

African Organic Agriculture Training Manual  
A Resource Manual for Trainers

# ORGANIC CABBAGE PRODUCTION



# IMPRINT

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## **Responsible authors:**

Irene Kadzere (FiBL), Brian Ssebunya,  
Paul van den Berge (FiBL), Gilles Weidmann (FiBL)

**Illustrator:** Deogratus Okudi (Uganda)

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The manual is intended for use by trainers of farmers or other trainers on organic vegetable production with a particular focus on cabbage.

Comments and recommendations for improvement to this version are welcome.

The manual is available free of charge in the internet at [www.organic-africa.net](http://www.organic-africa.net) and can be reproduced without permission. If adaptations are made to this publication to produce training materials which are more context specific, FiBL will appreciate to receive digital copies of these materials.

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## SET OF TRANSPARENCIES

### How to use this Manual

This manual is intended for use by trainers of trainers and trainers of farmers on organic agriculture. The manual highlights approaches to organic cabbage production. It has been developed with the understanding that farmers live in various contexts that may require unique adaptations of these guidelines.

Users may require other references of the Africa Organic Agriculture Training Manual for more guidelines (all available at [www.organic-africa.net](http://www.organic-africa.net)), e.g.

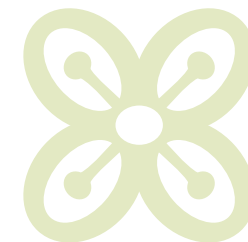
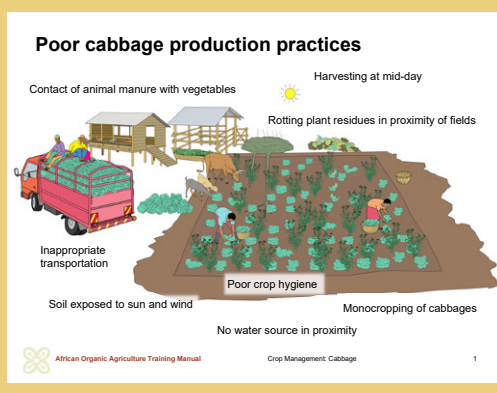
- > Module on definition and benefits of organic agriculture.
- > Module on soil fertility management.
- > Module on pest, disease and weed management.
- > Module on the principles and methods of organic vegetable production.

### Learning targets for farmers

- > Know that organic vegetable production can significantly contribute to small producers' income, especially in peri-urban and urban areas where the domestic demand for vegetables is steadily increasing.
- > Recognise that successful organic cabbage (*Brassica oleracea*) production requires a number of cultivation measures, such as good quality seeds and appropriate varieties, good soil fertility management using well prepared compost including green manures as well as rotations and other strategies, intensive crop management and provision of good quality water for irrigation, as well as good irrigation practices.
- > Appreciate the importance of integrated pest and disease management as well as weed management in organic cabbage production.
- > Understand that diversification in cabbage plots through a proper crop rotation, intercropping, as well as promotion of a diversity of other plants like flowers is very important for successful pest and disease management.
- > Be aware of good postharvest management and possible home-level preservation techniques, particularly when there is excess cabbage production.

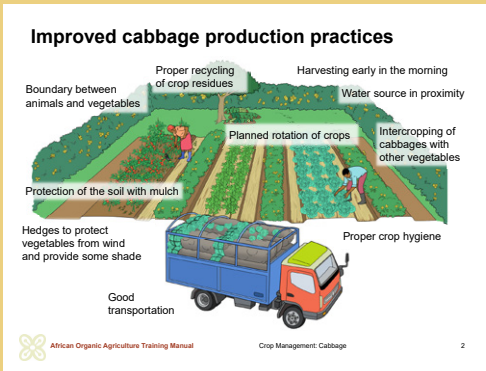


## POOR PRACTICES IN CABBAGE PRODUCTION





## IMPROVED CABBAGE PRODUCTION PRACTICES



## 1. Introduction and production requirements for cabbage

This Training Manual focuses on cabbage production under organic management. Even though the focus is on cabbage, the trainers are reminded that, in organic farming, diversified production is encouraged rather than mono-cropping. It is envisaged therefore, that the cabbages are grown in rotation or in consociation with other suitable crops as explained in the Training Manual. Well planned and well managed crop rotations and mixtures have many benefits to the main crop itself, the soil's health, the farm economy and general environment.

### 1.1 Background and common production challenges for cabbage

The *Brassicaceae* or *Cruciferae* family (commonly known as the Mustard family) to which cabbage belongs includes other vegetable crops such as kale, rape, mustard, broccoli, cauliflower, turnips, brussel sprouts and others.

Cabbages are a rich source of vitamin C and A, and minerals like calcium, potassium, iron and sodium. Cabbages occur in various head shapes (conical, round, flat-rounded or globe), head firmness (hard and loose), colours (green, red, purple, white) and the leaves can be smooth or savoy (with crinkly, lacy or wrinkled leaves). In this training manual, the focus is on the headed type of cabbage.

Brassicas are grown in most African countries, mostly for the local market and for household consumption. Cabbage is one of the economically important Brassicas in sub-Saharan Africa. However, production of cabbages is often constrained by damage caused by pests like insects and nematodes, and diseases. As cabbages are quite commonly grown by farmers, it is clear that the farmers have had different experiences in producing and managing this crop. Trainers can learn of some tips from the farmers, hence an exchange regarding farmer experiences is important.

### 1.2 Production requirements for headed cabbage

#### 1.2.1 Temperature and day length

Cabbages are adapted to a wide range of climates, but grow best in cool humid conditions. The adaptability of cabbage to a wide range of climates makes it an

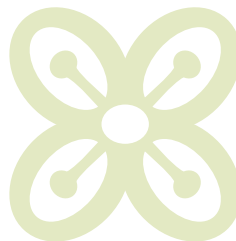
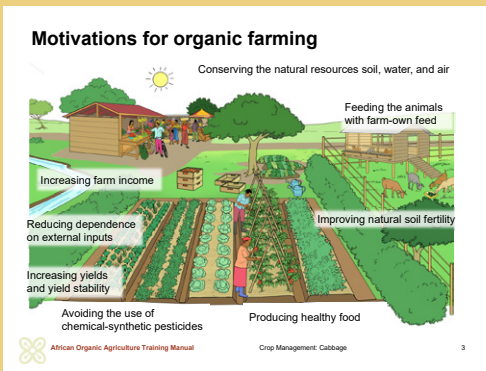


### Exchange of information on types of cabbages

Ask the participants what types of cabbages they grow or are grown in their area and why. Reflect on the different uses of the various cabbage types. Are some more preferred for home consumption and others for sale?



## MOTIVATIONS FOR ORGANIC FARMING





## DIFFERENT TYPES OF CABBAGE

### Different types of cabbage



Green (or white) cabbage

Red cabbage

Photo: Arja Heveger, FiBL

Photo: José Antonio Alba on Pixabay



Savoy cabbage

Chinese (or Napa) cabbage

Photo: Franck Baraki on Pixabay

Photo: yelstan on Pixabay

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## PRODUCTION REQUIREMENTS OF CABBAGES

### Production requirements of cabbages



- **Optimum temperature:** 18 and 20 °C
- **Day length:** neutral
- **Water requirements:** 30 to 40 mm per week (30 to 40 litres per m<sup>2</sup>)
- **Soil requirements:** deep, well-drained loamy, fertile soils with a slightly acidic to neutral pH (about 6 for light soils and 7 for heavier soils)

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important crop all year round in most places. However, production in summer periods is limited mainly by higher incidences of pests and diseases that result in significant yield losses. Production is, therefore, easier during the cool season as this requires less efforts, e.g. for pest and disease control, compared to the summer production.

Optimum temperatures for cabbage growth and development are reported to be between 18 and 20 °C, but the crops can withstand temperatures as low as -3 °C to a certain extent. Cabbage is known to be day length neutral and can be grown throughout the year. Even though cabbages can be grown all year round, their heads are formed best in relatively cool and moist weather conditions.

### 1.2.2 Water requirements

Cabbages are heavy water consumers and store a lot of water in their heads. They have a high water demand and a very shallow root system. This makes regular water supply important for good growth. Adequate water supply is required to prevent drying and cracking of the heads, and development of a bitter taste. A thorough watering should be done to the field before transplanting so that seedlings are transplanted into moist soil.

Once transplanted, the seedlings should be watered regularly until they have retained their turgidity. Once well rooted, irrigation can be reduced to once a week or every second week. In general, cabbages require 30 to 40 mm of water per week (30 to 40 litres per m<sup>2</sup>), but this depends on many factors such as the prevailing atmospheric temperature and relative humidity, wind speed, rainfall received, cabbage growth stage, soil conditions and other factors. Nevertheless, cabbages do not tolerate waterlogged conditions. When the heads are mature, irrigation should be reduced and carefully controlled in order to prevent the heads from cracking. Any heavy rains occurring during the mature stage pose high risks of head cracking. Cracked heads significantly reduce the market value of the cabbages besides providing easy entry points for pests and diseases.

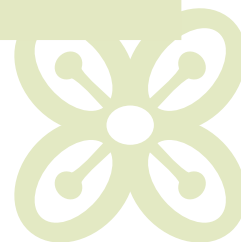


## Sharing of experiences on cabbage production

Ask the participants, how they grow cabbages and which types they grow most. Further possible questions are:

- > What experiences have you made with cabbage production under conventional and organic management?
- > What are your experiences on post-harvest management and marketing of the cabbages?
- > Have you met any challenges with these crops?
- > How have you managed the challenges?
- > Why do you (still) grow these crops?

Note down the answers on a board. You may have a look at the answers after having presented information on organic cabbage production and clarify whether organic production is an option for the farmers.





## CLUB ROOT SYMPTOMS

### Symptoms of club root disease

- Yellowing leaves
- Wilting during hot days
- Stunted growth
- Swollen roots, into thick, irregular club shapes.
- Formation of galls on the roots.
- Eventually rotting of the roots and dying of the plant



Photos: Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org



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### 1.2.3 Soils

Cabbages can be grown in a wide range of soils. However, they perform best in deep, well-drained loamy, fertile soils with a slightly acidic to neutral pH (about 6 for light soils and 7 for heavier soils). They are heavy feeders, hence soil nutrient management and high levels of organic matter are of utmost importance in their production.

When grown in highly acidic soils, cabbages suffer from leaf margin die back and the leaves can turn to a dark colour while other nutrient deficiencies may appear, e.g. purpling of leaves in phosphorus deficient soils. In highly acidic and wet soils, the cabbages are vulnerable to the phytopathogenic soil fungus (*Plasmodiophora brassicae*), which causes club root in cruciferous plants. If soils are too acidic, farmers can add lime to the soil so as to bring up the soil pH to appropriate levels.

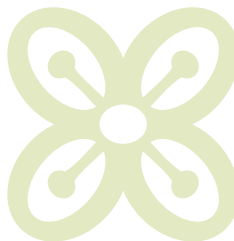
The amount of lime to apply depends on the existing pH of the soil. This can be determined by collecting a representative soil sample of the field and sending it to a soil-testing laboratory for assessing the chemical and other properties of the soil, or by using a simple pH test kit that is based on paper colour changes, or a digital version depending on availability and cost. In the absence of soil testing facilities, farmers can grow a test plant like lucerne, or white clover, which is very sensitive to acidic conditions to check if their soil is appropriate for cabbage production without liming.

Additionally, wood-ashes are alkaline in nature and can help to amend soil acidity. For small areas, farmers can mix ashes with their compost as a source of minerals, and also as an amendment to the acidity where the low soil pH problem exists.

As a general guide, lime can be applied at a rate of 10 to 30 kg per 100 m<sup>2</sup> (0.01 ha). Organic farmers are encouraged to consult with their organic advisory or extension agents, or their certifying bodies before using lime on organic fields.

#### Causes of soil acidity

While some soils, e.g. in high rainfall areas, are naturally acidic, low soil pH is often caused by production practices and other activities applied by humans. In the high rainfall areas, manganese and aluminium are often high in the soils and cause toxicities to the growing cabbages. For example, the cabbages grow thicker roots at the expense of the finer roots that are crucial for water and nutrient







## SOIL PH MEASUREMENT

### Soil pH test kit



Example of a simple set for soil pH measurement. With a small spoon, a little soil is placed on the pH measuring plate and drizzled with 1 ml indicator solution. Depending on the pH value of the soil, the soil sample changes colour to the indicator colour.

Photo: Thomas AT058 (FiBL)



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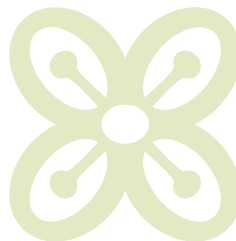
uptake from the soil. Affected plants have impaired nutrient and water uptake with consequent poor growth and development. Besides, some human activities can promote increased soil acidity in soils that are not problematic naturally. Chief among the causes are:

- › Continued and excessive use of nitrogenous fertilisers which cause acidification.
- › Continuous cultivation and removal of key nutrients such as Ca, K and Mg from the soil through harvested edible and non-edible plant parts coupled with no or limited application of organic soil amendments to replenish the soil nutrient contents.
- › Decomposing soil organic matter, especially with large amounts that decompose fast.
- › Acid rain in areas where industrial pollution is high in the atmosphere. When the rain falls, the acidic pollutants are carried down by the rain water into the soil and cause decreases in the soil pH.

### Saline soils and their effects on cabbage production

In general, cabbages are tolerant to saline soils or to irrigation water with an elevated salinity status. When grown in very saline soils, cabbages tend to become more susceptible to the blackleg fungal disease. Saline soils arise from many factors. Some examples include:

- › High salt contents of soil parental rocks.
- › Irrigating cabbages and other crops with water that contains high amounts of salts. After irrigation, the water added to the soil is used by the crop or evaporates directly from the moist soil. The salt, however, is left behind in the soil. If not removed, it accumulates in the soil; this process is called salinisation. Very salty soils are sometimes recognisable by a white layer of dry salt on the soil surface. If the risk of saline irrigation water is high, it is advisable that farmers get their water tested before producing cabbages and other sensitive crops.
- › Growing crops close to the sea where the saline water from the sea can contaminate the fields or plots.





## VARIETY SELECTION

**Variety selection**

- Length of growth (days to maturity)
- Resistance or tolerance to major diseases prevailing in the area
- Suitability for prevailing growing conditions, e.g. soil, temperature and others
- Market availability and target market requirements
- Type of head formed in relation to intended use



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### 1.2.4 Variety selection

A farmer has the option to choose among several types of cabbages – the smooth green leaves, smooth reddish or purple leaves, or the Savoy with crinkled leaves. While some cabbages are hard-headed, others are rather loose-headed as illustrated already in prior sections.

Cabbages also differ in the time they take to reach maturity, i.e. early, mid- and late season. To provide a uniform harvesting stage per plot, farmers should grow the early, mid- or late maturing varieties in separate plots. This also allows the farmer to perform certain management practices like applying ‘top dressing’ nutrients more easily according to the stage of growth. Depending on market availability, farmers can grow all three types so as to extend the harvest and marketing periods.

Apart from the length of growth (days to maturity), in choosing the varieties, farmers are encouraged to consider the following criteria also:

- > Resistance or tolerance to major diseases prevailing in the area.
- > Suitability for prevailing growing conditions, e.g. soil, temperature and others.
- > Market availability and target market requirements.
- > Type of head formed in relation to intended use.

## 2. Soil fertility management in cabbage production

### 2.1 Fertility requirements

#### Feeding the soil and the crop

Crop nutrient management in organic farming follows an approach where the aim is to feed both the crop and the soil. Strategies that improve general soil fertility, and maintain it in the long-term, are key in ensuring sustainability of production and building up resilience, also in vegetable production systems. In planning for the nutrition of organic cabbages, farmers are reminded to feed the crops in such a way that the soils are also fed to keep them fertile, healthy and alive rather than just targeting the crop nutrient demands.

Organic farmers strive to maintain high levels of organic matter in the soil and stimulating high soil biological activity in their farms. Soil microorganisms

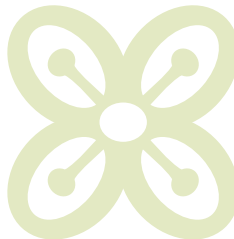


### Sharing experiences on varieties

Ask each participant to share their experiences or knowledge regarding the varieties and types of cabbages they use. How do the different cabbage types and varieties perform?

The participants can bring labelled cabbage seed packages which contain information about specific varieties for the discussions.

Do the farmers' experiences match each other? Try to draw conclusions with the participants on suitable types and varieties for the local area.

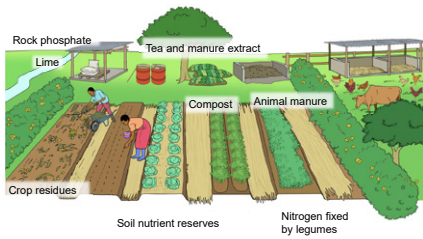






## NUTRIENT SOURCES

### Nutrient sources for fertilisation



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(micro- and macro-flora and -fauna) are important for many processes, including the decomposition of biomass, increasing the availability of soil nutrients by solubilisation of certain nutrients and connecting plant roots to a large soil horizon for better absorption of water and nutrients. Some facilitate better soil aeration, and others increase the plant's capacity to fix own nitrogen, among many other beneficial roles.

### Cabbage nutrient needs

Being heavy feeders, ensuring optimal fertilisation in cabbages is essential for the formation of high quality and firm heads in addition to the prevention of a whole range of physiological disorders. Cabbages need about 160 to 220 kilograms of nitrogen per hectare in about 18 weeks. Related crops such as broccoli and cauliflower need about 220 kilograms of nitrogen per hectare for a good yield during the period of approximately twelve weeks in the field. The nitrogen is supplied through a number of strategies as discussed in the next sections.

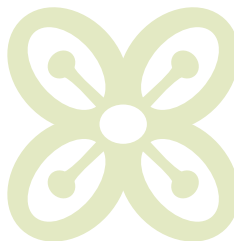
## 2.2 Sources of cabbage nutrition

### 2.2.1 Leguminous and non-leguminous crops and green manures

Some of the most important sources of nitrogen in organic cabbage production are previously grown leguminous crops or green manures. Green manure plants, with their extensive root system, can dissolve nutrients (especially potassium, magnesium and phosphorus) from deeper soil layers through their root excretions and transport them to the root region of the crop plants. Young green manures, with a low carbon to nitrogen (C/N) ratio, are quickly degraded in the soil through decomposition compared to organic materials such as dry maize stalks which contain higher amounts of carbon than nitrogen. The nitrogen contained in these young green manures is thus made available to the following crop in the short term.

#### Timely incorporation into the soil

Ideally, green manures are cut two weeks before their incorporation into the soil and then incorporated with the new growth. If the green manures are incorporated late in relation to the timing of crop planting, repeated shallow tilling will

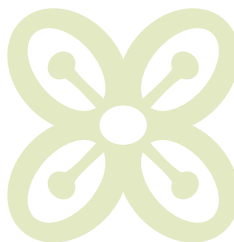


be needed to facilitate the biological decomposition of the materials to release nutrients into the soil early enough for uptake by crops. However, frequent soil cultivation, especially when it is deep, can be detrimental to the soil structure and exposes the soil to the elements such as high sun intensities and erosive wind or rainfall. This can lead to loss of organic matter through some chemical (oxidative) processes and soil loss through erosion. Green manures can be cut down by roller crimpers and left lying flat on the ground. Direct planting, with minimum soil disturbance, can be done by opening up planting holes or ripper lines in the green manure stubble.

### 2.2.2 Crop residues

Depending on the previous crop grown, harvested crop residues can be an important source of nitrogen. When incorporated into the soil, a large proportion of the nitrogen from the crop residues becomes available for the following crop as the residues decompose and release nutrients. Crop residues contain phosphorus, potassium and magnesium, which are also mobilised in large quantities upon decomposition.

It is important for the farmers to know that applying raw crop residues that have a high C:N ratio (like maize stalks) to fields just before planting or transplanting cabbages or any other crops may actually result in negative effects as the soil microorganisms responsible for decomposing the residues will take up available nitrogen from the soil and use it for their energy in breaking down the crop residues. Such a process can lock up nitrogen and make it less available for crop growth in the short term resulting in temporal nitrogen shortages. To reduce this risk, the farmers can mix the high C:N ratio crop residues with some green succulent biomass or poultry manure which can easily breakdown and release nitrogen for use by the decomposition microorganisms as well as the plants in the short term. Otherwise, another solution is to make sure that such materials are well decomposed before applying them to the fields.





## MATERIALS FOR COMPOSTING

### Raw materials for compost production

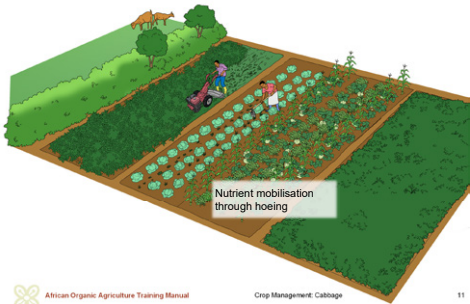


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## AVAILABILITY OF PHOSPHORUS

### Enhancing nutrient availability



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## 2.2.3 Manure and compost

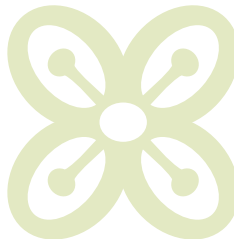
Cabbages benefit well from the application of well-prepared compost and, where farm manure is available, well-rotted manure before planting.

The raw materials for preparing compost include crop residues, farmyard manure, and suitable industrial waste such as coffee residues, slaughter house wastes or rice husks, etc.. Further raw materials include animal manure, grass; tree prunings, and others. For further details on compost making, trainers can refer to the posters and the guidance notes on 'Soil fertility management in organic farming' and 'Good quality compost making', available at [www.organic-africa.net](http://www.organic-africa.net).

Animal manure and compost are primarily suitable as basal fertilisers and suppliers of phosphorus, potassium and, importantly, organic matter, too. They contain nutrients in varying amounts. Poultry and pig manures tend to contain higher amounts of nitrogen compared to compost and farmyard manure. Therefore, the quantities of compost and well decomposed manure to apply must be adapted to the nutrient requirements of the crop as well as the inherent nutrient contents of these organic sources.

In contrast to solid animal manure, animal slurry can be used for top dressing in crops with a long cultivation period such as cabbages. Part of the nitrogen in the slurry is immediately available to plants. An application of 20 tons per hectare of well-rotted manure, or a slurry application (diluted 1:1 with water) of 30 cubic metres per hectare, will cover the basic nutrient needs of cabbages. However, to cover the nitrogen requirement sufficiently, another 80 to 100 kilograms of nitrogen per hectare are necessary from another source such as plant leaf tea extracts or manure tea.

For a more accurate estimation of the quantities of organic inputs to apply, where available, the farmers can send their soil to a suitable laboratory for testing. There are instances where some extension staff have field soil testing kits which can also be used. For larger scale cabbage production, soil testing is recommended before planting in order to get expert advice on the types and quantities of nutrients required for a successful and more cost-effective crop.





## N, P, K CONTENTS OF ORGANIC MATERIALS

### N, P, K contents of selected organic sources

Sources	Nitrogen (%)	Phosphorus (%)	Potash (%)
Saw-dust	0.1	0.2	0.4
Rice husks & hulks	0.3 – 0.5	0.2 – 0.3	0.4 – 0.5
Farmyard manure	0.4 – 0.5	0.25	0.5
Compost manure	0.5 – 0.6	1.5	2.3
Molasses	0.7	–	5.32
Bone meal	3 – 4	15 – 20	–
Poultry manure	3.8	1.5	1.7
Cotton cake (with rind)	4.0	1.9	1.6
Neem cake	5.2	1.1	1.5
Sesame cake	6.2	2.0	1.2
Cotton cake (without rind)	6.4	2.9	2.2

Source: <https://iwagri.in/india/nutrient-content-in-manures-and-fertilizers/>



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## 2.2.4 When to apply manure/compost and liquid nutrient sources

Before planting, depending on the general fertility status of the soil, farmers can add about 2 to 4 kg of well-decomposed compost or manure per square meter of land as a general guide. As cabbages are particularly responsive to phosphorus, the application of rock phosphate is recommended before planting where the soil has a low phosphorus content, or in soils that have a high capacity of binding phosphorus and making it unavailable for plant growth. During growth of the crop, farmers can apply diluted compost tea or extract every 2 to 3 weeks or 3 to 4 weeks to supply more nutrients (and especially nitrogen) to the growing cabbages.

Note:

- The full amounts of potassium and phosphorus should be applied at the time of planting the cabbages while only half of the nitrogen requirements should be applied at planting.
- When the heads begin to form, it is advisable to avoid adding more nutrients to the crop as this might result in rapid growth leading to cracking or splitting of the heads.

## 2.3 Enhancing nutrient availability to the cabbages

### 2.3.1 Nutrient deficiencies in cabbage and their causes

Nutrient deficiencies can arise from many causes, such as e.g.:

- Soils that are inherently low in nutrients will not support successful cabbage growth without significant amendments to the soil. Limited or poor replenishment of soil nutrients after removal by crops diminishes the amounts of nutrients available for subsequent crops grown on that particular piece of land.
- Soils with unsuitable pH limit nutrient availability to cabbages and other plants. Soils with low pH (acidic), high pH (alkaline) and low levels of organic matter reduce the availability of phosphorus and other nutrients. The acidic soils contain high amounts of iron and aluminum which can tie up phosphorus through some chemical reactions. Alkaline or high pH soils contain high



### Sharing experiences on fertilisation of cabbage

Discuss with the participants about their understanding of the phrase 'feed the soil and the plants' as it applies to vegetables such as cabbage and general crop production.

Ask them how and when they apply composts, well-rotted manure or other nutrient sources to the soil in relation to cabbage planting and growth.



## PHOSPHORUS AVAILABILITY

### Availability of phosphorus in relation to soil pH and organic matter content

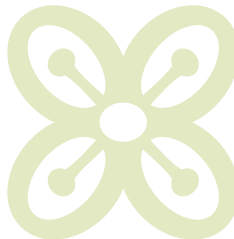
		Organic matter		
		<2 %	2 – 5 %	>5 %
pH	<4.5	very low	low	moderate
	4.5 – 6.0	low	moderate	high
	6.0 – 7.5	moderate	high	very high
	>7.5	low	moderate	high



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levels of magnesium and calcium which can react with phosphorus and reduce its availability for plant uptake.

- › As organic matter is a key source of phosphorus and other nutrients, low levels of organic matter in soils lead to low nutrient availability to plants due to little or no release of nutrients from organic sources.
- › The presence in the soil, in excess amounts or toxic levels of elements such as aluminium and manganese, interfere with the uptake of magnesium, calcium, potassium, and other basic nutrients by the plants.

Like many other plants, nutrient deficiency can result in overall plant stunting and in small and poorly formed cabbage heads.

### 2.3.2 Why splitting nitrogen application to cabbage is important

The nitrogen requirements and demands increase as the cabbage crop grows, until a certain maximum point. The application of nitrogen, therefore, must be synchronised with the cabbage nutrient demands.

Too much nitrogen applied at planting or during the early stages of growth can result in losses through leaching, particularly in sandy soils, as the young seedlings are not capable of utilising a lot of the nitrogen available at that time. Additionally, the demands from the newly planted seedlings is lower than at a later stage of growth, e.g. when the heads begin to form.

### 2.3.3 Enhancing nutrient availability through hoeing

Vegetable crops like cabbages, root crops, and others that have a long growing period respond well to regular hoeing. Hoeing in the cabbage crop helps to bring air into the soil. The air enhances microorganism activity and, in the process, helps to mineralise nitrogen from the organic matter and other sources in the soil and make it more available for plant uptake. Depending on the fertility of the soil and organic matter present, hoeing can help to mineralise up to 25 kg N per hectare, thus contributing to the cabbage nutrient needs.

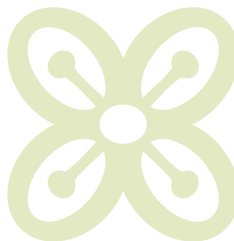
A loose soil surface also improves air exchange between the soil and the atmosphere while reducing water evaporation from lower soil horizons and hence



#### Sharing experiences with soil fertility and nutrient management

Ask the participants to share their experiences or knowledge regarding soil fertility and nutrient management in cabbage production. Discuss some specific issues such as performance of the cabbages in different soil types and fertility regimes.

Find out some of the key challenges encountered in cabbage fertilisation and how the farmers address these bottlenecks.



reduces the need for irrigation. Good water availability in the soil is important for many functions, including the transportation of nutrients to the root zone where the plants can take them up readily.

Ridging up the soil around the cabbage stems allows for secondary root-growth and consequent additional nutrient uptake. Ridging also gives the plant more stability and reduces weed-infestation on the space between the cabbage rows. Regular deep cultivation should be avoided due to the reasons presented in earlier sections.

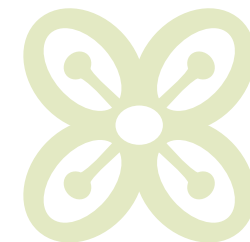
#### **2.3.4 Importance of water and soil air in nutrient availability**

Moisture stress on cabbages, like on other plants, affects growth and development. One way through which growth is affected, is the limited supply of nutrients to the plants. Many nutrients which are crucial for plant growth and development dissolve in soil water and are carried to the root zone where the plants can absorb them through their roots. When moisture is limited in the soil due to prolonged droughts or a lack of irrigation, fewer nutrients can reach the plant roots. During periods of prolonged droughts, applying irrigation helps to ensure sufficient soil moisture and thus improves the supply of nutrients to plants.

##### **Reduced nutrient availability in case of waterlogging**

On the other hand, heavy rains or excessive irrigation wets and compresses the soil and disturbs the water and air balance in the soil as the water drives out the air from the soil pores. This reduces mineralisation, or the release of nutrients from soil sources such as organic matter, and thereby limits nutrient availability to the plant roots.

When water logging continues in the soil, another mineralisation process, called anaerobic mineralisation, occurs and causes gaseous nitrogen losses and plant-toxic compounds to be produced in the soil. The waterlogged conditions also reduce the amount of air at the root zone and makes the roots less active in their capacity to absorb nutrients. Besides, heavy watering or heavy rains can lead to washing out (leaching losses) of nitrogen that has already been mineralised in the soil before the wetting. All these problems highlight the importance of good soil water management in order to facilitate good cabbage growth.

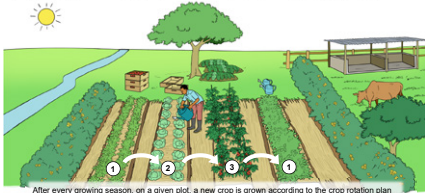






## PLANNING OF CROP ROTATION

### Cabbage in rotation with other vegetables



After every growing season, on a given plot, a new crop is grown according to the crop rotation plan

- 1 Green manure or legume crop  
e.g. velvet bean, sunhemp, bean or pea
- 2 Heavy feeder  
e.g. cabbage, broccoli, kale, spinach
- 3 Medium or light feeder  
e.g. tomato, pepper, potato, carrot, onion
- 4 Green manure or legume crop  
e.g. velvet bean, sunhemp, bean or pea



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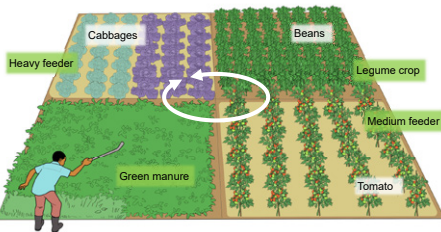
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## EXAMPLE OF A 4-YEAR ROTATION

### 4-year rotation with cabbage



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## Strategies for reducing the impacts of waterlogging in cabbage production

Good drainage is important to avoid waterlogged conditions. Additionally, reducing soil compaction through hoeing or shallow cultivation can also help to aerate the soil and improve the living conditions for microorganisms that are key for decomposition and other processes which release nutrients into the waterlogged soil.

Another strategy is to apply easily mineralisable nutrient sources to the soil, for example high quality green manures, plant tea extracts etc., to supply 20 to 30 kg N per hectare which can then stimulate the soil microorganisms to act and mineralise more nutrients from the soil.

## 3. Rotating and mixing cabbages with other crops or plants

### 3.1 Crop rotations in cabbages

As a rule, cabbages must not be grown after another cabbage crop nor another Brassica crop as this will perpetuate pests and diseases. Being heavy feeders, cabbages are ideally planted after a light feeder or a legume crop in a rotation sequence to avoid nutrient depletion. The cabbages should be rotated with vegetables from other families like carrots, different types of peas, beans, tomatoes, onions, pumpkins, and other crops.

#### 3.1.1 Cultivation break between cabbages to restore soil fertility

In order to quicken restoration of soil fertility after a cabbage crop, farmers can plant legume green manures or food legumes. These can grow relatively well with little soil nutrients as their roots can fix nitrogen from the air, to varying extents depending on the type of legume and prevailing growing conditions, for their use. This nitrogen can be used by neighbouring crops in the sample plot, or by subsequent crops.

If farmers have adequate land to practice full season rotations, then the non-food green manure crops should form part of the rotations in order to improve soil fertility through nitrogen fixation and by releasing nutrients when they are decomposed. These plants also contribute to the organic matter content of the

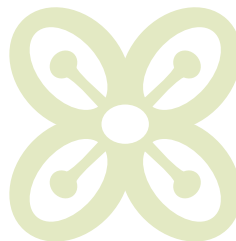


## Discussion on crop rotation and intercropping

Discuss the prevailing production practices on cabbage relating to rotations and intercropping and the reasons for this. You may ask the following question:

> Which crops are commonly used in rotations and which ones are commonly used in intercropping?

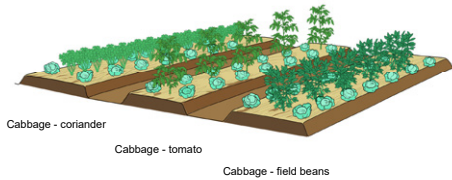
Discuss why these crops are used in cabbage rotations or intercropping. Find out if there are any key challenges faced by farmers in implementing crop rotations and intercrops involving cabbage.





## EXAMPLES OF INTERCROPS WITH CABBAGE

### Examples of intercrops with cabbage



Cabbage - coriander

Cabbage - tomato

Cabbage - field beans



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soil. Farmers with livestock can use some of the green manure legumes in supplementary feeding to their livestock and benefit from the improved quality of both the animals and the manure produced.

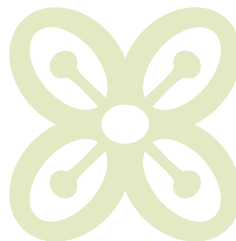
### 3.2 Intercropping cabbages with other crops

Cabbages can be grown simultaneously with other crops for synergies. Experience from some farmers indicate that beetroot, bush beans, celery, mint, onion, potato, oregano, chamomile, sage and asparagus are examples of good companion crops for cabbage. Aromatic plants like onion, celery and herbs are reported to help deter some cabbage pests, but this is subject to intensity of pest attack, use of other preventive measures, among other factors.

Intercropping cabbage with certain crops can increase production and economic returns, for example, growing cabbage with onion in India was found to increase economic returns to farmers. On the other hand, not all crops are suitable for intercropping with cabbage. Other farmers suggest that crops like strawberries, tomatoes, dill, climbing beans, etc. are less suited for intercropping with cabbage.

In suitable environments, clover can be planted between cabbage plants and acts as a live mulch. Such live mulches are beneficial in nutrient and moisture management. The live mulches can reduce certain pests, especially those that lay their eggs in the soil as the mulches will interfere with normal pest development cycles. In the presence of the living mulch, the pests will find it more difficult to reach the bare ground or soil to lay their eggs.

Farmers' own experiments and observations are the best sources of information regarding what works well and not for their situation in terms of intercropping. Trainers need to encourage farmers to be their own researchers and try out different plant combinations on small plots and deduce their own conclusions. Exchanges among the farmers can help them to learn from each other and to avoid reinventing the wheel.





## SEED QUANTITIES, GERMINATION AND PLANTING DISTANCES

### Seed quantities, germination and planting distances

	Chinese cabbage	Kale	White/red cabbage	Broccoli	Cauliflower
Thousand kernel weight (TKW)	3 to 4 g	3 g	3 to 4 g	2.5 to 3 g	2.5 to 4g
Seed requirement for transplanting	2 to 4 g/a	1 g = 180 plants	1 g = 100 to 150 plants	1 g = 100 to 150 plants	1g = 150 plants
Seed requirement for direct sowing	4 to 7 g/a	15 g/a	3.5 to 6 g/a	-	-
Sowing depth	2 cm	1 cm	1 to 2 cm	1 cm	1 cm
Germination temperature	18 to 22 °C	15 to 20 °C	18 to 20 °C	15 to 20 °C	15 to 20 °C
Germination duration	4 to 6 days	5 to 10 days	6 to 10 days	6 to 10 days	6 to 10 days
Planting distance (between rows / in the row)	35 cm / 30 cm	40 cm / 40 to 70 cm	40 to 60 cm / 50 to 80 cm	50 cm / 40 to 50 cm	50 cm / 50 to 60 cm



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## HOT WATER TREATMENT

### Seed hot water treatment for disease control

This treatment is useful to control seed-borne diseases like *Alternaria* leaf spot, bacterial leaf spot, black leg and black rot.

- Heat some water in a good sized pot to 50 °C.
- Wrap the seeds in a clean piece of cloth and immerse them into the water at the recommended temperature.
- Maintain the temperature and leave the seeds in the water for 25 minutes. Then cool the seeds in cold water for 5 minutes.
- Spread the seeds on a clean and dry piece of cloth or paper, and allow to dry before storage. Or sow immediately.



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## 4. Raising cabbage seedlings

### 4.1 Selecting a site for raising the seedlings

A well-drained site with fertile soils is best suited for a nursery for cabbages. The site must not have been planted with cabbages or other brassicas over the past 3 to 4 years. If the risk of soil pests and diseases is high, the nursery site should be treated through solarisation to kill pests and diseases. The site must be well protected from harsh environmental conditions and all types of pests – large and small animals, insects, etc.

### 4.2 Seed quantities and pre-treatments

About 5 to 6 grams of cabbage seed will produce enough seedlings to plant 100 m<sup>2</sup> (or a 10 m x 10 m plot), although quantities as low as 4 grams can also be adequate depending on the variety, germination percentage (consider seed viability), and plant spacing within and between rows.

#### Seed pre-treatment

Before sowing, it is important to soak cabbage seeds in hot water of about 50 °C for 25 minutes to control seed-borne diseases like black rot. Treating the seeds with *Trichoderma*, 5% solution, followed by drying under shade before sowing protects the seeds against some fungal diseases. The genus or group *Trichoderma* contains fungi commonly found in soil and have some antagonistic effects to disease causing soil borne fungal pathogens including *Fusarium* (wilts), *Rhizoctonia* (root rot), *Sclerotinia* (blight), and *Pythium* and *Phytophthora* (damping off). The *Trichoderma* fungal strains protect the cabbages by colonising the plant roots and hence prevent the pathogenic fungi from reaching the cabbage roots. The *Trichoderma* strains also grow in areas around the root zone (rhizosphere) and inhibit the growth of the pathogenic fungi, hence protect the cabbages and help to increase yields due to enhanced plant growth and reduced field losses.

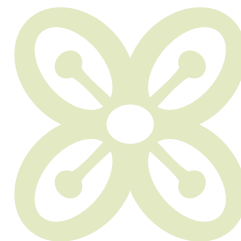
Farmers can purchase *Trichoderma* products from nurseries and other outlets where available, depending on the organic biocontrol regulatory restrictions in specific countries. Farmers can check with the extension agents if *Trichoderma* is available locally, and also seek for information or instructions on its proper use.



## Discussion on seedling production

Discuss with the participants about the main methods used to raise cabbage seedlings in the area.

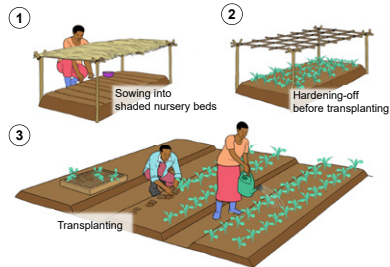
What are the key advantages and disadvantages of the different methods? Discuss also the timing of sowing and management of the seedlings before transplanting.





## SEEDLING PRODUCTION IN NURSERY BEDS

### Seedling production in nursery beds

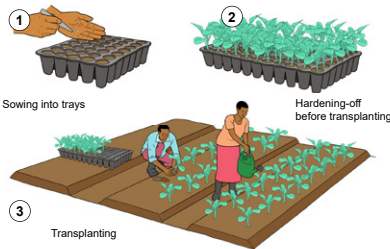


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## SEEDLING PRODUCTION IN TRAYS

### Seedling production in trays



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## 4.3 Preparing seedbeds and/or containers for sowing

Preparing the nursery beds involves digging up the soil carefully and ensuring a fine tilth. The seedbed can vary in size depending on the area to be transplanted, but the width of beds should not exceed one meter to enable easy access and nursery operations.

### Promoting seedling growth

To promote good seedling growth, chicken manure tea or leaf tea can be applied at a rate of 0.5 litres per nursery bed (measuring 1 m x 1.2 m) at about 2 weeks before sowing. Different types of containers, ranging from suitable home-made ones (tins, buckets, boxes, old tyres, etc.) to commercially available types like speedling trays, can be used for raising cabbage seedlings.

The seeds germinate after about 4 to 7 days depending on the prevailing environmental conditions including soil temperature. The soil temperature range in which cabbages can germinate well is 10 to 29°C. In cool areas, planting in cold soils towards the end of the cold season can delay germination, hence farmers can choose a warm nursery area, or better germinate the seeds indoors in trays to speed up germination. In hotter areas, farmers ought to germinate the seeds under shade to reduce damage from high temperatures and sun intensities. Cabbage seedlings are ready for transplanting within about 3.5 to 6 weeks after seed sowing. At this stage, the seedlings have 5 to 6 true leaves.

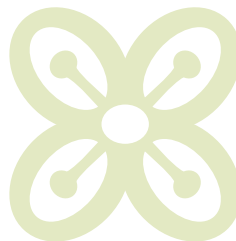
## 4.4 Sowing the seed

Cabbage seeds are small and, therefore, care is needed to avoid deep sowing that might interfere with germination and emergence. Seeds should be sown in nursery beds, containers or trays at 1 to 2 cm depth. Shallower depth of 0.5 cm bears the risk of exposure to the sun, irregular moisture cycles and higher germination losses due to pest damage when the seed is consumed before germination. The spacing for sowing should be 4 to 5 cm within a row in rows of 10 cm apart.



### Sharing experiences on sowing

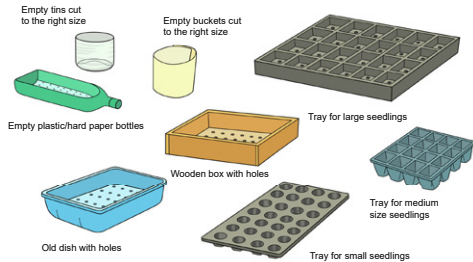
Discuss with the participants how farmers sow cabbage seeds. Reflect on choices of areas or containers used to raise the seedlings, timing of seed sowing, nursery preparation and management. Discuss the reasons behind their choices and practices.





## SEEDLING CONTAINERS

### Examples of containers for seedling production



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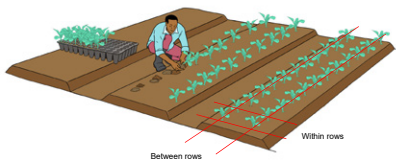
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## FIELD ESTABLISHMENT

### Field establishment



	Chinese cabbage	Kale	White/red cabbage
Distance between the rows	30 cm	40 to 70 cm	50 to 60 cm
Distance within the rows	35 cm	40 cm	40 to 60 cm



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## 4.5 Preparing cabbage seedlings for transplanting

Like tomatoes, hardening of the cabbage seedlings is recommended before field transplanting. This can be achieved by reducing watering for 1 to 2 weeks before transplanting in order to toughen and acclimatise the seedlings to the field conditions when they are transplanted later. Watering should be minimised to levels which prevent the seedlings from wilting. If seedlings have been raised in containers under shelter, they should gradually be exposed to direct sunlight conditions during the hardening process and brought back into the shelter at night if harsh conditions prevail.

## 5. Field establishment and management requirements

### 5.1 Field preparation

Cabbages must be transplanted into a well-prepared field. The plot or field needs to be dug and leveled to a fine tilth well before transplanting time. In areas that are prone to waterlogging and heavy rainfall, cabbages are best transplanted into raised beds.

When soils are too acidic, lime can be applied at a rate of 10 to 30 kg per 100 m<sup>2</sup> (0.01 ha) as a general guide. As indicated already, farmers who aim to have more accurate estimates of lime quantities to apply can send their soils for testing by a suitable laboratory or obtain soil pH testing from the local extension agents if the facilities exist. It is always a good idea to check with certification agencies if the type of lime to be used is permitted in certified organic agriculture.

### 5.2 Field spacing and transplanting

#### Appropriate field spacing

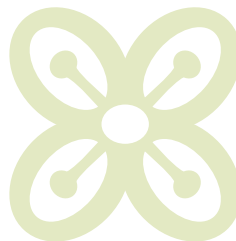
The recommended field spacing for cabbages ranges from 45 to 60 cm between rows, and from 30 to 45 cm between plants in a row. But, the spacing can vary depending on the type of cabbage and of intercrops to be planted with the cabbages. At the spacing stated above, a farmer can grow about 370 to 740 cabbages per 100 m<sup>2</sup>, i.e. 37,000 to 74,000 cabbages per hectare. Cabbage varieties with large



### Discussion on transplanting

Invite the participants to discuss about field transplanting of cabbages. Present the following questions:

- > What are the key challenges that you face during transplanting and the few weeks after seedling transplanting into the field?
- > How do you solve the problems, if any?
- > Do you practice any seedling hardening before transplanting into the field?
- > How do you protect the seedlings from the elements (wind, sun, water)?

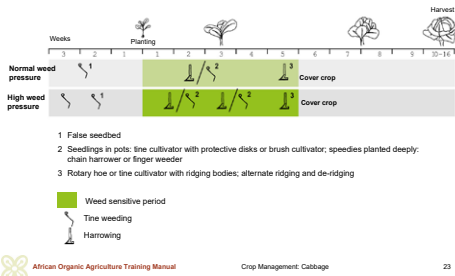






## WEED MANAGEMENT

### Mechanical weed management strategy



heads and/or late maturity require more space for growth (60 cm between rows and 45 cm in-row plant spacing). The higher populations are for early maturing varieties or those that are small headed.

### Transplanting

Transplanting is best done in the evening, or on a cool cloudy day, to protect the seedlings from the scotching sun during the early days after transplanting. If farmers wish to have a continuous harvest, they can stagger sowing and field planting at two-week intervals within the production season. Alternatively, they can plant different varieties of cabbages which mature at different times. This assures longer availability of the cabbages for household use and/or sale while also enabling the farmers to target certain market windows.

During growth, if cabbages are exposed to chilling conditions (around 1.5 to 7°C) when the stems are pencil thick they may bolt (initiate flowering) and fail to form heads. Therefore, it is recommended that seedlings are not exposed to such conditions at the sensitive stage. The tendency to bolt in cabbages can vary according to varieties. Farmers should be aware of this risk in the context of their own growing conditions even though cabbages are known to be adapted to a wide range of growing conditions.

## 6. Weed management in cabbages

The organic farming regulations do not allow chemical weed control through herbicides. Planting into a weed-free seedbed is important for good cabbage establishment and growth in organic production.

### Weed regulation before transplanting

Farmers are encouraged to prepare the planting beds well before transplanting (2 to 4 weeks before transplanting) and irrigate them to promote weeds to germinate. In case of high weed pressure, a shallow cultivation (3 to 5 cm deep with a harrow or rake) is done every 7 to 10 days to control the germinated weeds before transplanting. This technique is called the 'false seedbed'. Each instance of mechanical cultivation stimulates the germination of new seeds. Deeper cultivation to control the weeds will not only encourage loss of carbon from the soil,

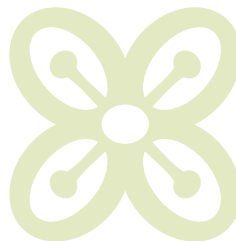


### Discussion on weed management

Discuss weed management throughout a cabbage season. When are cabbages most and least sensitive to weed competition?

Discuss which weeds are problematic in cabbage production in the area. Besides hand weeding, are there other techniques which farmers can use to control and manage weeds?

Discuss the challenges and possible solutions.





but also promote even more weeds to germinate when the cabbages are growing and should be avoided.

### **Weeding after transplanting**

As cabbages normally develop a shallow root system, care must be taken to avoid damage to the roots with weeding implements after transplanting. For organic farming, flaming (killing weeds with a controlled fire flame), steam or hot water treatment can be used in place of herbicides to control the initial weeds before transplanting. During cabbage growth, weeds can be removed by hand weeding or mechanical cultivation. Since cabbages are generally slow growing, they take time to cover the ground and this gives space for weeds to grow, hence a good control strategy is required.

Crops differ in their sensitivity to weeds and do not necessarily need to be kept free of weeds for their entire growth cycle. However, most crops, including cabbage, are most sensitive to weed competition when they are immature. During this susceptible stage, they must not face competition from weeds. As a general rule, cabbages should be kept free of weeds during the first half of their cultivation period. However, weeding may have to be repeated towards the time of harvest to control key late weeds such as blackjack as these may interfere with harvesting and packing of the cabbages. Not all late weeds need to be controlled and the farmers can make their own decision depending on the severity of the weeds and their possible interference.

To reduce future weed problems, farmers should try as much as possible to prevent weeds from setting seed in the first place. However, some seeds can remain viable in the soil for many years, hence the long-term control of weeds is important to reduce accumulation of such seeds in the soil.

## **7. Irrigation and moisture conservation**

### **Water demand of cabbages**

Water is one of the most important inputs to cabbage production considering the crop's high water demand and shallow root system. The soil must be kept moist, but not wet or soggy as this causes rotting of the plants. Dry soil conditions during growth can stimulate the cabbages to go into flowering and prevent them from forming heads, or causes them to develop a bitter or tart flavour. The

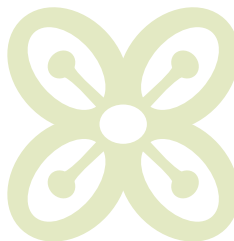


### **Sharing experiences with irrigation**

Ask the participants to share their experiences or knowledge about cabbage water requirements and irrigation practices.

- › Which methods of irrigation do you use, and why?
- › Are there problems with soil salinity resulting from irrigation? How are you addressing this?

Allow the farmers to explore and converse about water saving techniques that they use or know of in vegetable production in general.





## SPRINKLER OR DRIP IRRIGATION?

**Irrigation of cabbage**

	Drip irrigation	Sprinkler irrigation
<b>Advantages</b>	<ul style="list-style-type: none"> <li>Very high irrigation efficiency</li> <li>Lower investments than for mini-sprinklers</li> <li>Low labour requirement</li> <li>Minimal water losses through evaporation or percolation</li> <li>Irrigation possible at any hour during the day</li> <li>Low fungal disease pressure because of dry canopy</li> </ul>	<ul style="list-style-type: none"> <li>Suitable for light soils</li> <li>Suitable for sloping or uneven fields</li> <li>Can be used to reduce ET by reducing leaf temperature</li> </ul>
<b>Disadvantages</b>	<ul style="list-style-type: none"> <li>Clogging of emitters by algae, bacterial slime or sediments possible</li> <li>Root zone restricted to the wetted area</li> <li>Sub-optimal wetting pattern in light soils</li> <li>Needs an efficient filtering system</li> <li>Salt accumulation in the border zone between dry and wet soil</li> <li>Drip lines hinder mechanical weeding</li> <li>Subsurface drip systems: maintenance difficult and costly</li> </ul>	<ul style="list-style-type: none"> <li>Big droplets can damage the soil structure (especially from rain-guns)</li> <li>Requires high capacity pumps and pressure-walled piping</li> <li>Risk of increased disease pressure in over-canopy irrigation</li> <li>Uneven water distribution pattern</li> <li>Water loss through drift, evaporation and irrigation of unproductive areas</li> <li>Use of clean water only to avoid soiling</li> <li>High energy requirement</li> </ul>

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aim is to maintain a consistent water supply to the cabbages to prevent irregularities in soil moisture and crop growth.

### Suitable irrigation systems

Sprinkler irrigation, furrow irrigation or the more efficient drip irrigation system, are suitable for cabbage production. Drip systems can vary from simple versions which are manually operated to sophisticated automated types. Many small-holder farmers use the hand watering methods due to limited capacity or possibility to install other types of irrigation.

Drip irrigation is considered the most efficient type of irrigation. It has the advantage of conserving moisture and reducing incidences of leaf diseases, e.g. Alternaria leaf spot, which thrives in moist conditions. However, it has limited wetting to the soil, and sometimes farmers translate this to be a lack of sufficient water to the crop and may prompt the farmers to continue applying water. In sprinkler systems, water losses can occur through drift, evaporation and irrigating of areas outside the rooting zone.



## CRACKING OF CABBAGE

**Cabbage head cracking**

Cracked cabbage head due to irregular or too much water supply, or heavy rains during late growth

Photo: Irene Kadzere, FiBL

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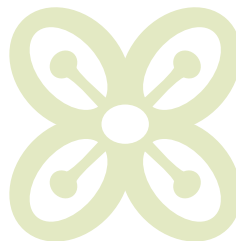
### Reduction of water evaporation

Farmers can apply a thin layer of mulch to the cabbage field to reduce water evaporation from the soil. Hygiene should be observed when mulching to avoid using diseased or pest infested plant residues. The mulches must also be free from chemical and other contaminants that are problematic in organic management.

### Suitable water quality

The water used for irrigation should be acceptable for organic production. It should be free from biological and chemical (including heavy metal) contaminants. Additionally, the salt content of the water should be within acceptable levels to avoid the build-up of soil salinity.

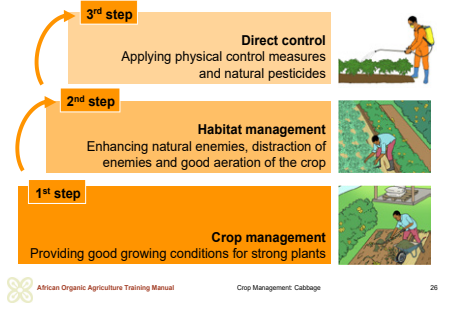
The best for certified organic farmers is to consult with their organic advisors or certifiers to assure compliance regarding irrigation water quality and types of mulches that are compatible.





## APPROACH TO PEST AND DISEASE MANAGEMENT

### 3-step approach to pest and disease management



## 8. Cabbage diseases and pests management in the field

In organic production, farmers are encouraged to apply a variety of innovations and interventions for plant protection which take into consideration the health of soils, humans, plants and the environment. Good hygiene and an integrated approach to pests and diseases management are, therefore, very important. Like for other crops and animals, organic cabbage plant health management follows a similar approach to human health management.

The first line of defense is prevention – and so goes the saying that prevention is better than cure. This is because relying on direct control measures can be costly, and sometimes not fully effective depending on timing, intensities, effectiveness of the direct control measures and some external factors such as climatic conditions. Overall, the pest and disease management strategy should follow the three-step approach as illustrated.

### 8.1 The key components of the 3-step approach to pest and disease management

#### Step 1: Apply good crop management and field hygiene practices such as:

- > Use of tolerant or resistant varieties.
- > Ensure adequate and balanced nutrient supply and ensure good soil health.
- > Remove and destroy highly or heavily pest infested and disease infected plants from the field.
- > Maintain a planned crop rotation with recommended intervals between crops of the same family to avoid build-up of pests and diseases.
- > Plant crops on a spot that provides adequate conditions (sun/shade; soil type; water supply, etc.).

#### Step 2: Habitat management

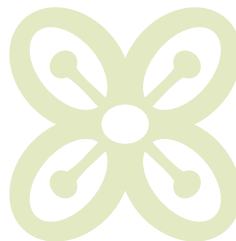
- > Ensure timely and effective weed management during the weed-sensitive periods of the crops.
- > Companion cropping using plants that can deter pest insects, but are not hosts to pests of other crops. Certain companion plants, such as cornflower (*Centaurea cyanus*), can be a host to natural enemies and help to reduce the



### Discussion on disease management

Discuss and document all the techniques and practices used by farmers to deal with these major diseases.

- > What are the most important cabbage diseases prevailing or observed in the area?
- > Which varieties do farmers grow to avert this problem?



pest-population. Others can act as pest traps and rather attract pests and reduce pest populations on the crop.

### Step 3: Direct control

- › Biological control where organisms like fungi are used to kill insects, or to antagonise pathogenic fungal strains.
- › Predation/parasitism where natural enemies (e.g. *Trichoderma*) are used to feed on or antagonise the insects.
- › Botanicals: use of plant extracts to kill pests.
- › Traps which attract insects by an attractive colour, food smell or a pheromone – attracted insects either stick to the trap (glue) or drown in a liquid.

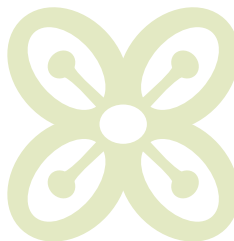
For further details on this approach, the trainers can refer to the Module on ‘Pest and Diseases Management in Selected Crops’ of the African Training Manual and other resources such as the Infonet Biovision.

### Regular monitoring

Organic farming entails regular observation of the crops throughout the crop production cycle – from sowing or seedling production to harvest. Besides looking at the general aspects of crop growth like nutrition and water requirements, regular attention needs to be given to pest and disease appearances, and, during weed-sensitive periods of a crop, to weed development. For proper pest and disease monitoring, it is essential to be able to identify pests and diseases, and to differentiate pests from beneficial insects, to distinguish pest damages from disease symptoms, and to differentiate pest or disease damages from nutritional problems or physiological disorders.

Regular monitoring for pest and disease occurrences allows for early detection of pests and diseases, and thus easier control in initial stages. Some pests like cutworms and other insects can do a lot of damage in just 1 or 2 days, therefore prompt action is required when the scouting exceeds threshold levels necessitating direct control.

When scouting for caterpillars and aphids in cabbages, attention should also be given to the presence of parasitised aphids (mummies) and larvae of the whitefly, and the presence of natural enemies such as ladybird beetles, hoverflies, lacewings, and braconid wasps. Since aphid populations are often clustered, all portions of the field and plants should be checked.





## DAMPING OFF DISEASES

### Damping-off diseases

(*Pythium*, *Rhizoctonia* and *Alternaria* species)



Photo: Mary Ann Hansen, Virginia Polytechnic Institute and State University, Bugwood.org

<b>Symptoms</b>	<ul style="list-style-type: none"> <li>Wilted plants which turn purple and die.</li> <li>Emerging seedlings collapse.</li> <li>Plants often without lateral roots.</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>Caused by several different fungi and fungus-like organisms.</li> <li>Often favoured by cool, wet conditions that slow germination and seedling growth.</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>Soil sterilisation through solarising or other heat treatments.</li> <li>Use of healthy seed and seedlings.</li> <li>Use high-quality compost only.</li> <li>Clean growing containers carefully.</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>Ensure optimum growing conditions (optimum temperature, even humidity, sufficient ventilation).</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>Rogueing off and destroying infected cabbages and volunteer crops or host weeds.</li> </ul>

## 8.2 Some of the common cabbage diseases and their control

Many diseases affect cabbages. These include black rot, early blight, and downy mildew among many. Preventive measures can help farmers to control the diseases and reduce damage and loss. Effective disease preventive measures in cabbage production include:

- › Use of disease-free planting material (seed and seedlings).
- › Practicing proper rotation with vegetables that are not members of the Brassicacea family for at least 2 to 3 cropping seasons. If brassicas are inevitably recurrently grown in the crop rotation, it is better to switch between types (e.g. cauliflower, kale, broccoli).
- › Ensuring proper field sanitation: diseased plants are removed and destroyed before they infect others, good hygiene (e.g. washing/cleaning hands and equipment or tools) should be observed at all times.
- › Controlling for vectors of disease pathogens – for example aphids transmit various plant viral diseases. Controlling for aphids, as well as other sucking pests, thus reduces direct losses caused by these pests and the indirect losses from damage by the transmitted diseases.
- › Permitted plant strengtheners can be sprayed onto the cabbages to increase their natural defense mechanism against disease infection.

Direct control measures are possible when diseases occur, but these are not always totally effective. Examples of direct control measures for selected diseases are provided in this section together with other strategies for pest and disease management. Further details on pest and disease control can be found in Module 4 of the African Organic Agriculture Training Manual and other sources.

### 8.2.1 Fungal diseases

**Damping off diseases** (*Pythium* species, *Rhizoctonia* species, *Alternaria* species)

Type of damage or symptoms:

- › Affected plants become wilted, turn purple and die. Often, these plants have no lateral roots as a result of the damage by the diseases. Damage to the roots prevents them from their key function of absorbing and transporting water and nutrients.

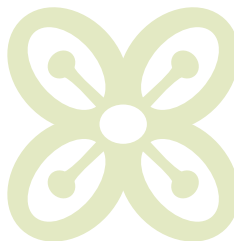


### Discussion on disease management

Ask the participants the following questions:

- › What are the most important cabbage diseases prevailing or observed in the area?
- › Have the farmers stopped growing cabbages due to severe disease attacks? Which varieties do farmers grow to avert this problem?

Discuss and document all the techniques and practices used by farmers to deal with these major diseases. Also, find out if farmers are aware of the seed hot water treatment method to control many bacterial and some fungal and viral diseases.





## CLUBROOT

### Clubroot

(*Plasmodiophora brassicae*)



Early symptoms on roots.  
Photo: Astrid Odenberg



Photo: Raabak, Wikipedia

<b>Symptoms</b>	<ul style="list-style-type: none"> <li>Stunting and wilting</li> <li>Infected plants turn purplish</li> <li>The roots form swellings which produce a foul smell when rotting.</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>The disease is aggravated by acidic soils and poor drainage.</li> <li>The spores can last for up to two decades in the soil.</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>Use of well drained sites</li> <li>Liming of acidic soils to increase pH</li> <li>Soil solarisation</li> <li>Planned crop rotation with recommended cultivation breaks between brassicas</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>Good irrigation management avoiding waterlogging</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>Removal and destruction of affected plants</li> </ul>



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### Suggested control measures:

- › Using healthy seed and seedlings.
- › Soil sterilisation through solarising or other suitable heat treatments.
- › Covering sown seeds with good quality compost or other relevant materials instead of using soil which may contain pathogens.
- › Providing good ventilation and air circulation to the growing seedlings, including thinning the seedlings to reduce overcrowding where necessary.
- › Avoiding overwatering – this is even more important during prolonged cloudy periods when evaporation is low as this keeps the seedlings wet.
- › Applying permitted products such as sulphur powder or botanicals such as extracts or teas of garlic, seaweed, chamomile, etc.
- › Roguing off and destroying infected cabbages and other host plants (like volunteer crops or weeds) to the damping off diseases.

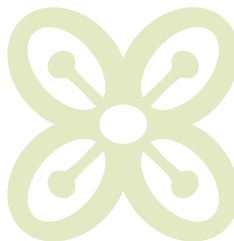
### Clubroot or the slime mold (*Plasmodiophora brassicae*)

#### Type of damage or symptoms:

The disease causes stunting and wilting. Infected plants turn purplish and the roots form swellings which produce a foul smell when rotting. The disease is aggravated by acidic soils and poor drainage. Note that the spores can last for up to two decades in the soil.

### Suggested control measures:

- › Using well drained sites or sowing media.
- › Treating the seed with 5% Trichoderma solution followed by drying under shade before sowing.
- › Good irrigation management – avoid waterlogging or poorly drained conditions.
- › Good soil pH management (liming of acidic soils to increase pH to recommended levels).
- › Soil treatment, e.g. solarising.
- › Practicing a good crop rotation with non-host crops or plants.
- › Removing and destroying infected plants.







## FUSARIUM WILT

### Fusarium wilt

(*Fusarium oxysporum* f.sp. *conglutinans* (cabbage fusarium wilt))



Photo: William C. NeSmith, University of Kentucky Research and Education Center, bugwood.org

<b>Symptoms</b>	<ul style="list-style-type: none"> <li>Yellowing of the lower leaves, often on one side of the plant only.</li> <li>Discoloured vascular tissue.</li> <li>Infested leaves turn brown and drop off.</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>More common during summer periods.</li> <li>Once present, the fungus survives indefinitely in the soil.</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>Avoid introducing the pathogen to clean fields.</li> <li>Use of resistant varieties</li> <li>Planned crop rotations with recommended cultivation breaks between brassicas</li> <li>Plant cabbage in periods with low temperatures when conditions are less favourable for the pathogen.</li> <li>Soil solarisation.</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>Practicing good crop hygiene.</li> </ul>



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## Fusarium wilt (*Fusarium oxysporum*)

### Type of damage or symptoms:

The disease causes leaf yellowing or manifests in discoloured veins. The symptoms can be on one side of the plant. Eventually, the leaves become brown and drop off. The plants are stunted and may wilt. The disease is more common during summer periods.

### Suggested control measures:

- > Selecting resistant varieties.
- > Observing effective crop rotations and other good hygiene practices.
- > Where possible, producing during winter when conditions are less favourable for the pathogen.
- > Soil treatment, e.g. solarisation.

## Black leg or Phoma stem canker (*Plenodomus lingam* / *Phoma linga*; *Plenodomus biglobosus*)

### Type of damage or symptoms:

This seed-borne disease can be devastating. A whole seedbed can become infected from just a single plant. Its name derives from the characteristic black cankers that form on the stem. It can also spread from infected transplants and be transmitted by insects.

- > The disease often causes tap root rot and lesions on the stems and leaves. These lesions have small black dots in the center.
- > Complete plant wilting and yellowing can occur and ultimate death of seedlings is not uncommon.

### Suggested control measures:

- > Using clean healthy seed which is disease-free.
- > If the soil is infested, then seedlings can be raised in containers in a disease-free medium.
- > Permitted recommended fungicides can be used if disease prevalence is high at the site. Organic farmers should check if the agents are permitted for their context before applying, particularly when growing for the market.
- > Transplanting of only healthy seedlings with no black spots on stems or leaves.



## BLACK LEG

### Black leg

(*Leptosphaeria maculans*, *Phoma lingam*)



Photo: Eleanor Brook, Wikimedia Commons

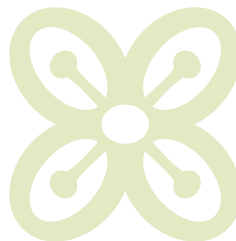
<b>Symptoms</b>	<ul style="list-style-type: none"> <li>Lesions on the stems and leaves with small black dots in the center.</li> <li>Complete plant wilting and yellowing possible.</li> <li>Ultimate death of seedlings possible.</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>The fungus is dispersed by the wind as ascospores or by rain splashes as conidia.</li> <li>Seed borne disease, but can also spread from infected transplants and by insects.</li> <li>In nurseries, an entire seedbed can become infected from a single plant.</li> <li>Grows best in wet conditions at 5 to 20 °C.</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>Use of disease-free seeds.</li> <li>In case of infested soil, raising of seedlings in containers in a disease-free medium.</li> <li>Practicing good crop rotations and field hygiene including removal and destruction of all old cabbage plants and related crops.</li> <li>Transplanting only healthy seedlings with no black spots on stems or leaves.</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>Spraying of recommended fungicides if disease prevalence is high.</li> </ul>



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## DOWNY MILDEW

### Downy mildew

(*Hyaloperonospora parasitica*)



Photo: Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org



Photo: Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org

<b>Symptoms</b>	<ul style="list-style-type: none"> <li>Yellow spots on the leaves.</li> <li>Fluffy white mold on the underside of the leaves during humid conditions.</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>Airborne disease</li> <li>More prevalent in humid cool weather</li> <li>Can survive in plant remains in the field.</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>Destroying cabbage and other susceptible plant remnants at the end of the season to prevent pathogen carryover to the next crop</li> <li>Planting in a clean bed or field</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>Spraying of allowed fungicides to the seedlings (copper preparations).</li> </ul>



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- › Practicing good crop rotations and field hygiene including removal of all old cabbage plants and related crops (these can be used for compost if they are not infected but should be destroyed if infected).

### Downy mildew (*Peronospora parasitica*)

#### Type of damage or symptoms:

This airborne disease is more prevalent in humid cool weather and can survive on plants and residues in the field.

- › Infected leaves have yellow spots on the affected areas and the yellow lesions can enlarge.
- › During humid conditions, a fluffy fine white mold appears on affected parts on the underside of the leaf.

#### Suggested control measures:

- › Planting seedlings into a clean bed or field.
- › Destroying cabbage and other susceptible plant remnants at the end of the season to prevent pathogen carry-over to the next crop.
- › Using appropriate plant spacing and row orientation to allow good air circulation and avoid pockets where high humidity can build up.
- › Spraying with permitted fungicides (e.g. Bordeaux mixture, baking soda solution). Organic farmers should check if these are permitted for their context before applying.

### Alternaria leaf spot or Alternaria leaf blight (*Alternaria brassicicola*)

#### Type of damage or symptoms:

This fungal disease is common during cool, rainy weather. The disease starts as small, dark spots on older leaves. These spots may rapidly enlarge to form large circular lesions with concentric rings. The lesion centers can drop off resulting in holes on the leaves. In wet conditions the lesions may become infested with a brown or black velvety mass of mold spores. The damaged parts can provide entry for other types of diseases which may cause rotting during storage.

#### Suggested control measures:

- › Using only healthy seed that is disease-free as the disease is easily transmitted through seeds.



## ALTERNARIA LEAF SPOT

### Alternaria leaf spot

(*Alternaria brassicicola*)



Photo: FiBL



Photo: Anja Vieweger, FiBL

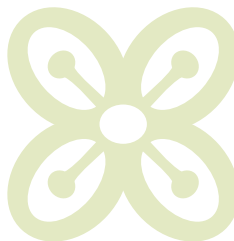
<b>Symptoms</b>	<ul style="list-style-type: none"> <li>Initially, small, dark spots on older leaves.</li> <li>Later, large circular lesions with concentric rings. The lesion centers can drop off.</li> <li>In wet conditions, brown or black velvety mass of mold spores on lesions possible.</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>Fungal disease.</li> <li>Common during cool, rainy weather.</li> <li>Transmission via seed and infested crop residues.</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>Using disease-free seeds.</li> <li>Hot water treatment of seeds before sowing.</li> <li>Transplanting of healthy seedlings only.</li> <li>Practicing good rotations.</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>Good crop hygiene.</li> <li>Dry crop management (ideally drip irrigation).</li> <li>Removal of insect nets after pest flights.</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>Spraying of allowed fungicides (copper preparations); however effect is insufficient.</li> </ul>



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## BLACK ROT

### Black rot

(*Xanthomonas campestris* pv. *campestris*)



Black leaf veins

Photo: Martin Koller, FiBL



Photo: Nelson, Wikimedia



<b>Symptoms</b>	<ul style="list-style-type: none"> <li>• Large V-shaped yellow to light brown patches starting at the leaf margins.</li> <li>• Black leaf veins, later brown dry patches.</li> <li>• Leaf drop and stunting of seedlings.</li> <li>• Death of whole seedlings.</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>• Seed-borne bacterial disease. Can also be spread by infected plants or insects.</li> <li>• The disease can survive for up to 5 years in stems of host plants or in the field.</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>• Selection of tolerant varieties.</li> <li>• Using healthy seed or seedlings.</li> <li>• Hot water treatment of the seeds before sowing.</li> <li>• Good hygiene, destroying affected plants and cruciferous weeds before transplanting.</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>• Where possible, avoiding sprinkler irrigation.</li> <li>• Increasing irrigation intervals, but taking care to not stress the plants.</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>• Remove nets when the foliage is dry.</li> <li>• Treatment with copper preparations is possible, but in general shows unsatisfactory effect.</li> <li>• Chopping up crop residues well and work in superficially to promote rapid decomposition.</li> <li>• Clean tools well after use.</li> </ul>

- › Treating seed with hot water (about 50 °C for 25 minutes) before sowing to kill the disease.
- › Transplanting only healthy seedlings.
- › Practicing good field hygiene, removing and destroying all plant residues that might harbour the disease and perpetuate it. Diseased plant material should not be buried or ploughed into the soil as it can be a source of infection.
- › Practicing good rotations with non-host plants or crops.
- › Controlling for pests as this might transmit some plant pathogens.
- › Using clean mulches.
- › Applying neem cake and good quality compost.
- › Using recommended fungicides if necessary.

### 8.2.2 Bacterial diseases

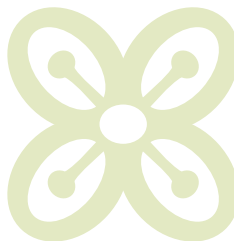
#### Black rot -(*Xanthomonas campestris* pv. *campestris*)

##### Type of damage or symptoms:

This is a seed-borne disease. The disease can survive for up to 5 years in stems of host plants or in the field and can also be spread by infected plants or insects. The disease manifests as large V-shaped yellow to light brown patches starting at the leaf margins. The veins turn black, later turning to brown dry patches ultimately causing leaf drop and stunting and death of whole seedlings.

##### Suggested control measures:

- › Choosing to grow tolerant varieties.
- › Using healthy seed or seedlings.
- › Treating seed in hot water before sowing.
- › Practicing good hygiene and destroying all affected plants and cruciferous weeds before sowing and/or transplanting.
- › Where possible, avoiding sprinkler irrigation as this causes the leaves to become wet and conducive to infection.
- › Increasing irrigation intervals, but taking care to not stress the plants.





## BACTERIAL SOFT ROT

### Bacterial soft rot (*Erwinia carotovora* var. *carotovora*)



Photo: Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bigwood.org

<b>Symptoms</b>	<ul style="list-style-type: none"> <li>Initial infection on the outer petiole (leafstalk), then progressing to the head.</li> <li>Infected heads become watery and often the entire head rots, emitting a foul odour.</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>The disease is most severe during storage.</li> <li>The bacteria is spread in the field by water splashes or contact with contaminated tools.</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>Planting on ridges or raised beds to prevent waterlogging around the plants.</li> <li>Preventing other or damage that may provide opportunities for soft rot to infest and develop.</li> <li>Applying good crop rotation.</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>Washing hands, field tools and harvesting knives – observing good hygiene at all times.</li> <li>Avoiding harvesting when conditions are warm and moist.</li> <li>Harvesting healthy cabbage heads first and storing them in a cool, dry, and airy place.</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>Removing and destroying diseased crop residues and volunteer brassicas.</li> </ul>



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## Bacterial soft rot (*Erwinia carotovora* var. *carotovora*)

### Type of damage or symptoms:

This disease affects cabbage and other crucifers in the field but is most severe during storage. The bacteria is spread in the field by water splashes or contact with contaminated tools such as hoes or knives during field operations and harvesting. If contaminated knives are used to harvest cabbages, the stored crop may rot quickly.

On cabbages, an initial infection occurs on the outer petiole (leafstalk) which is in contact with the soil, and then progresses to its head. The affected area becomes soft and mushy and generally turns dark in colour. Infected heads become watery and often the entire head rots. The rotting head emits a foul odour. Eventually the leaves, stems and roots are entirely decayed by the bacteria.

### Suggested control measures:

- › Planting on ridges or raised beds to prevent waterlogging around the plants.
- › Using clean mulches.
- › Preventing other diseases (e.g. black rot; damping-off) or damage that may provide opportunities for soft rot to infest and develop.
- › Avoiding harvesting when conditions are warm and moist. These conditions favour the development of soft rot.
- › Harvesting healthy cabbage heads first and storing them in a cool, dry, and airy place.
- › Washing hands, field tools and harvesting knives – observing good hygiene at all times.
- › Removing and destroying diseased crop residues or left-over stems in the field after the crop has been harvested. Also removing and destroying other host plants such as volunteer brassicas.
- › Applying good crop rotation, including avoiding growing brassica crops in the same field for a period of at least three seasons.

## Bacterial leaf spot (*Pseudomonas syringae* pv. *maculicola*)

### Type of damage or symptoms:

Bacterial leaf spot is more severe in cool, moist weather. The symptoms initially appear as small, faint, water-soaked areas on the underside of leaves. The affected areas develop into brownish to purplish grey necrotic spots that are fairly irregular after a few days. They may coalesce or join to form large irregularly



## BACTERIAL LEAF SPOT

### Bacterial leaf spot

(*Pseudomonas syringae* pv. *maculicola*)

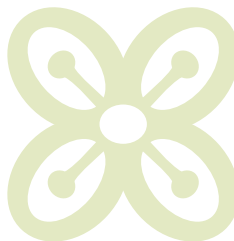
<b>Symptoms</b>	<ul style="list-style-type: none"> <li>Initially small, faint, water-soaked areas on the underside of leaves.</li> <li>Brownish to purplish grey irregular necrotic spots.</li> <li>The spots may coalesce or join to form large irregularly shaped spots.</li> <li>Wrinkled leaves with teared tissue.</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>More severe in cool, moist weather.</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>Planting tolerant or resistant cultivars.</li> <li>Using disease-free seed or seed treated with hot water before sowing.</li> <li>Using disease-free seedlings.</li> <li>Practicing suitable crop rotation.</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>Avoiding sprinkler irrigation.</li> <li>Increasing the interval between irrigation, but without detriment to plants.</li> <li>Controlling cruciferous volunteer crops and weeds which can harbour disease.</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>Ploughing infected plant material deep into the soil to bury them.</li> </ul>



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shaped spots as the disease progresses. Leaves become wrinkled and the tissue may tear when the lesions are many.

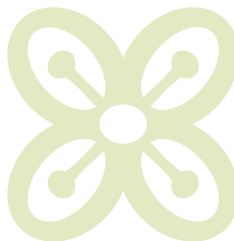
**Suggested control measures:**

- › Planting tolerant or resistant cultivars.
- › Using disease-free seed or seed treated with hot water before sowing.
- › Using disease-free seedlings.
- › Practicing suitable crop rotation.
- › Avoiding sprinkler irrigation.
- › Increasing the interval between irrigation, but without detriment to plants.
- › Controlling cruciferous volunteer crops and weeds which can harbour the disease.
- › Ploughing infected plant material deep into the soil to bury them.

### **8.3 Some of the common pests in cabbage and their control**

Cabbages are frequently attacked by pests like diamondback moth, aphids, cabbage moth or cabbage worm, cutworm, leaf miner and many others. The first line of defense by organic farmers is to apply preventive measures to reduce pest infestation. Planting tolerant varieties, planting in pest or disease free fields, ensuring good crop husbandry and good field hygiene, scouting for pests and diseases, etc. are some preventive strategies which organic farmers can use. Since varieties can change over time and their availability differs from place to place, farmers are encouraged to consult their extension agents and/or agro dealers regarding varieties that are tolerant to the prevailing main diseases and pests in their area.

Under heavy infestation by pests, spraying with natural repellent sprays such as *Tephrosia*, neem or rhubarb leaf, and permitted remedies will help to protect the crops and reduce yield loss. *Tephrosia*, however, is restricted or prohibited in some cases, e.g. in fish producing areas, as the plant is a strong fish poison. Suggested control measures for selected cabbage pests are provided in the sections below. Further details on pest control can be found in Module 4 of the African Organic Agriculture Training Manual.





## CUTWORMS

### Cutworms



Photo: Merle Shepard, Gerald R. Carter, and P.A.C.O. Insects and their Natural Enemies Associated with Vegetables and Soybean in Southeast Asia, Bugwood.org



Photo: Clemson University - USDA Cooperative Extension Slide Series, Bugwood.org

<b>Symptoms</b>	<ul style="list-style-type: none"> <li>• Cut or damaged stems close to the ground level, particularly in young succulent plants.</li> <li>• The caterpillars can be found curled at the base of the young plants or inside the soil near the seedlings.</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>• The damage occurs during the night as cutworms are nocturnal.</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>• Practicing good pest scouting.</li> <li>• Using pheromone traps to catch the male adult moths.</li> <li>• Spraying with garlic concoction to deter the cutworms.</li> <li>• Using seedling collars in small plots.</li> <li>• Placing abrasive materials, e.g. crushed bones, around the newly planted seedling.</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>• Removing the cutworm next to damaged plants to prevent further attack on remaining plants.</li> </ul>



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## 8.3.1 Selected pests of cabbage and suggested control measures

### Stem cutting insects

#### Cutworms (*Agrotis* species)

##### Type of damage or symptoms:

The pest manifests as cut or damaged stems close to the ground level (about 1 to 3 cm above ground) particularly in young succulent plants. The damage occurs mostly during the night as cutworms are nocturnal. The caterpillars can chew the stems and leaves of the young seedlings. The caterpillars can be found curled at the base of the young plants or inside the soil near the seedlings.

##### Suggested control measures:

- › Using pheromone traps to catch the male adult moths and stop them from mating with females. This causes the females to lay sterile eggs and hence fewer resultant larvae.
- › Avoiding the use of broad spectrum pesticides which kill natural enemies will help the pest's natural enemies to thrive and keep the pest populations down. Birds can also feed on the cutworms.
- › Practicing good pest scouting and applying direct control methods early enough when the pest populations reach critical threshold levels.
- › If the plot is small and the risk of cutworms is high, producers can use seedling collars that prevent the cutworms or caterpillars from reaching the bottom part of the plant.
- › Spraying with garlic concoction to deter the cutworms.
- › Placing abrasive materials, e.g. crushed bones, around the newly planted seedling to damage the larvae as they crawl. Some commercially available bone meals also supply calcium to soils and make the soils less favourable to cutworms.
- › Searching for and removing the cutworm next to damaged plants to prevent further attack on remaining plants.

### Sap sucking pests

#### Aphids -(*Brevicoryne brassicae*, *Myzus persicae*, *Lipaphis erysimi*)

##### Type of damage or symptoms:

Sap sucking pests result in malformed leaves which may become chlorotic. They deprive the plant of the much needed nutrients and cause growth deformations.



## APHIDS

### Aphids

(*Brevicoryne brassicae*, *Myzus persicae*, *Lipaphis erysimi*)



Photo: Whitney Cranshaw, Colorado State University, Bugwood.org



Photo: Martin Köhler, FiBL

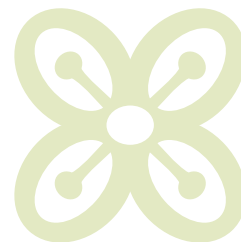
<b>Symptoms</b>	<ul style="list-style-type: none"> <li>• Malformed, distorted, curled leaves.</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>• Sap sucking pests.</li> <li>• Can transmit different viral diseases which can cause serious problems in cabbage.</li> <li>• Cool, dry weather favours aphid development.</li> <li>• The <i>Brevicoryne brassicae</i> aphids overwinter as eggs on plant residues.</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>• Only plant aphid-free seedlings.</li> <li>• Cover young plants with insect protection netting when growing outdoors.</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>• Ensuring rapid plant growth (e.g. with irrigation in dry conditions).</li> <li>• Regular checking of crops for infestation.</li> <li>• Cover the crop with fine-meshed nets.</li> <li>• Promoting natural enemies such as ladybirds.</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>• Removing and destroying infested plant residues, host weeds and volunteer host crops.</li> <li>• Spraying potassium soaps against aphids.</li> <li>• Spraying pyrethrin (mixed with sesame oil) or neem to prevent build-up of large populations.</li> </ul>



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## BAGRADA BUG

**Bagrada bug**  
(*Bagrada cruciferarum*,  
*Bagrada hilaris*)




Photo: Gevok Azatlian, LA County Dept. Agriculture, Bugwood.org




Photo: Jennifer Carr, University of Florida, Bugwood.org

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<b>Symptoms</b>	<ul style="list-style-type: none"> <li>• Wilted, deformation and dying of leaves due to sucking of sap.</li> <li>• Infected cabbage plants may fail to form heads and affected young seedlings may die.</li> <li>• Stunted growth and leaf deformation.</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>• Populations can build up quickly reaching damaging densities that require control.</li> <li>• Some wasps can feed on the eggs while the hover fly is reported to feed on the adult bugs.</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>• Rotating host plants with non-host plants.</li> <li>• Removing cabbage stumps and crop remains.</li> <li>• Frequent light soil cultivation to destroy eggs laid in the soil.</li> <li>• Soil solarisation to destroy the eggs and the hatching nymphs.</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>• Intercropping with strong smelling crops or plants such as garlic deters the bugs.</li> <li>• Handpicking of bugs in small plots.</li> <li>• Overhead irrigation to keep populations low.</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>• Spraying with soapy solutions or a mixture of chillies, soap, garlic and paraffin.</li> </ul>

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Feeding by aphids can distort leaves of older cabbages and causes leaf curl. Besides, the cabbage aphid and the false cabbage aphid can transmit different viral diseases which can cause serious problems in cabbage production. Cool, dry weather is most favourable for aphid development. Note that the *Brevicoryne brassicae* aphids overwinter as eggs on plant residues.

### Suggested control measures:

- › Removing and destroying infested plant residues, host weeds and volunteer host crops is of utmost importance before planting a new crop.
- › Ensuring rapid plant growth, favourable soil fertility and sufficient supply of nutrients, especially potassium, strengthens the plants and make them less vulnerable to aphid attack.
- › Covering seedlings and crops with fine nylon mesh starting from transplanting stage.
- › Promoting natural enemies such as ladybirds.
- › Releasing the parasitoid wasp *Diadegma semiclausum* for biological control.
- › Spraying permitted insecticidal soaps (potash soaps) against aphids.
- › Spraying pyrethrin (mixed with sesame oil) or neem to prevent build-up of large populations.

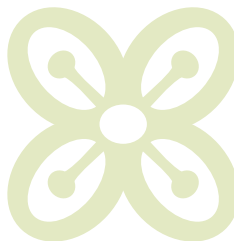
### Note:

- › Broad use of pyrethroids should be avoided or limited as they kill beneficial organisms, too.
- › The sprays are less effective when cabbage leaves are curled up.

### **Bagrada bug** (*Bagrada cruciferarum*, *Bagrada hilaris*)

#### Type of damage or symptoms:

The Bagrada bug is a smallish stinkbug which attacks cabbage and other crucifer plants. The adults lay many eggs and these hatch into nymphs after about a week. Damage is inflicted on host plants when adults and nymphs insert their needle-like mouth parts and suck sap from the plant. Sap sucking from the leaf veins causes leaves to wilt, deform and/or die. Infected cabbage plants may fail to form heads and affected young seedlings may die. Stunted growth and leaf deformation can persist even long after attack. Populations can build up quickly reaching damaging densities that require control.





## RED SPIDER MITE

### Red spider mite

(*Tetranychus urticae*)



Photo: Gilles San Martin on Wikimedia

#### Symptoms

• Red spider mites thrive in dry conditions. These tiny sucking pests weave a fine web on the underside of the leaves. They can be devastating, damaging plants permanently if left uncontrolled.

#### Measures before planting

• Practicing good rotations with non-host plants or crops such as celery, amaranthus and others.  
• Raising cabbage nurseries in pest free seedbeds.  
• Applying ashes to the leaves on seedlings in the nursery, especially when they are wet.

#### Measures after planting

• Removing and destroying known host crops and plants, like tomatoes, before planting.  
• Regular scouting for the pest.

#### Measures in case of infestation

• Spraying with neem oil mixed with a soap solution and warm water; or with a mixture of hot red chili mixed with permitted soaps.



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### Suggested control measures:

- › Removing unnecessary hosts, e.g. cruciferous volunteer plants, cabbage stumps (or the remains of other crucifers) after harvest to starve off the bugs.
- › Planting the cabbage crop far away from host crops such as cotton and grasses like bermuda and sudan.
- › Removing plant residues and planting into a clean field.
- › Practicing regular scouting and controlling before damage exceeds the 10 % threshold.
- › Promoting biological control: Some wasps can feed on the Bagrađa bug eggs while the hover fly is reported to feed on the adult bugs.
- › Practicing clean cultivation. Frequent light soil cultivation can help to destroy eggs laid in the soil.
- › Rotating host plants with non-host plants.
- › Intercropping with strong smelling crops or plants such as garlic to deter the bugs.
- › Handpicking of bugs in cases where infestations are low and plots are small.
- › Soil solarisation by using thin clear plastic covers to cover the soil for several weeks after a thorough irrigation before transplanting. The high temperatures that build up can destroy the eggs and the hatching nymphs.
- › Where farmers are practicing overhead irrigation, populations can be kept low as overhead irrigation disrupts the egg laying process by adult females. However, farmers must be aware of the disease-spreading risk associated with overhead irrigation.
- › Spraying with soapy solutions or a mixture of chillies, soap, garlic and parafin has been reported to be effective, especially to the nymphs.

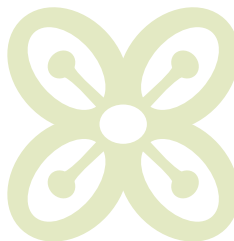
### Red spider mite (*Tetranychus urticae*)

#### Type of damage or symptoms:

Red spider mites thrive in dry conditions. These tiny sucking pests weave a fine web on the underside of the leaves. They can be devastating, damaging plants permanently if left uncontrolled.

### Suggested control measures:

- › Raising cabbage nurseries in pest free seedbeds, and far away from the pest's host plants.





## CABBAGE WHITEFLY

### Cabbage whitefly

(*Aleyrodes proletella*)



Photo: FiBL



Photo: Martin Köllner, FiBL

<b>Symptoms</b>	<ul style="list-style-type: none"> <li>Discoloured patches on the leaves.</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>Contamination of the harvest with sooty mould.</li> <li>At least 5 generations per year.</li> <li>The pest flies all day long.</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>Avoid proximity to last year's cabbage fields.</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>Cover crop with protective netting before infestation (max. mesh size 0.9 mm). Only effective if there are no other cabbage crops in the immediate vicinity.</li> <li>Promoting natural enemies.</li> <li>Scouting and monitoring the populations.</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>Treatment with pyrethrin + sesame oil + rapeseed oil, Azadirachtin, fatty acids, or <i>Beauveria bassiana</i> when the net is removed for hoeing.</li> </ul>



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- › Applying some ashes to the leaves on seedlings in the nursery, especially when they are wet.
- › Protecting the nursery or fields by planting crops or plants which repel the pest, e.g. garlic, lemon grass, marigold or others known to the farmers.
- › Removing and destroying known host crops and plants, like tomatoes, before planting cabbages, as they might be carrying the pest.
- › Practicing good rotations with non-host plants or crops such as celery, amaranthus and others.
- › Keeping a good scouting routine to identify presence of the pest and take control measures early enough.
- › Spraying with neem oil mixed with a soap solution and warm water; or with a mixture of hot red chilli mixed with permitted soaps.

#### Note:

- › It is important to spray both the top and undersides of the leaves as high populations can be found underneath the leaves.
- › Control is best done earlier during the infestation.
- › Spraying early in the morning before the pests start to move around gives best results.

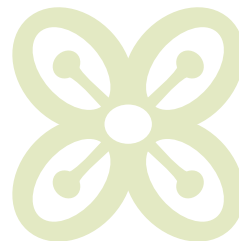
### Cabbage whitefly (*Aleyrodes proletella*)

#### Type of damage or symptoms:

Cabbage whiteflies, like many other whitefly species, suck sap from their hosts. Affected leaves develop discolored patches. Furthermore, as the whiteflies suck out the sap, they release toxic substances into the parts of the stem responsible for transporting nutrients to growing parts. These toxins spread throughout the plant and inflict further damage.

#### Suggested control measures:

- › Promoting natural enemies such as the parasitic braconid wasps, e.g. *Encarsia* species. Their larvae develop inside the whitefly eggs and thus destroy the pest by damaging the eggs. The adult wasps thrive in areas where nectar and honeydew are easily accessible, hence maintaining flower strips around the cabbage fields or between, even within, can help the natural enemies to survive. For hibernation, these efficient natural enemies need shrubs and woody plants as well as perennial fallows and margins at a maximum distance of





## THRIPS

### Thrips

(*Thrips tabaci* *Frankliniella* spp.)



Photo: Hansueli Höpfl, Agroscope



Photo: Gerald Holmes, Strawberry Center, Cal Poly San Luis Obispo, Bugwood.org

<b>Symptoms</b>	<ul style="list-style-type: none"> <li>Rough bronzed blisters on leaves inside the cabbage head.</li> <li>Sap sucking insect.</li> </ul>
<b>Important to know</b>	
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>Practicing good crop rotations.</li> <li>Cultivating and harrowing before transplanting to destroy pupae in the soil.</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>Promoting natural enemies, such as predatory bugs, predatory mites and predatory thrips.</li> <li>Planting non-host crops like oilseed rape, and winter cereals such as oats.</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>Spraying the cabbages with neem oil mixed with a permitted soap and water can repel thrips.</li> <li>If available, Spinosad-based sprays can control the thrips.</li> </ul>



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200 m from the crop. Other natural enemies include predators like thrips, ladybird beetles, lacewings and predatory mites like *Amblyseius* spp.

- › Covering the cabbages with insect protection net (maximum mesh size 2 mm)
- › Scouting and monitoring the populations. The damage threshold levels are 10 to 20 small or 1 to 4 young whiteflies on 10 plants (5 at the edge of the field, 5 in the middle of the field).
- › When direct control becomes necessary, a mixture of spinosad plus pine oil is effective against the larvae, especially when applied to the young stages of the whiteflies. A mixture of pyrethrin and sesame oil is effective against the adults.
- › Use yellow sticky traps which attract the white flies.
- › If the risk of foliar diseases is low, and where possible, spraying water on the cabbage leaves can dislodge the whitefly eggs and young ones.

### Thrips (various species)

#### Type of damage or symptoms:

The feeding on cabbages by thrips causes rough bronzed blisters on leaves inside the cabbage head.

#### Suggested control measures:

- › Cultivating and harrowing before transplanting to destroy pupae in the soil.
- › Promoting natural enemies, such as predatory bugs, predatory mites and predatory thrips.
- › Planting non-host crops like oilseed rape, and winter cereals such as oats as part of a cabbage rotation.
- › Practicing good crop rotations.
- › Spraying the cabbages with neem oil mixed with a permitted soap and water can repel thrips.
- › If available, Spinosad-based sprays can control the thrips.

### Foliage eating pests

#### Diamondback moth (DBM) (*Plutella xylostella*)

#### Type of damage or symptoms:

Mostly attacks cabbage and broccoli. Other cruciferous crops and plants are also attacked. The newly hatched larvae burrow into the leaf tissues where they feed and form mines or tunnels. As they grow, the larvae chew and create small holes



### Scouting for Diamondback Moth (DBM)

Discuss with the farmers or participants and take note of their knowledge regarding scouting procedures for key cabbage pests in general. Using the DBM pest example, conduct a practical session with the farmers on how to best scout for the DBM.

Before conducting the field practical session, discuss the key steps to be followed including when, where in the field, and where on the plant to check for the pests, the symptoms to look out for, and related aspects such as presence of natural enemies and how to recognise them.



## DIAMONDBACK MOTH

### Diamondback moth

(*Plutella xylostella*)



Larva

Photo: Clemson University, Wikimedia



Moth

Photo: James Lindsey, Wikimedia

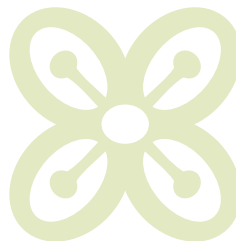
<b>Symptoms</b>	<ul style="list-style-type: none"> <li>Small holes on the outer side of leaves or growing points of young plants</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>Some fungi such as <i>Entomophthorales</i> can attack the larvae.</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>Intercropping brassicas with trap plants such as Indian mustard, and repellent plants such as tomato.</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>Covering seedlings and crops with fine nylon mesh from the beginning.</li> <li>Promoting natural enemies, or release the parasitoid wasp such as <i>Diadegma semicausum</i> and the egg parasite <i>Trichogramma pretiosum</i>. Other natural enemies include spiders, lacewings larvae, syrphid fly larvae, and some beetles.</li> <li>Sprinkler irrigation or heavy rainfall can drown young larvae.</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>Spraying insecticidal soaps against aphids.</li> <li>Spraying pyrethrum or neem punctually only to prevent build-up of large populations.</li> <li>Spraying Bt-based products.</li> <li>Avoid broad use of pyrethroids.</li> </ul>



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## CABBAGE WEBWORM

### Cabbage webworm

(*Hellula undalis*)



Photo: Ben-Sae-Wikimedia

<b>Symptoms</b>	<ul style="list-style-type: none"><li>• Webs over leaves and growing points.</li></ul>
<b>Important to know</b>	<ul style="list-style-type: none"><li>• The webworm larvae feed on leaves and growing points.</li></ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"><li>• Removing and destroying plant debris which might be carrying the pest.</li><li>• Planting repellent plants such as tomatoes, onions, garlic and herbs like thyme and sage which deter the larvae.</li></ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"><li>• Promoting natural predators of the pest by planting flowering plants around or near the cabbages to ensure a good habitat for them.</li><li>• Practicing good rotations.</li></ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"><li>• Spraying the cabbages with neem extracts and Bt.</li></ul>



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on the outer side of leaves or growing points of the young cabbage plants.

#### Suggested control measures:

- › Scouting for the build-up of DBM moth populations to monitor threshold levels. In warm weather, the populations build up more rapidly than under cool conditions.
- › Covering seedlings and crops with fine nylon mesh from the beginning including nursery stage.
- › Intercropping brassicas with trap plants such as Indian mustard, and repellent plants such as tomato to repel DBM.
- › Promoting natural enemies like lacewings larvae, spiders, syrphid fly larvae, and some beetles to thrive.
- › Where available and permitted, releasing some reared natural enemies, e.g. parasitoid wasps such as *Diadegma semiclausum* and the egg parasite *Trichogramma pretiosum* into the field.
- › Some fungi, e.g. *Entomophthorales* can attack the larvae of DBM moths and interfere with the pest's life cycle.
- › Spraying Bt (*Bacillus thuringiensis*) or botanicals such as neem-based products or soap solutions to control DBM.
- › Sprinkler irrigation or heavy rainfall can drown young larvae.

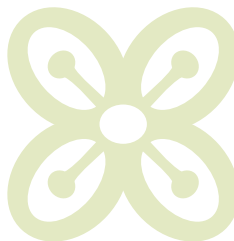
#### Cabbage webworm (*Hellula undalis*)

##### Type of damage or symptoms:

The webworm larvae feed on leaves and growing points. They spin a web over the feeding areas.

##### Suggested control measures:

- › Removing and destroying plant debris which might be carrying the pest.
- › Planting repellent plants such as tomatoes, onions, garlic and herbs like thyme and sage which deter the larvae.
- › Promoting natural predators of the pest by planting flowering plants around or near the cabbages to ensure a good habitat for them.
- › Practicing good rotations.
- › Spraying the cabbages with neem extracts and Bt.





## CABBAGE FLEAS

### Cabbage fleas

(*Phyllotreta* spp.)



Photo: Arja Vieweger, FiBL



Photo: Martin Lichtnerhahn, FiBL

<b>Symptoms</b>	<ul style="list-style-type: none"> <li>• Small holes, some of which may not go all the way through the leaf.</li> <li>• Hole surrounded by pale brown scar tissue.</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>• Newly transplanted seedlings are most susceptible, especially in dry, warm weather.</li> <li>• The beetles hibernate in the soil near cruciferous plants such as weeds, green manures, and crops.</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>• Avoiding plots or fields where cruciferous plants were growing before.</li> <li>• Transplanting seedlings that are strong and can withstand the pest pressure</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>• Maintaining a rough tith during cultivation.</li> <li>• Covering the seedlings with nets if possible.</li> <li>• Dusting the cabbages with stone meal.</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>• Spraying with permitted substances, e.g. Heliosol to delay infestation.</li> <li>• Avoiding dry conditions which promote beetle multiplication. Regular watering can help to control the pest.</li> <li>• Treatment with Spinosad.</li> </ul>



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### Cabbage fleas (*Phyllotreta* spp.)

#### Type of damage or symptoms:

The adult cabbage fleas or beetles and their larvae can cause damage to above-ground plant parts. Newly transplanted seedlings are most susceptible, especially in dry, warm weather.

#### Suggested control measures:

- › The beetles hibernate in the soil near cruciferous plants such as weeds, green manures, and crops. Avoiding plots or fields where such plants were growing can help to control the pest.
- › Transplanting seedlings that are strong and can withstand the pest pressure. Maintaining a rough tith during cultivation as a fine tith can make it easier for the beetles to move.
- › Covering the seedlings with netting if possible.
- › Dusting the cabbages with stone meal.
- › Spraying with permitted substances, e.g. Heliosol to delay infestation.
- › Avoiding dry conditions which promote beetle multiplication. Regular watering can help to control the pest.
- › Treatment with spinosad when the beetles occur.



## CABBAGE LOOPERS

### Loopers

(*Trichoplusia ni*)



Photo: Wikimedia Commons



Photo: Lusi Eva Blue, Wikimedia Commons

<b>Symptoms</b>	<ul style="list-style-type: none"> <li>• Irregular holes in the leaves.</li> <li>• Complete defoliation in case of heavy infestations.</li> <li>• Burrowing of the loopers into the cabbage heads.</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>• Practicing suitable crop rotations and mixtures.</li> <li>• Promoting natural enemies like parasitic wasps and flies. Birds and bats feed on the adult moths.</li> <li>• Planting clean seedlings (inspect the seedlings for eggs before transplanting).</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>• Removing plant residues after harvest to prevent possible carry-over of the pest.</li> <li>• Covering the crop with nets.</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>• Picking caterpillars by hand and destroying them.</li> <li>• Sprinkling food grade diatomaceous earth onto the leaves.</li> <li>• Spraying neem-based products or Bt in the early growth stages.</li> </ul>



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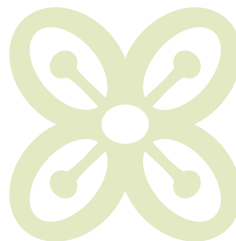
### Cabbage loopers (*Trichoplusia ni*)

#### Type of damage or symptoms:

The loopers eat the cabbage leaves resulting in irregular holes or complete defoliation in heavy infestations. The loopers also burrow into the cabbage heads.

#### Suggested control measures:

- › Practice suitable crop rotations and mixtures to starve off the pest.
- › Promoting natural enemies like parasitic wasps and flies. Birds and bats feed on the adult moths.
- › Removing plant residues after harvest to prevent possible carryover of the pest to the next season, as the pest can overwinter in the residues.
- › Planting clean seedlings – inspect the seedlings for possible egg masses before transplanting.
- › Covering the cabbages with suitable nets to prevent the moths from laying eggs.







## NEMATODES

### Nematodes

(*Meloidogyne* species)



Photo: Jeffrey W. Lutz, Florida Department of Agriculture and Consumer Services, Bugwood.org

<b>Symptoms</b>	<ul style="list-style-type: none"> <li>Stunted growth with signs of nutrient and/or moisture stress.</li> </ul>
<b>Important to know</b>	<ul style="list-style-type: none"> <li>Tiny organisms.</li> <li>Easily transmitted through soil movement, with runoff water from infected fields, with soil on transplanted seedlings, on farm implements and tools</li> </ul>
<b>Measures before planting</b>	<ul style="list-style-type: none"> <li>Selecting or planting tolerant varieties.</li> <li>Using clean nursery beds or sowing media (soil solarisation before sowing).</li> <li>Using clean seedlings and planting them into a clean field.</li> </ul>
<b>Measures after planting</b>	<ul style="list-style-type: none"> <li>Removing and destroying infected host plants, and other good hygiene strategies such as cleaning farm implements and tools after use.</li> <li>Practicing good plant rotations.</li> <li>Applying heavy mulch to limit runoff and reduce nematode movement.</li> </ul>
<b>Measures in case of infestation</b>	<ul style="list-style-type: none"> <li>Applying neem cake can suppress some harmful nematodes.</li> </ul>



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- › Checking for and removing eggs laid by moths on the cabbages.
- › Checking for and removing larvae from the plants and destroying them.
- › Sprinkling food grade diatomaceous earth onto the leaves to scratch and damage the larvae as they move.
- › Promote the predatory or beneficial organisms such as *Trichogramma* wasps which parasitise the looper moth eggs by laying their own eggs inside of them and hence destroying the moth eggs.
- › When control is necessary, spray neem-based products or Bt in the early growth stages.

### Nematodes

#### *Meloidogyne* species

#### Type of damage or symptoms:

These tiny organisms attack plant roots and cause stunted growth with signs of nutrient and/or moisture stress to the affected plants. Nematodes can be easily transmitted through soil movement from infected fields through soil on transplanted seedlings, on farm implements and on tools such as ploughs, hoes, boots, etc. Runoff water can also carry nematodes along and infect clean fields.

#### Suggested control measures:

- › Selecting or planting tolerant varieties.
- › Using clean nursery beds or sowing media practicing soil solarisation before sowing.
- › Using clean seedlings and planting them into a clean field (solarisation, bio-fumigation with marigolds or rapeseed can control the nematodes).
- › Removing and destroying infected host plants, and other good hygiene strategies such as cleaning farm implements and tools after use.
- › Practicing good plant rotations, rotating cabbage with non-host plants like legumes, and also those that repel nematodes, e.g. marigolds, or with paddy rice in rice growing areas. If possible allow a cropping break of half a year to a year fallow to starve off the nematodes.
- › Applying heavy mulch, as this also limits runoff and reduces nematode movement.
- › Applying neem cake can suppress some harmful nematodes.



### Discussion on nematode problems

Ask the following questions to the farmers:

- › Do you know how to identify nematode problems?
- › How have you controlled them?
- › Have you tried out growing non-host crops or green manures in rotations or intercrops to reduce nematodes?



### Identifying nematode problems

Carry out the following exercise with the farmers using mono-cropped and intercropped fields.

1. Identify weak tomato or potato plants with signs of unexpected wilting
2. Dig out a few plants with the roots.
3. If galls are observed on the roots, these are likely to be nematode galls. Nitrogen fixing nodules are normally pink in colour inside.





## ADVANTAGES AND DISADVANTAGES OF NETS

### Nets (and fleeces) for pest control



#### Advantages:

- Effective protection against pests.
- Reduced reliance on (expensive) pesticides that can impact beneficial organisms.
- Reduced evaporation of water (higher water efficiency).
- Higher temperatures under the net improving the growing conditions in cold weather.
- Reduction of damage from hail.

#### Disadvantages:

- Relatively high costs for large-scale use.
- Additional labour for removing and reapplying the nets (e.g. for weed control).
- Promotion of fungal diseases towards the end of the crop (especially under fine nets). Early removal of the nets can prevent this.
- Risk of pressure damage to leaves on sensitive crops (e.g. lettuce) in strong winds and rain.
- Risk of heat accumulation in hot weather.



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## USING NETS

### How to use nets



#### Key considerations:

- Use suitable nets for the specific pest and crop.
- Cover seedbeds even before the seedlings emerge, and cover seedlings immediately after transplanting.
- Transplant only pest-free seedlings.
- Transplant only into pest-free fields.
- Anchor the nets well in the ground at the edges and close them tightly.
- Regularly inspect net-covered crops for pests. Pest populations under the net can rapidly increase.
- Do operations which require removal of the net when the pest is less active (e.g. cabbage flies fly in the morning and evening, earth fleas are active in the sun).
- Put back nets in place immediately after crop operations.
- Pay attention needs to possible heat accumulation under the net, and to increased disease pressure in humid weather.
- After harvest, cleaned the nets of any plant debris and store them in a clean and dark place.



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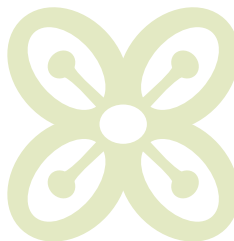
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## 8.3.2 Crop protection using nets and fleeces

Nets are a popular technique in protecting organic cabbages from various insect pests and wild animals. In colder climates, especially for those countries in the subtropics, the use of fleeces, rather than nets, during the spring and autumn times help to keep warmth for the crops and can facilitate earlier planting.

### Key considerations when using nets for protecting cabbages from pests

- › Identify a suitable source of the nets for the specific pest and crop in question.
- › Nets can be expensive, but if used properly, they can be effective against some key pests, save costs and generate higher yields.
- › Some pests attack the seed when it is sown. When nets are available, farmers are encouraged to cover seedbeds with nets even before the seedlings emerge, and to cover seedlings immediately after transplanting.
- › Farmers should transplant only those seedlings which are free from pests as nets cannot protect the cabbages from pests carried over on seedlings from the nursery.
- › Cabbages should be transplanted into fields that are free from pests like aphids and whiteflies. A suitable crop rotation is essential to prevent thrips, aphids, flea beetles and other pests from overwintering in the soil. It should be noted that pests present in the soil multiply well under the net, hence starting with a clean field is important.
- › The nets need to be anchored well in the ground at the edges and closed tightly. There shouldn't be any gaps that could provide entry for the pests into the net.
- › Even net-covered crops should be regularly inspected for the presence of pests. Pest populations under the net can increase rapidly.
- › Any operations which require partial or complete removal of the net should be done at a time when the target pest is less active (e.g. cabbage flies fly in the morning and evening, cabbage fleas are active during the day). Consideration of time of day or weather conditions can help to determine the best time to carry out field operations. Once the weeding or operations that required net removal are completed, the nets must be placed back immediately.
- › For an effective control of cabbage pests, nets with the appropriate mesh size against the target pest(s) must be used. Cabbages require heavier nets (>20 g/





## INSECT TRAPS

### Types of insect traps

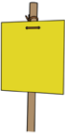
Pheromone sticky trap  
against swede midge



Traps with attractant  
(e.g. pheromone) for  
sampling moths,  
hoppers and beetles  
mainly.



Yellow sticky trap  
against whiteflies,  
thrips, winged aphids,  
leaf miners, etc. (may  
also catch natural  
enemies such as  
parasitic wasps, midge  
flies and ladybirds)



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m<sup>2</sup>) while the lighter nets (<20g/m<sup>2</sup>) are particularly suitable for protecting fine crops such as lettuce against aphids. For the control of caterpillars, the mesh size should be not more than 1.4 mm. The nets must be installed before the moths and other insects lay eggs. Nets against cabbage fleas must have a maximum mesh size of 0.8 mm. Nets with small mesh size offer protection against small and large pests.

- › In case of high temperatures, farmers need to be aware that heat can build up under the net and care must be taken to avoid excessive heat build-up. The high temperatures under the net can also favour more rapid disease and pest development.
- › In case of high infestation risk or actual pest or disease infestation, nets should be removed to avoid further promotion or rapid development under the nets.
- › From the time when moths begin to fly, the crops must be checked weekly for early detection of infestation and timely action taken.
- › Once the crop is harvested, the nets should be cleaned of any plant debris and stored in a clean and dark place to prevent possible carryover of pests to the next field or crop and to prevent the nets from deterioration.

### 8.3.3 Repellents, pheromone traps and sticky traps

Repellents are used to deter pests away from crops. This makes use of strong scents or smells emitted by some plants or substances that are permitted for organic production. The unfavourable smell pushes the insects away from the crops, hence saves the crop from damage.

The use of traps is hinged on the fact that most adult insects fly. While some fly for short distances, others fly for longer distances. The fact that a farmer does not observe any insects flying today does not mean that there are no insects which potentially cause harm the following day. Farmers can prepare themselves for possible invasion by flying insects through monitoring of their activity.

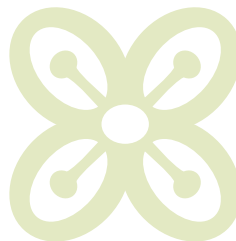
Coloured traps with a sticky surface or traps with attractants such as pheromones, dead fish or a sweet liquid can be used to catch the insects. Pheromone traps contain sexual attractants that are specific to the target pest. By checking the number of insects caught on or in the trap each day, farmers will know when the numbers of these insects are at a threshold point where direct control inter-



### Discussion on repellents and pheromones

Discuss with the participants or farmers, whether they use any repellents in vegetable production. If yes, list all the key types of repellents used, discuss their advantages and disadvantages. Discuss about the types of pheromones known to them. For which pests do they normally use pheromone traps? What are the challenges for these and how can they resolve them?

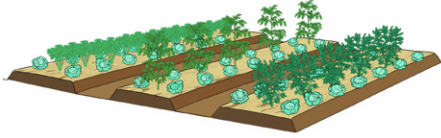
Undertake an exercise to set up a pheromone trap and monitor the types of pests trapped, their quantities, timing and other observations.





## COMPANION CROPPING

### Companion cropping for pest control



- **Coriander:** strong scent helps to repel some pests.
- **Tomatoes:** can reduce diamondback moth.
- **Chillies:** repel the diamondback moth.
- **Indian mustard:** acts as trap for the diamondback moth.
- **Dill, spinach or beans:** can reduce aphid infestations on cabbage.
- Additional good companion crops to cabbage: lettuce, cucumbers, celery

**X Not suitable:** other brassicas and alliums like garlic and onions



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ventions are required. By trapping the males, the numbers of successful mating partners, and as a result the number of fertilised eggs, decreases. Hence, fewer caterpillars will emerge resulting in less damage to the cabbage or target crops. The traps must be replaced regularly.

### 8.3.4 Companion cropping in pest control

Companion cropping involves planting two or more crops together to derive agronomic, ecological and socio-economic benefits. Alternatively, one or more of these could be non-crop plants that impart different benefits and synergies to the crop and/or soil.

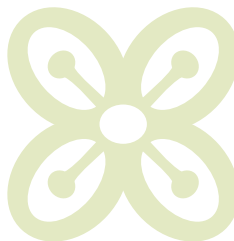
#### Benefits of companion cropping

The benefits of companion cropping can be:

- › Soil fertility improvement, nutrient improvement through e.g. nitrogen fixation by legumes.
- › Increased total production if the companion plant is also a crop.
- › Improved plant health if the companion crop repels or attracts (traps) pests thereby protecting the main crop.
- › Diversity, including biodiversity, brought in by the companion crops or plants which can also provide shelter to beneficial organisms or natural enemies that can help to control crop pests, or cushion the farmers from total crop failure in case of severe calamities to the main crop. The natural enemies such as ladybirds, parasitic wasps and some spiders can antagonise the pests, e.g. by destroying pest eggs or larvae, and prevent them from completing their normal natural life cycles.

#### Attributes of a good companion crop

Good companion crops should not compete significantly with the main crop for growth factors such as nutrients, light/sunlight, water, and physical space both below and above ground. For example, a companion crop should be taller or shorter, have a shallower or deeper root, or more sparse foliage than the main crop. Besides compatibility between or among intercrops, the timing of planting can also influence the effectiveness of the companion crops. For example, tomatoes are more effective to reduce damage by moths to cabbages if the tomato



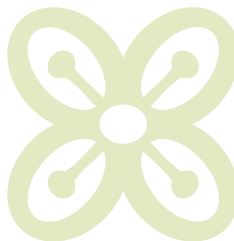
plants are planted 2 weeks before the cabbages are planted. Combining some companion crops with other techniques, e.g. applying neem seed extract to cabbages that are intercropped with coriander or garlic or tomatoes, can enhance the protection to cabbages. The placement of companion crops in the cropping mixture is also of importance. Outer row, or edge planting of the companion crops can reduce the pest from coming into the cabbage plots and this needs to be strengthened with some rows inside the plots.

#### **Examples of companion cropping in cabbage**

- › Coriander grows taller than cabbage and its strong scent helps to repel some pests.
- › Tomatoes, when grown together, can reduce diamondback moth damage to cabbages through repelling the moth while on the other hand, the cabbage repels the tomato bollworm.
- › Chilies, when mixed with cabbages, are also known to repel the diamondback moth.
- › Indian mustard has been shown to act as traps for the diamondback moth.
- › Dill, spinach or beans can reduce aphid infestations on cabbage.
- › Additional good companion crops to cabbage include lettuce, cucumbers, celery and others.
- › Not suitable: other brassicas and alliums like garlic and onions are reported to be unsuitable companions for cabbage. However, some reports and also observations show that some farmers actually intercrop cabbages with garlic and/or spring onions for pest protection purposes even though this may increase the chances of damage by thrips as both crops are susceptible to this key pest.

### **8.3.5 Flower strips for promotion of natural enemies**

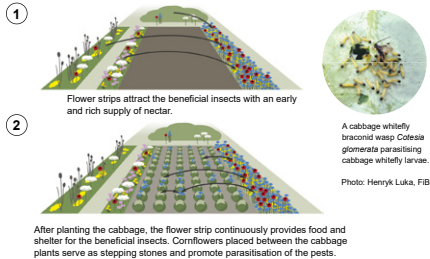
Flower strips on farms or fields improve the food base and overwintering opportunities for beneficial insects that are natural enemies of some pests. These strips help to promote and increase the performance of predatory species, e.g. spiders, ladybirds, and of parasitic beneficial insects such as ichneumon wasps. Parasitism performance by parasitoids depends largely on their egg-laying performance and lifespan. Both can be increased by the intake of sugary nectar.





## FLOWER STRIPS

### Promoting beneficial insects with flower strips



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Some nectar plants selectively promote the beneficial insects without favouring the pests at the same time. Therefore, to promote beneficial insects, farmers should choose strip flower plants that predominantly or exclusively favour the development of the beneficial insects.

Flowering strips composed of suitable nectar plants planted along cabbage fields can ensure large numbers of the beneficial insect populations to build up close to the crop where they are needed. Farmers can increase the efficiency of flowering strips by creating a network of near-natural habitats such as species- and structure-rich hedges, extensively used meadows or flowering fallow land near the cabbage fields. Vetch and cornflower plant mixtures can extend availability of nectar while buckwheat offers easily accessible nectar to the beneficial insects. Bees also benefit from these flowering strips. Growing many of these flowering plants near cabbage crops significantly increases the effectiveness of biological pest control by parasitoids, especially of the small, less mobile species of beneficial organisms. In autumn, the beneficial insects seek out the perennial habitats for overwintering as may be applicable.



## NETS AND/OR FLOWER STRIPS?

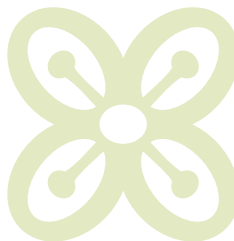
### Using nets and/or flower strips?

	Without net	With net
<b>Climate</b>	<ul style="list-style-type: none"> <li>Rapid drying of the moist crop</li> </ul>	<ul style="list-style-type: none"> <li>Increased humidity and risk of leaf spot diseases such as <i>Alternaria</i></li> <li>Heat accumulation possible</li> </ul>
<b>Beneficials</b>	<ul style="list-style-type: none"> <li>Access to the crop</li> </ul>	<ul style="list-style-type: none"> <li>No access to the crop</li> <li>Pests that are under the net can multiply unhindered.</li> </ul>
<b>Pests</b>	<ul style="list-style-type: none"> <li>Regulation with selective plant protection products partly possible</li> </ul>	<ul style="list-style-type: none"> <li>Effective against all pests with suitable mesh size</li> </ul>
<b>Cultural measures</b>	<ul style="list-style-type: none"> <li>No restriction</li> </ul>	<ul style="list-style-type: none"> <li>The net must be removed before hoeing and weeding and the crop must be covered again immediately afterwards.</li> <li>The weeds wither less well.</li> </ul>

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### How to plant flower strips, and other tips

- › Select the flowering plants to include in the mixed plant strips. Farmers can also check for local plants which they have observed to attract beneficial insects for aphids and caterpillar pests.
- › Sow about 3 meter wide strips, e.g. 40% forage vetch, 11% buckwheat, 4% cornflowers and 0.1% corn poppy along cabbage fields.
- › To increase the efficiency of the beneficial insects, additional cornflowers can be planted between the cabbage plants.
- › After planting the cabbage, the flowering strip continuously provides food and shelter for the beneficial insects. Cornflowers placed between the cabbage plants serve as stepping stones and promote parasitism of the pests.
- › Beneficial insect promotion with flower strips is possible with or without crop protection nets. If nets are used, they serve to protect the young plants against the pests. When the cabbage seedlings are well rooted, the nets are removed so that the beneficial insects can make their contribution. When using crop protection nets, cornflowers cannot be planted as companion plants in the crop. The combination of flower strips and crop protection nets requires careful and regular observation of the crop.







## BROWNING OF THE MIDRIP

### Browning of the midrib

<b>Symptoms</b>	<ul style="list-style-type: none"> <li>When leaves are damaged, the midrib part often turns to a brown colour (discoloration). This is more common in cabbages that are harvested late or at an overmature stage. The damaged parts also serve as entry points for pathogens.</li> </ul>
<b>How to prevent</b>	<ul style="list-style-type: none"> <li>Avoiding or minimising damage to the leaves during harvest and postharvest handling.</li> </ul>



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## YELLOWING

### Yellowing

<b>Symptoms</b>	<ul style="list-style-type: none"> <li>Gradual loss of the green colour from the leaves resulting in yellowing of the leaves.</li> </ul>
<b>How to prevent</b>	<ul style="list-style-type: none"> <li>Minimising storage at room temperature.</li> <li>Providing adequate ventilation during storage.</li> <li>Avoiding storing cabbage with ethylene producing vegetables and fruits or other products that produce ethylene.</li> </ul>



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## 8.4 Selected cabbage disorders that can be prevented through good management

### Browning of the leaf midrib

#### Description

When leaves are damaged, the midrib part often turns to a brown colour (discoloration). This is more common in cabbages that are harvested late or at an overmature stage. The damaged parts also serve as entry points for pathogens leading to further deterioration. Besides, the browning makes the cabbages less appealing to consumers.

#### Preventive measures

- > Avoiding or minimising damage to the leaves during harvest and postharvest handling.
- > Removing the damaged leaves to prevent possible secondary problems caused by pathogen entry through damaged parts.

### Yellowing

#### Description

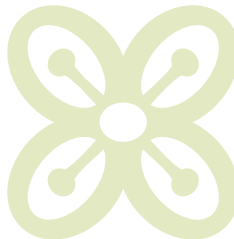
This manifests as a gradual loss of the green colour from the cabbage leaves resulting in yellowing of the leaves.

#### Preventive measures

- > Minimising storage at room temperature.
- > Providing adequate ventilation during storage.
- > Avoiding to store cabbage with ethylene producing vegetables (e.g. tomatoes) and fruits (e.g. apples, avocados, and bananas) or other products that produce ethylene. Cabbage is very sensitive to ethylene damage.

#### Note:

The term ethylene might not be well understood by farmers. It is defined as a colourless, flammable gas with a faint 'sweet and musky' odour in its pure form. It is also defined by some as an odourless, colourless gas that exists in nature and triggered at maturity in certain fruit and vegetables types. It has some hormone properties and sometimes known as the ripening hormone. It can enhance the ripening process of some fruits and vegetables such as tomatoes and bananas,





## PEPPER SPOT

### Pepper spot or black leaf speck

<b>Symptoms</b>	<ul style="list-style-type: none"><li>The specks may initially develop randomly on the leaves as small spots and may coalesce to form larger ones.</li></ul>
<b>How to prevent</b>	<ul style="list-style-type: none"><li>Using resistant varieties</li><li>Avoiding growing conditions which cause lush or vigorous growth. Minimising storage at room temperature.</li><li>Ensuring good management of potassium in the soil; high K levels reduce the incidence of the disorder.</li><li>Avoiding exposure of the heads to warm temperatures after cold storage</li></ul>



but can also accelerate deterioration in sensitive fruits and vegetables such as cucumbers.

### Pepper spot or black leaf speck

#### Description

The symptoms occur on over mature cabbage heads in the field, but are most common on heads that have been in storage for a long time. The specks may initially develop randomly on the leaves as small spots and may coalesce to form larger ones. These specks are a result of the collapse of tissue surrounding the natural opening on leaves (stomata) and are reportedly more common in cabbages that grew vigorously in the field.

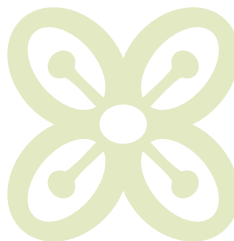
#### Preventive measures

- > Using resistant varieties.
- > Avoiding growing conditions which cause lush or vigorous growth.
- > Ensuring good management of potassium (K) in the soil; high K levels reduce the incidence of the disorder.
- > Minimising cabbage storage at room temperature.
- > Avoiding exposure of the heads to warm temperatures after periods of cold storage.

## 9. Harvesting of cabbages

In general, most vegetables are fragile and require great care during harvest and postharvest. Cabbage outer leaves can break easily while the heads are susceptible to cracking or bursting due to impact damage. Harvesters should exercise care to minimise bruising damage, leaf puncturing and any other types of damage to the leaves and heads, particularly when they are intended for storage or marketing. Nevertheless, cabbages are quite hardy and can be loaded into bulk containers with minimal physical damage compared to most other fresh leafy vegetables, if done well. Damage to the cabbage heads provide easy entry points for decay disease pathogens and water loss, hence faster wilting and deterioration.

For longer transportation or longer storage the outer leaves of the cabbage are retained to protect the cabbage from bruising damage, hence fewer leaves





## DETERMINING HARVEST MATURITY

### Determining maturity for harvest

#### Criteria:

- Number of days from transplanting
- Firmness or compactness of the heads
- Head size (most commonly used indicator); diameter of 10 to 15 to 25 cm
- Arrangement of the wrapper leaves (well spread wrapper leaves with the head exposed)



Delays in harvesting cause rotting and further cracking of the cabbages in the field. Photo: Irene Kadzere

Type/variety of cabbage	Time from transplanting to maturity	Shelf life at 98 to 100 % RH and 0 °C storage
Early maturing varieties	30 to 45 days	3 to 6 weeks
Late maturing varieties	62 to 120 days	5 to 6 months



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have to be removed during ‘cleaning’ of the heads destined for distant markets. The remaining outer leaves can be removed once the cabbages reach their market.

## 9.1 Timing of harvest

Farmers can determine when to harvest cabbages based on the number of days from transplanting and also on firmness or compactness of the head. Head size is the most commonly used indicator of maturity. Harvesting can start when the heads are as small as 10 cm diameter until they are 15 to 25 cm diameter. Another indicator of maturity in cabbage is the arrangement of the wrapper leaves. Mature cabbages have well spread wrapper leaves with the head exposed. Cabbages intended for storage should be harvested when mature. Immature harvests result in poor keeping quality. On the day of harvest, harvesting is preferably done early in the morning when it is cool. At this time of day, the cabbage heads will be at or near full firmness (turgidity). The cool conditions help the cabbages to maintain their quality for longer periods.

Harvesting at full maturity (firm heads) presents the highest yields. Farmers should, however, take care to avoid head splitting and increased disease incidence if harvesting is delayed, especially in wet weather. Head splitting or cracking can also occur due to uptake of excessive water amounts following heavy rains occurring, or heavy irrigation applied to mature heads.

## 9.2 Methods of harvesting

Harvesting is done by cutting the stem on the lower surface of the head leaving some basal leaves on the stem stump. Sharp knives or machetes should be used to cut off the cabbage heads. If no cutting devices are available, the cabbage heads can also be harvested by twisting the head until they break. This harvesting method is not recommended for cabbages intended for markets as the twisting can result in damage to the cabbage head and also results in unevenly cut stems. If required, another set of heads can be allowed to sprout on the remaining stumps and harvested when firm. However, such a practice can promote perpetuation of pests and diseases in the garden or field and should be avoided



### Discussion on the timing of harvest

Discuss with the participants timing of harvest in cabbages. Ask the following questions:

- > What indicators do you normally use?
- > Do they differ among the farmers, and among varieties?
- > Which indicators are most common and most effective?



## HARVESTING

### Cabbage harvest

#### Cleaning



- Trimming the stem end to 2 cm
- Removing torn and loose wrapper leaves leaving only 3 to 6 wrappers

#### Grading

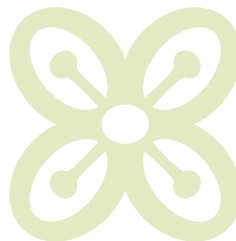
Attributes	Types
Head shape and form	Round Conical Flat Savoy leaves or smooth leaves
Head size	Small (0.8 kg or less) Medium (0.9 to 1.4 kg) Large (1.5 kg or more)
Head compactness	Loose Medium firmness Hard
Leaf colour	Green Red Purple



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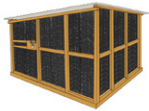




## POST-HARVEST MANAGEMENT

### Cabbage post-harvest management

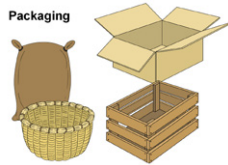
#### Cold storage



Charcoal insulated storage structure

For cabbages ideally at more than 95% relative humidity and 0 °C.

#### Packaging



- Disease and insect free
- With no signs of wilting
- Rigid containers such as boxes, cartons or large baskets are preferable
- Careful handling

as much as possible unless if the farmers can guarantee good pest and disease control practices. Late maturing varieties can also be harvested by pulling up the whole plant and hanging the cabbages by the stem in a shed to store them. This way, they can store for longer periods.

### 9.3 Harvesting containers

Cabbages can be harvested into baskets and emptied into larger containers in the field or in a shed. Care must be taken not to expose the harvested cabbages to high sun intensities as this will cause the leaves to wilt. High levels of heat will also lead to high respiration rates in the cabbages and may require longer cooling hours for those farmers who have access to cooling facilities. High respiration rates in harvested produce are undesirable as they hasten deterioration during storage or marketing.

## 10. Postharvest management of cabbages

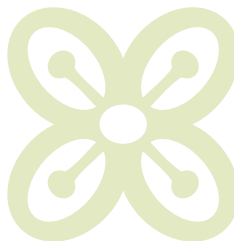
### 10.1 Cleaning, grading and packaging

#### Cleaning

Before transporting to the market, cabbages can be cleaned by trimming the stem end to only 2cm. Any torn wrapper leaves including the loose ones must be removed to leave only 3 to 6 wrappers. This will give the cabbages a clean, compact and fresh appearance. Leaving too many wrapper leaves will interfere with proper ventilation when the cabbages are placed in storage and also increase volumes to be transported, hence increased costs.

#### Grading

After cleaning, if necessary (according to market needs) the cabbages can be sorted according to desirable attributes depending also on the varieties and combinations of varieties grown.



### Packaging

For marketing, farmers are encouraged to select only those cabbages that are disease and insect free, and with no signs of wilting. Rigid containers such as boxes, cartons or large baskets are preferable for packing compared to flexible ones such as bags. The rigid containers will help to reduce compression and other damages during transportation or storage.

## 10.2 Preserving the quality of harvested cabbage

In general, early maturing varieties do not store well. The late maturing varieties have a longer storage life. The red varieties tend to store longer than the green types. Bruised or damaged cabbages will store shorter compared to non-damaged ones. Wrapping the cabbages in appropriate materials can help to prolong their shelf life. For example, for home consumption, the farmers can wrap the cabbage heads in newspapers. For organic marketing, farmers should consult with their advisors or certification bodies before using any wrapping materials as some of them can contaminate the cabbages.

### 10.2.1 Quality preservation through cooling and cold storage

#### Pre-cooling or removing field heat from cabbages

At the time of harvest, cabbages may contain some heat, especially if they are harvested outside the cool hours of the day. Such heat should be minimised, or removed from the cabbages through cooling. The harvested cabbages should be stored in a shaded, cool and well-ventilated area to reduce deterioration through decay (slimy rot between the leaves, etc.).

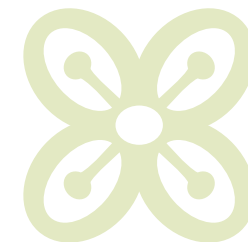
In the field, shade must be provided to the harvested cabbages pending their transfer to cooling facilities or prior to being transported to markets. If delays in transferring the cabbages to the shed are foreseen, farmers can sprinkle clean water onto the leaves to reduce dehydration, but this carries the risk of stimulating the development of rotting diseases especially if the leaves are wet for long periods.

Before storage or transporting to the markets, if farmers have access to cooling facilities (by vacuum or forced air to suck out or blow away the heat), then



#### Sharing information on storage

Invite the participants to share information on cold storage facilities or techniques to keep cabbages cool after harvest. These techniques should include traditional methods and modern methods applied by the farmers, or participants.



pre-cooling the cabbages to 0°C before long distance transportation ensures that the cabbages arrive at the market in good quality. In the absence of sophisticated cooling facilities, farmers can construct their own cooling structures as described in the General Vegetable Production Module of the African Organic Agriculture. For open truck transportation, the best time to transport the cabbages is during the cool times of the day. A cloudy day offers good conditions for transporting, too.

### Storing cabbages without and with cold facilities

In general, cabbages can store for relatively long periods. Fresh whole heads of cabbage that are disease and insect free can be stored for about two weeks without refrigeration. Where controlled cold storage facilities are available, headed cabbages store best at more than 95% relative humidity and 0°C. They can spend up to a day before being transferred into the cold storage provided that the heads are not exposed to the sun after harvest and that harvesting is done at a cool time of the day. Regardless of storage method, those intended for storage should not be washed because this can promote rapid deterioration as disease pathogen spores germinate well in moist conditions. The Savoy cabbage types generally store for shorter periods than the firm head types due to higher water loss from the leaves and wilting.

## 10.2.2 Preservation by processing

### Dehydration

Cabbages are best dried when raw or blanched (blanching refers to heat treatment before freezing, drying or storage). The cabbage leaves are shredded into 3mm thick slices and steamed for 5 to 6 minutes (thinner slices should be steamed for less time like 2 minutes) before drying. Solar drying is commonly used by small-holder farmers. If available, dehydrators or conventional ovens can be used for drying the cabbage at 60°C. In a dehydrator, the cabbages can be ready after 10 to 12 hours, but will be dry after 18 hours or longer in conventional ovens. When a lower temperature (30 to 40°C) is used, the drying time is much longer.

For the best quality, it is important that the cabbages are protected from rain, wind, dust, pests and foreign materials during drying. Turning the large pieces



### Sharing experiences on cooling of vegetables and alternatives to cabbage preservation in the absence of proper cooling facilities

Discuss with the farmers about their practices in ensuring some cooling to cabbages (or other vegetables) after harvest. Find out from the participants about the following:

- > How do farmers in the area normally preserve cabbages?
- > Are there any cooling facilities available for individuals, or farmer groups?
- > Do they practice any drying?
- > How do they deal with gluts at the markets without any cooling facilities to extend the shelf life of the cabbages?
- > Is there a market for dried cabbages?





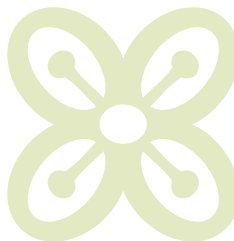
every 3 to 4 hours can enhance the drying process. Care should be taken to avoid scorching of the cabbage, particularly towards the end of the drying.

The dried cabbage pieces should be brittle, and must be kept in airtight containers and out of light as this may cause discolouration. The dried cabbage can be rehydrated by covering it with cold water containing a little lemon juice for 30 minutes. The red cabbages often develop some discolouration when rehydrating.

### **Preservation by pickling**

Fermentation is traditionally used for the preservation of foods and has been practiced for a long time. The most popular and successful way of preserving cabbage is through pickling. Pickled or fermented cabbages are prepared by cutting the leaves into small pieces and immersing them in a clean bowl containing a salt solution. Massaging the leaves in the salt solution for about 10 to 15 minutes until they feel soft is recommended. The salt solution should be strong enough (2 % or 2 g of salt in 100 ml of water) to kill the harmful pathogens while allowing fermenting bacteria to grow. When soft after messaging, the cabbage slices are transferred to clean glass jars, but taking care to not overfill the jars, enough space should be left at the top of the jar after filling. In each jar, the cabbage slices should be pressed continuously with a wooden spoon during filling to drive out air from the bottom of the jar. Ensure that the salt solution is covering the slices before placing a clean cabbage leaf on top of the slices in the jar to cover the top. Place an appropriate weight or object to press on the leaf and keep the slices submerged in the solution before closing the jar with a suitable lid. If a metallic lid is used, then a piece of clean cloth should be used to cover the mouth of the jar first before screwing in or inserting the lid as the salty water can make the lid turn rusty. The jars are checked regularly to see if the fermentation process is progressing well – bubbles start to develop at the bottom of the jar. The jars should be opened to drive out the air and closed again. The slices will be ready to consume after 10 to 15 days or more of fermentation depending on the prevailing temperatures.

The pickled cabbages can be stored at room temperature in a cool dark place. Although this preservation method may not be currently common in many African societies, it has the potential to help address problems of household seasonal unavailability of cabbages and provision of vitamin C, vitamin B6, folate and other nutrients and health benefits to families.



### 10.3 Cabbage postharvest diseases

During their postharvest life, cabbages are susceptible to many diseases which cause decay. These include:

- › Bacterial soft rot
- › Gray mould
- › Dark leaf spot
- › Phytophthora rot
- › Rhizoctonia rot
- › Watery soft rot

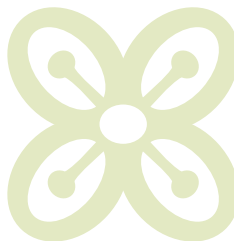
The diseases can be controlled by using the following strategies:

- › Using clean seed at sowing – some of the diseases are seedborne.
- › Maintaining good agricultural practices and sanitary measures at all stages.
- › Avoiding or minimising damage to the cabbage leaves at all stages from harvest to packing (this reduces entry points for the pathogens).
- › Removing any infected wrapper leaves before packing or storage.
- › Cold storage (near 0°C) if available – storing in cool conditions also helps in the absence of refrigeration.
- › Postharvest fungicides can be applied to conventional cabbages but, for organic cabbages, farmers are recommended to check with their certifying agents regarding any permitted substances for postharvest disease control.

### 11. Economic considerations in organic cabbage production

Before planting organic cabbages, farmers ought to ask themselves about the objective and what they aim to achieve. Whether for household consumption or marketing, there are some basic inputs required for the production and management of a cabbage crop. Some of the questions for self-reflection by the farmer are:

- › Do cabbages fit well into the existing crop rotation?
- › How much does the household require for consumption?
- › Is there a demand for organic cabbages – potential for income generation?
- › Is there a premium for organic cabbages?



- › Is there a market for the other organic crops in the rotation?
- › Will organic production require additional work and lead to labour bottlenecks?
- › Does organic (cabbage) production bear higher risks?
- › Are any investments necessary (e.g. nets, tools for weeding, cool storage facilities)?

Other economic considerations are:

- › Inputs requirements by the cabbages
  - o Land requirements
  - o Water (and associated equipment depending on type of watering to be used)
  - o Capital (cash or in-kind)
  - o Knowledge and skills – including training costs
  - o Labour and its distribution over the season – forecasts on peak labour needs
  - o Seed or seedlings sources
  - o Nutrient sources (organic permitted sources of nutrients)
  - o Equipment or tools including containers and handling facilities
  - o Pest and disease management techniques and materials
  - o Energy at different stages of production and postharvest management
  - o Others – the farmer can list more requirements depending on his/her situation.
- › Markets and market requirements, e.g. type of certification required to sell as certified organic if that is the aim, observing all required expectations by the certification standard.
- › Transport – appropriate types and timeliness are crucial.

For optimum returns, farmers should regard their farming activities as a business. An organic farm should not only pay for production costs, but also meet the household income needs of the farmer's family. To achieve this, organic farmers are encouraged to consider the following economic goals:

- › Yields and how to sustain higher productivity.
- › Competitiveness in the cabbage growing business through, e.g. lowering of expenditures on external inputs and investments. Organic relies on farm-

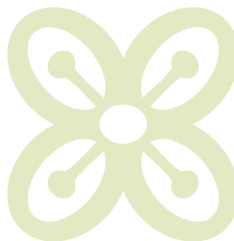


### Discussions on marketing of cabbages

Discuss with the participants, how farmers in their area sell any cabbages – whether as individuals, or as a group. Ask the following questions:

- › Are there any farmers who sell their produce as organic certified?
- › Which types of certification do they use?
- › Are you familiar with the group certification approaches such as the Participatory Guarantee System (PGS)?
- › Are any farmers organic certified by 3<sup>rd</sup> parties?

Discuss the pros and cons of these certification methods in the context of cabbage within the surround area.



own sources, e.g. recycling of nutrients on the farm and can reduce production costs.

- › Diversified sources of income for better risk management – through e.g. rotation crops or intercrops that have an economic value.
- › On-farm value addition – e.g. packing, processing into sauerkraut, etc. depending on markets.
- › Niche markets – distances, transport and distribution channels need to be considered.
- › Sustainability – survival as a businessperson, and environmental sustainability:
  - o Consider other farm benefits through improved soil fertility, improved resilience to harsh weather conditions, diversified availability of food for households, and other socioeconomic benefits.
  - o Organic cabbage production reduces the need for purchasing agro-chemicals. By being more self-sufficient in terms of manures, biopesticides, and other inputs organic farmers minimise cash outlay to purchase off-farm production inputs and are, therefore, likely to save more resources in the long run. For farmers to understand how their vegetable enterprises are performing, they would need to undertake some basic farm economic analysis based on inputs and outputs.

## 12. Recommended further reading

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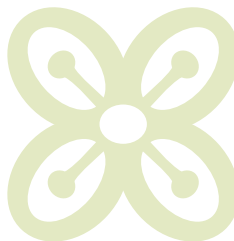
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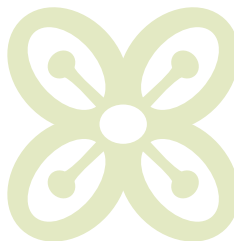
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