks from the berries.

Post-harvest actions include:

- Pathogen Control: Treat plants with fungicides or copper-based solutions to eliminate pathogens and harmful fungi on the leaves, targeting issues like anthracnose and lichen. This helps in shedding old leaves.
- Plant Maintenance: Trim the shoots, remove eel peppers and any parts too close to the ground to maintain plant hygiene.
- Waste Management: Collect old and diseased leaves for incineration to prevent disease spread.

These measures aim to curb disease proliferation and foster conditions conducive for the pepper plants to initiate the development of flower buds.

10 On-farm processing

10. On-farm processing	**10.1 Threshing and processing Black pepper**	10.1.1 General guidelines for black pepper should be followed. Always follow specific requirements of buyer when processing. 10.1.3 Clean pepper should be soaked for between 1 to 2 minutes in water of 80˚ to 90˚ C to reduce contaminants, facilitate drying and improve appearance of the dried pepper. 10.1.4 Pepper must be dried at temperatures below 60˚C, to prevent loss of volatiles and should be dried to a moisture level below 12% if it is to be stored.
	10.2 Threshing and processing White pepper	10.2.1 General guidelines for white pepper should be followed. Always follow specific requirements of buyer when processing. 10.2.2 Equipment for decorticating should be thoroughly cleaned before and after use. 10.2.3 The drying area, cement yard, should be clean and kept free of any source of contamination. 10.2.4 During drying the pepper should be turned frequently to ensure uniform drying. Pepper that is to be stored should be dried to a moisture content of 11-12 % moisture level the weight is from 630g/l.
	10.3 Packing and storage peppercorn	10.3.1 Dried pepper must be packed in clean, dry bags that are free from any material that may contaminate the pepper 10.3.2 Bags previously used for chemical fertiliser, pesticides or other materials must no be used for harvesting or storing peppercorn. 10.3.3 Store in a clean, dry and cool place, allowing air circulation around the stack.

10.1 Threshing and processing Black pepper

When processing black pepper through threshing and sieving, adhere to the following best practices to ensure the highest quality of the final product:

Harvest Handling

Pepper bunches can be processed immediately upon collection or stored for 2-3 days before plucking.

Threshing

Pepper spikes should be threshed to separate berries from the stalks. Threshing of green pepper spikes may be done mechanically or manually. Where the quantity of pepper to be threshed is significant, mechanical threshing using one of the many types of threshers available is recommended.

Threshing of green pepper spikes may be done mechanically or manually. Where the quantity of pepper to be threshed is significant, mechanical threshing using one of the many types of threshers available is recommended. Care should be taken to ensure that berries are not damaged during threshing and that stalks are separated from the berries. Ensure that threshers are properly cleaned before use especially if they have not been used for a long period of time. Threshers should also be cleaned after use, at the end of the day.

Washing pepper in clean running water is advisable. Where adequate water is not available, extra care must be taken to ensure that the harvested pepper is free from leaves, stems, stalks and other field matter. Sieving can be done mechanically or manually, using a mesh with 4mm diameter, with berries that pass through the mesh being set aside for drying separately.

Hot Water Treatment

Clean pepper should be soaked for between 1 to 2 minutes in water of 800 to 900 C to reduce contaminants, facilitate drying and improve appearance of the dried pepper. Soaking of pepper can be done in wire mesh or rattan baskets immersed in boiling water. The water should be changed as necessary, as it becomes dirty with each immersion. Drying

Pepper should be dried at temperatures below 60 0C, to prevent loss of volatiles, in clean surroundings, free from any possible contact with dust, dirt, farm animals and/or other possible sources of contamination. Black pepper should be dried to a moisture level below 12% if it is to be stored.

Tips for drying Peppercorn

Sun Drying

Pepper may be dried in the sun, on clean drying platforms raised above the ground. The drying area should be fenced or otherwise protected from any pests or farm animals. Care must be taken to ensure that pepper is adequately dried and to prevent spoilage from mould or other contaminants, particularly when there is no sun.

For optimal quality, sun drying of pepper should be accomplished within 3-4 days, aiming for a final moisture content of 11-12%. The transition of pepper from green or yellow to a black hue indicates successful drying. The process may vary based on the quantity of pepper being dried. To ensure uniform drying, spread the pepper in a layer 2 to 3 cm thick and stir it 4 to 5 times daily. Adequate airflow is critical to prevent mold in the final product.

Drying pepper should occur in a clean environment to avoid contact with dust, dirt, farm animals, or other sources of contamination. The cemented drying area should be swept clean and covered with a tarpaulin to protect the pepper from direct exposure to contaminants. It's crucial to ensure the drying yard remains dry, without any stagnant water nearby. The tarpaulin used must be clean and free from contaminants to maintain the quality of the pepper. Additionally, the drying area should be fenced or secured to protect against pests and farm animals. Pepper must be placed on clean, elevated drying platforms to prevent ground contact. Spread the pepper in a layer 2-3 cm thick and stir it 4-5 times daily for even drying. Special attention is needed to ensure the pepper dries thoroughly, especially in the absence of sunlight, to prevent mold and spoilage. Finally, during the drying process, it's important to prevent animals and people from walking on the pepper, particularly with shoes, to maintain cleanliness and hygiene.

Solar Dryers

These dryers offer an efficient way to accelerate the drying process while safeguarding the pepper against dust and contaminants. This method is cost-effective and environmentally friendly, providing a controlled drying environment that enhances product quality.

Solid Fuel Dryers

Fueled by wood chips, coconut waste, and other sustainable farm materials are also viable for quickening the drying process, minimizing contamination risks. It's crucial to maintain the drying temperature below 60°C to avoid smoke contamination, loss of volatile compounds, and undesirable changes in color or appearance. Continuous monitoring of temperature ensures the integrity and quality of the dried pepper are preserved.

On-farm Packing

Dried pepper should be packed in clean, dry bags that are free from any material that may contaminate the pepper. Care must be taken to ensure that the Pepper is not contaminated by the use of bags that have been previously used for chemical fertilizers, pesticides or other materials. Bags should be thoroughly cleaned, if necessary and carefully inspected to ensure that they are free of dirt or foreign matter. Preferably new bags may be used to avoid possible contamination. Pepper that is adequately dried (i.e. below 12% moisture level) may be put in the bags with poly liners to prevent absorption of moisture.

Sieving

Post-threshing sieve the green pepper to remove small, immature berries and pinheads, which could detract from the quality of the black pepper. Sieving can be performed either mechanically or manually. Utilize a mesh of 4mm diameter to segregate the berries, with those small enough to pass through being dried separately to maintain quality standards.

By following these guidelines, you can ensure the black pepper undergoes optimal processing, leading to a quality product ready for the market.

10.2 Threshing and processing White pepper

To produce high-quality white pepper, it's essential to start with fully matured fresh pepper, where each spike has at least one or two ripe berries. Care must be taken to ensure that the berries are not damaged in the process. The process for threshing white pepper closely mirrors that of black pepper. However, the preparation of white pepper involves specific soaking techniques:

Threshing

The pepper spikes should be threshed to separate the berries from the pepper stalks and then sieved to separate smaller berries. Mechanical threshing, with the threshed berries falling into a container with water, is recommended as this will prevent discolouration of the pepper. Small berries may be dried to make black pepper.

Soaking Process

The green pepper berries then need to be soaked in clean, running water for up to 14 days, or until the outer skin becomes soft and easily removable. This soaking process can be conducted in bags or baskets, which are placed in streams or tanks. When using tanks, weights should ensure the containers remain fully submerged. It's crucial to prevent any potential upstream contamination when soaking in streams, safeguarding the water quality and, consequently, the pepper. If the soaking occurs in tanks, the water must be refreshed at least every two days to avoid any unpleasant odors developing from prolonged exposure to stagnant water.

Fresh pepper is immersed in water heated to 90-100 degrees Celsius for 11-13 minutes. If starting with black pepper, the soaking period extends to 60-90 minutes. This process facilitates the peeling of peppercorns, which are then washed in a sieve designed to separate the pepper shells, allowing them to be collected efficiently. Once peeled, the white pepper is sun-dried on a clean cement area for 1-2 days until it reaches a moisture content of 11-12% and a density of 630g/l or higher.

Regularly turning the bags ensures that the pepper evenly undergoes the retting process. Following the soaking period, the pepper should be decorticated mechanically to remove the softened skin effectively.

Decortication

Pepper may also be decorticated mechanically after a short period of soaking to soften the skin. Equipment for decorticating should be thoroughly cleaned before and after use. Decorticating can be done using various types of equipment. Care must be taken to ensure that the berries are not damaged in the process. It is best that decorticating is done in water, or with flowing water, to prevent discolorations. Equipment must be cleaned before and after use, taking care not to damage the berries (COP 10.2.2). Decorticating in water or with flowing water is preferred to avoid discoloration.

Washing White Pepper

After decortication, thoroughly wash the pepper in clean water to remove any leftover skin, then dry the pepper in the sun for 2-3 days until it achieves a creamy white color.

Drying White Pepper

White pepper should be dried in the sun to get the desired creamy white colour. The drying area should be kept free of any source of contamination. In areas where the sunshine hours are inadequate or where rain can disrupt drying, other forms of drying may be used (solar dryers, solid fuel dryers, tray dryers, etc.) to complement sun drying. White pepper should be dried to at least 14% moisture before packing. Ensure the drying area is clean and uncontaminated, mirroring the conditions recommended for black pepper (COP 10.2.3).

Adequate air flow is important to prevent mould and musty smells from developing. Where solid fuel or other dryers are used, care must be taken to ensure that temperature is kept below 60o C, to prevent loss of volatile substances, browning or discolouration.

Frequent turning is essential for uniform drying, targeting a moisture content of 11-12% and a density of 630g/l for storage-ready pepper. During drying the pepper should be turned frequently to ensure uniform drying (COP 10.2.4).

10.3 Packing pepper

Dried pepper must be packed in clean, dry bags that are free from any material that may contaminate the pepper (COP 10.3.1). Pepper may be winnowed to remove light pieces of skin or dust and sieved to remove pieces of leaf and stalks as well as small or broken berries. Pepper should be packed in 2 layers, each bag about 50-70 kg with an inner nylon layer and outer fiber bag to prevent moisture absorption. Pepper stacks should be not more than 6-8 bags high and the bags should be at least 10- 20 cm away from the wall or floor of the store. Bags should be thoroughly cleaned, if necessary, and carefully inspected to ensure that they are free of dirt or foreign matter. If possible, new bags may be used to avoid possible contamination.

Care must be taken to ensure that pepper is not contaminated using bags that have been previously used for chemical fertilizers, pesticides or other materials.

Store in a clean, dry and cool place, allowing air circulation around the stack (10.3.3).

Pepper should be stored in clean, dry, well ventilated stores, on pallets or raised floors, in areas free from pests such as rodents and insects. Pepper should not be stored together with agricultural chemicals or fertilisers that may lead to contamination. Pepper stores should be well ventilated but free from high humidity. Stored pepper should be regularly inspected for signs of pest damage or contamination.

Care must be taken at all times to prevent contamination of the pepper during handling, particularly microbiological or chemical contamination. Workers handling pepper must take care to ensure that all equipment and utensils that come into contact with the pepper are clean and safe. Hands should be thoroughly washed before pepper is handled and clean gloves should be used where possible.

Grading

Pepper should be graded at farm level before sale, to ensure that the price received is commensurate with the quality. For black pepper, moisture level, bulk density (grams per liter), moldy berries and foreign matter content are the main considerations in determining grade or quality of pepper. For white pepper, quality may be determined by color of the pepper, content of black or grey berries, moisture level and foreign matter content. IPC Standards for untreated black or white pepper, together with the relevant testing methods, may be used as a guide in determining quality of pepper.

General Maintenance

All equipment, utensils and materials used for processing pepper should be cleaned before and after use and maintained in good working condition. Processing areas, drying areas and stores should be kept clean and free from contamination.

11 Hygiene

11. Hygiene Practices	**11.1 Safe handling of peppercorn**	**11.1.1** Processing of black and white pepper must be done in a clean, safe, and hygienic manner by adhering to the following guidelines **11.1.2** Only store packed pepper in a safe condition

11.1 Safe handling of peppercorn

The processing of black and white pepper must be conducted with the utmost care to maintain cleanliness, safety, and hygiene throughout all stages, according to these guidelines:

- Ensure that drying tarpaulins, threshing machines, and containers are completely free from impurities. Begin by removing all contaminants from the harvest in the field and continue meticulous removal throughout the processing phases.
- Regular inspection and adjustment of machinery are essential to prevent seed damage. Aim for a thorough separation and elimination of impurities. Utilize clean rigs and canvas for drying to ensure the final product is of the highest purity.
- Utmost cleanliness is required when cleaning black or white pepper. All utensils and equipment must be cleaned to eliminate any potential sources of contamination.
- After drying, both black and white pepper varieties should undergo winnowing, sifting, and additional cleaning to remove any residual skin, stalks, or foreign materials, ensuring a clean and pure product.

For storage:

- Pepper should only be stored in a packed state under secure conditions to prevent contamination.
- Avoid the use of chemicals to control mould, termites, and pests within storage areas. Instead, ensure that all packaging is secure and all tools are removed from the vicinity.
- Store pepper bags in cool, well-ventilated, and dry warehouses to maintain quality and prevent spoilage or contamination.

Annex 1 Example record sheets

Name and surname: ……. Village:_____
……

House no: ……. Unit: ……. District:
……..

Province: ……. Tel: .....

1. Farm location ……. Peppercorn area. ……ha. Farmer code ……

Farm code…… District……...
Province……

2. Variety

No.	Name of variety	Area (ha)	Density	Date of growth

3. Water resource: ☐ Irrigation ☐ Pond ☐ Rain

   Other. ……

4. Soil type: ☐ Gian ☐ Sand Other. …….

5. Soil preparation: ☐ Machine ☐ Labour ☐ Plough the field

6. Agri input usage, management and price

7. Crop management

No.	Practice	Date	Method	Price
1	Soil preparation			
2	Fertilizer application			
3	Equipment and material			

4	Labour			
5	Pesticide application			
6	Irrigation			
7	Other			

7.1 Insect pest survey, pest control and weed management

a. Insect pest survey and control

Date	Pest and Disease	Outbreak duration	Damage level			Control
			Small	Medium	Outbreak	
	Mealybug					
	Aphids					
	Spider mites					
	Fruit borer					
	Leaf miner					
	Fusaruim disease					
	Phytopthora disease					
	Anthracnose disease					

b. Weed management

Date	Weed type	Weed duration	Control

8. Fertiliser and pesticide application

8.1 Fertiliser application

Fertiliser compost

name of compost	material	production date	processing	production (kg)	usage date	expiry date

Chemical fertiliser

No.	Fertilizer type	Price	Where do you buy	Date of usage			Rate of use (kg/ha)			How to apply
				Time 1	Time 2	Time 3	Time 1	Time 2	Time 3	
1.Chemical fertilizer										
2.Bio fertilizer										
3. Other										

8.2 Pesticide and herbicide application

No.	Trade name	Common name	Number of permit	Where do you buy	Price	Date		Date of usage		Rate of apply		How to apply
						Produce	Expiry	Time 1	Time 2	Time 1	Time 2	

8.3 Harvesting

Please use ✓ in the box

Description	Note
1. Peppercorn mature 80%	☐ Sight ☐ By Hand Other .....
2. Stop the water before harvesting	☐ Before harvesting ..... date Other .....
3. Peppercorn yield	☐ How many kg/ha.....
4 Method	☐ Handle ☐ Machine
4.1 . Dry peppercorn	☐ Sun drying ☐ Dryer machine
4.2 ☐ Fresh peppercorn sale.....kg ☐ Dry peppercorn sale.....kg	

8.4 Storage (if the farmer sells direct to company, no need to fill table below)

Farm code	Quantity (kg)	Plastic bag	How it's kept in storage

Date …….

Name ……

Signature ……

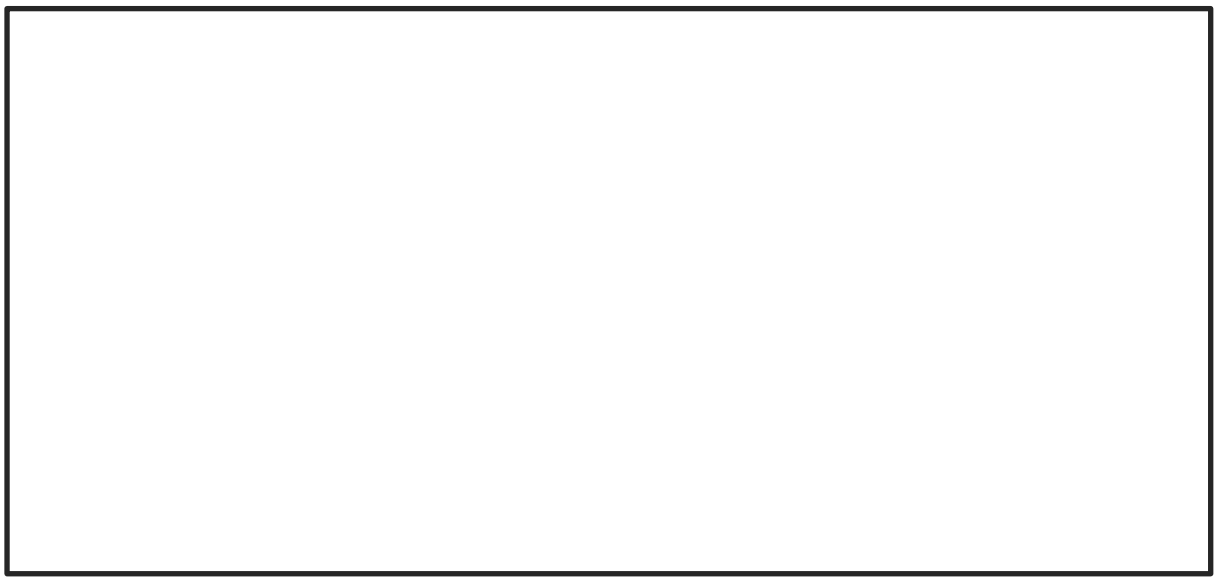
Field mapping

Name and surname ……. Farmer code …….. Village …….

District ……..… Province ……..

Farm no …….. Name of farm ……..……..

Area no ……. Hecta …….



Note: If you have any more fields, please add the field map

Date
……

Owner ……

Annex 2 Organic fish compost

"HOUSEHOLD ORGANIC FISH COMPOSING" MODEL

Currently, the market price of inorganic fertilizer (NPK) has increased too high, while the price of rice and other agricultural products sold have not increased. Therefore, farmers are facing difficulties due to increased production costs and are at risk of loss.

Organic fertilizer brings many benefits to soil and plants. Applying a lot of organic fertilizer will help the soil be rich in humus, creating adhesion in the soil structure. Organic fertilizers are full of nutrients. Although the amount is not high, plants can absorb them completely over a long period of time, sustainably. Organic fertilizer helps retain moisture, retain fertilizer, retain water, and helps the roots develop well, last a long time, and helps make the soil porous. In particular, organic fertilizers help the microbial system in the soil grow strongly.

In addition to organic fertilizers and organic matter, buying trash fish and fish waste and composting fish fertilizer (fish protein) at home to fertilize plants is also a way to supplement fertilizer sources for plants to help reduce cost pressure. Fertilizer costs are rising too high in current conditions. Organic fish fertilizer helps plants easily absorb and convert into nutrients; improve bad soil, sandy soil and degraded soil. Organic fish fertilizer can be used to water roots or spray on leaves for effective results.

Organic fish composting process:

Figure 1: types of fish by-products.

Prepare ingredients and tools:

Prepare all ingredients and equipment as follows:

- Fresh fish: Can use freshwater fish such as tilapia, pangasius, or by-products such as fish head, fish fins, fish intestines.
- Fish incubation probiotic products: EM probiotic probiotic products
- Molasses: If you don't have molasses, you can use granulated sugar or crushed sugar instead.

<table>
<tr>
<td> 

Figure 2: EM probiotic products</td>
<td>Step 1: Use 1 liter of Original EM + 3 kg of molasses (or granulated sugar) + 21 liters of water = 25 liters of secondary EM

Incubate the secondary EM for 5-7 days to multiply the number of beneficial microorganisms cultured in the solution.

Container: You should choose a large container with a drain spout to hold a lot of fish and make it easy to extract</td>
</tr>
<tr>
<td> 
Figure 3: tank for incubation and composting fish manure.</td>
<td>Step 2 : Put 20 kg of fish or fish by-products from previously prepared fish heads, fish fins, and fish intestines into the tank containing the above secondary EM solution. (Note: do not soak more than 80% of the tank volume)</td>
</tr>
<tr>
<td></td>
<td>Step 3: Stir well and cover tightly.</td>
</tr>
</table>

Figure 4: Secondary EM solution incubated for 5-7 days.

Figure 5: Put the fish into the secondary EM tank to proceed with soaking and composting the fish manure

Step 4: After incubation for 10 days, open the lid and stir well.

Figure 6: fish nitrogen fertilizer solution after incubation.

Step 5: After a incubation period of 25-30 days, when the compost solution is dark yellow, it is successful.

Effects of biological products in fish composting:

The original EM probiotic fish incubation product contains many beneficial microorganisms such as: *Streptomyces, Rhizobium, Lactic, Bacillus,* Photosynthetic bacteria, yeast, during the incubation process, the microorganisms begin to ferment, in Microbial fermentation secretes protease enzymes to decompose protein in fish muscle into peptides and amino acids.

In preparations used to compost fish provide many beneficial microorganisms. When fish compost is successful, microbial fish fertilizer will be created, increasing the effectiveness of fish protein fluid for plants.

How to use fish nitrogen fertilizer solution after incubation*:*

1 liter of fish protein solution + 200 liters of water: used to spray, evenly wet all leaves and stems of plants

1 liter of fish protein solution + 100 liters of water: use for root irrigation

Fish residues are added to fertilize plants

Use fish protein solution to water plants once every 10 - 15 days

With the cost of NPK fertilizer rising too high today, composting fish manure (fish protein) at home helps farmers somewhat reduce the pressure on investment costs for the upcoming crop. Combining the use of organic and inorganic fertilizers in production can be considered a solution to help reduce investment costs somewhat while still ensuring crop productivity and bringing profits to farmers. farmers.

Annex 3 Symptoms of nutrient deficiency in peppercorn

Nitrogen Deficiency:

Symptoms: Initially, poor growth and yellowing of the lower leaves are observed, while the upper leaves remain green. In severe cases, all leaves on the plant may turn yellow.

Management: To address nitrogen deficiency, apply urea fertilizer to the soil. The quantity of fertilizer needed varies with the age of the plant.

Potassium Deficiency:

Symptoms: This condition typically manifests in older leaves, starting with necrotic spots at the leaf tips. The leaves may first show slight yellowing before progressing to a silvery appearance, and the leaf blade becomes brittle.

Management: To rectify potassium deficiency in pepper plants, the application of potassium chloride (KCL) varies by the age of the plant:

- For 1-year-old pepper plants: Apply 70g of KCL per pillar annually.
- For 2-year-old pepper plants: Apply 140g of KCL per pillar annually.
- For mature, commercial pepper plants: Apply 200-350g of KCL per pillar annually.

Phosphorus Deficiency:

Symptoms: Initially, leaves transition from green to a bronze color. Additionally, necrotic spots may appear along the edges of the pepper leaves, eventually leading to leaf drop.

Management: To counteract phosphorus deficiency, administer phosphate fertilizer (such as fused phosphorus) directly to the root zone. The required dosage varies with the age of the plant:

- For 1-year-old pepper plants: Apply 240g of phosphate fertilizer per pillar annually.
- For 2-year-old pepper plants: Apply 500g of phosphate fertilizer per pillar annually.
- For commercial pepper production: Apply 1,000g of phosphate fertilizer per pillar annually.

Magnesium Deficiency:

Symptoms: The initial signs include the development of yellow streaks on the fleshy areas of older leaves, which gradually extend to the leaf margins. However, the veins retain a blue color.

Management: Utilize foliar fertilizers specifically formulated for pepper plants that contain magnesium. Alternatively, Magnesium Sulfate ($MgSO_4$) can be applied as a spray. For soil nutrition enhancement, incorporate fertilizers that contain fused phosphate.

Calcium Deficiency

Symptoms: The initial signs of calcium deficiency include yellowing of older leaves, with the yellowing beginning at the leaf margins before spreading towards the center of the leaf blade.

Management: During the initial planting phase, apply 1 kg of powdered lime per pillar annually. In the production phase, the application should be reduced to 0.5 kg of powdered lime per pillar annually. For severe cases of calcium deficiency, Calcium Nitrate at a 1% concentration can be sprayed twice, with a 30-day interval between applications.

Iron Deficiency

Symptoms: Primarily affects young leaves, causing them to transition from green to pale yellow or even white in severe cases. A notable symptom of advanced iron deficiency is the shortening of the distance between two segments of the pepper plant, resulting in leaves clustering together.

Management: For acute iron deficiency, spraying with a 0.5% iron sulfate solution 1-2 times may be necessary. Pepper plants experiencing mild iron deficiency often recover without intervention.

Manganese Deficiency

Symptoms: Noticeable on leaves closer to the apex, affecting both young and old leaves which turn a yellow-white color, the veins stay green. In severe cases, small necrotic spots emerge on leaves and gradually spread.

Management: For significant manganese deficiency, spraying leaves with a 0.5% solution of manganese sulfate one to two times may be beneficial.

Boron Deficiency

Symptoms: results in stunted or halted growth. The upper leaves may appear small, curled, and exhibit a yellow-white discoloration across both the leaf and its veins. Additionally, there is reduced branch development and shortened nodes.

Management: To address boron deficiency, applying 10g of Borate per pillar annually is recommended. Spraying pepper plants with specialized foliar fertilizers that contain boron can also be effective.

Annex 4 Factsheet on intercropping

Coffee

Corn

Taro

Benefits of Intercropping:

- Enhances product diversity and mitigates risks associated with crop failure and fluctuations in market prices.
- Boosts income generation per unit of land while contributing to climate regulation.
- Facilitates the production of green manure, thereby improving soil fertility.
- Helps in preventing soil erosion and the loss of topsoil.

Intercropping Techniques with Coffee:

- Implement a pattern of alternate planting, consisting of one row of pepper plants followed by one row of coffee, maintaining a density of 1110 trees per hectare for each crop.
- Alternatively, you can plant one row of pepper between every two rows of coffee. In this setup, pepper plants should have a density of 555 plants per hectare, while coffee maintains a density of 1110 trees per hectare.

Plants Not Recommended for Intercropping:

- Avoid intercropping with plants that share common pests and diseases, such as quick wilt disease and decline disease, to prevent the spread and intensification of these issues.
- Certain plants, including gourds, squash, chili, passion fruit, and tomatoes, are not suitable for intercropping with coffee and pepper due to their susceptibility to similar pests and diseases, potentially leading to exacerbated problems.

Annex 5 Peppercorn pest and disease factsheets.

DISEASES

Phytopthora capsici (Quick wilt disease)

Scientific name

Phytopthora capsici

Common name

Quick wilt disease

Source: PlantwisePlus Knowledge Bank

Symptom

- Plant: leaves on the plant will yellow, wilt, and fall
- Leaves, young shoots and vines: appear black, spreading and necrotic spots
- Underground stems: dark, rotten, slippery and has an unpleasant smell
- Roots: root system will rot, the plant will see poor growth, yellowing leaves

Distribution

- Spread through soil, water, air, insects, people
- Movement of spores in the soil, the raindrops that carry fungus, working tools, the movement of farmers and animals
- Has a wide host spectrum (over 1,000 plants)
- Using infected seedlings, water contaminated with Phytophthora for irrigation

Prevention and Control

Prevention

- Use disease free planting materials
- Prune ground runners and lateral branches up to 1- 1.5 feet from collar area
- Avoid standing water in the field, improve the drainage system

- Avoid splashing of water to the foliage during irrigation
- Remove mulches and keep weed free around the vine base (3 feet diameter) in rainy seasons
- For nursery plant production, obtain rooted cuttings (ground runners) from disease free mother vine gardens

Monitoring

- Look for the following symptoms especially 3-4 weeks after heavy rain on foliage and roots
- Sudden wilting of vine
- Leaf yellowing and black colour patches on the leaves
- Severe shedding of leaves, internodes and spicks
- Rotting and decaying at the collar region, feeder roots and main root

Direct control

- Remove all the affected parts/plants from the field and burn

Slow Wilt

Scientific name

Nematodes Meloidogyne incognita combined with Phytophthora capsici and Fusarium solani

Common name

Slow wilt

Symptom

- Damage to the roots that causes slow growth, yellowing leaves, dropped leaves, branches drop gradually
- Older leaves usually turn yellow first
- Sparse set of foliage
- Flowering and fruiting are poor, and yield is decreased
- The disease often appears in small localized areas
- Symptoms usually develop slowly. The plant dies after a few years.

Distribution

- The disease is spread mainly through planting material (infected seedlings) and infected water source.
- Irrigation in the garden
- Through working tools carrying pathogens
- Nematodes and fungi with a broad host spectrum (across many crops)

Prevention and Control

Cultivation measures

- Destroy severely diseased or dead plants, do not replant immediately
- Do not replant black pepper on coffee or black pepper gardens infected with nematodes, without first rotating with a crop that is not affected by this disease.
- Do not use the land already planted with black pepper to make seedlings
- Using disease-free seedlings for planting

- Plough and dry the soil in the dry season before planting
- Plants should be planted on the live supports
- Intercropping with coffee, fruit plants
- Apply inorganic fertilizer fully, in balance, use organic fertilizer once every 1-2 years
- Limit ploughing, do not overwater on the black pepper garden

Biological measures

- Use nematodes in combination with fungicides as recommended.
- Bio-nematicides: Chitosan, Clinoptilolite, Trichoderma harzianum. Paecilomyces lilacinus, Hirsultela rhossiliensis
- Bio-fungicides: Trichoderma spp., Chaetomium cupreum
- Treated twice: the first time in May- June and the second time in Sep - Oct

Colletotrichum gloeosporoides (Anthracnose)

Scientific name

Colletotrichum gloeosporoides

Common name

Anthracnose

Source: Plant Village

Symptom

- There are large yellow spots on the leaves

- The spots turn brown and gradually black
- Lesions have an irregular shape
- There is a large black halo surrounding, separating the diseased tissue from the healthy tissue

Distribution

- Fungi exist in black pepper and plant residues in the garden
- Infection begins during twig and leaf growth and flourishes thereafter
- Anthracnose is spread mainly by raindrops and wind

Prevention and Control

Prevention

- Systemic fungicides are required to prevent chemicals leaching from the plant
- 1% Bordeaux mixture can be applied during monsoon season
- Metalaxyl and Fosetyl are also effective

Cephaleuros virescens (Red algae disease)

Scientific name

Cephaleuros virescens

Common name

Red algae disease

Symptom

- Lesions usually appear on the upper surface of leaves, fruits and branches
- The wound is round, has a smooth velvet layer
- There is a large black halo in the middle of the body

Distribution

- The fungal mass produces sporangia and releases fungal spores
- Fungal spores are spread by dew or water droplets

Prevention and Control

12 **Cultivation measures**

- There are no varieties resistant to red algae disease
- Algae pruning shade plants to create a clear garden
- Balanced inorganic fertilizer application
- Increase organic fertilizer application
- Adequate watering in the dry season
- Clean the garden, collect the infected leaves, stems, etc., out of the garden and destroy

Tobacco mosaic virus (CMV) (Stunted disease)

Scientific name

Tobacco mosaic virus (CMV)

Common name

Stunted disease

Symptom

- Leaves have areas of light green and dark green or green and yellow
- The leaves are small, wrinkled, brittle, thick with yellow patches/bands
- Leaves are small, distorted, crescent-shaped, or wrinkled
- Black pepper plants grow stunted, drooped on the tops at all stages of development
- The black pepper plant drop leaves and fruits, after that a bare plant
- Plants rarely die but yield is reduced

Distribution

- The disease is spread mainly through planting material (infected seedlings)
- Through working tools (scissors to cut branches, knives, grafting tools carrying virus)
- Types of sucking insects (aphids, beetles, leafworms, especially 2 types of aphids *Toxoptera aurantii* and *Aphis gossypii*)

Prevention and Control

Cultivation measures

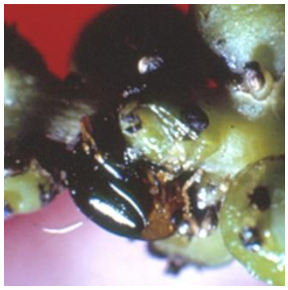
- Do not take cuttings from plants showing symptoms of the virus
- Do not use knives or scissors to prune and graft from diseased plants, then cut to healthy plants
- When the plant is seriously infected, uproot, remove from the garden and burn

Biological measures

- Inspect and destroy stinging insects that are vectors of disease
- Use biological to control insects
- Depending on the type of insects, the biological products used will be different

PESTS

Longitarsus nigripennis (Beetles)



Scientific name

Longitarsus nigripennis

Common name

Beetles

Prevention and Control

Cultivation measures

- Regular pruning from May to June is an important measure to limit beetle populations
- Sanitize the field to remove beetles
- Prune branches for live pillars
- Regularly inspect black pepper garden
- Catch and kill adults
- Collect damaged parts, take them out of the garden and destroy

Biological measures

- Use only on lightly damaged plants
- *Beauvaria bassiana*, *Metarhizium Anisopliae* and *Spathious piperis* are biological control agents
- Hunting spiders help reduce beetle populations
- Applying neem powder at the base will help kill the pupae

Lophobaris piperis (Stem borer)

Scientific name

Lophobaris piperis

Common name

Stem borer

Symptom

- The young borers dig into the shoots and flowers, causing the shoots to wilt
- The upper part of the black pepper stem is broken and the plant dies
- Borers on fruit can cause fruit drop or poor development

Prevention and Control

Cultivation measures

- Sanitize the field to remove pests
- Prune leaves to keep the plant open
- Avoid wounding on trunk and branches
- Regularly check black pepper garden
- Catch and kill adult stem borers
- Immediately cut off the stem and branches that are bored
- Cut damaged stems and branches to kill all larvae and eggs
- Collect damaged parts, take them out of the garden and destroy

Biological measures

- Maintain natural enemies such as: spiders, parasitic wasps, ants, etc.
- *Beauvaria bassiana*, *Metarhizium Anisopliae* and *Spathious piperis* as potential biocontrol agents
- Treat on plants in the morning when they are still wet to increase the effectiveness of the control

Elasmognathus nepalensis (Tingid bug)

Scientific name

Elasmognathus nepalensis

Common name

Tingid bug

Symptom

- Tingid bugs attack flower stalks and fruits, causing drop
- When attacked by bugs, black pepper fruits will grow abnormally
- Sucking young leaves, causing leaves to be necrotic in patches
- Injecting and sucking the buds, causing the buds to fall off

Distribution

- Tingid bugs move from one plant to another

Prevention and Control

13 **Cultivation measures**

- Regularly inspect the garden especially early in the morning for early detection
- Collect damaged parts and destroy
- Weeding to destroy bugs' habitat
- Plant the appropriate density, create airy canopy

14 **Biological measures**

- Maintain natural enemies such as ladybugs, spiders, parasitic wasps...
- Use bio-pesticides from Neem and white *Beauveria bassiana* effective in preventing and reducing the number of bugs

Planococcus spp (Mealybug)

Scientific name

Planococcus spp

Common name

Mealybug

Symptom

- Harmful parts: buds, fruits, young buds, underside of leaves. These parts can not grow, become dry, fall off
- Secretion of sweet nectar causes soot fungus to grow, affecting photosynthesis
- Sucking underground stems and roots, making a wound for the fungus to enter and rot the roots. When it's heavy, there are usually big galls

Distribution

- Young bugs move very quickly. The larger bug, the slower it moves
- Mealy bugs secrete wastes that serves as food for many ants to spread pests
- Mealy bugs are also spread through rainwater, irrigation water, and working tools

Prevention and Control

Cultivation measures

- Inspect the garden regularly for early detection and control Mealy bugs
- Limit planting black pepper on severely damaged areas by Mealy bugs
- Cut off branches close to the ground, clean the field
- Cut off branches heavily affected by Mealy bugs, uproot and burn plants severely infected with Mealy bugs

Biological measures

- Maintain natural enemies such as: red ladybugs, black ants, parasitic wasps, flies
- Only spray plants having aphids when necessary with active ingredients such as: Matrine (extract from gentian) or Rotenone