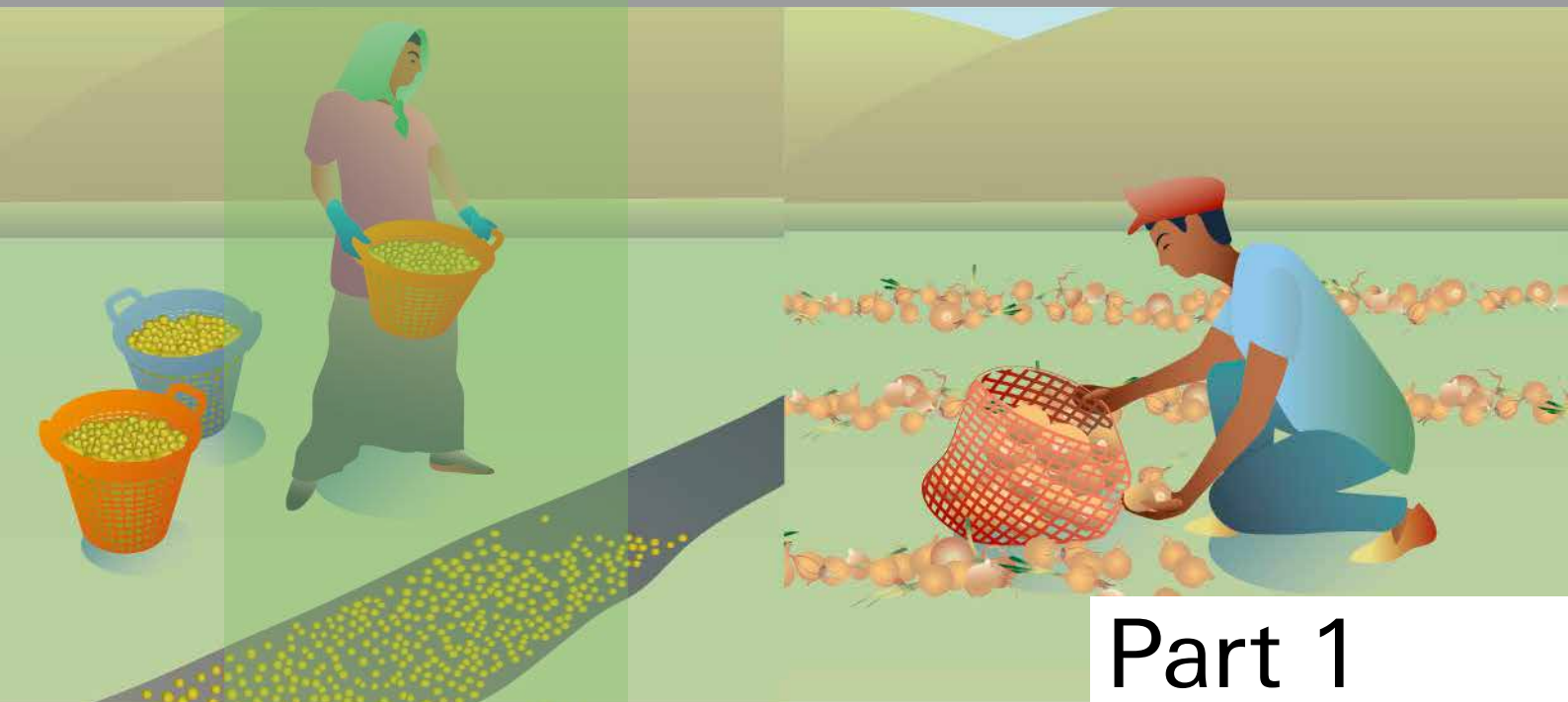


# Minimizing microbial contamination in primary production of fruits, vegetables, herbs and spices



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**Concept**

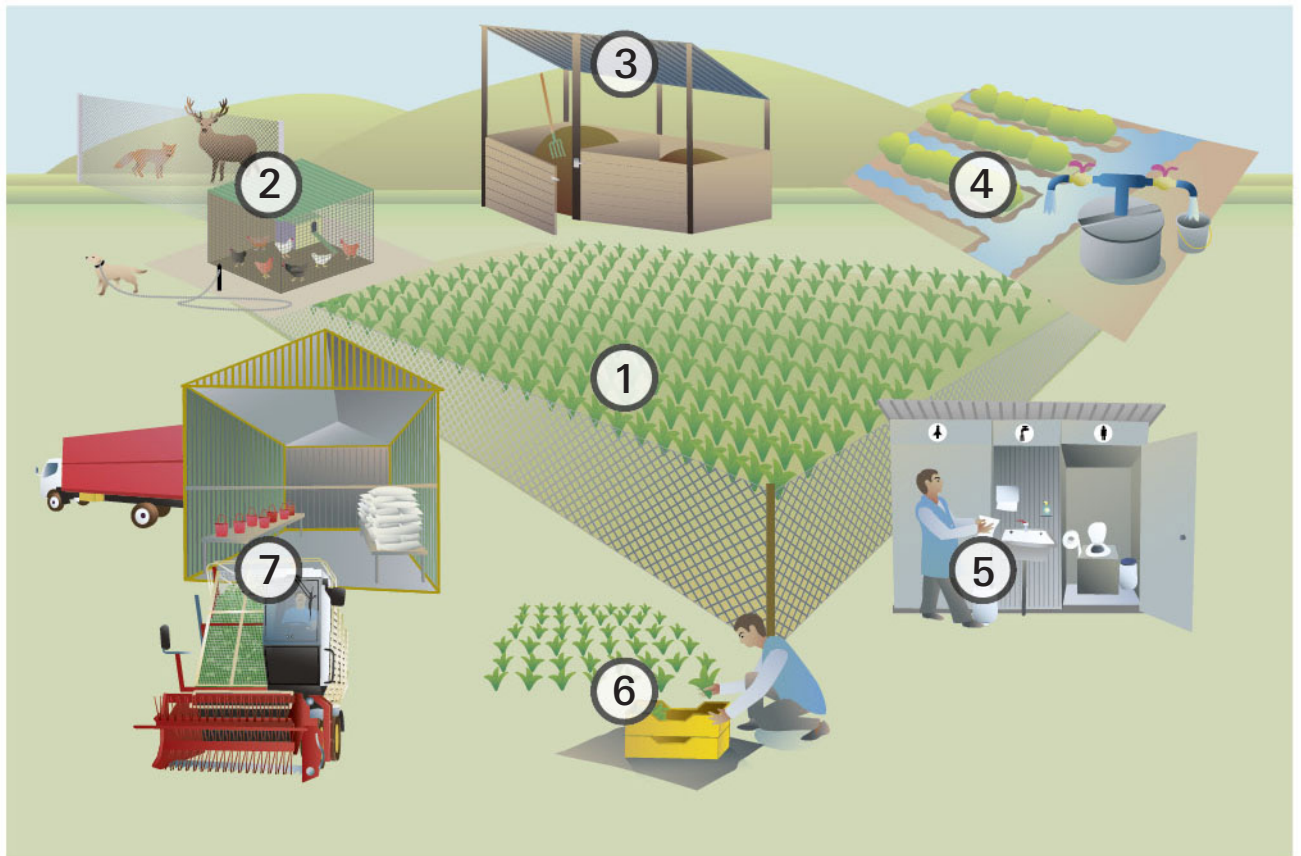
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# Minimizing microbial contamination in primary production of fruits, vegetables, herbs and spices



In the recent past, many plant-based ingredients, either processed or unprocessed, were found to be contaminated with pathogenic bacteria, viruses or parasites:

- In 2010, 272 individuals were infected with the bacterium *Salmonella*. This US outbreak was traced back to contaminated black pepper.
- In 2003, 640 people were sick and four died due to Hepatitis A virus in green onions. This was the most widespread Hepatitis A outbreak in the US.
- In 2015 in the US, 546 people were ill due to the parasite *Cyclospora* in fresh cilantro. Contamination was found to be caused by poor agricultural practices.

Where does the contamination at farm level come from? Contamination can have several origins, these are the so-called “routes of microbial contamination”. Seven routes have been identified, which are represented in the above illustration:

1. Growing field and adjacent land;
2. Animals;
3. Manure-based soil amendments;
4. Agricultural water;
5. Hygiene and human health;
6. Worker harvesting practices;
7. Equipment, premises and transportation.

(Continuation page 2)

This training booklet comprises seven chapters, one per route of microbial contamination. Each chapter illustrates good agricultural practices to follow during farm activities in order to minimise the risk of microbial contamination posed by this particular route. By following these practices\*, you will improve the safety of the crop(s) you are growing and the safety of the people who are consuming them, as well as the health of your workers.

The scope of this training booklet is: fruits, vegetables, herbs and spices expected to be eaten raw or mildly processed (e.g. washed, frozen, freeze dried, dried...). However Good Agricultural Practices should be adhered to at any time, even for plant-based ingredients that will be subjected to a microbiological kill step such as pasteurization. This booklet was developed based on five “model” ingredients illustrated in the icons below: black pepper, onion, raisin, basil and parsley. Most recommendations given in this booklet can be extended to other plant-based ingredients. Sprouts are excluded from the scope: follow local regulation or guideline(s) when existing.



This document refers to the Nestlé Supplier Code and the Responsible Sourcing Guideline.



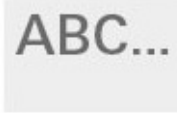
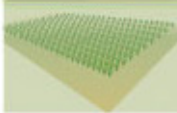

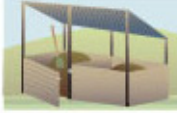

The primary target audience is:

- Farmers
- Farm workers (e.g. hand pickers, supervisory personnel in the field...)
- Raw material buyers (at supplier or at Nestlé level)

Never forget that safety starts in the growing field! Within a robust food safety management system, minimizing the risk of microbial contamination at farm level (during pre-harvest, harvest and post-harvest activities) is key to ensure the safety of the consumer.

\*Note: If local regulation is more stringent than a recommendation from this booklet, always follow local regulation.

# Contents

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2. Animals	19	
3. Manure-based soil amendments	29	
4. Agricultural water	41	

---

# Primary production flows

The following ingredients were selected as model crop to illustrate the recommendations given in this booklet. There are undoubtedly variations in practices depending on the country/region, operation size, individual grower preferences, subsequent primary processing (e.g. drying versus freezing) and distance between farm and primary processing plant. Therefore, the primary production steps described here

represent an example of what can be performed.

Recommendations given through the whole document aim to minimize the risk of microbial contamination at each step of these primary production flows. They can be extended to other plant-based ingredients having similar, or partially similar primary production flows.



**Black pepper**



**Onion**



**Raisin**



**Basil**



**Parsley**

# Primary production flows

## Black pepper

Sun-dried



Manual harvesting

Manual or mechanical separation of berries and spikes

Cleaning or blanching\*

Sun-drying

Bagging

Transportation to primary processing (e.g. grading)

## Onion



Manual or mechanical harvesting

Drying in the field

Collection from the field

Transportation to storage areas\*

Ventilated storage\*

Transportation to primary processing (e.g. drying)



# Primary production flows

## Raisin

Sun-dried



Manual or mechanical harvesting

Dipping\* and sun-drying

Mechanical separation of raisins and stems

Transportation to primary processing (e.g. cleaning and sorting)

## Basil and parsley



Manual or mechanical harvesting

Unloading into crates at on-farm post-harvest facility\*



















Cooling and short cold storage before transportation\*

Transportation to primary processing (e.g. freezing or drying)

\* optional steps depending on country/region, operation size, individual grower preferences, subsequent primary processing (e.g. drying versus freezing) and distance between farm and primary processing plant.

# Symbols

The following symbols will be used to guide the reader through the document

			
<b>Pathogenic Bacteria</b>	<b>Raw manure</b>	<b>Detergent</b>	<b>Worker</b>
			
<b>Pathogenic Viruses</b>	<b>Treated manure</b>	<b>Disinfectant/sanitizer</b>	<b>Farmer</b>
			
<b>Pathogenic Parasites</b>	<b>Generic crop</b>	<b>Hand soap</b>	<b>Competent supervisory personnel</b>
			
<b>Molds</b>		<b>Hand disinfectant</b>	<b>Competent professional</b>
			
<b>Foreign bodies</b>		<b>Do/Don't do</b>	<b>Raw material buyer</b>

# Symbols

The following symbols will be used to guide the reader through the document



**Hand washing**



**Potable water**



**Harvested  
rain water**



**Irrigation**



**Pesticides  
dilution**



**Non potable  
water**



**Municipal  
water**



**Drip  
irrigation**



**Cleaning**



**Surface water**



**Secondary  
treated sewage  
water**



**Furrow  
irrigation**



**Training**



**Ground water**



**Disinfected  
water**



**Overhead  
irrigation**



**Flood  
irrigation**

# Definitions

---

## **Crop production area:**

A plot of land where all growing, harvesting, and on-farm post-harvesting activities (e.g. sun-drying) are performed. This includes the growing field, toilet and hand washing facilities, potential storage areas and post harvest premises.

## **Growing field:**

A plot of land used to grow crops.

## **Storage area:**

A facility/contained area inside or outside the crop production area, used to store harvesting containers before use and/or harvested crops before their transportation to the processing plant.

## **Agricultural water:**

Water used for agricultural activities in the crop production area, such as: irrigation, pesticide and fertilizer preparation, cleaning of equipment and hand washing. In this document, agricultural water does not include water used during post-harvest processes.

## **Potable water:**

Water that meets the microbial standard for drinking water from World Health Organization (*E. coli* must not be detectable in any 100 mL sample).

## **Non potable water:**

Water that does not meet the microbial standard for drinking water from World Health Organization.

## **Municipal water:**

Potable water provided by the municipality.

## **Primary treated sewage water:**

Sewage water treated with a primary treatment. A primary treatment aims to reduce any settleable solid within the sewage water via mechanical treatment (filtration and sedimentation).

## **Secondary treated sewage water:**

Sewage water treated with primary and secondary treatment. Secondary treatment aims to decompose remaining suspended solids from the primary treated sewage water and to greatly reduce the microbial load via biological treatment (e.g. stabilization ponds).

## **Disinfected water:**

Water treated (e.g. chlorination) to remove pathogenic microorganisms such as *Salmonella* and viruses. Secondary treated sewage water can be disinfected to remove remaining pathogenic microorganisms that were not removed by previous treatments.

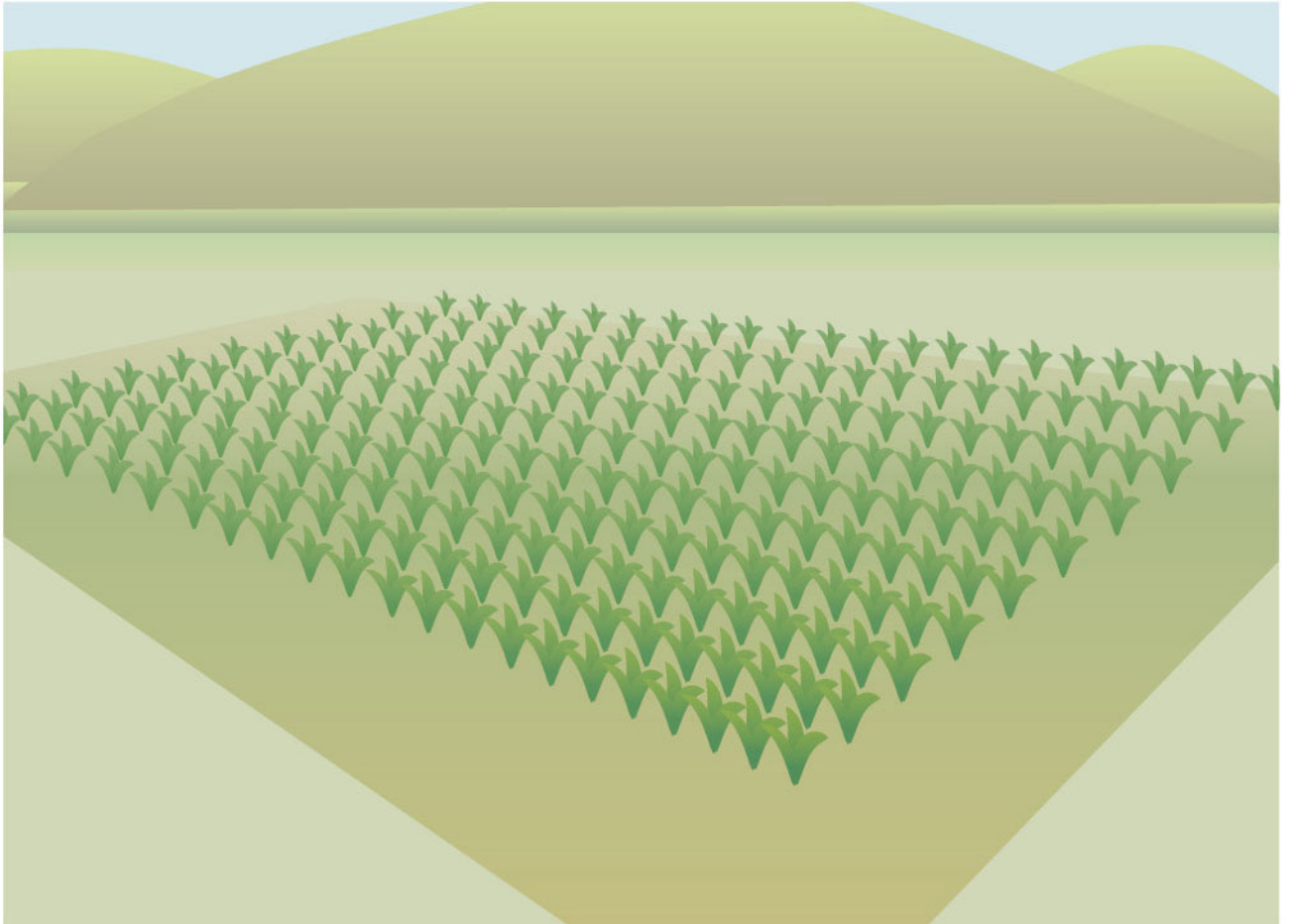
## **Turned pile/windrow composting:**

Process to produce stabilized compost in which air is introduced into a manure pile or windrow by turning on a regular basis. Turning is performed with the specific intention of moving the outer, cooler sections of the manure being composted to the inner, hotter sections.

## **Static aerated composting:**

Process to produce stabilized compost in which air is introduced into manure by a mechanism that does not include turning.

# 1. Growing field and adjacent land



Previous land use (land and adjacent land): pathogens in the soil	13
Water and/or soil run-off	14
Adjacent land use: Livestock production facilities (cattle, poultry, pigs...)	15
Adjacent land use: Industrial and urban activities	16



# Previous land use (land and adjacent land): Pathogens in the soil

**A** Previous land use (land and adjacent land) should minimize the risk of microbial contamination of the soil: avoid use of land that may have been contaminated by microbial hazards, especially fecal contamination and contamination by organic waste (e.g. animal production site, municipal waste/sewage disposal or treatment sites...).



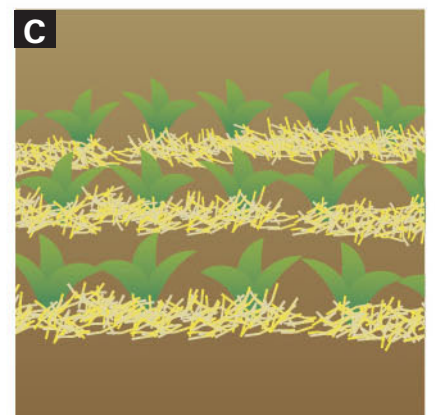
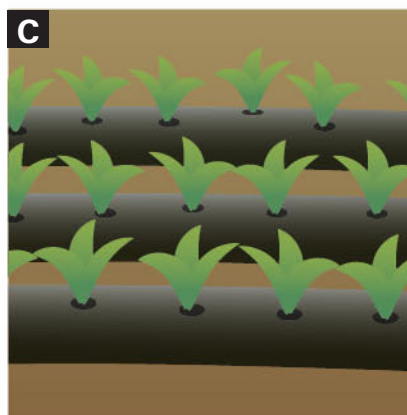
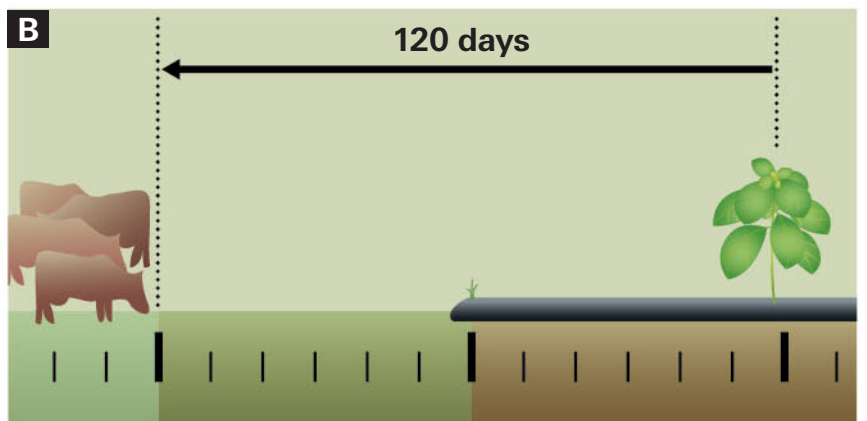
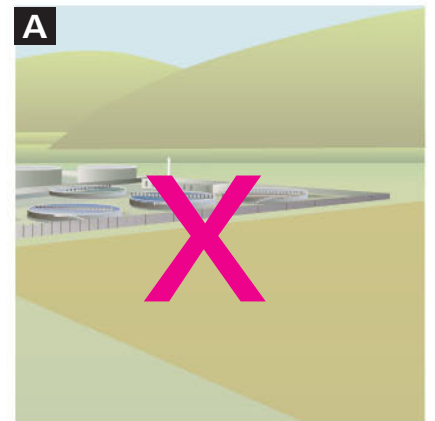
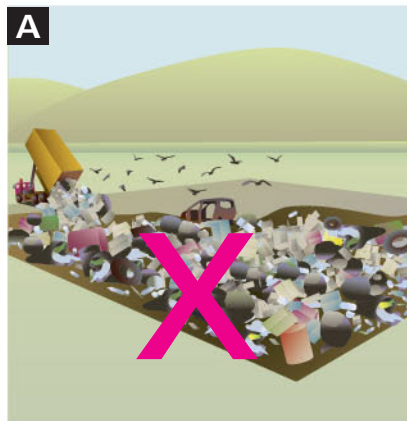
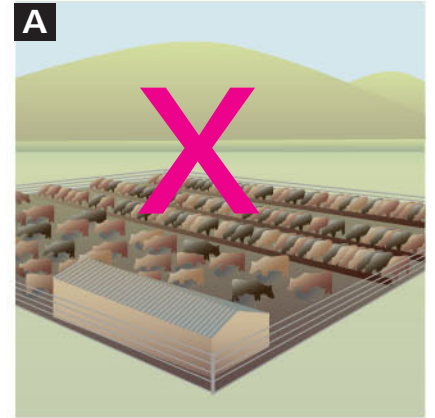
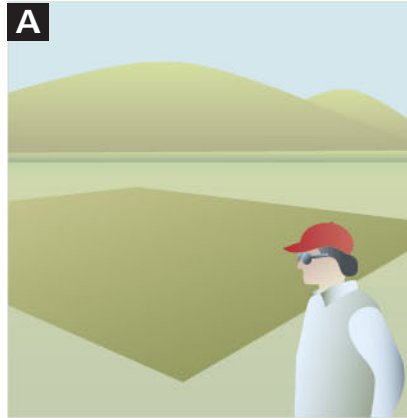
Select fields carefully to reduce the risk of microbial contamination.

**B** If livestock has been grazing in the field, ensure a time lapse between livestock grazing in the field and harvest of minimum 120 days or according to local regulation.

**C** Irrespective of previous land use, a protective system should be implemented when the crop can be contaminated by the soil e.g. plastic coverage or straw on soil (not applicable for root crops).

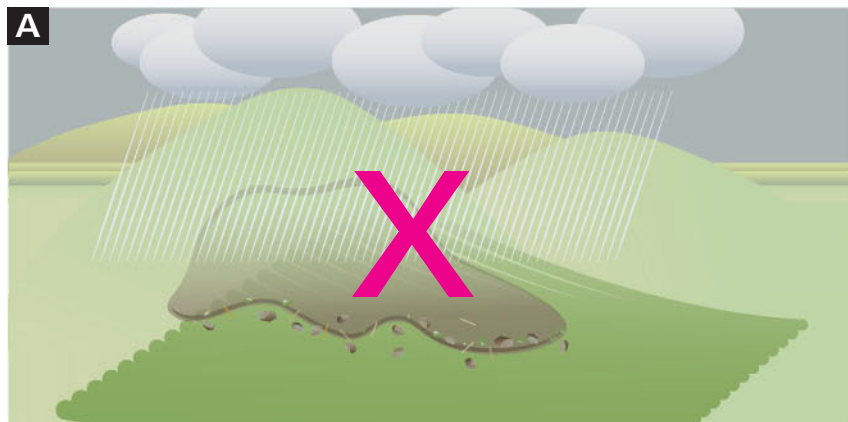


Plastic that will be reused should be easy to clean and disinfected. Plant material should be used only once.



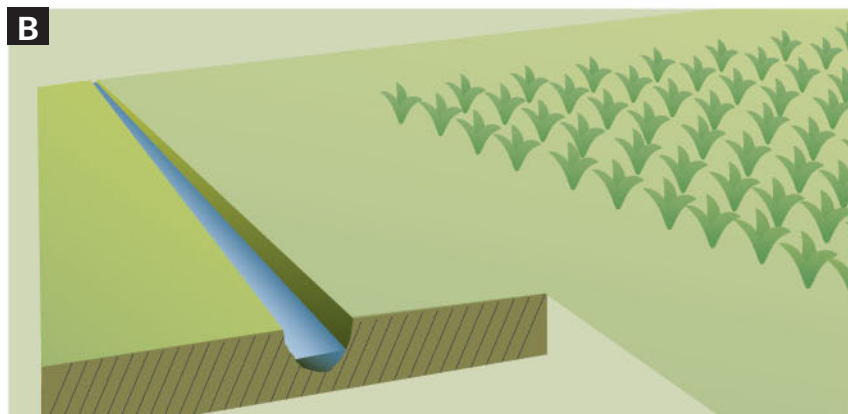
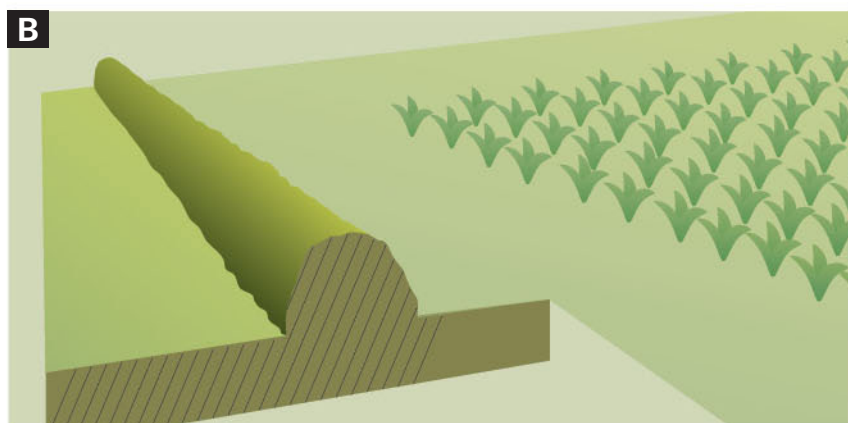
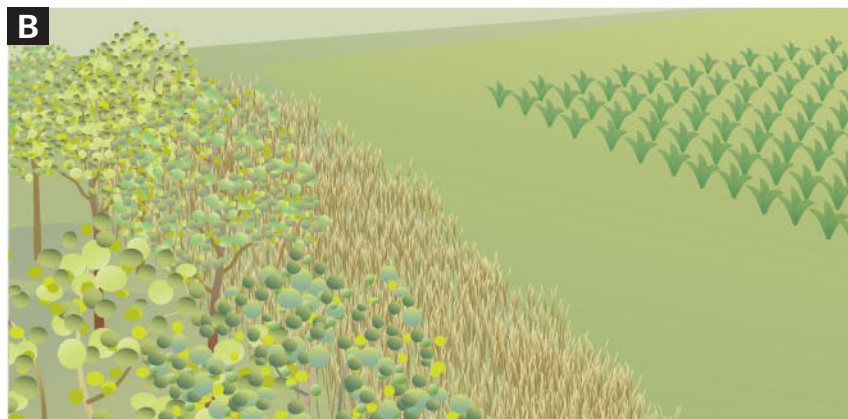
# Water and/or soil run-off

**A** Avoid using land which may be subject to water and/or soil run-off from higher land/or neighbouring land.



**B** If water and/or soil run-off can occur, implement physical barriers between higher/neighbouring land and the crop production area such as:

- vegetative buffer areas e.g. grass land, trees or another crop production which is not sensitive to microbial contamination;
- mounds;
- ditches.





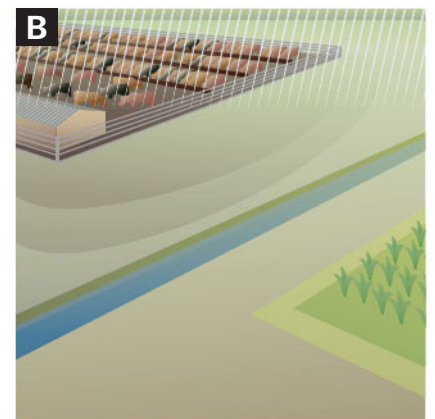
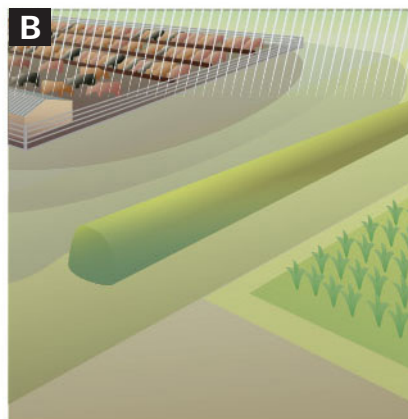
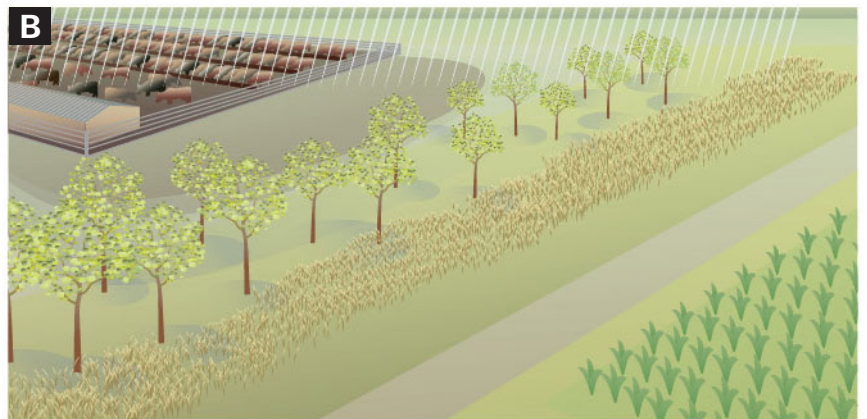
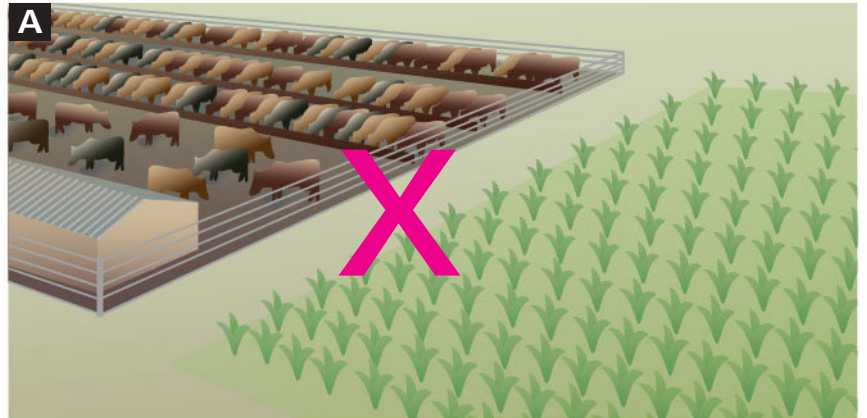
# Adjacent land use: Livestock production facilities (cattle, poultry, pigs...)

**A** Avoid the use of land adjacent to animal production facilities.



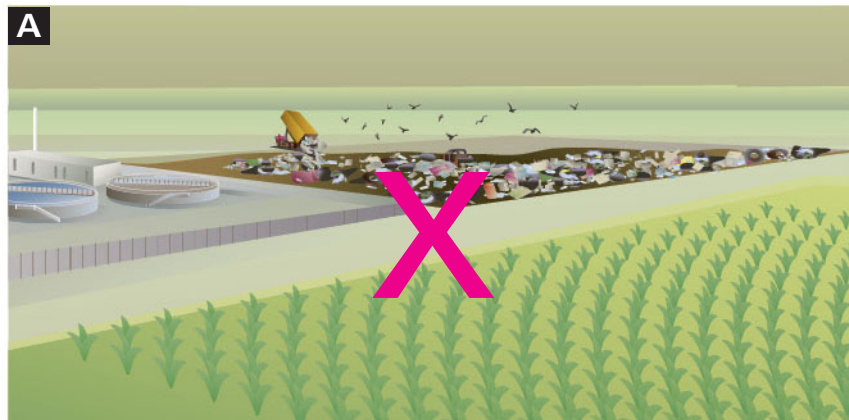
It is reasonable to assume that increasing distance will help to reduce the risk, although distance by itself is not a guarantee of no risk.

**B** If there is a risk of animal waste contamination from land in the vicinity of the crop area (e.g. during heavy rains), implement physical barriers between adjacent land and the crop production area such as described in section B of "Water and/or soil runoff", page 14.

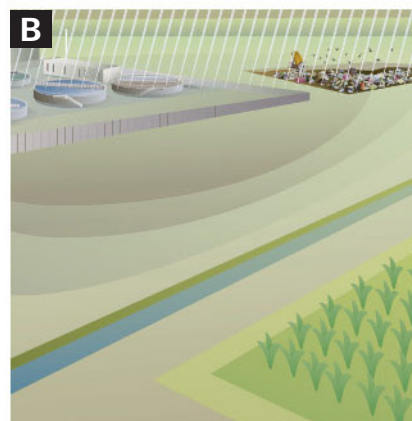
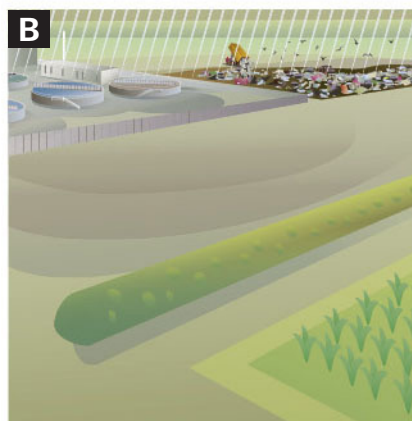
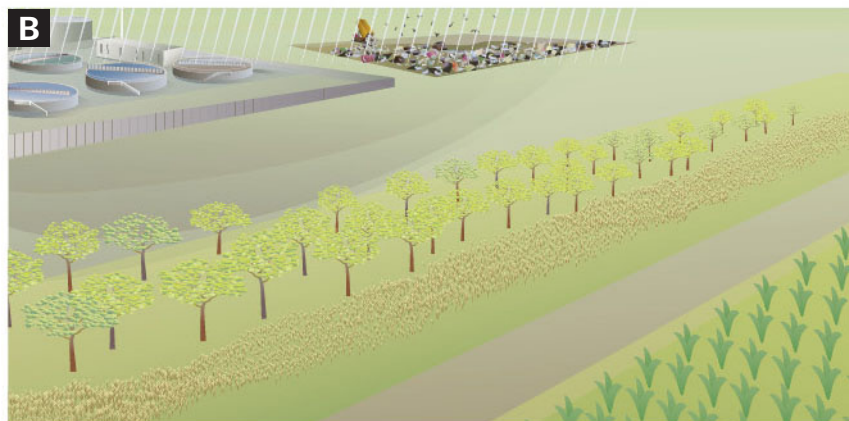


# Adjacent land use: Industrial and urban activities

**A** Avoid the use of land adjacent to industrial and/or urban activities such as sewage treatment or municipal waste collection.



**B** If there is a risk of industrial and/or urban waste contamination from land in the vicinity of the crop area (e.g. according to the slope of adjacent land), implement physical barriers between adjacent land and the crop production areas such as described in section B of "Water and/or soil run-off", page 14.

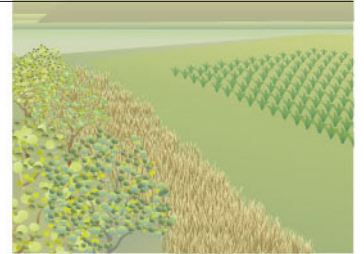


# Growing field and adjacent land: REMEMBER!

**1. Select fields carefully to reduce the risk of microbial contamination.**

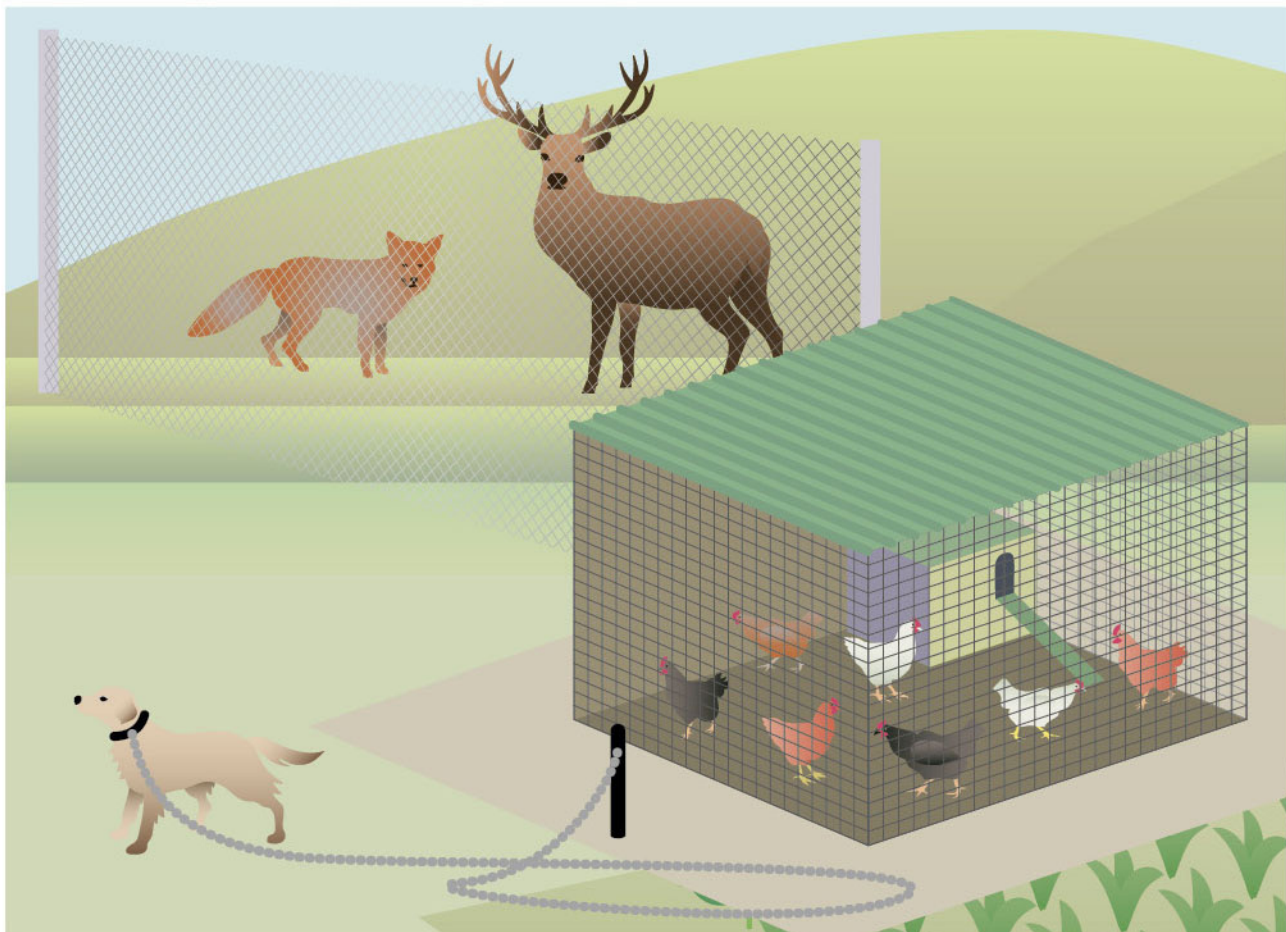


**2. If there is a risk of contamination from land in the vicinity of the crop production area (e.g. during heavy rains), implement physical (vegetative) barriers.**





## 2. Animals (domestic, farm and wild animals)



Domestic animals (dogs, cats...)

21

Farm animals (cattle, poultry, pigs...)

22

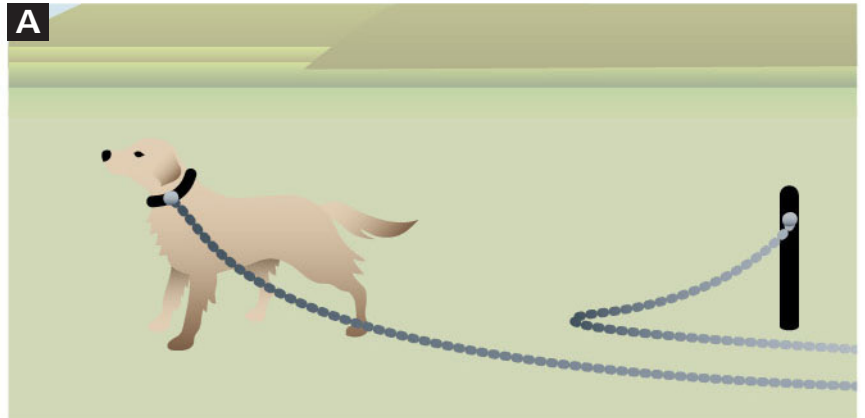
Wild animals (deer, wild pigs,  
birds, rabbits, reptiles, rodents...)

24



# Domestic animals (dogs, cats...)

**A** Limit access of domestic animals to crop production areas during the growing season and during harvesting: their movements on the farm should be controlled and their fecal waste discarded outside the crop production area (e.g. buried).

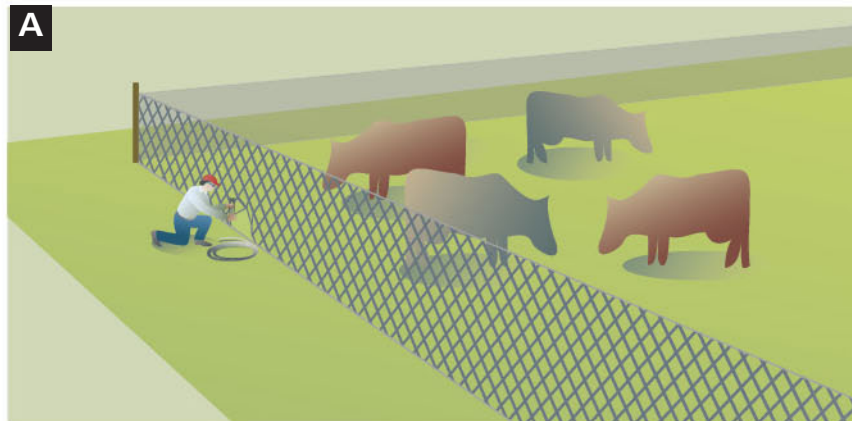
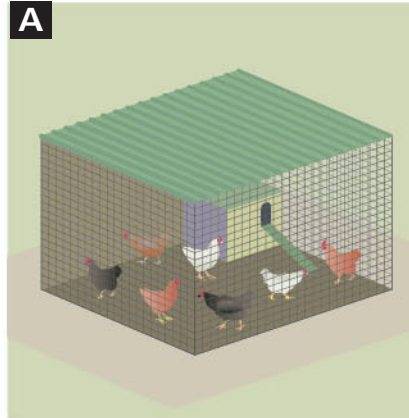


**B** Inform all workers that they are not allowed to bring animals onto the crop production area. Consider the use of signs to inform workers (e.g. as part of the general restrictions in the crop production area).

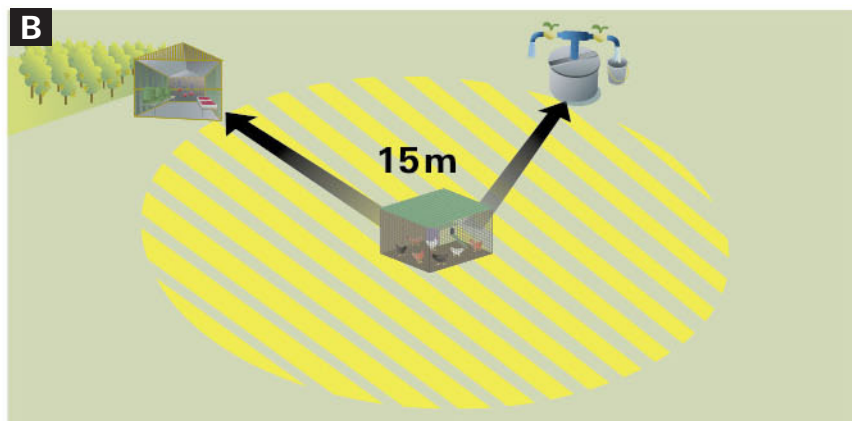


# Farm animals (cattle, poultry, pigs...)

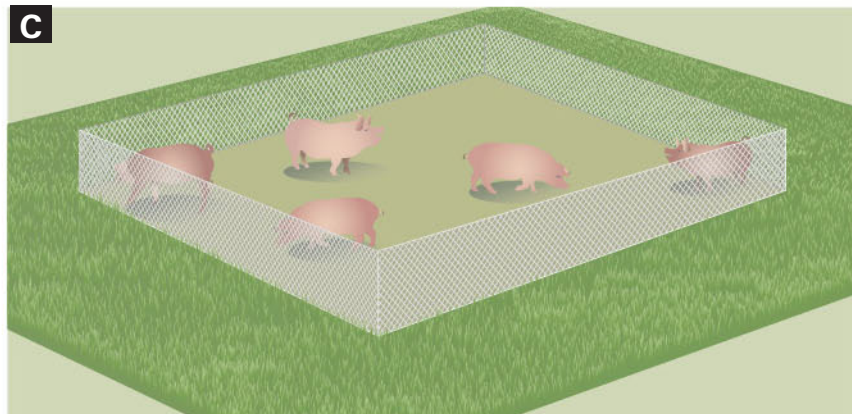
**A** Keep farm animals confined or prevent their entry in the crop production area using physical barriers (fences). Inspect the good condition of the fences and restore if necessary.



**B** Locate animals at least 15 meters\* (and if possible downhill) from agricultural water sources (e.g. ponds, wells), growing fields and storage areas.



**C** Consider the implementation of vegetated buffer strips (e.g. grass strips) around animal areas, to reduce contamination from runoff.



\*or according to local regulation



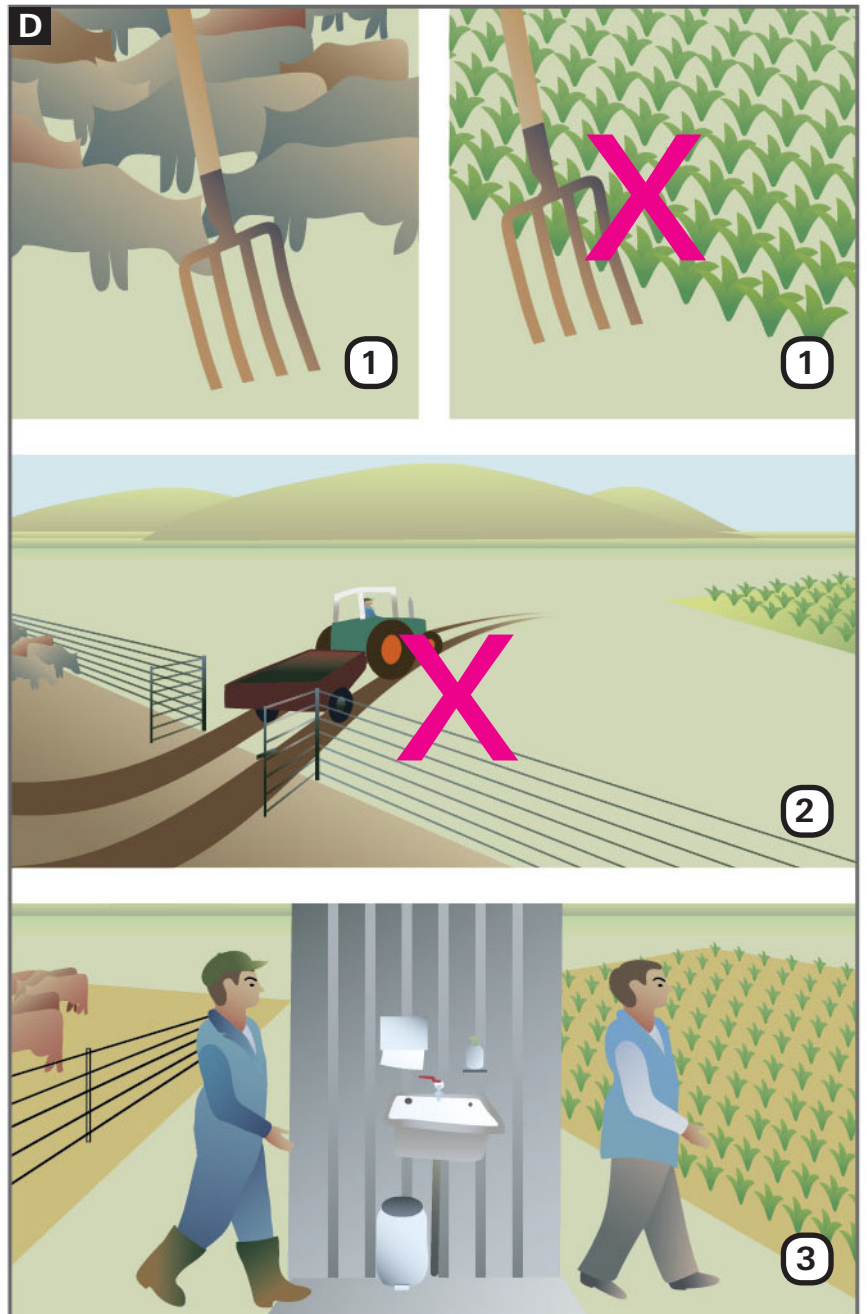
# Farm animals (cattle, poultry, pigs...)

**D** Avoid cross contamination from farm animal activities to the crop production area by:

1. Not using utensils and tools from farm animal activities for activities related to crop production, unless they have been cleaned and sanitized. If possible, use dedicated tools for farm animal activities and for crop production;
2. Restricting vehicles associated with farm animal activities from entry to the crop production area;
3. Washing hands and changing boots (and changing clothes if necessary) while moving between animal and crop production area.



If farm animal activities cannot be conducted in ways which prevent animal fecal contamination of the crop (e.g. through run-off, aerosols...), these farm animal activities and crop productions should not be performed at the same farm!



# Wild animals (deer, wild pigs, birds, rabbits, reptiles, rodents...)

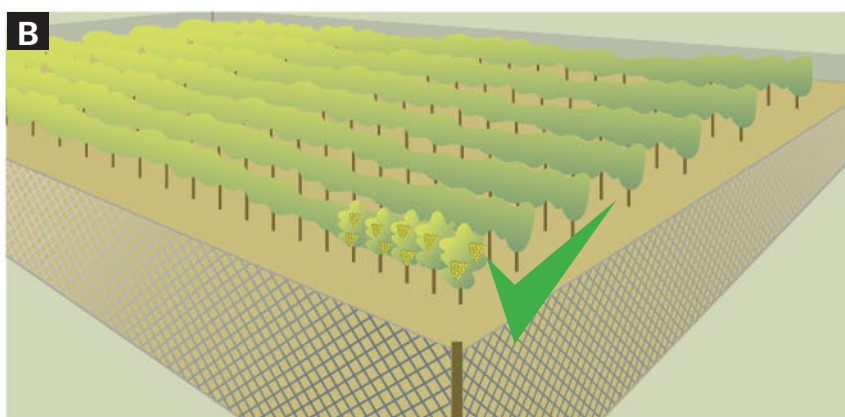
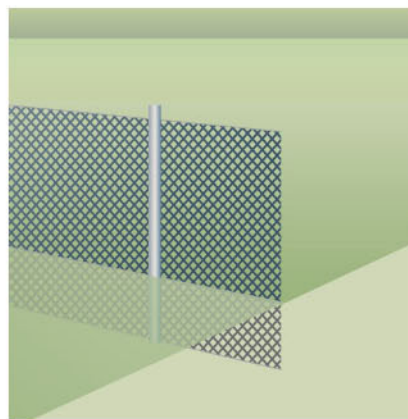
Farmers should be careful to not endanger protected species or remove their habitat.

**A** Prevent the entry of wild animals onto the crop production area using fences (unless it has been demonstrated that there is no risk associated with wild life). Inspect the good condition of the fences and restore if necessary.



Fences are only effective for larger animals such as deer or wild pigs, but are not completely effective for birds or small terrestrial animals such as rodents and reptiles. Furthermore, it is best to build the fence into the ground to make it more effective against animals that can burrow into the ground (underneath the fence) such as rabbits.

**B** Minimize habitat, nesting and feeding of birds and small terrestrial animals (e.g. rodents, reptiles) in and around the field e.g. remove waste and stagnant water, avoid too many bushes.



# Wild animals (deer, wild pigs, birds, rabbits, reptiles, rodents...)

Farmers should be careful to not endanger protected species or remove their habitat.

**C** If necessary, deter birds from the crop field: Make use of visual repellants such as shiny ribbons, reflective strips, scarecrows, or acoustic repellants emitting unfamiliar loud noise, predator bird calls or bird distress calls. Ultrasonic devices are commonly ineffective for many types of birds.



Combined sight and sound repellants which are varied regularly are most successful, since birds can easily overcome repellants.

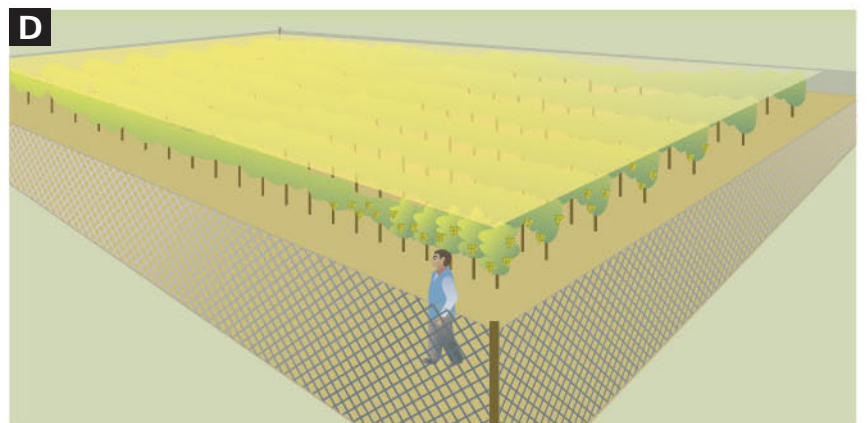
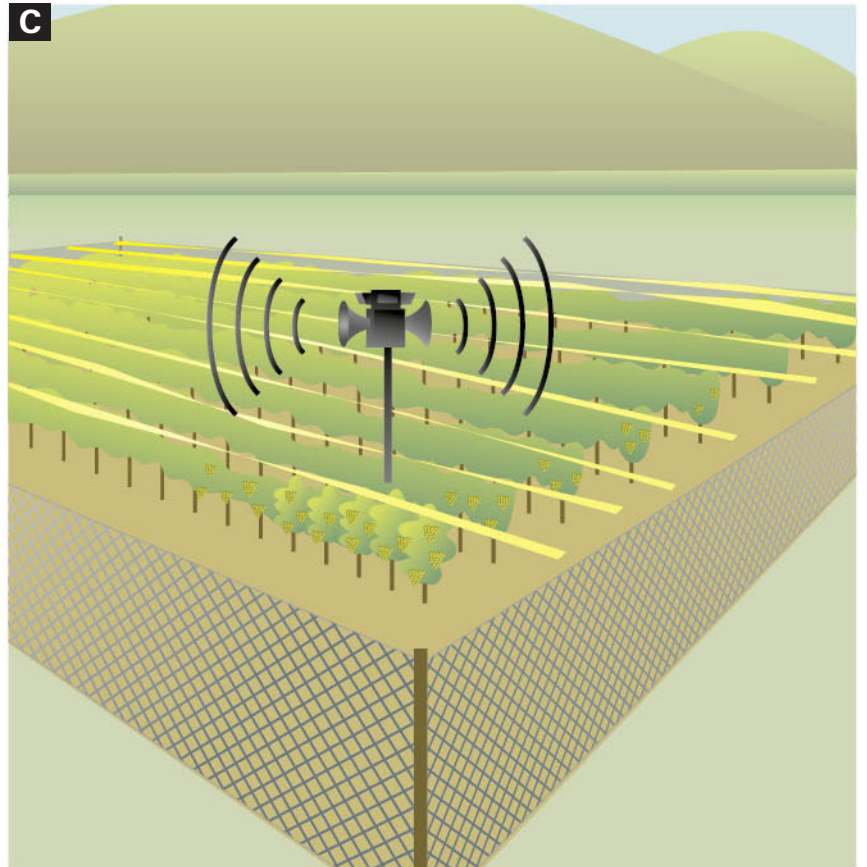


Do not use chemical repellants in the crop production area.

**D** If necessary, consider the use of nets to protect crop areas from bird invasion.



Use the right mesh size according to the bird species of concern. An inappropriate size could lead to ineffectiveness or bird injury such as wing damage.



# Wild animals (deer, wild pigs, birds, rabbits, reptiles, rodents...)

Farmers should be careful to not endanger protected species or remove their habitat.

**E** Do not use rodenticides in the crop production area, because of the risk of secondary poisoning of other animals and the risk of crop contamination. In storage area, rodenticides might be exceptionally needed to control an infestation, if legally permitted (refer to page 101 for specific requirements on storage areas).

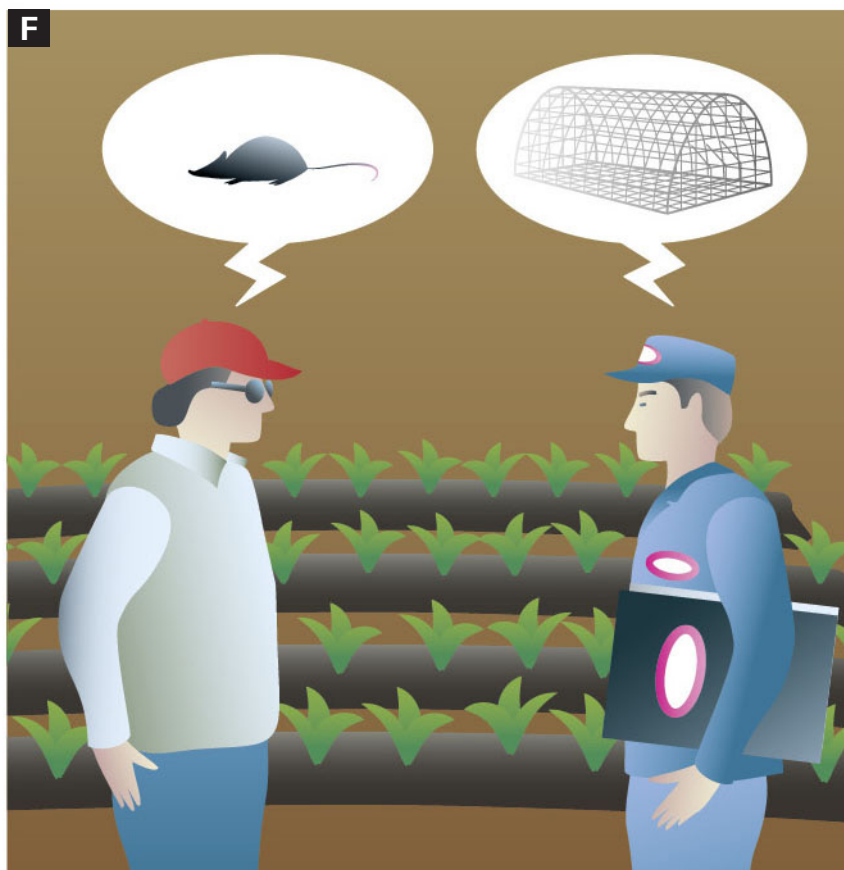


To prevent contamination from rodents, the focus should be on "restriction measures" minimizing hiding places and feeding, such as described in B page 24.

**F** If restriction measures are not effective enough to control rodents in the crop production area, traps may be used. These traps must be legal in the country of use and live traps (i.e. no killing) should be favored as far as possible.



A competent professional should be consulted to ensure the legality and design of the trap, so that the correct species is targeted. If you do not know whom to contact, discuss first with your raw material buyer.



# Wild animals (deer, wild pigs, birds, rabbits, reptiles, rodents...)

Farmers should be careful to not endanger protected species or remove their habitat.

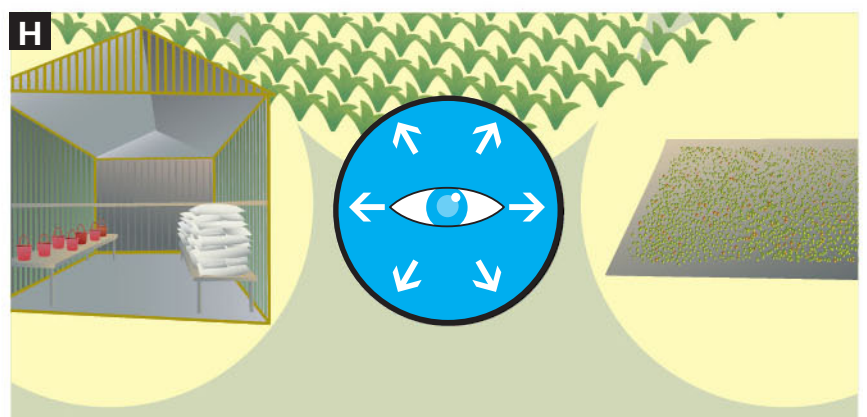
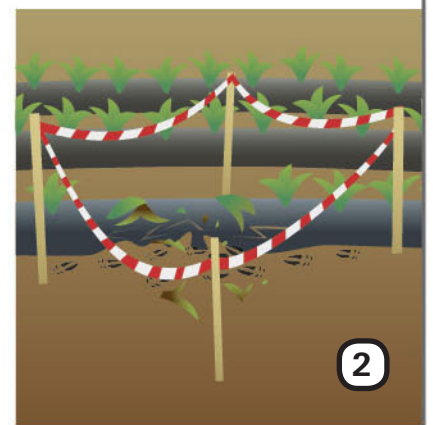
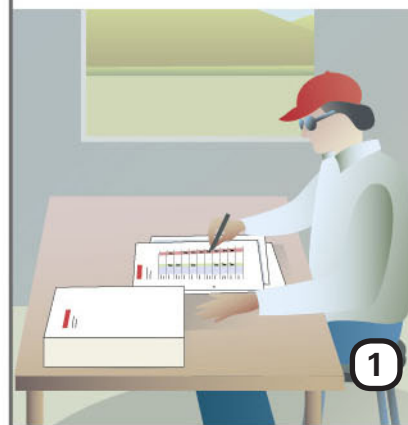
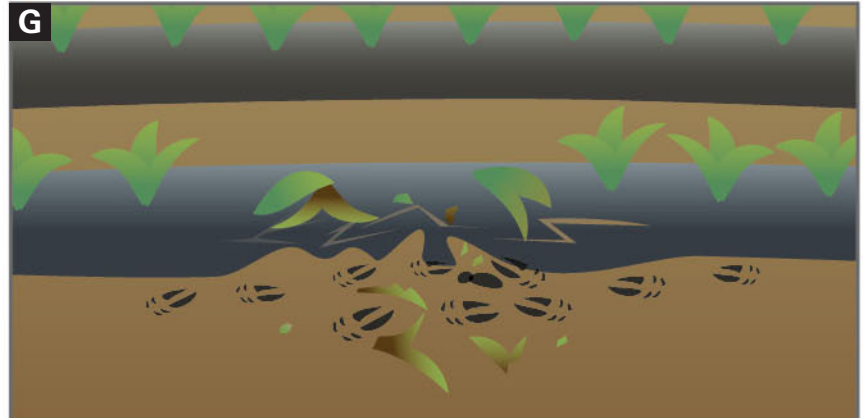
**G** Before harvesting, scouting for signs of substantive intrusion in the field should be performed (e.g. tracks, gnawing, burrowing etc.). When clear evidence of intrusion is found:

1. This should be reported and recorded;
2. Access to this zone should be restricted and crop should be harvested separately;
3. When relevant, further use of the crop from this zone should be discussed with your raw material buyer.



If animal faeces are found in the field, this area should not be harvested. The no-harvest buffer zone should have a 1.5 m radius.

**H** Scouting for signs of intrusions should also be performed in the entire crop production area, especially where crop and/or equipment is exposed e.g. storage area, sun-drying area. Like before harvesting, any sign of intrusion should be reported and recorded and corrective action taken e.g. cleaning and disinfection of the storage area (and of potential equipment inside), decision on further use or discard of the crop etc.

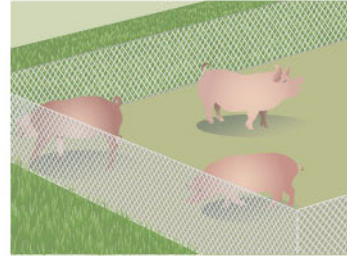


# Animals: REMEMBER!

**1. Control movements of domestic animals.**



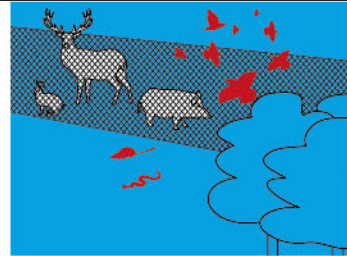
**2. Keep farm animals confined and far away from water sources, growing fields and storage areas.**



**3. Use dedicated tools for farm animal activities and crop activities.**



**4. Prevent intrusion and minimize habitat of wild animals in the crop production area e.g. using fences and bird repellants, avoiding waste.**



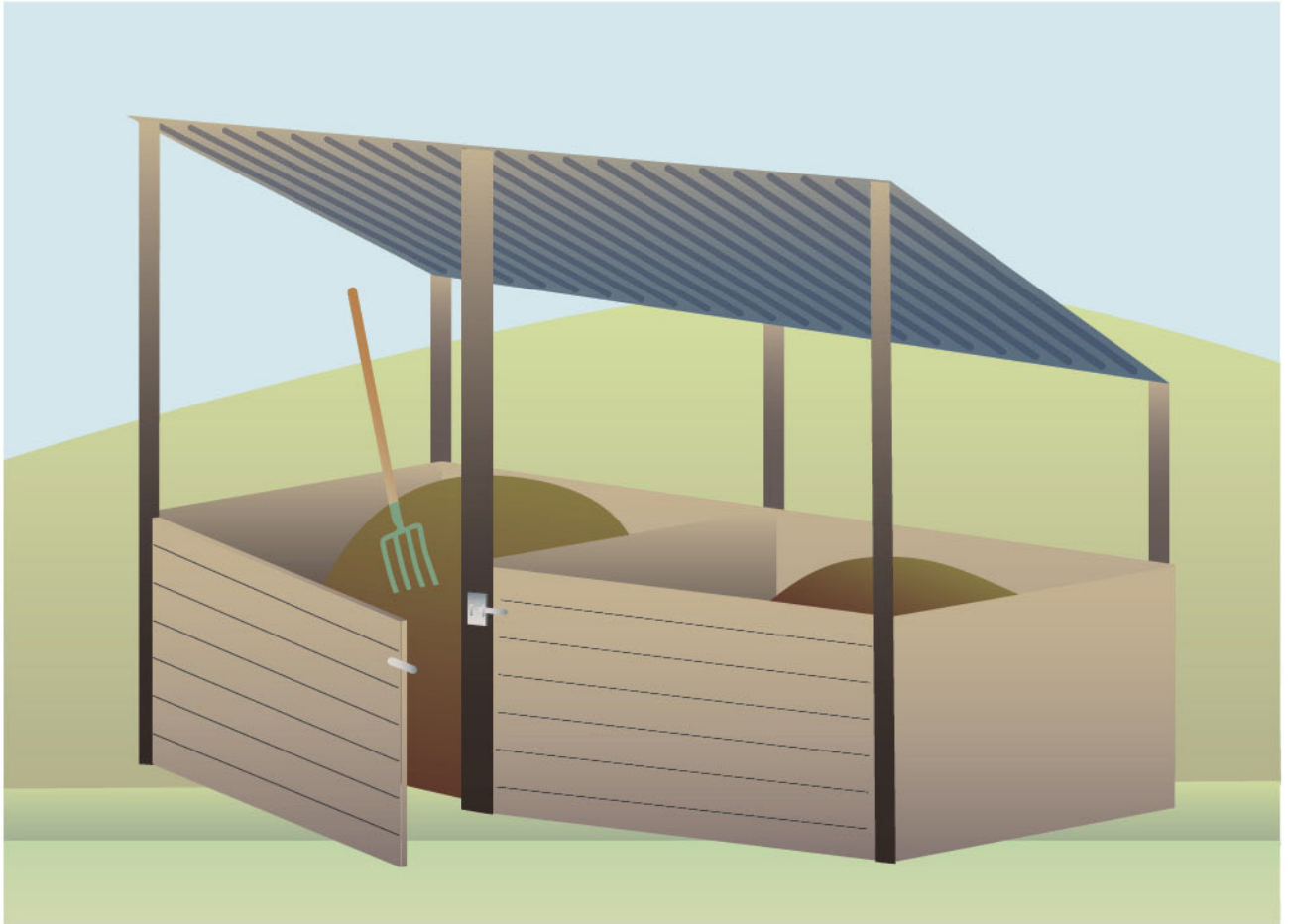
**5. Do not use rodenticides or chemical repellants in the growing field.**



**6. Take corrective actions when clear evidence of animal intrusion in the field is found.**



# 3. Manure-based soil amendments



Use and application of raw manure in soil	31
Use and application of treated manure in soil	32
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# Use and application of raw manure in soil

**A** Apply raw manure prior to planting (perform immediate incorporation of manure after spreading to get best effects of nutrients).



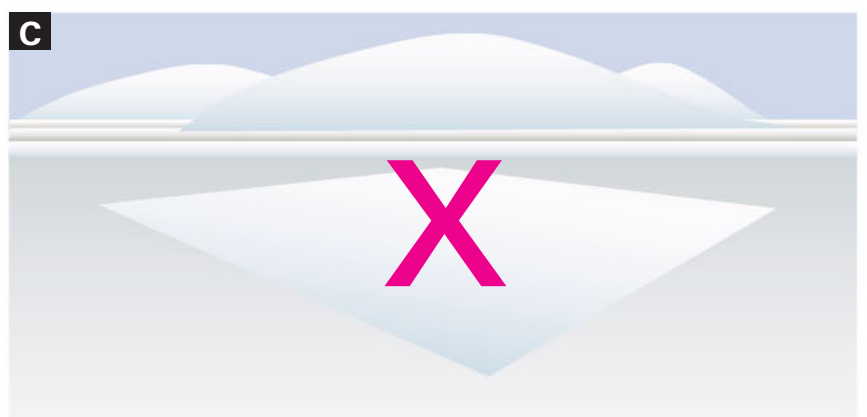
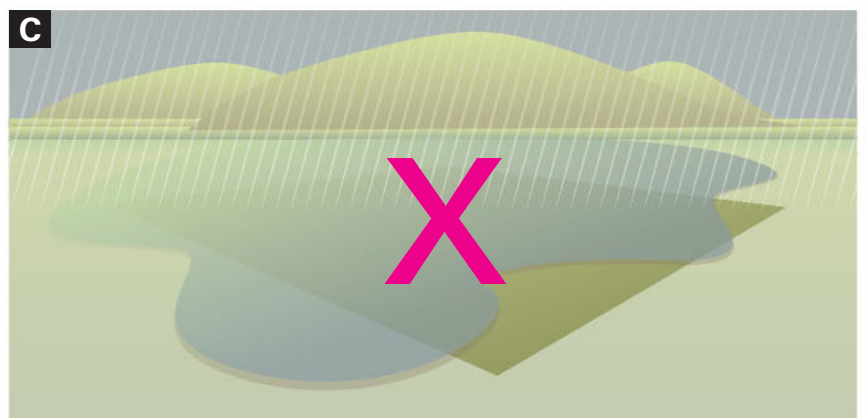
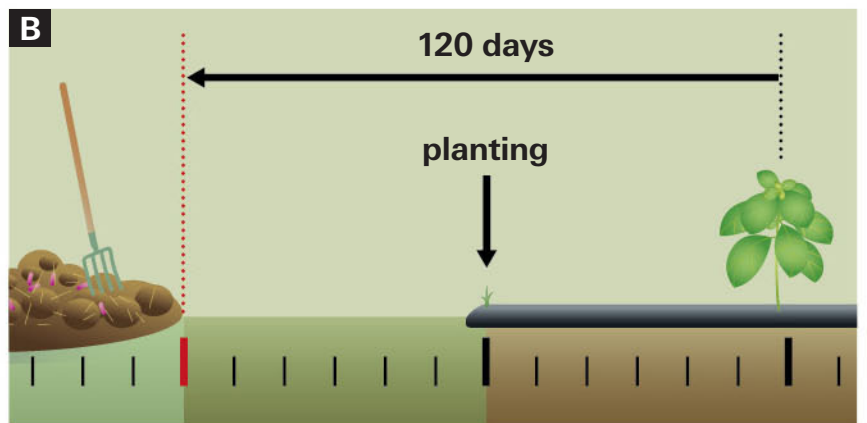
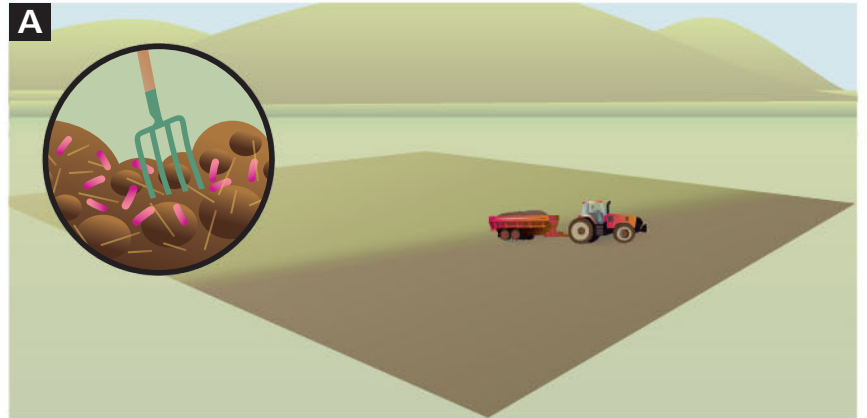
For tree crops, apply raw manure before bud burst and never less than 60 days before harvest.

**B** Apply raw manure at least 120 days before harvest or according to local legislation.



When it is not possible to apply this interval restriction, do not use raw manure.

**C** Do not spread raw manure on fields that are water saturated, prone to annual flooding/run-off, frozen or snow-covered.



# Use and application of treated\*

## manure in soil

\*treated by a scientifically valid controlled process (e.g. controlled composting)

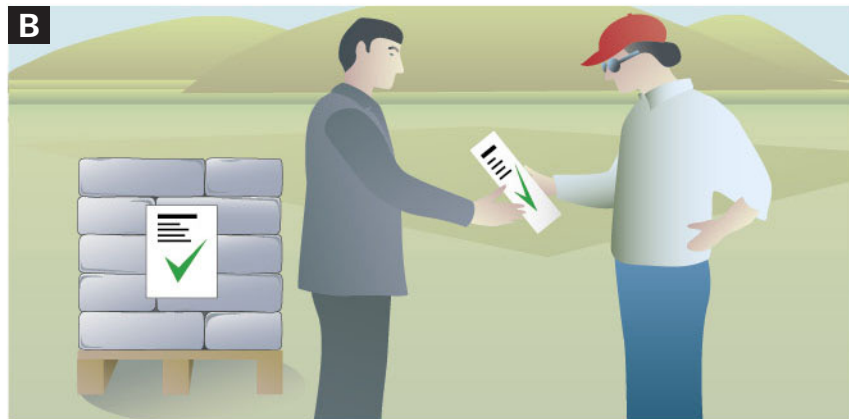
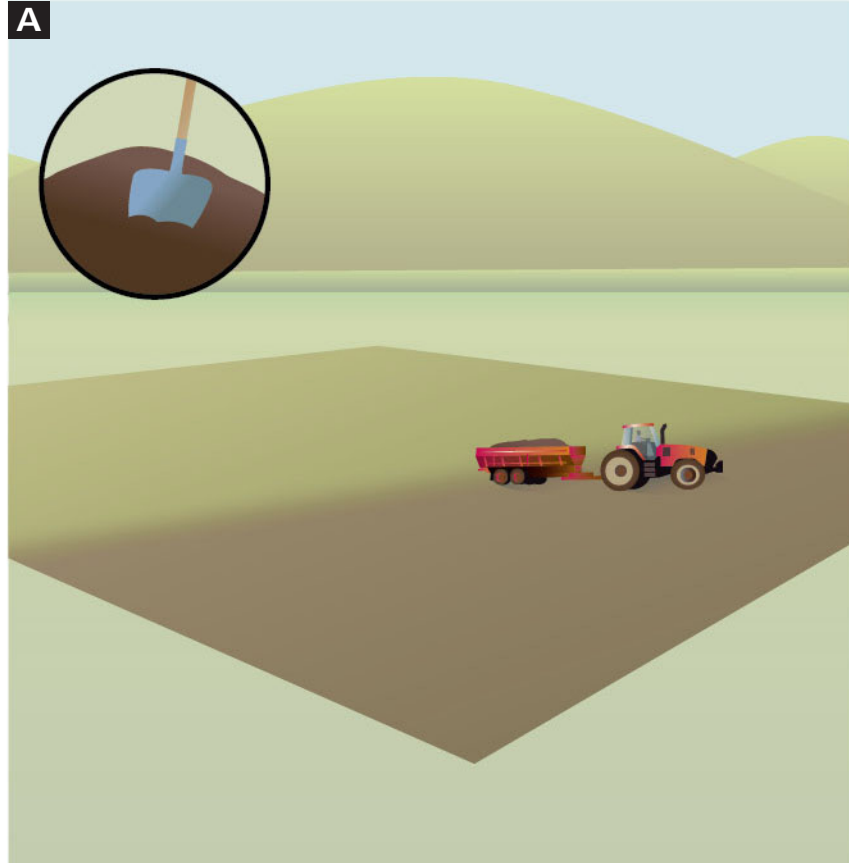
**A** Apply treated manure prior to planting. The 120 days interval restriction of raw manure (see B page 31) does not apply for treated manure.



For perennial crops, when absolutely essential to the production system, treated manure can be also applied during the dormant period but only where edible part of the crop will not come into physical contact with the manure/soil.

**B** If treated manure is purchased from an external source (commercially treated), it should be purchased only from suppliers which provide information on:

- origin;
- treatment used;
- tests performed and test results showing that human pathogens of concern have been effectively controlled (see section E “On-farm composting of manure”, page 35).

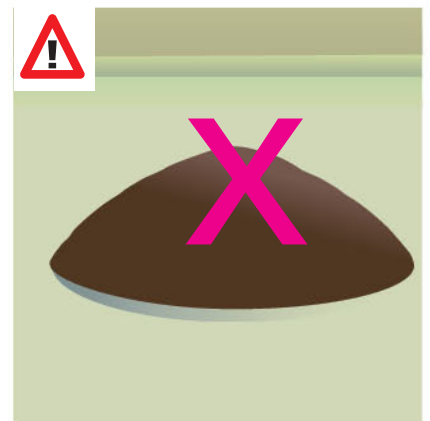
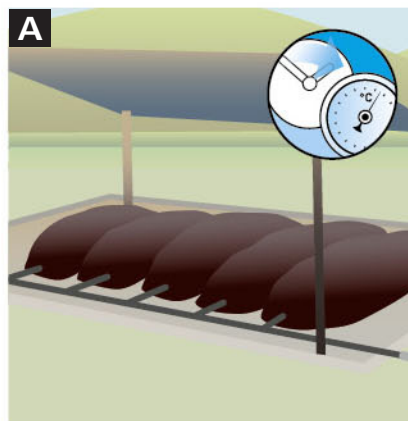
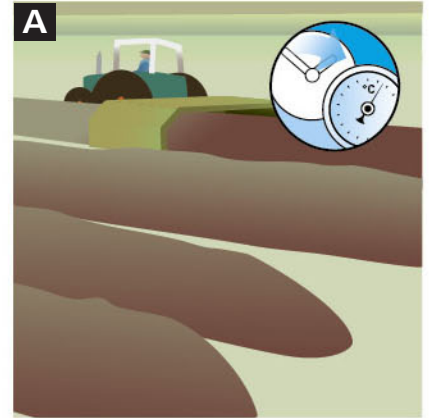
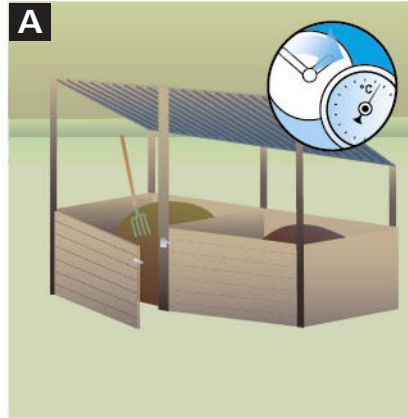


# Treatment of manure: On-farm composting of manure with a controlled process

**A** For any type of composting (i.e. turned pile/turned windrow composting or static aerated composting), raw manure has to remain for a period of time at a designated temperature.



Simple stock piling is not appropriate to ensure that all pathogenic bacteria and/or viruses have been killed.



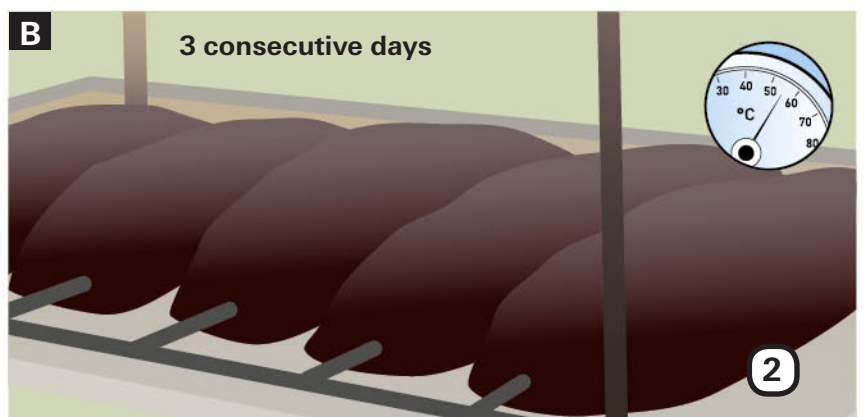
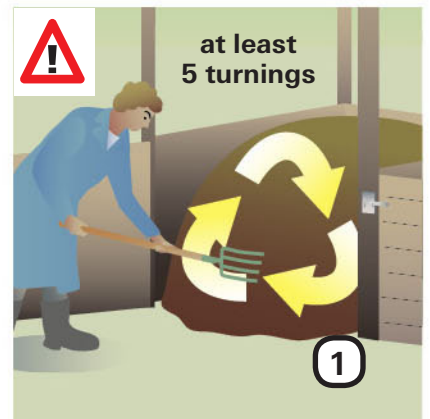
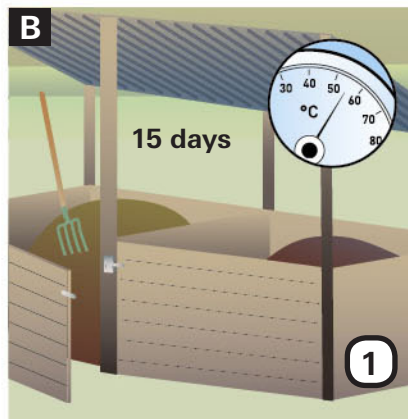
**B** The temperature needs to reach:

1. At least 55°C for 15 days (need not be consecutive) in the hot zone of a turned pile/turned windrow, with at least 5 turnings (around 3 times a week).



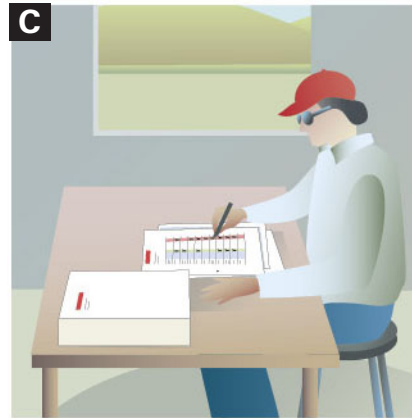
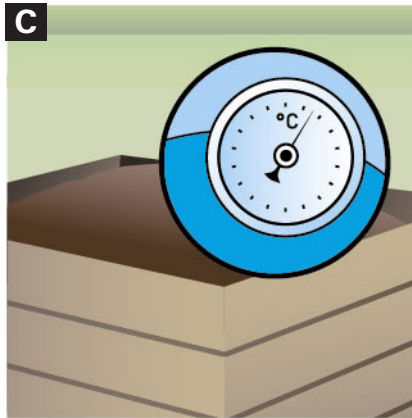
Piles/windrow should be turned so that the outer mass can be exposed to the highest temperature inside the pile.

2. At least 55°C for 3 consecutive days in a static aerated pile.

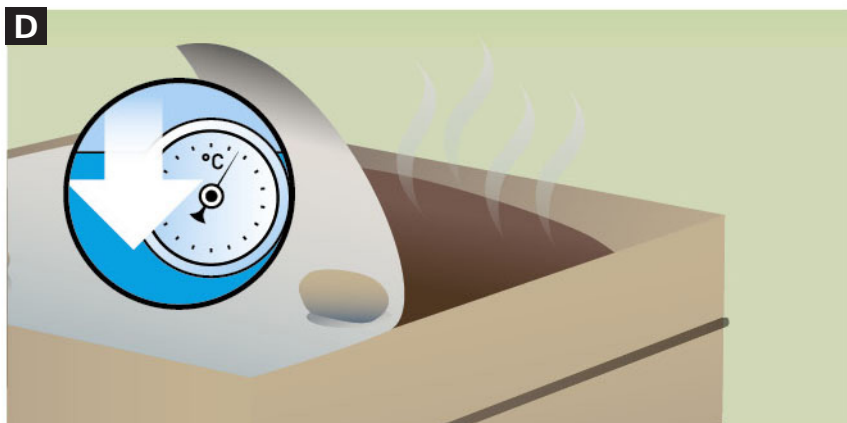


# Treatment of manure: On-farm composting of manure with a controlled process

**C** Monitoring and recording of the temperature at selected places within the manure pile has to be performed, as well as recording of time (days) and number of turnings (when applicable).



**D** After the correct period of time at the designated temperature, allow temperature of the manure to decline gradually (approximately 45 days) to reach cooler conditions (the curing stage). This curing stage generates a stabilized compost which is dark brown, crumbly and earthy-smelling.



# Treatment of manure: On-farm composting of manure with a controlled process

**E** Pathogen testing should be performed by a laboratory ISO 17025 accredited for method of testing (or one approved by an official government scheme), at least once to validate the compost process (at the end of the curing stage):

- *Salmonella* absence in 25g portion;
- And *Listeria monocytogenes* absence in 25g portion;
- And *E. coli*  $\leq 1000$  CFU/g;
- Or according to local regulation.

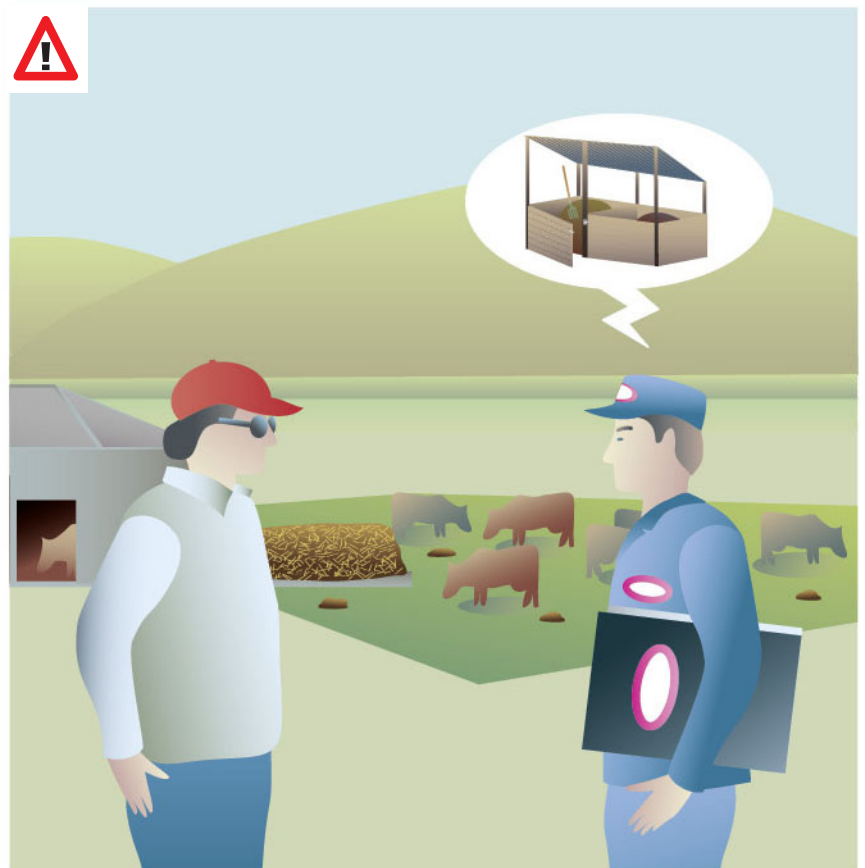


Before initiating on-farm composting, a competent professional should be consulted to ensure the treatment will produce stabilized compost that can meet the microbial standards. If you do not know whom to contact, discuss first with your raw material buyer.

**E**



*Salmonella* absence in 25g  
*L. mono* absence in 25g  
*E. coli* < 1000 CFU/g



# Treatment of manure: On-farm composting of manure with a controlled process

**F** Compost tea (made from composted manure steeped in water) should be prepared with:

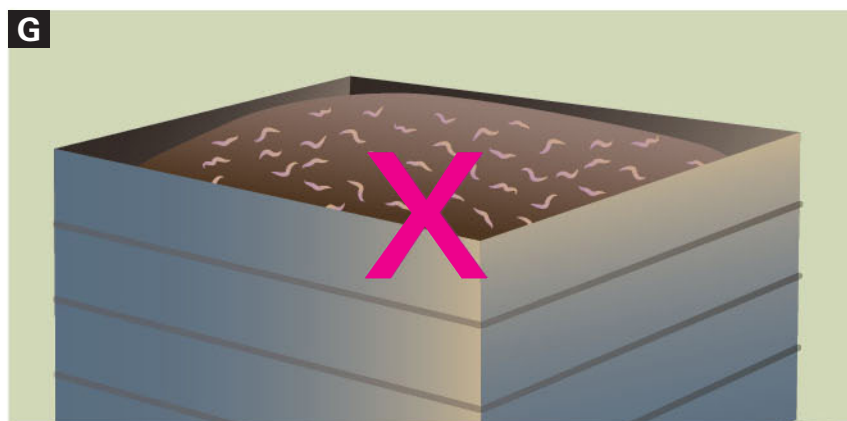
- Potable water (absence of *E. coli* in 100 mL);
- Properly composted manure (see A to E page 33 to 35).



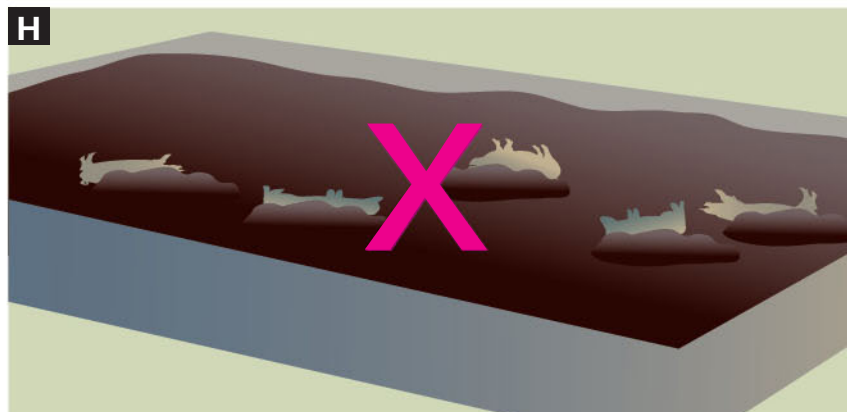
Do not use compost tea for which production process uses supplemental nutrients because these nutrients can support growth of even a few surviving cells of pathogenic bacteria.



**G** Do not use Vermicomposting of manure (worm composting), unless manure is pre-treated by a thermal method or significantly diluted (50% at least) before worm composting.

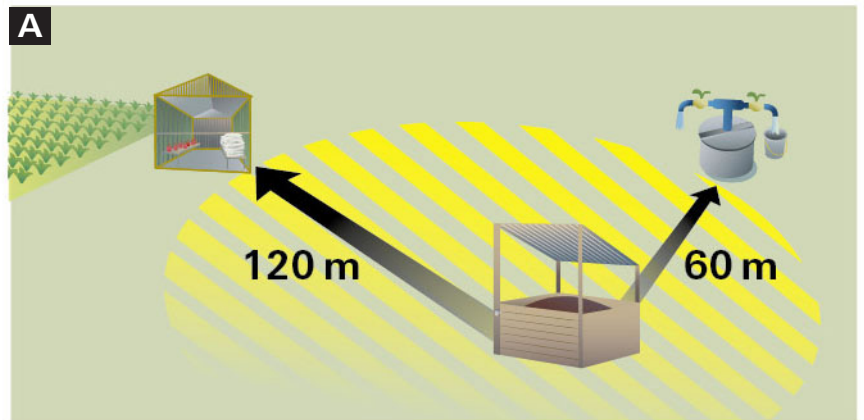


**H** Do not use carcass composted products or untreated human sewage sludge.



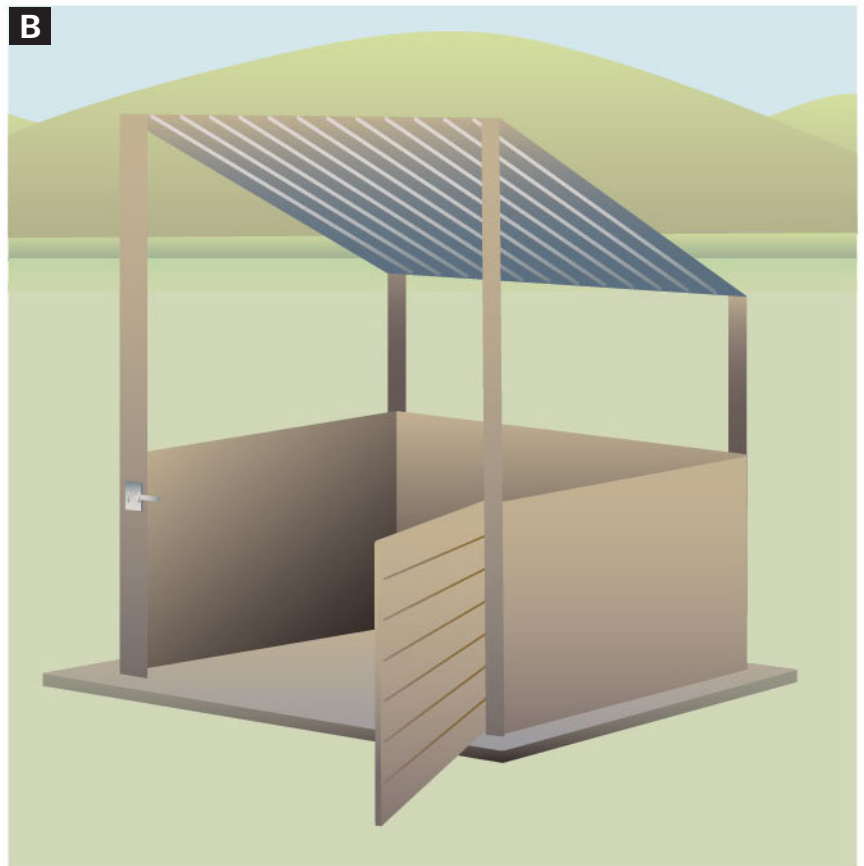
# Cross-contamination between raw manure/composting activities and crop production area

**A** Keep raw manure storage and composting areas far away from growing field and harvested produce (at least 120 meters\*) and from water sources (at least 60 meters\*) and, if possible, downhill.



**B** Avoid any risk of leakage or wind spread of raw manure during composting by using:

- Physical barriers such as wall, sheeting;
- Appropriate covering;
- A stabilized surface.

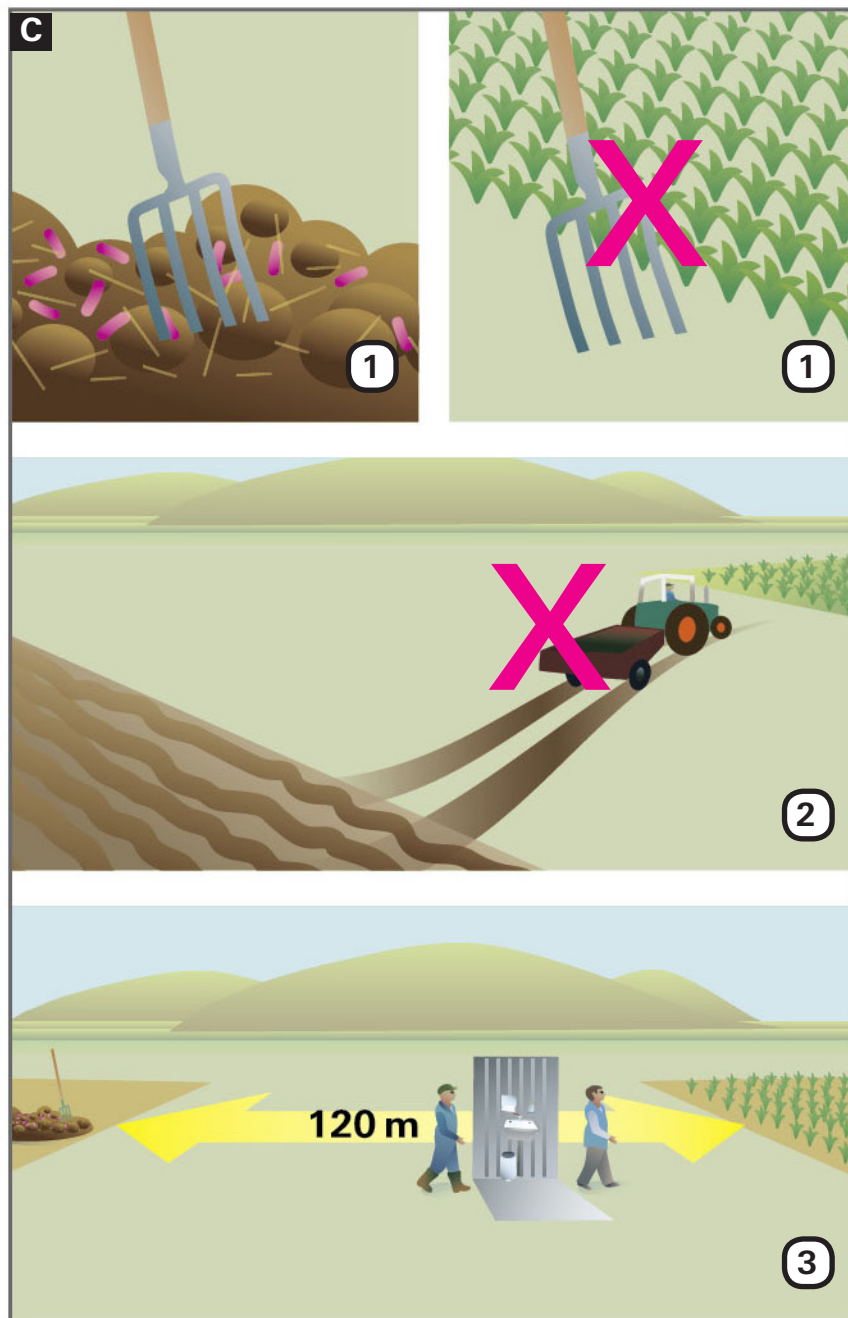


\*or according to local regulation

# Cross-contamination between raw manure/composting activities and crop production area

**C** Avoid cross contamination from raw manure and composting activities to the crop production area by:

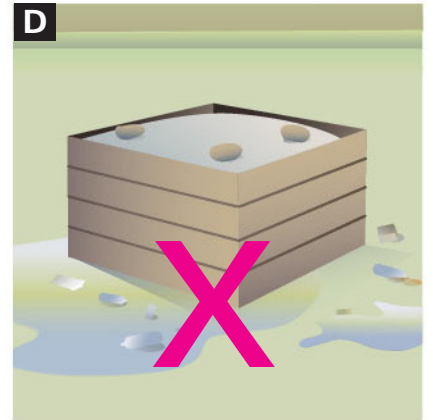
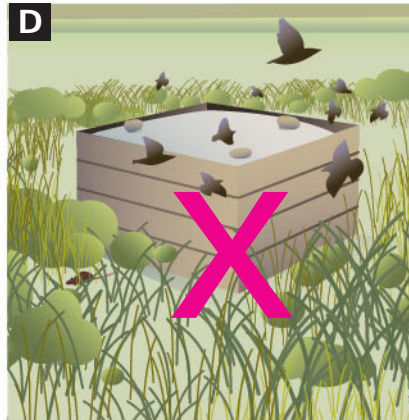
1. Not using utensils and tools from raw manure and composting activities for activities related to composted manure and crop production, unless these equipment or tools have been cleaned and disinfected. If possible, use dedicated tools for raw manure/composting activities, for composted manure and for crop production.
2. Avoiding vehicles from these raw manure and composting activities to enter the crop production area during growing season and harvesting.
3. Washing hands and changing boots (and changing clothes if necessary) when going from raw manure/composting area to crop production area during growing season and harvesting.





# Cross-contamination between raw manure/composting activities and crop production area

- D** Minimize the potential recontamination of composted manure by:
- Using covered storage;
  - Avoiding bushes and cutting the grass around storage to avoid pest nesting;
  - Removing waste and avoiding stagnant water around storage.



- E** Train employees on the risk of raw manure and composting cross-contamination.



Do not discharge untreated or improperly treated manure and faeces into surface waters.

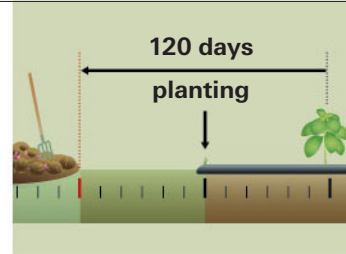


# Manure-based soil amendments: REMEMBER!

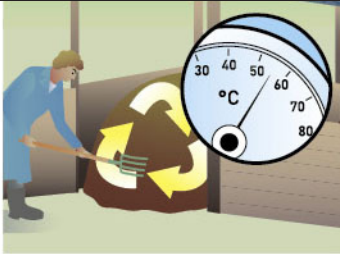
1. Apply manure prior to planting.



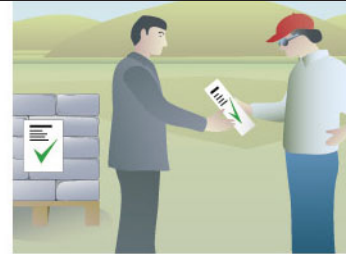
2. Apply raw manure at least 120 days before harvest.



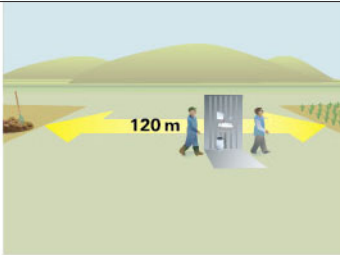
3. Use composted manure which has followed controlled composting (rather than simple stock piling): record temperature, time and, when applicable, number of turnings.



4. Validate on-farm controlled composting and/or ask for a certificate of compliance if you purchase treated manure from an external source.



5. Avoid cross-contamination between raw manure/composting areas and crop production area.



# 4. Agricultural water



**Water used in on-farm post-harvest processes (e.g. cooling, washing, blanching) is out of the scope of this chapter (see Definitions section page 10). Water used in post-harvest processes that comes in contact with the crop should be only potable water (i.e. water that meets the microbial standards for drinking water from WHO). Ice used in post harvest processes should be obtained from potable water.**



Water source and irrigation method (Type A and Type B water)	43
Wells, water collection, storage and distribution systems (e.g. tanks, ponds, pipes)	47
Agricultural water testing	50
Water disinfection treatments	53
TABLE 1 Microbiological risk ranking of agricultural water according to water source and type of application	55
TABLE 2 Microbiological testing recommendations for type A agricultural water according to the water source	56



# Water source and irrigation method (Type A and Type B water)

**A** Identify the source of the water to be used for applications listed in section B:

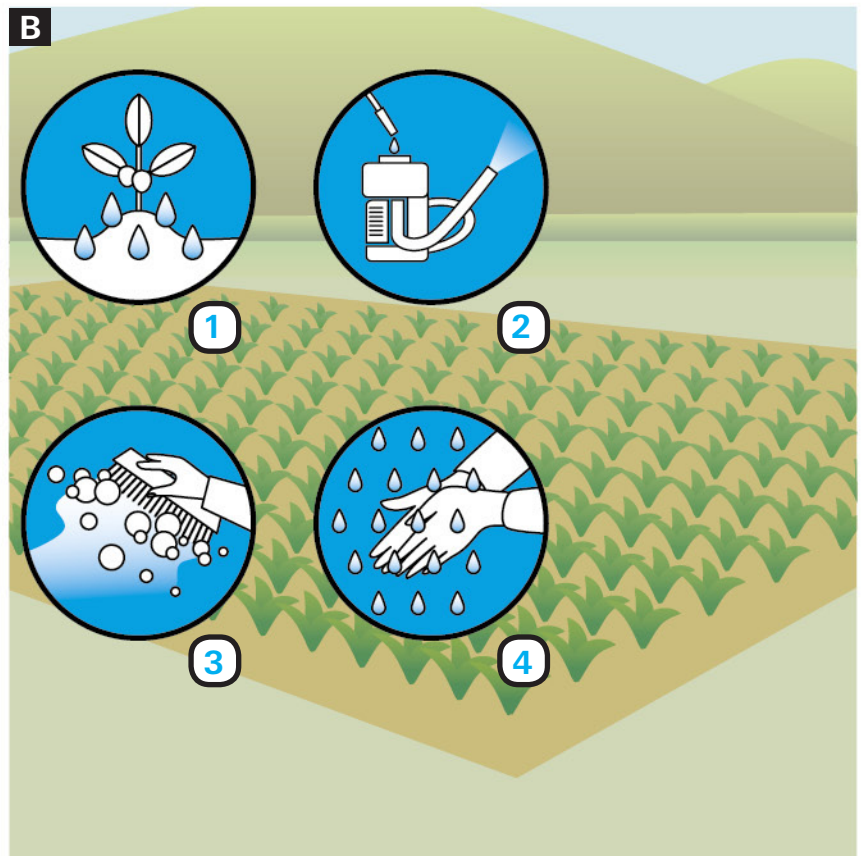
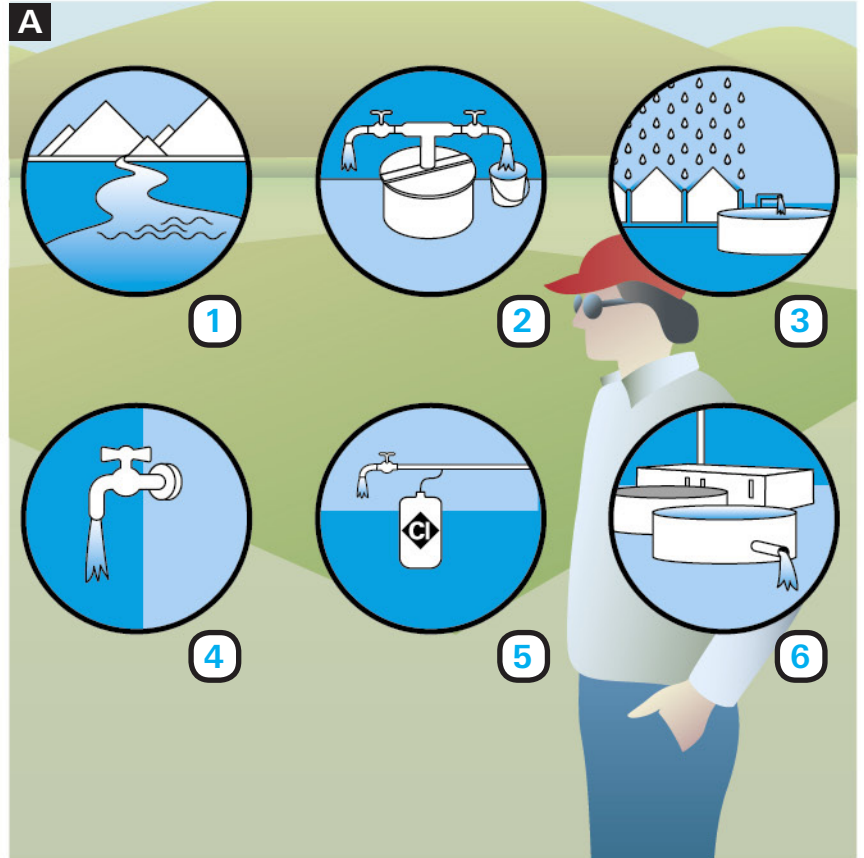
1. Surface water;
2. Ground water (= well water/borehole);
3. Harvested rain water;
4. Municipal water (i.e. potable water);
5. Disinfected water (e.g. chlorinated) on-farm;
6. Secondary treated sewage water.



**DO NOT** use untreated sewage water as agricultural water.

**B** The identification of the water source has to be performed individually for the following water applications:

1. Irrigation;
2. Pesticide dilution;
3. Cleaning of equipment in contact with the crop (e.g. harvesting equipment);
4. Worker hand washing.



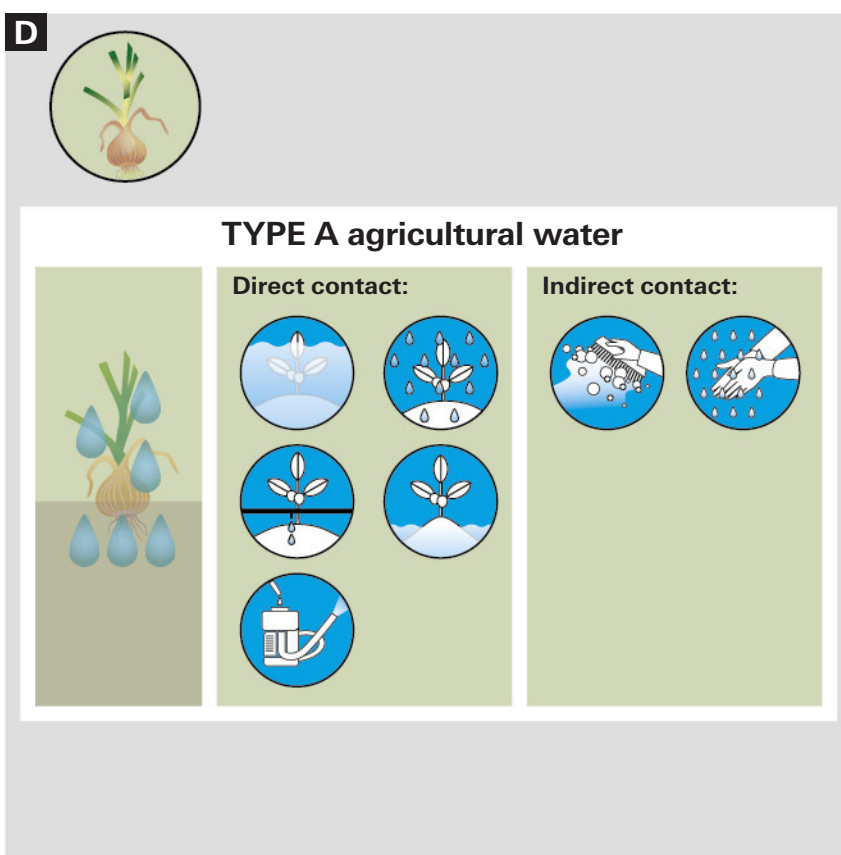
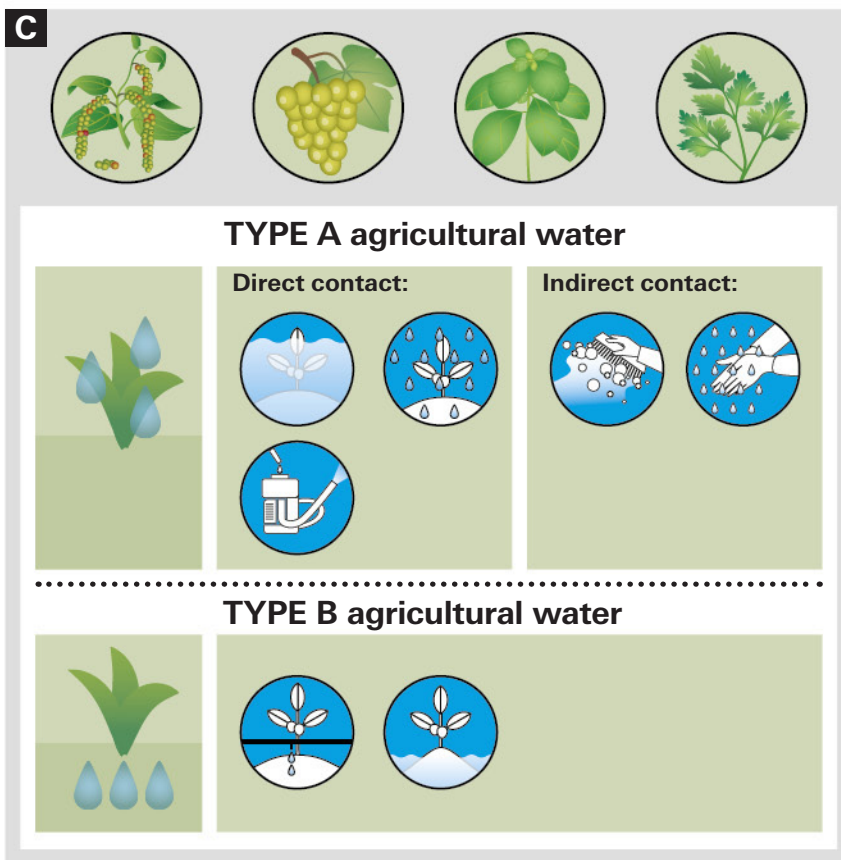
# Water source and irrigation method

**C** Depending on its use, there are two types of agricultural water:

- **TYPE A agricultural water:** Agricultural water having direct or indirect contact with the the harvestable part of the crop. Direct contact: e.g. water used for overhead or flood irrigation, water used for preparation of pesticides. Indirect contact: e.g. water used for cleaning of equipment in contact with the crop, water used for hand washing.

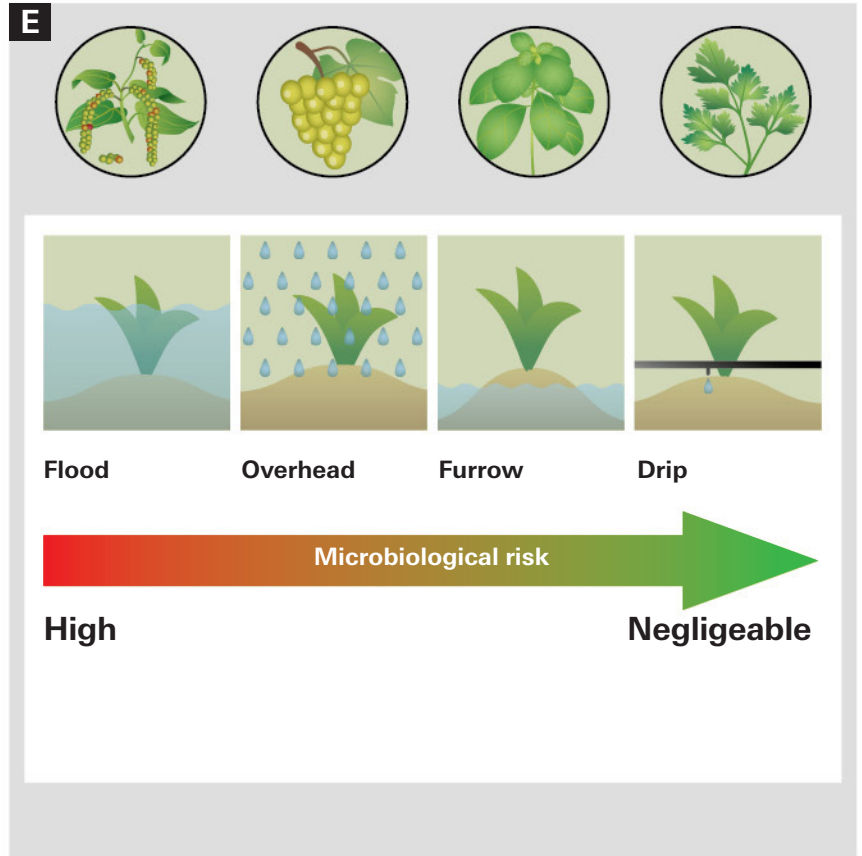
- **TYPE B agricultural water:** Agricultural water having no direct or indirect contact with the harvestable part of the crop, e.g. water used for drip or furrow irrigation (provided there is no risk that water from the furrow splashes onto the the crop).

**D** For bulbs and root crops, agricultural water is only of Type A.



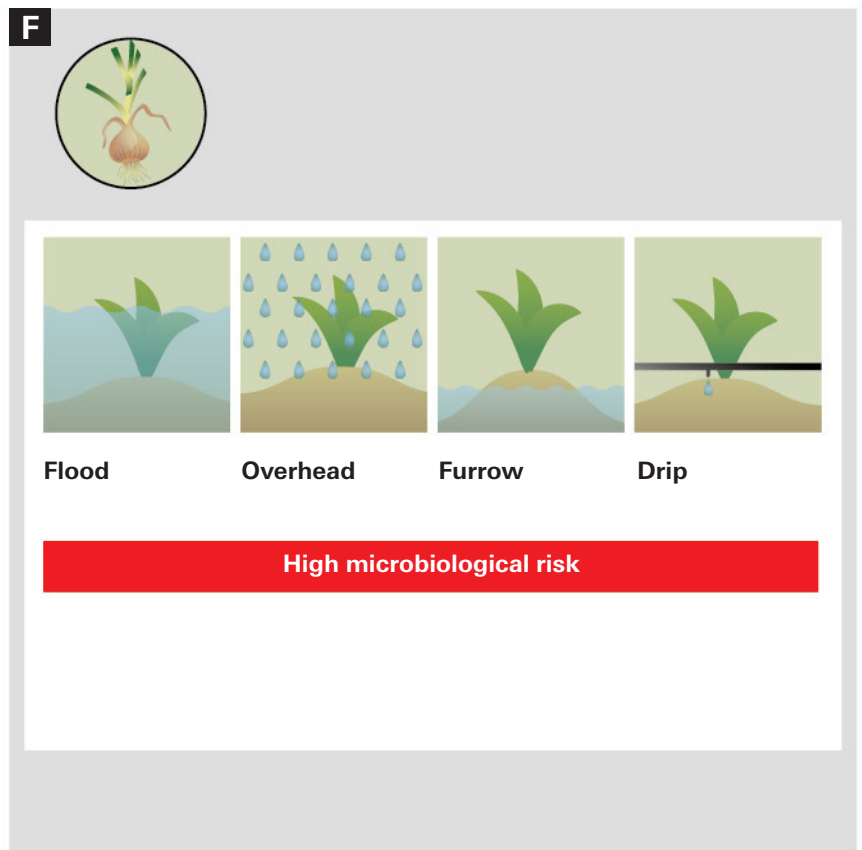
# Water source and irrigation method

**E** Apart from bulbs and root crops, the risk of microbial contamination will vary depending on the irrigation method, i.e. the risk will increase when there is contact between water and crops. Where possible, use of drip or furrow irrigation is recommended (unless irrigation water has negligible microbiological risk i.e. potable water, see table 1 page 55).



**F** For bulbs and root crops, the risk of microbial contamination from water does not decrease by using furrow or drip irrigation

Table 1 (see page 55) summarizes the level of microbiological risk according to the water source type and its application type.



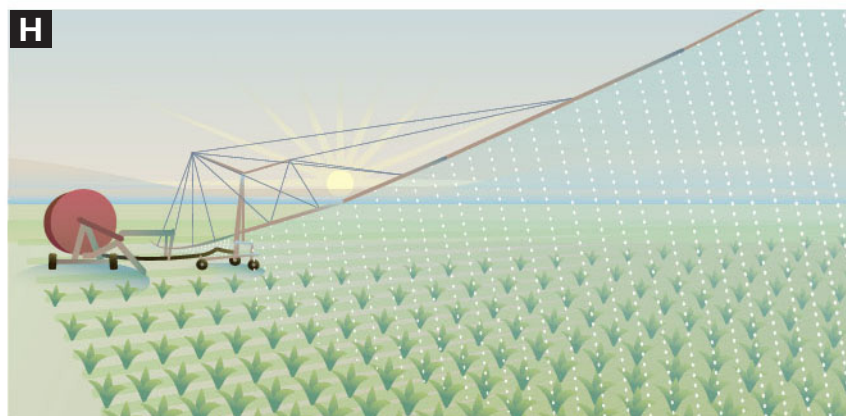
# Water source and irrigation method

**G** Surface water is vulnerable to microbial contamination from human and animal activities. Secondary treated sewage water (not disinfected) may still contain microbial pathogens.



If possible, do not use surface water and secondary treated sewage water as type A agricultural water, unless treated. If it is not possible to use another source of water or to treat it, follow testing recommendations and microbiological limits given in table 2 page 56–57.

**H** If overhead irrigation is used, use it preferably early in the morning, so that crops dry quickly and thus microbial growth is minimized.





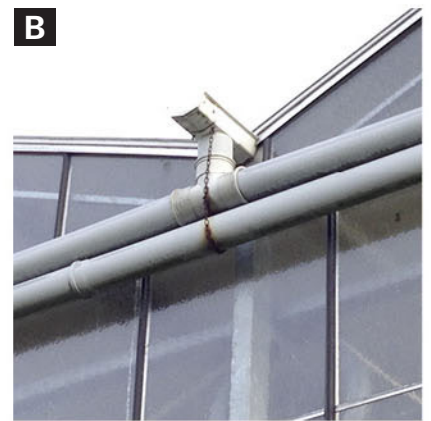
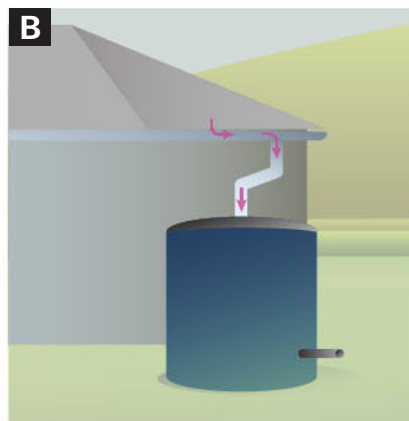
# Wells, water collection, storage and distribution systems (e.g. tanks, ponds, pipes)

**A** Protect well (bore-hole) water from intrusion of surface water, run-off water and animals by:

- Using concrete wall construction with intact covering.
- Inspecting wells regularly for potential leaks or cracks and repair when needed.
- Elevating the edge of the well above the surrounding ground surface (i.e. the top of the well should be at least 30 cm above the ground).



**B** Harvest rain water using a well maintained clean collection system (e.g. clean roofs without bird nesting, pipes and tanks cleaned).



# Wells, water collection, storage and distribution systems (e.g. tanks, ponds, pipes)

**C** Prevent animal ingress into water collection and storage systems:

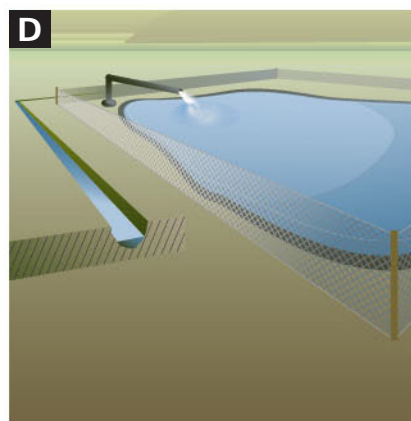
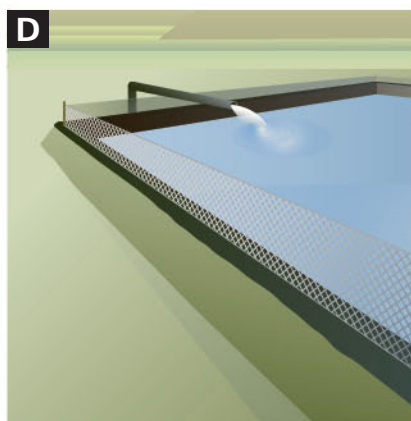
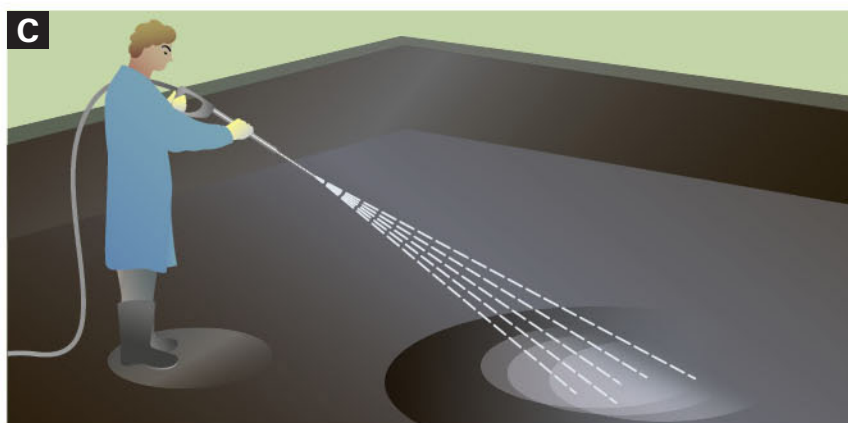
- Cover tanks;
- Fence ponds (and cover them if feasible);
- Empty and clean tanks and ponds at least once per year.



Ponds that cannot be covered are not fully closed storage systems. Care should be taken to ensure the hygiene and biosecurity of the pond is maintained (e.g. yearly cleaning, fences and construction design as defined in D).

**D** Build berms (raised soil or grass barriers) or ditches around ponds to prevent overland runoff of manure/compost and other contaminants into the ponds.

**E** Inspect the conditions of pumps, pipes, collection and storage systems regularly for leaks and cracks to ensure the integrity of the water system.



# Wells, water collection, storage and distribution systems (e.g. tanks, ponds, pipes)

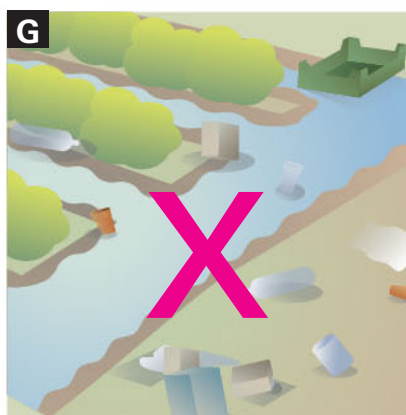
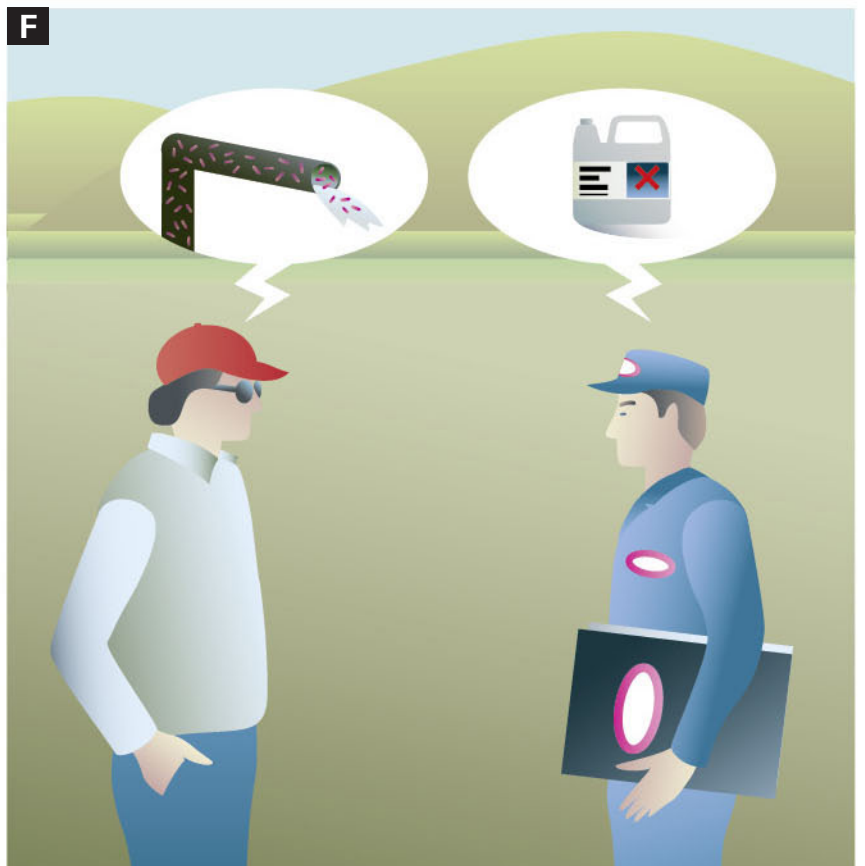


**Repairing damaged equipment is very important: broken water distribution systems can turn a drip system into an overhead sprinkler, thereby bringing water in direct contact with the edible part of the crop.**

**F Minimize biofilm formation in pipes:**

- Use black pipes that minimize growth of pathogens (including plant pathogens).
- Apply disinfection treatment to prevent biofilm formation in the pipes whenever necessary (at least once per year, e.g. before the start of the growing season, using a locally approved disinfectant). Competent personnel should be consulted to ensure type of treatment is fit for purpose (chemical component, concentration, flushing time, rinsing and frequency of treatment). If you do not know whom to contact, discuss first with your raw material buyer.

**G Keep flood and furrow irrigation channels (if applicable) free of rubbish/waste.**



# Agricultural water testing

**A** For Type A agricultural water, microbiological water testing for *Escherichia coli* (*E. coli*) is required. In the absence of local regulation, the *E. coli* target level is  $\leq 100$  CFU/100mL but should not exceed 1000 CFU/100mL. Corrective actions should be initiated to achieve the target of  $\leq 100$  CFU/100mL when higher values are detected.

**B** Microbiological testing may require two steps:

- **STEP 1: Validation** of the water quality profile by taking at least six samples over two growing seasons (three per season, one just before harvest).
- **STEP 2: Verification** of this water quality profile during each following season, by taking one to two samples per season (one for short harvest seasons and two for long harvest seasons).



The validation step is not always necessary depending on the water source: table 2 (page 56–57) gives recommendations on microbiological type A water testing frequency, limits and corrective actions in case of deviations (results above the limits) for all water sources, for both validation and/or verification steps.

**A** TYPE A agricultural water

*E. coli*  $\leq 100$  CFU/100 mL

**B** Microbiological water testing

STEP 1: Validation		STEP 2: Verification
Growing season 1	Growing season 2	Growing seasons 3, 4, etc.
3 X	3 X	1–2 X

# Agricultural water testing

**C** For type B agricultural water (see page 44), no microbiological testing is required (unless otherwise stated by local regulation).



However, in the event of an adverse situation where water has come into contact with the harvestable part of the crop, assess immediately the microbiological quality of the water using the same microbiological analysis and limits as for type A water.

**D** Water microbiological testing should be performed by a laboratory ISO 17025 accredited for methods of testing or one approved by an official government scheme.

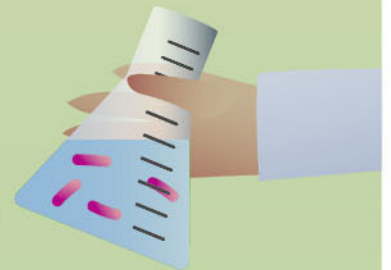
**E** For municipal water, request or ensure you have access to municipal water system results or certificates of compliance.



## TYPE B agricultural water



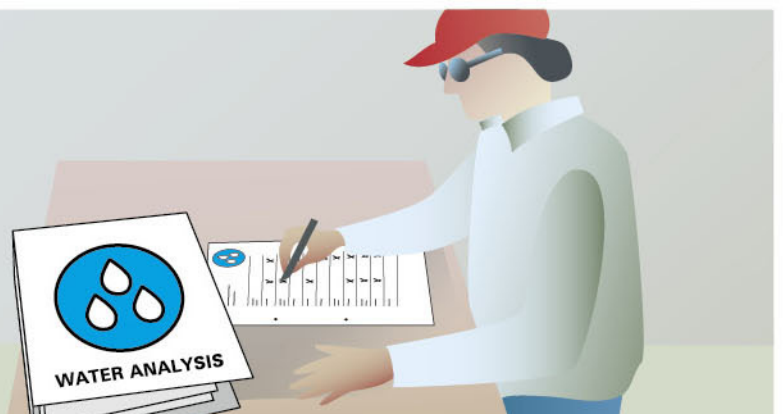
*E. coli* ≤ 100 CFU/100 mL



**D**



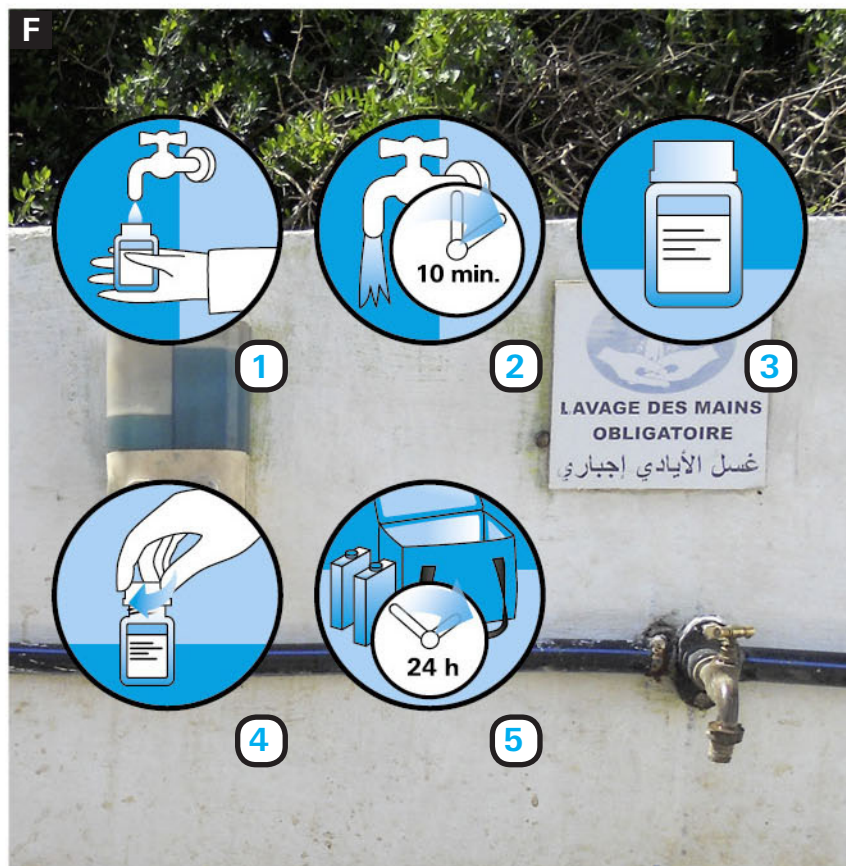
**E**



# Agricultural water testing

## **F** Tips to perform good water sampling:

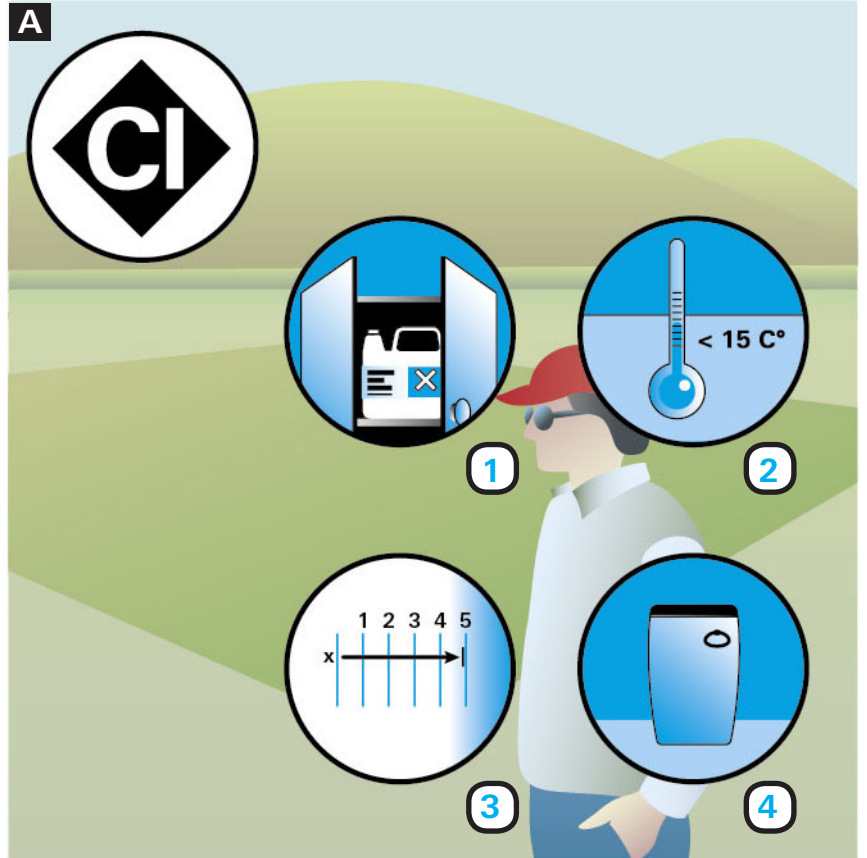
1. Perform the sampling at the nearest practical sampling point of water application (not on the source itself), e.g. from the sprinkler or at the tap for hand washing etc...
2. Run the irrigation system the amount of time needed to flush the "hold up" volume of the system plus additional 5–10 minutes, before the sample is taken. For distribution system taps, open the tap fully and allow the system to run for at least 10 minutes.
3. Use only sterile containers to collect water (might be provided by the testing laboratory). Do not rinse the sterile containers prior to taking samples.
4. Slowly fill the container and close it tightly.
5. The sample should be delivered to the laboratory as soon as possible after its collection (sent on the day of sampling for a delivery within 24 hours is the best practice) and in a cooler with ice or gel packs during transportation. Check with the laboratory for any additional procedure/recommendation (e.g. volume to be sent).



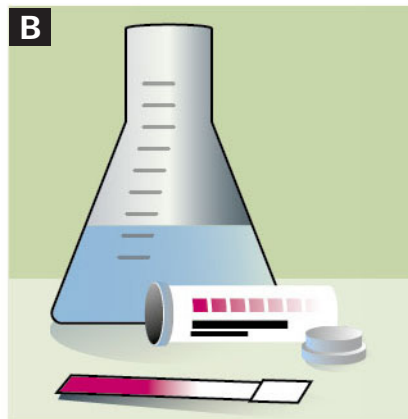
# Water disinfection treatments

**A** If water chlorination is applied, avoid production of degradation products such as chlorite and chlorate by storing hypochlorite:

1. In the dark (dark packaging or dark room);
2. At cool temperature (below 15°C);
3. If possible in a diluted format (e.g. two times dilution of a 13 % bulk hypochlorite solution) and by using it within 5 weeks;
4. In a container made of Teflon, rubber, PVC, PET, plastic (to avoid storage in direct contact with carbon steel or stainless steel).



**B** If water chlorination is applied, monitor the free chlorine (e.g. once a week) at the nearest practical sampling point of water application using a commercially available chlorine test (e.g. dipstick) to verify that the free chlorine concentration is in the range of 0.2 to 1 ppm.



Monitor especially after specific events that may have an impact on the microbiological quality of the water (e.g. heavy rain, drought).

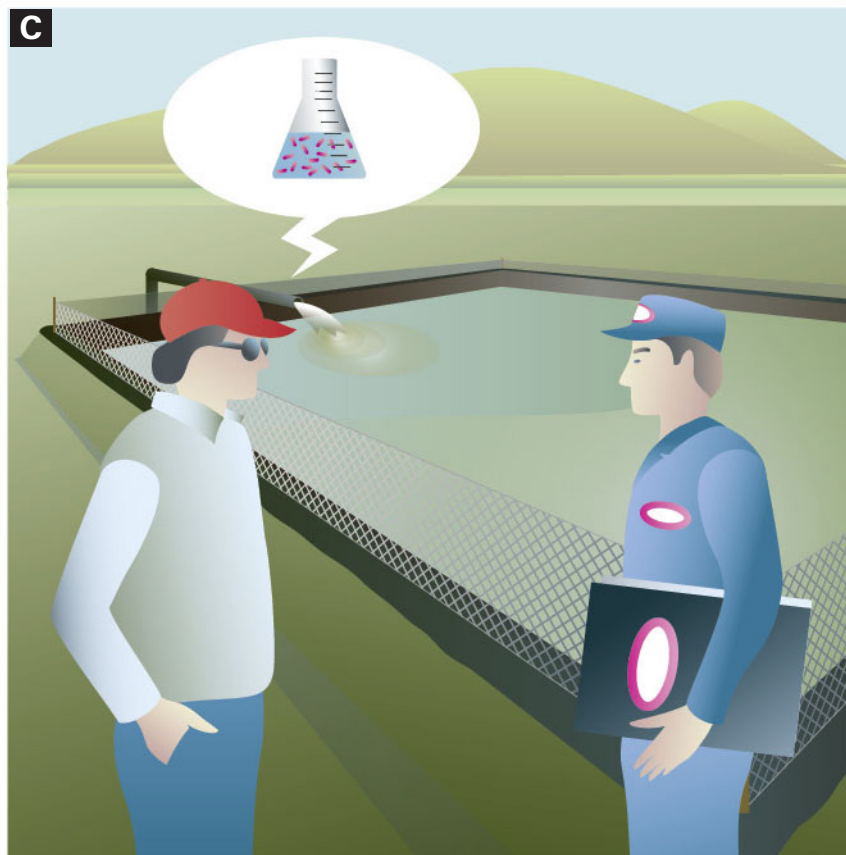
# Water disinfection treatments

**C** When a disinfection treatment is implemented as routine or as part of a corrective action (see Table 2, page 56–57), a competent professional should be consulted. He will ensure type of treatment is fit for purpose and legally permitted, and will give guidance on how to apply and monitor it (e.g. free chlorine level). He will advise on the corrective actions in case of deviation (e.g. deviation in the free chlorine level). If you do not know whom to contact, discuss first with your raw material buyer.



Some parasites can show more resistance to chlorination

than *E. coli* at normal dose. Additional risk mitigation measures may be required if parasite contamination is suspected e.g. water filtration or control measure at primary processing (e.g. heating or freezing).





# TABLE 1 Microbiological risk ranking of agricultural water according to water source and type of application

		WATER: TYPE OF APPLICATION					
		IRRIGATION				OTHER USE OF WATER	
		Flood irrigation	Overhead irrigation	Furrow irrigation <sup>2</sup>	Drip irrigation	Pesticide and fertilizer preparation	Cleaning of equipment and hand washing <sup>3</sup>
WATER: SOURCE	Untreated Surface Water (including shallow wells)						
	Secondary treated Sewage Water						
	Untreated ground Water						
	Untreated rain Water						
	On-farm disinfected Water <sup>1</sup>						
	Municipal Water (potable water)						

**High microbiological risk** – Untreated surface water and shallow wells are vulnerable to microbial hazard contamination; secondary treated sewage water may still contain pathogens.

**Medium microbiological risk** – Depends on the microbiological quality profile of the ground water and rain water (usually good – if installations for collecting and storing the water are in good condition and well maintained, see section “Wells, water collection, storage and distribution systems” page 47 for details).

**Negligible microbiological risk** – Either municipal or on-farm disinfected water or water which is never used in contact with the harvestable part of the crop e.g. furrow irrigation or drip irrigation.

1 Disinfected water can be surface water or ground water or rain water or secondary treated sewage water which has followed a disinfection process at farm, such as chlorination.

2 Negligible risk ranking when there is no risk that the irrigation water from the furrow splashes on the harvestable part of the crop. If there is a risk of splashing then the risk ranking becomes the same than Type A water.

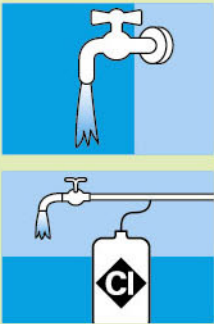
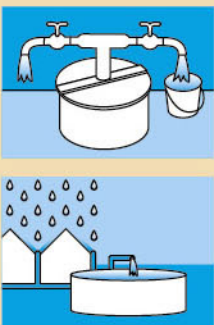

3 It is best practice to use potable water (water that meets microbial standards for drinking water) for hand washing and cleaning of equipment in contact with the crop. When it is not possible to use such potable water, agricultural water with *E. coli* ≤100 CFU / 100 mL is allowed (see chapter 5 on Hygiene and chapter 6 on Equipment).

4 For root and bulb crops, type B water becomes type A water with its associated high, medium or negligible risk according to the water source.

**If multiple water sources are mixed (e.g. in one storage) before application, the risk category of the higher risk water source should be applied.**

# TABLE 2 Microbiological testing recommendations for type A agricultural water\* according to the water source

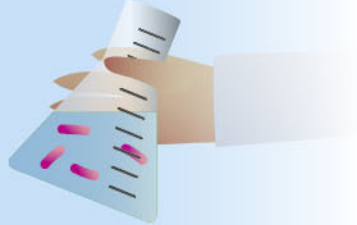
\*Type A agricultural water: Agricultural water having direct or indirect contact with produce

WATER SOURCE		STEP 1: Validation of the water quality profile	
		Growing season 1	Growing season 2
Negligible microbiological risk	<p data-bbox="194 752 488 806"><b>Municipal water and on-farm disinfected water</b></p> 	<ul style="list-style-type: none"> <li>• Validation not required because water is disinfected. Start directly at STEP 2 (page 57).</li> </ul>	
	Medium microbiological risk	<p data-bbox="194 1173 450 1258"><b>Untreated ground water, untreated rain water</b></p> 	<ul style="list-style-type: none"> <li>• <b>Sampling frequency:</b> at least 3 samples per growing season (with one before first harvest) over two growing seasons to build the microbiological quality profile of the water → at least 6 samples in total.</li> <li>• <b>Analysis and target limit:</b> <i>E. coli</i> ≤ 100 CFU/100 mL, but should not exceed 1000 CFU/100mL</li> <li>• <b>Corrective actions:</b> <ul style="list-style-type: none"> <li>- <b>Immediate corrective actions during the validation study:</b> when a result is &gt; 100CFU/100 mL but do not exceed 1000 CFU/100mL (Scenario 1) or when a result is &gt;1000 CFU/100mL (Scenario 2), follow corrective actions from step 2.</li> <li>- <b>Corrective action at the end of the validation study:</b> If two or more consecutive values are &gt;1000 CFU/100 mL during validation, either: <ul style="list-style-type: none"> <li>- Reduce the vulnerability of the water system if possible (e.g. construction work to have a deeper well, modification of rainwater collection system) then start a new validation study.</li> </ul> </li> </ul> </li> <li>OR</li> <li>- Switch to another water source of water if possible then start a new validation study.</li> <li>OR</li> <li>- Implement disinfection treatment of the water.</li> <li>• This validation should be repeated every 5 years or sooner if significant changes that may impact the water quality have occurred.</li> </ul>
High microbiological risk		<p data-bbox="194 1850 421 1935"><b>Untreated Surface Water (including shallow wells)</b></p> 	<ul style="list-style-type: none"> <li>• Validation not required: microbiological quality of surface water is linked to environmental factors which are highly variable in time, i.e. it is not possible to rely on a validation period to move to a lower testing regime. Therefore we recommend one testing regime per season, which is described in STEP 2 (page 57).</li> </ul>

## WATER SOURCE

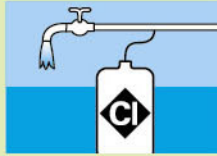
## STEP 2: Verification of the water quality profile

Growing seasons 3, 4, etc. (i.e. for any following season)



Negligible  
microbiological risk

### Municipal water and on-farm disinfected water



- Done to verify that there is no recontamination of water through irrigation equipment and/or distribution pipes and to verify effectiveness of on-farm disinfection treatment.
- **Sampling frequency:** One sample per growing season, during period of use and as close as practical to harvest.
- **Analysis and target limit:** *E. coli* ≤ 100 CFU/100 mL.
- **Corrective actions:** If results are above the limit, corrective actions should be taken to find the source of the contamination and to correct it, i.e. verify disinfection parameters, integrity from distribution pipes and irrigation equipment and initiate disinfection if necessary. Retest the water to verify that the problem has been solved. Do not use as type A water if *E. coli* > 1000 CFU/100 mL.

Medium  
microbiological risk

### Untreated ground water, untreated rain water



- Done for verification of the microbiological water quality profile.
- **Sampling frequency:** One or two samples per growing season (one as close as practical to harvest and a second one for long harvest seasons).
- **Analysis and target limit:** *E. coli* ≤ 100 CFU/100 mL, but should not exceed 1000 CFU/100mL
- **Corrective actions:** If results are above 100 CFU/100 mL but do not exceed 1000 CFU/100 mL, corrective actions should be initiated to achieve the target of <100 CFU/100 mL (Scenario 1). If results are above 1000 CFU/100 mL (Scenario 2), do not use as type A water until actions are taken to find the source of the contamination and to correct it, e.g. verify integrity of wells and of collection, storage and distribution systems. Retest the water to verify that the problem has been solved before using it as type A water.

High  
microbiological risk

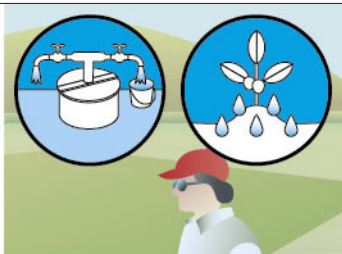
### Untreated Surface Water (including shallow wells)



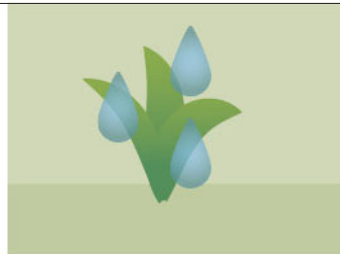
- Done for establishing the microbiological water quality, every season.
- **Sampling frequency:** 4 samples per growing season (one as close as practical to harvest) and one per month if the growing season is longer than 4 month.
- **Analysis and target limit:** *E. coli* ≤ 100 CFU/100 mL but should not exceed 1000 CFU/100 mL
- **Corrective actions:** If results are above 1000 CFU/100mL, do not use as type A water, initiate actions to find the source of the contamination (e.g. presence of animals, contamination from surrounding manure or waste water) and implement proper corrective measures (e.g. vegetative buffer, mounds or ditches). Retest the water to verify that the problem has been solved before using it as type A water. If the problem cannot be identified/solved, either treat the water or move to another water source if possible.  
If results are above 100 CFU/100 mL but do not exceed 1000 CFU/100 mL, corrective actions should be initiated to achieve, if possible, the target of ≤ 100 CFU/100mL e.g. implementation of vegetative buffers, mounds or ditches between surface water and surrounding lands.

# Agricultural water: REMEMBER!

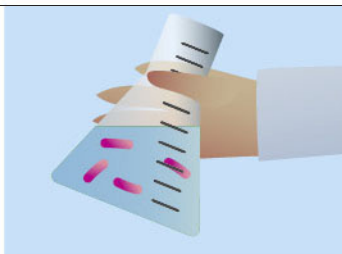
1. Identify the source of the water (e.g. surface, well, municipal...). Perform this identification for all water applications (e.g. irrigation, hand washing etc...).



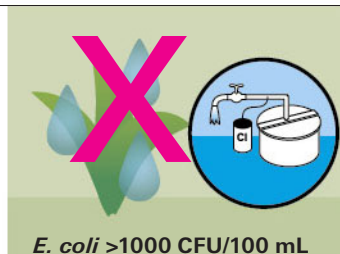
2. Type A agricultural water is agricultural water having direct or indirect contact with crop and requires microbiological testing for *E. coli* in 100 mL.



3. The testing frequency of type A water will vary according to the water source (see Table 2, page 56–57).



The *E. coli* target for type A water is  $\leq 100$  CFU/ mL but should not exceed 1000 CFU/100 mL. Water sources with *E. coli* >1000 CFU/100 mL cannot be used as type A water, unless treated to decrease the microbial numbers.

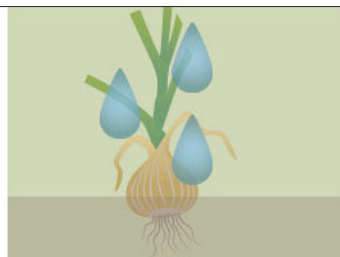


*E. coli* >1000 CFU/100 mL

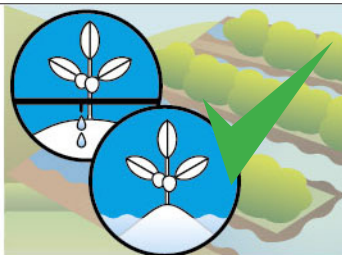
5. Type B agricultural water has no direct or indirect contact with crop and does not require testing.



6. For bulbs and root crops, agricultural water is only of type A.



7. Use of drip or furrow irrigation of crop is recommended.



8. Prevent contamination of water in wells and in water collection/storage systems: cover wells and water tanks, fence ponds etc...

