Chapter 9

Guide to Exercises and Answers to Quizzes

9.1 Guide to exercises

This chapter provides a guide to the exercises and answers to exercises and quizzes in the manual. For each exercise in Chapters 2-7 of the manual, you will find information on the purpose of the exercise and some guidance on how to teach it. You will see that in many cases, exercises are often done in pairs or small groups, then the class is brought together for discussion. When checking the answers, make sure you not only KNOW the answers but UNDERSTAND and can EXPLAIN the answers to your trainees.

> ***NOTE:*** ***You will need to ask your trainees to draw up tables on butchers or brown paper to fill in their answers for some exercises if you are unable to photocopy the templates for them***

If you think some of your trainees prefer to work alone, allow them to do so from time to time. Remember, your job is to facilitate learning in ways that work best for your trainees to build their knowledge and confidence in a non-threatening, supportive learning environment. Also, remember that in your class there are likely to be some very experienced people as well as beginners. It is important that everyone has an opportunity to learn so don't be afraid to call on those with more experience to help others. This will also help their ability to be trainers. You will also be building your own knowledge at the same time – we never stop learning!

> ***REMEMBER***
>
> ***Some of the exercises have definite answers, others do not. This is because:***
>
> - ***some answers depend on the examples you as the trainer decide to use***
> - ***some answers depend on the samples you or the trainees bring to the class***
> - ***some exercises have more than one correct answer.***

9.2 PHC trainer planning and preparation checklist

IMPORTANT

Thoroughly plan and prepare before conducting your training workshop. Before you begin, complete this checklist:

- ❑ read through the manual carefully to become familiar and confident with the contents
- ❑ work through the exercises and know how to facilitate them with your trainees. This will build your confidence as a trainer
- ❑ you do NOT need your trainees to work through EVERY exercise. It will depend on how much time is available and your judgment of how much they know already
- ❑ do not be afraid to give your trainees reading to do for homework if you need to have something finished or to be prepared for the next session
- ❑ make sure you have all the resources you need — a list is provided at the beginning of each chapter
- ❑ arrange to run one or two plant health clinics during the training — a simulated one so that your trainees know the process and how to fill in the Prescription and Farmer Feedback forms, then a full clinic with local farmers.

9.3 Chapter 2 answers

Chapters 2 to 6 are the most difficult and important in the manual. Without good knowledge of identification, diagnosis and management, it is very difficult to be an effective plant health doctor.

In Chapters 2 to 6, you are helping your trainees to develop their identification skills by carefully observing and describing symptoms before they move to a diagnosis. It is worth taking time to go through these chapters very carefully before you teach them, checking your own understanding by completing the exercises yourself.

EXERCISE 2.1: A, B, C?

Crop	Correct answer
Banana	1. BIOTIC: Banana black cross, *Phyllochora musicola,* fungus.
	2. BIOTIC: Banana diamond leaf spot, *Cordana musae,* fungus
	3. ABIOTIC: Natural variation of an ornamental variety
	4. BIOTIC: Cucumber mosaic virus
	5. BIOTIC: Banana burrowing nematode, *Radopholus similis*
	6. BIOTIC: Scab moth, *Nacoleia octasema*
	7. ABIOTIC: Natural colour variation
	8. BIOTIC: Banana bunchy top virus.
Bele	1. CONFUSED: Could be i) feeding of a jassid (leafhopper), ii) hibiscus chlorotic ringspot virus, or the iii) plants are lacking an essential nutrient
	2. BIOTIC: Hibiscus chlorotic ringspot virus
	3. BIOTIC: Shoot borer, *Erias vitella,* moth
	4. BIOTIC: Leafminer, *Acrocercops* species, moth
	5. BIOTIC: Flea beetle, *Nisotra basselae*
	6. BIOTIC: White peach scale, *Pseudaulacaspis pentagona*
	7. BIOTIC: Cotton leaf roller, *Haritalodes derogata,* moth
	8. CONFUSED: Same as 1
Cabbage	1. BIOTIC: Turnip mosaic virus
	2. BIOTIC: Damping-off, fungi
	3. BIOTIC: Chinese cabbage stalk rot, *Erwinia* species, bacteria
	4. BIOTIC: Cabbage centre grub, *Helula undalis,* moth
	5. CONFUSED: Possibly stalk rot (see 3) or Black cutworm, *Agrotis ipsilon,* moth
	6. BIOTIC: Cabbage black rot, *Xanthomonas campestris* pv. *campestris,* bacterium
	7. ABIOTIC: Boron deficiency
	8. CONFUSED: Possible snail damage
Cassava	1. BIOTIC: Cassava green mottle virus
	2. ABIOTIC: Natural variation of an ornamental variety
	3. BIOTIC: Cassava *Amblypelta* dieback, bug
	4. BIOTIC: Spiralling whitefly, *Aleurodicus dispersus*
	5. BIOTIC: White peach scale, *Pseudaulacaspis pentagona*
	6. BIOTIC: Spider mite, *Tetranychus* species
	7. BIOTIC: Bacterial blight, *Xanthomonas axonopodis* pv. m*anihotis.*
	8. CONFUSED: Possible mineral deficiency

EXERCISE 2.1: A, B, C? continued...

Crop	Correct answer
Citrus	1. CONFUSED: Caused by scale insects on the underside of the leaf
	2. BIOTIC: Citrus sooty blotch, *Meliola citricola*, fungus
	3. BIOTIC: Greening or Huanglongbing disease of citrus, *Candidatus liberibacter asiaticus*, bacterium
	4. BIOTIC: Citrus tristeza virus
	5. BIOTIC: Greening or Huanglongbing disease of citrus, *Candidatus liberibacter asiaticus*, bacterium
	6. BIOTIC: Citrus scab, *Elsinoe fawcettii*, fungus
	7. ABIOTIC: Zinc deficiency
	8. BIOTIC: Fruit piercing moth, *Eudocrima fullonia*
Coconut	1. BIOTIC: Foliar decay virus
	2. ABIOTIC: Potassium deficiency on fan palm
	3. BIOTIC: Coconut thread blight, *Corticium penicillatum*, fungus
	4. CONFUSED: Coconut Bogia disease or lightning strike
	5. BIOTIC: Coconut termite, *Neotermes rainbowi*
	6. BIOTIC: Coconut leafminer, *Promecotheca* species
	7. CONFUSED: Sooty mould, fungi - but this is not the main cause of the problem
	8. CONFUSED: Feeding lines created by *Promecotheca* species — *Brontispa longissima*, the coconut hispine beetle causes similar symptoms.
Tomato	1. BIOTIC: Tomato black leaf mould, *Pseudocercospora fuligena*, fungus
	2. ABIOTIC: Calcium deficiency, blossom end rot
	3. CONFUSED: One of the many tomato fungal leaf spots
	4. ABIOTIC: Catface. Cause unknown, possibly irregular growth during flowering
	5. CONFUSED: Purple patches on leaves can be caused by phosphorus deficiency, one of a number of viruses, or old age
	6. CONFUSED: Spots on fruit can be caused by fungi or bacteria
	7. BIOTIC: Eriophyid mite, *Polyphagotarsonemus latus*
	ABIOTIC: Tomato fruit splitting caused by irregular temperatures and/or watering
	9. BIOTIC: Bacterial wilt, *Ralstonia solanacearum*
Mixed	1. BIOTIC: Maize mosaic virus
	2. ABIOTIC: Tomato sunscald
	3. CONFUSED: Cocoa cherelle wilt or *Phytophthora palmivora*, oomycete
	4. BIOTIC: Maize boil smut, *Ustilago zeae*, fungus
	5. CONFUSED: Cocoa dieback caused by lack of shade, sunscald or nutrient deficiency
	6. ABIOTIC: Maize zinc deficiency
	7. BIOTIC: Coconut tinangaja viroid
	8. CONFUSED: One of several tomato viruses or herbicide damage

EXERCISE 2.2: Speed dating

This exercise gives more practice on how to describe symptoms on plants carefully and accurately before making a diagnosis.

Ask the trainees to form two lines facing each other so they are standing opposite a partner. Give each trainee a sample of a plant pest or disease or nutrient deficiency, or they could collect their own. One of the pair now carefully describes the symptoms to their partner (their 'date') opposite them, and then both try to decide whether it is caused by abiotic (A) or biotic (B) factors, or it is confused (C).

Give no more than two minutes! When you say 'stop' the other partner has to do the same with their sample. Next, everyone in one line moves to the left so that each has a new partner. Repeat the process of describing the symptoms one more time each (or more if you think trainees need more practice).

Now ask the trainees to place their sample on one of three tables marked A, B or C, depending on whether they think the cause is abiotic, biotic, or it is confused.

Do not give any answers at this stage!

Preparing for Exercise 2.3

Now that you have gone through Exercises 2.1 and 2.2, you have set up your trainees' 'need to know' about pests and diseases. It is time to introduce your PowerPoint presentation on pest and diseases which you will need to prepare from the information in Sections 2.3 to 2.8 in Chapter 2.

Alternatively, if they have access to the manual, you can ask trainees to read these sections for their homework, emphasising how important this information is, and ask if there are any questions. These are long sections with a lot of information, so take your time and give trainees plenty of breaks and time for discussion and questions during the presentation, and check for understanding.

EXERCISE 2.3: Similar symptoms, different groups

Table 2.3 shows that pest symptoms can be confusing as similar symptoms can be caused by very different types of pests. Exercises 2.3 and 2.4 will help your trainees to think about symptoms of pest damage and the range of possible causes. This is a challenging exercise, but the purpose is for your trainees to recognise that similar symptoms can have many causes. It is not necessary for them to learn the names of every pest.

By thinking about and discussing the possible answers in their groups and then with the whole class, your trainees will have a deeper understanding of the complexity of pest diagnosis, so they do not immediately jump to one answer when they see symptoms.

The answers filled in the table below are examples; there will be many other possibilities. Check with Table 2.3 for details.

Symptom	Damage type	Possible causes (pest orders — common names)	Life stage of pest	Confirmed by fact sheet #
Holes (leaf/ fruit)	Chewing	1. Fly 2. Moth/butterfly	Larva (maggot) Larva (caterpillar)	291 23
Speckling (leaf/fruit)	**Sucking**	**1.Thrips 2. True bugs**	**Adult, nymph Adult, nymph**	**49 253**
Mines (leaf)	**Chewing**	**1. Fly 2. Moth/butterfly**	**Larva (maggot) Larva (caterpillar)**	**110 378**
Galls (leaf)	**Sucking**	**1. Psyllid 2. Mite (broad mite)**	**Nymph Adult, nymph**	**366 138**
Holes (seed)	**Chewing**	**1. Beetle/weevil 2. Moth/butterfly**	**Adult, larva (grub) Larva (caterpillar)**	**338 337**
Wilt, dieback (leaves/ branches/ plants)	**Sucking**	**1. True bugs 2. Scale insect**	**Adult, nymph Adult, nymph**	**19 343**
Sooty mould (leaf)	**Sucking**	**1. Leafhopper 2. Scale insect**	**Adult, nymph Adult, nymph**	**263 271**
Distortions (leaf)	**Chewing**	**1. Aphid 2. Mealybug**	**Adult, nymph Adult, nymph**	**38 373**
Scraping (leaf)	**Chewing**	**1.Beetle/weevil 2. Moth/butterfly**	**Adult, larva (grub) Larva (caterpillar)**	**58 31**
Egg-laying strike (fruit)	**Piercing**	**1. Weevil 2. Fly**	**Adult, larva (grub) Adult, larva (maggot)**	**437 425**

EXERCISE 2.4: Understanding chewing, sucking and piercing damage

For this exercise, try to find samples of leaves, fruit or roots that show symptoms of chewing, sucking or piercing, but with no visible pests. This often happens at a plant health clinic.

- give each pair or group of trainees a **different sample of pest damage** (or a photograph if you cannot find field samples)
- your trainees should **examine their sample** carefully with a hand lens and answer the questions in the exercise
- then they should **share their answers** with the whole class and discuss the diagnosis process and any difficulties.

Refer to Tables 2.2 and 2.3 for answers.

EXERCISE 2.5: Using symptoms to make a diagnosis

Once your plant health doctor trainees have received more information about pests and diseases from your PowerPoint presentation and/or worked through the sections in the manual, they should collect their samples from tables A, B or C from Exercise 2.2 and have another look at them, using a hand lens.

Again, ask the trainees to look at the symptoms (signs) on the plant carefully, and try to make a diagnosis. They may want to change their minds or add information. This is good; it means they have learned something new. Being wrong or only partially correct is an important part of learning.

Once they have finished this, discuss what they have learned and ask your trainees to complete Exercise 2.5 and fill in the last column.

The answers to this exercise will depend on the samples you or the trainees have collected. You will need to make sure you are able to identify as many of them as you can before discussing the answers.

EXERCISE 2.6: What have you learned about pests and diseases?

Your trainees should now be able to summarise their learning about insects and pathogens. They should complete the table in pairs or threes.

In the manual, some cells have been filled in as an example (red text). Here is the table completed with some answers, but there are many other possible answers.

	Fungi	Bacteria	Viruses	Nematodes	Insects
Size – can they be seen with the naked eye?	Spores — No. Fruiting bodies and cottony growth (mycelium) — Yes.	**No**	No	No, with a very few exceptions.	Yes, with very few exceptions.
How do they reproduce?	**Spores**	Cells split in half (binary fission).	Use chemicals from host cells to make more virus particles.	There are males and females reproducing via eggs.	Incomplete or complete life cycles. Males and females reproducing via eggs; some give birth to living young without need for males.
How do they spread?	Produce masses of spores, spread in wind and rain; hyphae and mobile spores in soil, on or in planting materials; also via plants and soil associated with horticultural trade. More rarely carried by boring insects.	In wind, rain, movement of water in soil, on or in planting materials; also via plants and soil associated with horticultural trade.	In insects as they chew and suck sap, on tools, on or in planting materials; also via plants associated with horticultural trade. More rarely in fungi and nematodes.	Move though soil, transported in soil water, or in planting materials; also via plants and soil associated with horticultural trade.	Mostly by flying (adults) that lay eggs on plants; also via plants and soil associated with horticultural trade.
How do they survive?	In soil, remains of plants after harvest, on leaf litter, on weeds. Many fungi have special survival spores.	In soil, in plants after harvest, on weeds. Some form resistant spores.	**In living cells**, either in plants or in insects.	In soil, feeding on weeds; as eggs. Some form cysts.	Many survive as eggs between crops, or on alternative hosts, especially weeds, and volunteer plants. In the tropics, survival occurs by moving from harvested to new planted crops.
What are some typical symptoms/ signs on plants?	Spots, blights, rusts, wilts, mildews, rots, root decay.	**Wilts**, spots, rots, blights.	Mosaic (light and dark green patterns on the leaves), yellowing, stunting, distortions.	Wilts, yellowing of leaves, stunting, root galls.	Holes, mines, chewing leaves, wilts due to root damage, silvering of leaves, distortions, rots, galls. Frass sometimes present.

EXERCISE 2.7: Completing a 'stem' table

This exercise helps your trainees to summarise their learning so far about pests and diseases. Trainees should do this on their own or in pairs.

- it is like **completing a sentence** (the 'stem' is the beginning of the sentence).
- **starting with the first column** (Insect pests), they fill in the answers — then they fill in the second column (Nematodes) and so on, until the table is completed — the example in red reads: insects are …a biotic factor
- there will be many correct answers — the prefilled table below provides some possible answers — ask trainees which ones they had difficulty with and discuss.

	Insect pests	Nematodes	Nitrogen deficiency	Viruses	Fungi	Bacteria	Drought
Are:	**a biotic factor**	a small worm-like animal	a lack of an essential element needed by plants	**very small**	a biotic factor guidelines	a single celled organism	Lack of water
Are not:	a mite	**an insect**	a biotic factor	visible to the naked eye	an insect	a virus	a biotic factor
Can:	reproduce quickly	live in soil	cause plants to turn yellow	be spread by insects	form fruiting bodies called a mushroom	spread very quickly	kill crops
Cannot:	**produce spores**	fly	be treated by applying a pesticide	live outside a host cell	photo-synthesise	reproduce sexually	help plants to grow well
May cause:	holes in leaves	wilting	Low yields	mosaics	leaf spots	**wilting**	loss of income for farmer
Does not cause:	mildew	rust	holes in a leaf	nutrient deficiency	**chewing of leaves**	rust symptoms	floods
Can be controlled by:	beneficial insects	marigolds	adding well-decomposted manure to the oil	rogueing	fungicide	copper	irrigation
Cannot be controlled by	herbicide	white oil	**fungicide**	companion planting	insecticide	parasitoids	**fertiliser**

EXERCISE 2.8: What am I?

This guessing game exercise is fun and can be carried out at any point during the training. It is also a useful icebreaker to do at the beginning of a training session. It can be as easy or difficult as you decide to make it, and you can make up any words you like that relate to what you are teaching. It makes sure your trainees really focus on the characteristics of what they are trying to guess.

- write a word on a group of cards, then stick one card to each trainee's back with masking tape — do not allow the trainees to see their card!
- when you are giving out the cards, try to match the words to the trainees, e.g. give the more knowledgeable trainees something more challenging, while you give a simpler word to those who are not as experienced or confident — everyone needs to be able to guess their word, as this builds confidence
- the trainees pair up or move around the class, asking questions of each other — the idea is to find out what the word is, but the questions can ONLY be answered with **'yes', 'no'** or **'sometimes/maybe'** — you may need to demonstrate this with a trainee first
- check in with the trainees while the exercise is in progress, as they may have been given wrong information! ask: "What do you already know so far about your word?" Correct them where necessary. If a trainee is stuck, you may give a clue
- ask trainees to **sit down after** they have found the correct answer
- discuss the exercise afterwards: **Was it easy? Difficult? Why?**

EXERCISES 2.9, 2.10, 2.11: Using the possible and probable approach

By this stage in Chapter 2, your trainees have covered a lot about symptoms and have started to think about diagnosis. In Exercises 2.9, 2.10 and 2.11, they apply their A, B, C learning to use the possible and probable step approach to making a diagnosis. This is something they need to be able to do at the plant health clinic.

First of all, carefully go through the example of eggplant with the class to demonstrate the steps.

Your trainees should then use the same steps to work through the examples in Exercises 2.9, 2.10 and 2.11, working in pairs or threes, or alone if they prefer.

Once they have finished, it is important to ask them why they have decided on a diagnosis, as you may be able to pick up any misconceptions.

Only when they have carried out the steps should they check their answers with the Pacific Plant Pests, Pathogens & Weeds App. They also need to think about what extra information they might need for a diagnosis, and what further questions they would ask if a farmer brought in this problem. If you think that your trainees need more practice, you can make up your own examples.

EXERCISE 2.9: Using the possible and probable approach

EXAMPLE: Cassava with mosaic and distortions

Symptoms:

1. Yellow irregular spots scattered throughout the leaves
2. Leaflets distorted
3. Symptoms mostly and clearest on young leaves

Possible causes	Possible? ✓✗	Probable? ✓✗	Why do you decide this?
BIOTIC			
Insect	✗	✗	Not a symptom of insects; no presence of insects or sign of frass.
Mites	✓	✗	Unlikely, but turn the leaf over to look for mites & webbing to make sure.
Fungi & oomycetes	✗	✗	Not a symptom for fungi.
Bacteria	✗	✗	Not a symptom for bacteria
Virus	✓	✓	Irregular yellow patches & leaf distortions are typical of known viruses of cassava. Viruses of cassava only reported from Solomon Islands.
Phytoplasma	✓	✗	Phytoplasma of cassava do exist in the region, albeit rare (Wallis & Futuna). Symptoms are a yellowing of leaves, stunting.
Nematode	✗	✗	Not a symptom for nematodes.
Weeds	✗	✗	Not a symptom associated with weeds.
Parasitic plants	✗	✗	Not a symptom associated with parasitic plants.
Slugs & snails	✗	✗	None present, and not a symptom associated with slugs & snails.
Mammals	✗	✗	Not a symptom associated with mammals.
Birds	✗	✗	Not a symptom associated with birds.
ABIOTIC			
Nutrient deficiencies	✓	✗	Nutrient deficiencies do cause yellow mottling on leaves, but none known similar to this on cassava.
Sun scald	✗	✗	Not a symptom caused by sun scald.
Water (too much or too little)	✗	✗	Not a known drought symptom of cassava.
Lightning	✗	✗	Not a symptom of lightning strike.
Herbicide	✓	✗	Yellow patterns and leaf deformation could be caused by herbicide damage, but farmer insists no herbicide was used before planting or during growth, or by neighbours.
It's natural	✗	✗	Not at all natural!

EXERCISE 2.10: Using the possible and probable approach

EXAMPLE: Sweet potato with folded and collapsing leaves

Symptoms:

1. Leaves with small holes round, up to 1 cm across
2. Most leaves dying and rotting
3. Some leaves folded with frass inside the fold
4. Only the vines remain alive.

Possible causes	Possible? ✓✗	Probable? ✓✗	Why do you decide this?
BIOTIC			
Insect	✓	✓	Leaves have large numbers of roughly round holes, and some leaves are folded with frass inside the fold.
Mites	✓	✗	Mite damage on this scale not known on sweet potato.
Fungi & oomycetes	✓	✗	Leaves have wilted and collapsed but no spots, blight, or other symptoms present suggesting a bacterial cause.
Bacteria	✓	✗	Leaves are rotting & collapsed but not spots, blight, or other symptoms present suggesting a bacterial cause.
Virus	✗	✗	Not a symptom normally associated with a virus infection, i.e., No mosaic patterns, mottles or deformation.
Phytoplasma	✗	✗	Not a symptom normally associated with phytoplasma infection.
Nematode	✓	✗	Root infection by nematodes leading to leaf collapse is a possibility, but not likely as whole garden has been affected and the problem came rapidly.
Weeds	✗	✗	Not a symptom associated with weeds.
Parasitic plants	✗	✗	Not a symptom associated with parasitic plants.
Slugs & snails	✓	✗	None present, day or night, and no slime trails that might be expected on damage of this severity.
Mammals	✗	✗	Not a symptom associated with mammals.
Birds	✗	✗	Not a symptom associated with birds.
ABIOTIC			
Nutrient deficiencies	✗	✗	Nutrient deficiencies do not result in holes in folding leaves and severe collapse and death of leaves
Sun scald	✗	✗	Not a symptom caused by sun scald.
Water (too much or too little)	✓	✗	It has been dry but not so severe to cause holes to develop in the leaves followed by widespread collapse.
Lightning	✗	✗	Not a symptom of lightning strike.
Herbicide	✓	✗	Some herbicides could kill the plants and result in collapse of the leaves, but farmer insists that none was used before planting & none used by neighbours.
It's natural	✗	✗	Not at all natural!

EXERCISE 2.11: Using the possible and probable approach

EXAMPLE: *Xanthosoma* wilt

Symptoms:

1. At most, only three leaves on each plant
2. Leaves with marginal necrosis (brown decay)
3. Roots mostly dead.

Possible causes	Possible? ✓✗	Probable? ✓✗	Why do you decide this?
BIOTIC			
Insect	✗	✗	Unlikely, no sign of insect infestation either on leaves or on roots.
Mites	✗	✗	Unlikely, no sign of mites on leaves, no webbing.
Fungi or oomycetes	✓	✓	Plants have fewer leaves than normal, i.e. Some have died early; those remaining show signs of marginal necrosis. Roots show decay. Area was flooded previouly. Oomycetes (*Pythium* sp. known to cause root rot/wilt worldwide). Isolation from roots is required.
Bacteria	✓	✗	The loss of leaves and decay of roots could indicate a bacterial wilt; however, bacterial root rot of *Xanthosoma* is not recorded in Pacific island countries.
Virus	✗	✗	Wilt is not a symptom normally associated with a virus infection.
Phytoplasma	✗	✗	Not a symptom normally associated with phytoplasma infection.
Nematode	✓	✗	Root infection by nematodes leading to leaf collapse is a possibiltiy. Isolations of nematodes from roots required.
Weeds	✗	✗	Not a symptom associated with weeds.
Parasitic plants	✗	✗	Not a symptom associated with mammals.
Slugs & snails	✓	✗	Unlikely that slugs or snails could cause the collapse of large plants of Xanthosoma; root decay by Pythium is a well known problem and more likely to be the cause especially as the area was flooded recently.
Mammals	✗	✗	Not a symptom associated with mammals.
Birds	✗	✗	Not a symptom associated with birds.
ABIOTIC			
Nutrient deficiencies	✗	✗	Marginal scorch of the leaves could indicate K deficiency, but loss of leaves and root rot is not likely to be caused by nutrient deficiency.
Sun scald	✗	✗	Not a symptom caused by sun scald.
Water (too much or too little)	✓	✗	It has not been dry; in fact, the area was flooded recently when the plants were still young, suggesting too much water may have exacerbated the problem but unlikely to be the cause.
Lightning	✗	✗	Not a symptom of lightning strike.
Herbicide	✓	✗	Some herbicides could cause a collapse of the leaves, but the farmer insists that none was used before planting & none used by neighbours.
It's natural	✗	✗	Not at all natural!

CHAPTER 2 QUIZ: Test your knowledge — answers...

The answers are given in **bold**. When they have all finished, go through the answers. You do not need to ask what marks the trainees got; they will have learned the correct answers by going through the test as a class.

Make sure you always discuss with the class any answers they are not sure about.

Explain that if there is anything they are still not sure about, trainees should read the manual again and/or ask for help. You can change or add your own questions.

1. In ORDER, abiotic and biotic factors that cause damage on plants are:

A. a fungus and a mite
B. a bird and drought
C. potassium deficiency and bacteria
D. phytoplasma and poor soil

2. Symptoms on tomatoes and cabbages caused by bacteria are:

A. leaf spots and evenly spread leaf yellowing
B. wilt and V-shaped yellowing at the edges of leaves
C. rust spots and mosaics
D. dieback and with leaves going purple

3. A common disease of tomatoes in the Pacific is:

A. witches' broom
B. tobacco mosaic
C. early blight
D. ring spot

4. The smallest of these pathogens is:

A. virus
B. phytoplasma
C. bacterium
D. fungal spore

5. A plant doctor finds a plant with symptoms of wilt. The most unlikely cause would be:

A. bacteria in the soil
B. powdery mildew
C. nematodes
D. stalk borer

6. Pests with eight legs are:

A. mites
B. insects
C. nematodes
D. millipedes

7. Which of these diseases is caused by a fungus?

A. bunchy top on banana
B. blossom end rot on tomato
C. citrus canker
D. damping-off on cabbage seedlings

8. A plant doctor finds a cabbage with a lot of holes in the leaves. Which are not possible causes?

A. diamondback moth
B. large cabbage moth
C. leaf chewing nematodes
D. snails

CHAPTER 2 QUIZ: answers continued...

Multiple choice. Pick one answer only...

9. A virus cannot usually be spread between plants by:

A. nematodes
B. tools
C. rhinoceros beetles
D. aphids

10. Two insects with complete life cycles are:

A. aphids and beetles
B. butterflies and bugs
C. grasshoppers and ants
D. bees and moths

11. Where do you find the eggs of this spiralling whitefly?

A. inserted into the leaf
B. whiteflies do not lay eggs, they give birth to living young
C. in the waxy spirals
D. underneath the female whiteflies

12. What is the most likely cause for this hibiscus wilt?

A. mites or thrips have attacked the young leaves, and they have wilted
B. it was planted on a slope, and there has been a long drought
C. old age
D. a fungus or an insect is destroying the roots.

9.4 Chapter 3 answers

Exercise 3.1: Practical activity — describing soil

This is a good exercise to start with, as it encourages your trainees' need to use their senses to focus on their soil. Their answers will depend on the soil samples. In general, good soil has a crumbly texture, an earthy smell and is dark brown in colour.

When your trainees have filled in the table, discuss the different soils.

Are they similar? Different? How might they be useful to support good plant growth?

Plan to come back to these answers at the end of the chapter so you can compare what has been learned through the exercises with the trainees' initial ideas.

Exercise 3.2: Traditional knowledge of soil

This exercise builds on Exercise 3.1 as many (but not all) of your trainees will have some experience of working on farms, or with farmers and their soil, and have some idea about how soil relates to farmers' challenges. Again, discuss the trainees' ideas so they can begin to make connections between soil and healthy plant growth.

Exercise 3.3: What is in soil?

As you work through the exercises and activities, adding new learning on wall charts helps keeps the new ideas visible and helps trainees to see that they are building understanding. From time to time, take a moment to add new information to the chart as the workshop progresses.

This will also help you know which exercises and activities to focus on, and which you can omit or move through quickly.

It is essential that the trainees understand the four main components of soil:

Minerals

Mineral particles are inorganic — they do not contain carbon except as carbonates. Mineral particles come from the weathering of rocks, and their components — sand, silt and clay — form the texture of soil. They provide all the nutrients essential for plant health, though some may be missing, which leads to nutrient deficiency symptoms in plants.

Exercise 3.3: continued...

Organic matter

Organic matter (carbon containing compounds) in soil comes from the decay of living organisms — plants and animals — which break down into humus. Humus gives the soil its dark colour. Organic compounds are important for holding the soil particles together and giving soil its structure.

Air and water

Air and water are essential for plant growth. They are held in the soil in the pores and spaces between the soil particles.

Minerals, organic matter, air and water make up the non-biological components of soil and contribute to its structure.

Living organisms

The biological components of soils are the living organisms — macroorganisms (those we can see with the naked eye or a binocular microscope) and microorganisms (those we can only see with a more powerful microscope). Together, they make up the soil microbiome. The living organisms are important for making nutrients available to plants and performing many other important functions to keep plants healthy.

Exercise 3.4: Practical activity — composition or texture of soil, the ribbon test

Exercise 3.5: Practical activity — sedimentation test

These two (Exercises 3.4 and 3.5) give your trainees a good idea about the various composition of soils. When they have finished, trainees should share their results. Encourage them to use technical language that describes their soil in terms of its sand, silt and clay components, as well as any unbroken organic matter. These results are used in Exercise 3.11 to describe the type of soil structure.

Exercise 3.6: Interpreting the soil composition triangle diagram

The USDA soil triangle is commonly used as a simple way of working out the composition of soil.

The composition creates the soil texture.

Work through steps in the example with the trainees; you can make up some of your own results as well if you think your trainees need more practice. They should understand the process, so they are able to work out the composition of their own soil when they have some results from their experiments.

Exercise 3.7: Practical activity — organic soil carbon content

You may be able to find potassium permanganate in a pharmacy, or from your agriculture department laboratory. You will need to prepare the solution beforehand, a concentration of about 3 g/L.

The lighter the colour the purple potassium permanganate solution becomes, the more organic matter is in the soil, and the healthier the soil. Compare the colour with the original solution and ask trainees to line their samples in order from darker and more purple to lighter and less purple. The order can be compared with the soil type.

In general, a soil with a high level of organic matter will turn the permanganate lighter and is an indication of the health of the soil.

Exercise 3.8: Practical activity — growing soil microorganisms

Seeing soil organisms which are usually invisible growing on agar plates is exciting for your trainees. The agar plates need to be prepared before the practical activity, unless you want the trainees to make them themselves. The plates need time to cool down and the agar to set before they are used. Keep the plates in the dark for a few days to allow the bacteria and fungi to grow.

Keep the plates covered as far as possible and make sure your trainees do not breath in any spores from the plates.

Compare the plates from the different soil samples. Fungi usually look furry while bacteria tend to be shiny. If you have access to binocular microscopes, trainees may be able to see spores. Even a hand lens will show some of the structures.

Exercise 3.9: Practical activity — examining soil for earthworms

You can also usually find earthworms under compost heaps. Keep them in a bottle with food scraps and keep moist. Exercise 3.21 shows you how to do this.

Earthworms are fascinating creatures, and it is interesting for your trainees to see them under a binocular microscope or even a hand lens. It is best to have some earthworms available before the exercise as earthworm populations are very patchily distributed and variable, so your trainees may not find any.

Put the earthworms back into the soil after the exercise, do not allow them to dehydrate as this will kill them.

Exercise 3.10: The carbon food web role play

This exercise helps trainees to understand the way carbon cycles in the soil food chain/web, and that everything is connected to form an integrated system.

Once the exercise has finished, the strings will look like a complicated spider's web. This is good as it gives a visual picture of the complexity of the carbon food web. Ask trainees to explain their connections. For example, if someone with a carbon dioxide card has connected with someone with a photosynthesis card, they should explain why they are connected — see Figure 3.10.

Also, discuss how energy moves through the web, from sunlight via photosynthesis to being stored in sugars, then used as food by animals/humans, and then by soil organisms when the plants or animals die.

Exercise 3.11: Practical activity — soil infiltration rate

This is probably best done as a demonstration unless you have enough equipment. If you do have the equipment, your trainees can test different soils in their groups.

The longer the soil takes to infiltrate, the more compacted it is and/or the higher the clay content. For a healthy light or medium soil, the water should drain away within 2 to 5 minutes. A compacted or heavy clay soil with poor structure could take 20 minutes or longer.

Once your trainees have completed their measurements, discuss the results and what they have learned about soil compaction.

By this stage, your trainees should have a good understanding of the components of soil. They should also be able to see differences between their soil samples.

Exercise 3.12: Practical activity — measuring the water holding capacity of soil

This exercise is a simple one, but needs to be carried out very carefully to get the most accurate results. Generally, a good soil will have an adequate water holding capacity, but still allows water to filter through.

Once you have everyone's results, look back at the answers to Exercises 3.4 and 3.5 and discuss any relationship between soil holding capacity and type of soil. Also, come back to think about these results again once you have carried out Exercise 3.11.

In general, sandy soils have a low water holding capacity, clay a high one.

Exercise 3.13: Practical activity — soil horizons (layers), digging a soil pit

Trainees may not be aware that there are different layers in soil (soil horizons). It is important to find soil that is relatively easy to dig down into, as you need to dig to a depth of about 1 m to see the layers clearly.

Make sure samples of the different layers are kept for testing. If time, you can test each layer using the tests in Exercises 3.4, 3.5, 3.6, 3.12, 3.15 & 3.16.

Exercise 3.14: Practical activity — measuring soil pH

This is a simple activity, but it is very important to be as accurate as possible, as pH has such an important impact on soil health.

If you have access to a pH meter this will give you a more accurate measure of pH.

Your discussion should focus on the trainees' answers, and what soil pH means for plant health. They should also discuss whether there is any relationship between pH and soil texture. It relates closely to the next section which shows how important pH is for plants to take up soil nutrients.

Exercise 3.15: pH and nutrient availability

This activity applies the idea of soil pH to the availability of nutrients to plants. Trainees should use the diagram in Fig. 3.19 to work out which elements are available and unavailable to plants.

They should also think about which nutrients might not be available in their own soil samples.

Exercise 3.16: Deciding on nutrient deficiencies

Nutrient deficiencies are extremely difficult to diagnose and may look different on different plants. Also, some are very hard to tell apart from disease symptoms cause by fungi, viruses or bacteria. It is important that you collect as many examples of known deficiencies as you can, to provide your trainees with as much experience as possible.

Trainees should describe the symptoms as clearly as possible, such as the colour of the veins and the rest of the leaf and/or fruit.

You should also look at Section 2.9.1 Exercises 2.9, 2.10 & 2.11 in Chapter 2 — diagnosis through the process of Possible/Probable, as nutrient deficiency symptoms can be confused with disease symptoms.

Use Figures 3.20 to 3.30 in the manual in Section 3.9.2, but also any from the field that you are aware of. If you can, ask your agriculture department or local farmers to indicate any nutrient deficiency examples that are found in your area that you can collect and show to the trainees.

Exercise 3.17: Data from soils from three Pacific countries — Fiji, Samoa and Tonga

These data come from the Pacific Soil Portal and show your trainees how different soils can be across the region. Once they have analysed the data, discuss the differences with the trainees and what problems farmers may have when working with these soils and what will grow well and what will not.

Soil location	Source of soil (parent material)	Texture	Soil pH	Fertility	Minerals lacking	Drainage/ flooding	Soil quality — good for growing crops?	Soil amend -ments necessary
Fiji	River alluvium	One or more of 0-25 cm clay loam 25-35 cm silt loam	< 7	Low organic carbon (C) values. Low potassium (K) values in subsoils	Impossible to say. All available at this pH.	Minor risk	Good	Organic matter
Samoa	Basalt	10 cm stony clay loam 20cm very stony clay Base very rocky clay	5.1	Moderate fertility Potassium (K) very high, low in subsoil	Mg, Ca, Mo	Good, no risk	Moderate	Mg, Ca, Mo
Tonga	Not given	0-17 cm black coarse sand; 17-50 cm sand on coral limestone	> 7	High organic carbon (C), nitrogen (N) in A horizon; phosphorus (P) high to very high	Possibly Fe	Good, no risk	Moderate	Possibly Fe, need to test

EXERCISE 3.17: answers...

Exercise 3.18: Review — what have trainees learned so far about their soils?

At this point in the workshop your trainees will be able to bring their learning together so they can begin to understand how complex soil is, and that soil health is so important for plant health. It is also a good time to add any new information to the charts on the wall.

Exercise 3.19: Analysing CO_2 burst test results

Now that your trainees have developed an understanding of what is in soil, in the following sections, your trainees learn about how to keep soil healthy and what degrades it.

The CO_2 burst data gives an idea of which treatments are best for soil – the higher the CO_2 burst, the healthier the soil. Trainees should be able to look at the figures and work out which soil treatments work best. These are the results from the CO_2 burst test placed in order from best to worst treatment.

Crop / treatment	CO_2 burst (ppm)
Topsoil, cover crops for 20 years	230
Multispecies cover crop	137
Virgin grassland	137
Maize, no till	115
Rye cover crop	107
Vegetables, truck soil	69
Subsoil (below topsoil) no till	71
Tobacco, tilled	57

Clearly, the soil that had a cover crop for 20 years is the best in this list. It is important for trainees to see that a cover crop is really important, and that tilling the soil is damaging.

Discuss these results and ask trainees whether they could be applied to the farmers they work with. Why or why not?

Exercise 3.20: Practical activity — making hot compost

A compost heap needs 3-4 days to heat up. You can start the heap with your trainees at the beginning of the workshop, alternatively start it yourself beforehand. Check the heap daily. Point out to the trainees how it is heating and that it needs turning regularly to add oxygen, and water if it dries out.

Exercise 3.21: Practical activity — building a mini worm farm in a bottle

Seeing worm activity in this way is interesting to your trainees. You can use the activity to emphasise how important worms are and how they need healthy soil to thrive.

Exercise 3.22: Practical activity — what is in a fertiliser?

For this activity you will need to obtain bags of fertilisers that are used locally. It is important that your trainees are able to read the information on any fertiliser a farmer is using and think about whether it is the best fertiliser for the soil.

This is similar to the exercises on reading a pesticide label in Chapter 6.

Trainees should discuss what fertiliser (if any) needs to be added to their own soil sample and why, and which type/trade name would be the best to apply. This also relates to Exercise 3.18.

Exercise 3.23: Crop rotation

Direct trainees to read Section 5.4 — Crop rotation, in the manual Chapter 5. They should carry out Exercise 5.3 in Chapter 5 and discuss their answers with the class.

Exercise: 3.24: Thinking about all the components of healthy soil

The idea that healthy soil is complex cannot be stressed enough. This exercise helps your trainees recall all the components of soil that they have learned about.

Once the trainees have filled in as much as they can, pin the sheets to the wall and use them to draw attention to the complexity of soil.

Some answers:

- minerals
  - sand
  - silt
  - clay
- other components
  - water
  - air
- organic components
  - carbon containing compounds
  - humus
  - worm castings
- microoganisms
  - bacteria
  - fungi
  - mycorrhizae
  - archaea
  - viruses
    protozoa
  - nematodes
- macroorganisms
  - worms
  - spiders
  - beetles
  - other arthropods — millipedes, centipedes
- nutrients
  - nitrogen
  - phosphorus
  - potassium (and other elements present in the soil)
- texture
  - sandy
  - clay
  - loam
- pH.

Exercise 3.25: Comparing landscapes

The main idea here is that healthy soils have a high level of carbon, and healthy agricultural systems are as biodiverse as possible. High levels of biodiversity support the soil microbiome, as well as help reduce the level of pests and diseases in crops.

1. The first figure shows a small farm with a high level of biodiversity and with a lot of cover over the soil. It is likely to have healthy soil and low levels of pests and diseases.
2. The second figure shows a landscape that has been overgrazed by animals (sheep, cattle) so the soil is depleted and has very little vegetation cover. The hoofs of the animals destroy the fragile topsoil. It also shows a lot of soil erosion along a creek bed which has not been fenced off from grazing. There is some tree planting taking place to restore the soil and environment. It is likely that the soil is depleted, particularly regarding organic matter and its pH is likely to be low.
3. The third figure shows a small food garden in Solomon Islands. This also shows a high level of biodiversity, what appears to be raised beds for planting, with good soil. It is likely to have healthy soil and few pests and diseases.
4. The fourth figure shows a landscape heavily overgrazed by sheep, possibly in time of drought. The vegetation has been eaten down to the soil and the top soil is being eroded away. The soil is likely to have a very poor structure.

Exercise 3.26: Creating a concept map

See Chapter 8, Section 8.5.3 for details on concept mapping.

This and Exercises 3.27 and 3.28 help your trainees to check your understanding at the end of this chapter. You can choose as many concepts as necessary. These types of exercises can be made as easy or as difficult as you decide and can be carried out at any point during the training to strengthen learning.

Concept mapping is very useful for both learning about and assessing your trainees' understanding of relationships between important concepts. Ask your trainees to write the concepts on small pieces of paper, card or post-it notes and stick them on a large piece of brown paper with blu-tak or sticky tape. The pieces of paper can be moved around till the group is satisfied with the arrangement. The words describing the relationships between the concepts are written on lines or described orally (see Figures 8.2 & 8.3).

Soil	Carbon	Bacteria	Earthworms	pH
Texture	Mycorrhiza	Molybdenum	Fertility	One Health

Exercise 3.27: What am I?

This guessing game exercise is described in the answers to Exercise 2.8 in Chapter 2. Using relevant words, it can be carried out at any point during the training.

Exercise 3.28: Match the term to the definition

Answers:

Term	Definition
1. Mycorrhiza	D. Network of fungal hyphae
2. Endophyte	A. Fungus that lives inside a plant cell
3. Agro-ecology	I. The application of ecological principles to make agricultural systems more sustainable
4. Cover crop	Q. Crop planted to be ploughed into soil as a fertiliser
5. Manganese	M. A necessary micronutrient for plant health
6. One Health	L. Idea that all life forms are interconnected and affect each other
7. Water holding capacity	B. Amount of water that a soil can hold measured in grams of water/ gram of soil
8. Weathering	H. Breaking down of rocks into small particles
9. Soil horizon	S. Layers of soil from surface downwards
10. Humus	F. Decomposed organic matter in soil
11. Vermicompost	C. Fertiliser produced by worms
12. Crop rotation	T. Sequence of crops grown that keep soil healthy, prevent pests and diseases and provide nutrients
13. Microbiome	J. All the microorganisms present in soil
14. Carbon sequestration	P. Carbon held in soil
15. Loam	K. A soil that is a good mixture of sand, silt and clay
16. pH	O. The level of acidity
17. Aggregate	G. Small clumps of soil
18. Archaea	N. A type of microorganism, part of the soil microbiome
19. Biochar	E. Carbon formed by the anaerobic combustion of plant material
20. Hartig net	R. Network of hyphae between epidermis and the cortex in a plant root

Exercise 3.29: Applying learning about soils — giving a farmer advice

This exercise challenges your trainees to bring together their learning about soil to give advice to a farmer, something they may need to do at a PHC.

You can combine this exercise with Exercise 7.9 in Chapter 7.

SCENARIO 1: Watermelon on the Guadalcanal plains, Solomon Islands

Possible diagnosis with reasons

Yellowing of the leaves suggests nitrogen deficiency. The farmer has used a crop rotation over the years that has depleted the soil of nitrogen and, perhaps, also sulphur due to burning the grassland.

What can the farmer do now?

Add some inorganic nitrogen fertiliser (NPK) if the crop is still growing.

What can the farmer do in the longer term?

- plant a legume crop next time to fix nitrogen into the soil
- or plant a cover crop and plough it into the soil before flowering.

SCENARIO 2: Tomatoes in Fiji

Possible diagnosis with reasons

Blossom end rot, a calcium deficiency in the plant. This may be caused by uneven watering of the crop which means it was unable to transport calcium to the developing fruit, as well as low levels of calcium in the soil. Also, overuse of nitrogen can cause calcium to be unavailable. Note, calcium does not move from old to young parts of the plant.

What can the farmer do now?

Nothing at this stage, unless the fruits are still producing fruit; in which case ensure there is regular watering.

What can the farmer do in the longer term?

- make sure the soil has a good supply of calcium through a top dressing of lime or dolomite. If possible, test calcium levels in the soil
- do not add too much nitrogen, especially when fruiting is starting
- it is not possible to control rainfall, but do not allow the crop to dry out during the growth stage.

Exercise 3.29: continued...

Scenario 3: Banana in Kiribati

Possible diagnosis with reasons

Interveinal chlorosis on the young emerging leaves, with veins remaining green at first, suggesting iron deficiency. In severe cases, the leaves are undersize and, on atolls, may become pale white, including the veins. Results in fruits of poor quality. Occurs in soils where pH is above 6.5.

What can the farmer do now?

Iron is not a mobile element, and does not move from old to young leaves, so if immediate action is required, a foliar spray is necessary: apply iron sulphate or iron chelate (Fe EDTA).

What can the farmer do in the longer term?

Best to replant the sucker in a pit with plenty of compost or manure and/or soil taken from local trees. Alternatively, use ammonium sulphate as the source of nitrogen as this may lower the pH of the soil. Probably, the best solution is to add rusty tin cans to the pits together with the compost/manure/soil mixture. Also, seek local knowledge on varieties; some varieties of bananas or plantains may be more tolerant of iron deficiency than others.

Now re-visit Exercise 3.1 and discuss whether your trainees' ideas about soil have changed after working though this chapter.

CHAPTER 3 QUIZ: Test your knowledge

Answer are in bold...

1. Sand particles are:

A. the largest particles in soil and float on the top of water
B. the smallest particles in soil and float on top of water
C. the largest particles in soil and sink in water
D. the smallest particles in soil and sink in water

2. Organic matter in soil is found in:

A. the bedrock
B. humus
C. clay
D. water

3. Which of these are NOT normally found in the soil microbiome:

A. archaea
B. bacteria
C. worms
D. fungi

4. Fungi that live inside the cells of plants are called:

A. endophytes
B. mycorrhizae
C. spores
D. microbiome

5. Soils with plenty of organic matter are likely to be rich in:

A. carbon
B. magnesium
C. potassium
D. iron

6. Which of these are NOT ways in which nitrogen can be made available to plants:

A. nitrogen fixing bacteria
B. using leguminous cover crops
C. drawing in nitrogen from the atmosphere
D. applying fertiliser

7. 'One Health' refers to:

A. the health of people in the Pacific
B. the idea that the health of all life forms is interconnected
C. how bacteria affect plant roots
D. the health of soil

8. The term 'aggregate' refers to:

A. soil particles bound together in clumps by organic matter and microbes
B. all the layers in a soil horizon
C. compost
D. the total of minerals in a particular soil

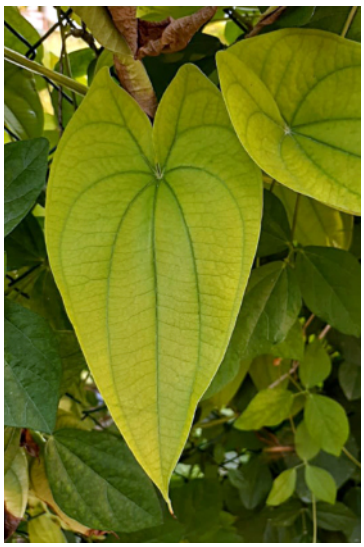
9. A soil has a pH of 8. Which three minerals are likely to be less available to plants?

A. K, S, Fe
B. Mn, Cu, Zn
C. Ca, Mg, Mo
D. N, Ca, Mn

10. A soil contains 30% clay, 30% silt and 40% sand. It is best described as:

A. silty loam
B. compost
C. clay loam
D. sandy clay

11. The symptoms on this yam leaf (right) suggest:



A. nitrogen deficiency
B. boron deficiency
C. it is the normal colour of the leaf
D. iron deficiency

12. Practices that contribute to soil health are:

A. cover crops
B. flooding
C. use of pesticides
D. raising soil pH to above 8

13. Physical weathering of soil refers to:

A. minerals within rocks reacting with water, air or other chemicals.
B. splitting of rocks through temperature changes and collisions of rocks with each other
C. breakdown of rocks by living organisms
D. ploughing the soil

14. Which of these is not true:

A. *Mucuna pruriens* can be used as a cover crop
B. a plant under stress is less resistant to disease
C. a soil with a pH of 7.5 is slightly alkaline
D. compost requires a carbon to nitrogen ratio of about 1:25

15. the plant's rhizosphere includes:

A. roots, root exudates and microbes
B. rhizomes
C. flowers and leaves
D. compost

9.5 Chapter 4 answers

There are no exercises for Chapter 4. Just work through the chapter to ensure your trainees have joined their country social media groups for plant health doctors and know how to use KoboToolbox (if available), the Pacific Pests, Pathogens & Weeds app, and are familiar with PestNet.

9.6 Chapter 5 answers

In Chapter 2, your plant health doctor trainees learned to identify and diagnose pest and disease symptoms on plants, and Chapter 4 introduced digital resources to help diagnose unknowns. Chapters 5 and 6 help your trainees to understand ways of managing pests and diseases. Chapter 5 covers IPDM options using cultural and biological control methods, which should always be the first option. Chapter 6 covers pesticides.

EXERCISE 5.1: What do you already know about IPDM cultural control methods for specific pests and diseases?

Your trainees will already have a lot of knowledge about cultural methods of control. In groups, they should write down and discuss any IPDM pest and disease control methods they know about for two pests and two diseases from their region, for both large and small scale cropping, and how the methods work. They should fill in the table below, then share and discuss their answers with the rest of the class. Answers will depend on the examples chosen.

An example is given for an insect and an example of a disease.

	Crop	What IPDM cultural control methods are possible?			
		For large scale	How it works	For small scale	How it works
Insect/mite pest					
Example: Diamondback moth (DBM)	Brassicas	Remove weeds in the Brassica family	Reduces DBM populations that maintain populations between crops	Hand pick caterpillars	Removes pests
1					
2					
Diseases					
Example: Citrus scab (*Elsinoe fawsetti*)	Citrus	Isolate nurseries from orchards	▪ prevents spread of fungus ▪ prune to keep canopy open	▪ isolate nurseries from orchards ▪ prune to keep canopy open	Prevents spread of fungus
1					
2					

EXERCISE 5.1: answers...

EXERCISE 5.2: Using IPDM — working out the steps

For IPDM to work properly, several important steps need to be taken.

These steps are what the plant health doctors need to tell farmers at the PHC.

This exercise helps your trainees work through the correct steps for applying IPDM. When they have had time to think about their answers, ask each group to share their ideas with the class. If they have anything in the wrong order, discuss this.

CORRECT ORDER

A. E: Knowledge — identify the pest or disease and know its life cycle.

B. A: Go to the garden regularly. Look for damage.

C. D: Decide how much damage is acceptable.

D. C: Make a plan of action for the present crop and the next crop: A) before planting (next crop); B) during growth of present crop; and C) after harvest of present crop. If it is a pest, count the pests (can you see natural enemies?). Is the problem getting worse or not? KEEP NOTES.

E. B: Was your plan successful or not? Are any changes needed? Is it a problem likely to be caused by a pest or a disease? Use the possible/probable approach in Chapter 2.

EXERCISE 5.3: Applying crop rotation

It is important that your trainees are familiar with the principles of crop rotation and are able to explain it.

The example shows possible crops to plant in a rotation based on Fig. 5.4. Each column represents a separate plot and has four cycles.

Note that as long as the crops are in the correct families and follow the current sequence, the actual crop that the trainees suggest does not matter. There is more than one correct answer, but there are also incorrect answers.

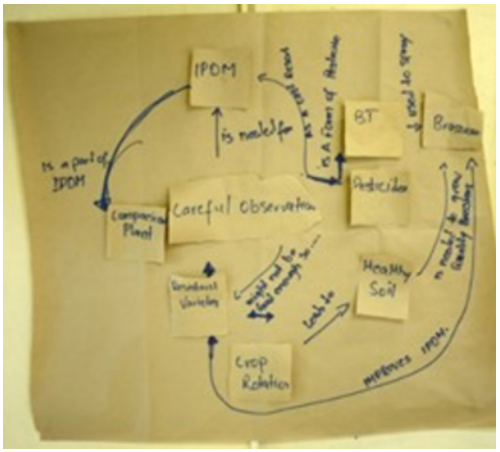
Cycle	Plot 1	Plot 2	Plot 3	Plot 4
1	Leafy crop e.g. *bele*	Legume crop e.g. Mucuna	Root crop e.g. taro	Legume crop e.g. Mucuna
Reason why you chose this crop rotation:				
2	Solanaceae crop e.g. capsicum	Curcubit crop e.g. cucumber	Brassica crop e.g. bok choy	Leafy crop e.g. lettuce
Reason why you chose this crop rotation:				
3	Root crop e.g. cassava	Root crop e.g. carrot	Legume crop e.g. bean	Solanaceae crop e.g. chilli
Reason why you chose this crop rotation:				
4	Legume crop e.g. peanut	Brassica crop e.g. cabbage	Cereal crop e.g. maize	Cucurbit crop e.g. watermelon
Reason why you chose this crop rotation:				

EXERCISE 5.4: Concept mapping of IPDM — answers

Creating a concept map is a very useful exercise to help your trainees make connections between concepts in any topic. It is best done in pairs or small groups. The concepts are written on a sticky note or piece of paper with blu-tak or sellotape on the back, then moved around on brown paper or butchers paper until the group agrees where they fit. The process of discussing and making decisions is an important part of the learning process.

You might want to start with a simple map of concepts that all trainees are familiar with, e.g. **house, mother, garden, chicken, taro, child,** so that they understand the process. They should write on the connecting lines how the concepts are linked.

You can decide to leave out or add other terms or change them if you think others might be better. About eight terms work well, but you can add more if your trainees need more challenges. Alternatively, you can ask the trainees to give you the terms to work with.



There is no one correct answer, but some answers could be incorrect. Some trainees will decide to create a flow diagram — 'this' leads to 'that' — while others will link the concepts. It does not matter how people relate the concepts, but trainees must write how they are related on the linking lines, as in the example here.

See Figs. 8.2-8.3 in Section 8.5.3 for other examples.

When they have finished, ask the trainees to put their map on the wall, and explain it to the rest of the class.

You can use concept mapping at any time during the training to help your trainees deepen their learning and make connections between content.

EXERCISE 5.5: Summary of cultural practices for IPDM control of some common pests and diseases

Exercise 17 is designed to help your plant health doctor trainees bring all their knowledge about cultural control for IPDM together. They should discuss the answers in their small groups, using their own knowledge as well as the resources and information you have covered in this chapter, to complete the table. Or you could set it as a homework exercise. When they have finished, discuss the answers with the whole class. Not everyone will be aware of all these cultural controls, so spend some time on the discussion.

The answers will depend on the examples the trainees use. You can provide them with examples, or they can come up with their own. Some examples are provided here.

Cause	Example	Crop & part affected	CR	GH	F	GD	CP	V	HPM	HP	TC	BC
Pests (insects & mites)	Tomato fruit borer	Tomato fruit	✓	✓	✗	✗	✗	✗	✗	✓	✓	✓
Pathogen (Nematodes)	Dry rot *(Pratylenchus)* nematode	Yam, roots, tubers	✓	✓	✓	✗	✗	✗	✓	✗	✗	✓
Pathogens (fungi, bacteria & viruses	Bacterial wilt	Tomato, whole plant	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗

Key

CR: Crop rotation

GH: Good hygiene

F: Fertiliser/compost/organic matter

GD: Good drainage

CP: Companion planting

V: Resistant variety

HPM: Healthy planting material

HP: Hand picking

TC: Trap crops

BC: Biological control

CHAPTER 5 QUIZ: Test your knowledge

The answers are given in **bold**. When they have all finished, go through the answers. You do not need to ask what marks the trainees got, they will have learned the correct answers by going through the test as a class.

Make sure you always discuss with the class any answers they are not sure about. Then explain that if there is anything they are still not sure about they should read the manual again and/or ask for help.

1. In IPDM, pesticides should be used:

A. always
B. never
C. as a last resort
D. only if the farmer can afford them.

2. The adult in the picture below is most likely to be:

A. a beetle
B. a wasp
C. a lacewing
D. a fly.

3. In order, a companion plant, a bio-insecticide and a beneficial organism are:

A. taro, DBM, Trichoderma
B. Chinese cabbage, kocide, ladybird
C. coconut, pyrethrum, Trichogramma
D. marigold, Metarhizium, spider.

4. An example of good crop rotation would be:

A. lettuce, cabbage, broccoli, bean
B. cucumber, squash, potato, cassava
C. potato, tomato, eggplant, capsicum
D. bean, cabbage, cassava, cucumber.

5. Rogueing means:

A. using bio-insecticides
B. destroying infected plants
C. using companion plants
D. planting resistant varieties.

6. In IPDM, monitoring involves:

A. deciding whether the problem is caused by a pest or a disease
B. using the best pesticide for the pest
C. checking the level of damage and looking for bugs and eggs
D. identifying the pest or disease

7. The correct sequence for applying IPDM is:

A. monitoring, evaluation, making a plan, identification of pest or disease
B. evaluation, monitoring, identification of pest or disease, making a plan
C. making a plan, identification of pest or disease, monitoring, evaluation
D. identification of pest or disease, monitoring, decide amount of damage acceptable, making a plan

8. Which plants are all in the same plant family?

A. cabbage, bok choy, broccoli, chilli
B. potato, cassava, taro, sweet potato
C. bitter gourd, pumpkin, cucumber, squash
D. capsicum, chilli, eggplant, bean

9. The best way to control a soil-borne bacterial infection is:

A. to use a resistant variety if it can be obtained
B. to spray with a pesticide
C. to find a virus that attacks the bacteria
D. to add compost to the soil.

10. Which of the following is NOT thought to be a characteristic associated with companion planting?

A. companion plants can provide food for parasitoids
B. companion plants may have a smell that repels pests
C. companion plants put copper into the soil
D. companion plants may repel root knot nematodes

9.6 Chapter 6 answers

In Chapter 5, your plant health doctor trainees learned about some of the cultural controls that can be applied to IPDM. Chapter 6 introduces them to pesticides. Remember to stress that these should be used only as a last resort, given the damage they cause to humans, natural enemies and the environment, as well as the problem of build-up of resistance in pest populations.

Chapter 6 reviews many aspects of pesticides and their uses, and Exercises 6.1-6.8 will test your trainees' knowledge on this topic.

EXERCISE 6.1: What do you already know about commercial pesticides?

This exercise helps you find out what your trainees already know about some commonly used (commercial) pesticides. They can check their own answers in Table 6.2. If any answers are incorrect, discuss. Add any others not on the list. This exercise also draws your trainees' attention to the fact that some pesticides may contain the same active ingredients but are sold under different trade names. It is important that they know this to be able to advise farmers properly.

Trainees should carry out this exercise in pairs or small groups. Discuss with the class and add any they do not know. Pesticides with different trade names, but the same active ingredients, are grouped and highlighted below.

Pesticide name	Purpose	Type of pesticide	Active ingredient
Attack	Caterpillar, aphids.	I	Pirimiphosmethyl/ permethrin
Sundomil	Broad-spectrum.	F	Mancozeb
Glyphosate	Perennials, woody weeds.	H	Glyphosate
Kocide	Broad-spectrum.	F (and a bacteriocide)	Copper hydroxide
Confidor	Sucking insects — aphids, leafhoppers, thrips, whitefly, mealybugs, scale insects and taro beetle.	I	Imidacloprid
Orthene	Chewing and sucking insects — caterpillars, aphids, thrips, leafminers, leafhoppers, planthoppers, cutworm — on vegetables and fruits.	I	Acephate
Agazone	Annual and grass weeds.	H	Paraquat
Suncloprid	Sucking insects — aphids, leafhoppers, thrips, whitefly, mealybugs, scale insects and taro beetle.		Imidacloprid
Talendo	Broad-spectrum.	F	Chlorothalonil/ Thiophanate
Blitzem	Snails and slugs.	M	Metaldehyde
Steward	Caterpillars, pod borer, armyworm, centre grubs, cutworm, leafroller, leafminers.	I	Indoxacarb
Prevathon	Caterpillars, pod borer, armyworm, centre grubs, cutworm, leafroller, leafminers.	I	Rynaxypyr or chlorantraniliprole
Others:			
Farmers' imidacloprid	Sucking insects — aphids, leafhoppers, planthoppers, thrips,whitefly, mealybugs, scale insects and taro beetle.	I	Imidacloprid
Manzate	Broad-spectrum.	F	Mancozeb
Kotek	Broad-spectrum.	F	Mancozeb

EXERCISE 6.2: Understanding the pesticide label

Understanding a pesticide label is critically important for the correct and safe use of pesticides. This exercise focuses your trainees on how to understand the label. Make sure each group has a different label to work with. They should write their answers on brown paper or butchers paper. When finished, each group should hold their paper up and read out their answers to the class and discuss.

What is the pesticide used for?	Depends on label allocated to trainees
What is the common name of the pesticide?	Depends on label allocated to trainees
What is the trade name of the pesticide?	Depends on label allocated to trainees
Is the label divided into separate panels? If so, what information does each of these panels give you? Centre panel? Left panel? Right panel?	Depends on label allocated to trainees
What is an emulsifiable concentrate (EC)?	This will form a milky liquid when mixed with water
What is a sticker?	A substance that is put into a pesticide to make it stick to crop plants
What is a spreader?	A substance that helps spread the pesticide across the leaf surface
What is meant by 'compatibility'?	Pesticides that can be used together
What should you avoid doing when spraying, but do immediately after spraying?	Avoid contact with undiluted pesticide during preparation. Avoid getting spray on people, animals or into waterways. Clean the tank immediately after spraying so that the chemical does not dry on the inside: ▪ to do this, open the tank, remove the strainer, fill the tank with 1.5 L of water, replace the cap and shake ▪ pour the water out onto area that has been sprayed, or the ground nearby ▪ add another 1.5 L of water and spray to clean the hose, lance and nozzle
What clothing is recommended when preparing the spray and spraying?	Masks (including respirators) and goggles to protect the mouth and eyes, gloves, boots, hat and overalls. As a minimum, wear a long sleeved shirt, long trousers, rubber boots and a hat
What is the recommended way to store the pesticide?	Store the product in its original container, tightly closed, and away from heat and food, and out of reach of children, preferably in a locked cupboard
What does 'run-off' mean?	Pesticide that has left the crop and run off into the soil, drains, waterways, etc.
Is there a hazard number on the label? What is it and what does it mean?	1a — extremely hazardous 1b — highly hazardous II — moderately hazardous III — slightly hazardous U — unlikely to present acute hazard

EXERCISE 6.2: continued...

What should you do after spraying and before eating, drinking or smoking?	Remove your clothes and shower. Wash the clothes separately from other clothing. Do not eat or drink after spraying until you have washed
Can you wash the sprayer or empty container in the river? If not, why not?	No. It may contaminate the water to make it undrinkable, as well as kill fish and other aquatic creatures that live there
Where are the best places to put the container when it is empty?	Bury it or send it to a landfill. Do not re-use the container or leave it in the field
Is it recommended that you induce vomiting if a person has drunk the pesticide?	Depending on the pesticide, the label will tell you whether vomiting should be induced or not
If you spill the pesticide, what should you do?	Wear protective clothing Cordon off the area Prevent the chemical from entering drains Absorb it with inert material (soil, sand or sawdust) Place it in bins for disposal in a landfill Wash the contaminated area with water
Can you give livestock feed that has been sprayed with the pesticide?	Depends on the pesticide. There may be a withholding period till the animals can be slaughtered when they have grazed on sprayed crops. The pesticide label should tell you this
What is meant by the pre-harvest interval (also known as the withholding period)?	How long before the crop can be marketed after spraying to be considered safe to eat
What do these pictograms mean? a)  b)  c)  d) 	a) Wear protective clothing b) Always wash after applying pesticide c) Wear gloves d) Wear a mask or face guard

EXERCISE 6.3: Making up a pesticide for spraying

This exercise asks trainees to calculate the quantities needed to make up pesticide concentrations correctly for spraying. It is very important that they are confident with this sort of calculation. Go through it step by step if anyone is having difficulties.

- the pesticide label (Eko) tells you that you should apply Eko in 400 L of water per ha
- Eko is made up at 34 ml per 20 L sprayer (see Fig. 6.6)
- the farmer has a 5 square chain tomato field.
- area: 5 square chains is equivalent to 0.2 ha (25 sq chains = 1 ha, 5/25)
- spacing: 0.5 m x 1 m
- the farmer has a 15 L knapsack.

1. How many knapsack sprayers are needed to spray 1 ha of tomato?
   Answer: 26.7 knapsacks if using a 15 L sprayer (40 if a 10 L sprayer; 20 if a 20 L sprayer).
2. How much (Eko) chemical will you need to spray 1 ha of tomato?
   Answer: 680 ml of Eko chemical.
3. What advice would you give the farmer about the amount of chemical (Eko) … that he/she will use?
   Answer: 136 ml of Eko chemical.

Trainees should check their answer with a partner and then discuss with the whole class.

EXERCISE 6.4: Important factors in spraying

In pairs or small groups, trainees should write down at least four important things that they need to know before, during and after spraying. Discuss answers with the class.

Spraying	Important things you need to know
Before spraying	▪ do not spray on windy days ▪ have another person with you ▪ check that your knapsack is not leaking and was cleaned properly after its last use ▪ check you have the correct nozzle for the pesticide you are using ▪ check you have the correct concentration of pesticide (consult label) ▪ wear proper protective clothing
During spraying	▪ spray either early in the morning or late in the afternoon, when wind is less strong ▪ spray down wind ▪ use a spray shield to prevent chemical drift ▪ if accidents happen, refer to the label ▪ in case of a spill, cover with sand, sawdust or soil, and bury away from the house at the edge of the garden or field, or take to land fill
After spraying	▪ clean the tank immediately after use so that the chemical does not dry on the inside ▪ open the tank, remove the strainer, fill the tank with 1.5 L water, replace the cap and shake ▪ pour the water out onto the area that has been sprayed, or the ground nearby ▪ add another 1.5 L water and spray to clean the hose, lance and nozzle ▪ after spraying, remove your clothes and shower ▪ wash these clothes separately from other clothing ▪ do not eat or drink after spraying until you have washed

EXERCISE 6.5: Advantages and disadvantages of using pesticides

Your trainees have now covered Chapters 5 and 6 on IPDM methods of management of pests and diseases. They should now be able to discuss what they have learned about the advantages and disadvantages of using pesticides compared with other methods included in IPDM.

Some possible answers are given here:

Advantages of using pesticides	Disadvantages of using pesticides	Safer alternatives

▪ they are cheap
▪ farmers see their effects immediately
▪ they can be applied quickly over large areas
	▪ they are toxic to human beings and the environment
	▪ they destroy beneficial insects
	▪ pests become resistant to them.
	▪ for many people, they are difficult to choose and use at the correct rate
		▪ cultural control strategies for example:
		  ▪ crop rotation
		  ▪ destruction of crop debris at harvest
		▪ resistant varieties
		▪ biological pesticides

EXERCISE 6.6: Using trainees' knowledge to identify and develop a management strategy for a farmer

Your trainees have studied the identification, diagnosis and management of pests and diseases, now they need to put their knowledge into practice. Practice and experience are essential; becoming a competent plant health doctor is complicated and takes work!

This is an important exercise, as it prepares your trainees for plant health clinics and is a good introduction to Chapter 7: Running a plant health clinic. It also gives them practice in filling out the Prescription Forms that are used at clinics, and asks them to reflect on their advice and to think about what they could do better.

This exercise is in five parts:

1. Identify and diagnose the problem.
2. Ask the farmer questions about the problem.
3. Manage the problem — make a plan.
4. Completing the Prescription Form.
5. Discuss and reflect.

EXERCISE 6.6: Using trainees' knowledge to identify and develop a management strategy for a farmer

Part 1: Identifying and diagnosing the problem

Trainees should now work through the process of identification and diagnosis of the problem in their photos. They should use all the information from the manual, Fact Sheets in the Pacific Pests, Pathogens & Weeds app, as well as their own experience.

Remind trainees to use the identification and diagnosing process in Chapter 2:

1. Is it A, B, or C? (abiotic, biotic or confused).
2. Possible and probable?
3. They should check with the fact sheets in the Pacific Pests, Pathogens & Weeds app only after they have done steps 1 and 2.

Part 2: Identifying and diagnosing the problem

As well as examining the sample, at a clinic, plant doctors will need to ask the farmer questions to provide more information about the pest or disease.

Trainees should make a list of questions they would ask the farmer. These questions could include:

1. How widespread is the problem? (e.g. a whole field, a few plants only)
2. Have other farmers in the area got the same problem?
3. Has the farmer seen the problem before?
4. Is it a new problem or does it occur every year?
5. How serious is the problem? (e.g. only a few leaves affected, the whole plant is affected)
6. How has the farmer tried to manage the problem? Was he or she successful?
7. What has the weather been like? (e.g. rain, drought, cyclone, frost, etc.)
8. Other questions?

Each pair should show the class their photos, discuss their diagnosis and read out their questions.

For unknowns, refer your trainees to the online tools in Chapter 4.

EXERCISE 6.6: Using trainees' knowledge to identify and develop a management strategy for a farmer

Part 3: Managing the problem — making a plan

Once you are satisfied that the trainees have the correct diagnosis, next ask them to discuss and write down all the different ways the problem could be managed, both now and into the future.

- biological control
  - are there any natural enemies that are important to preserve which might be killed with some pesticides?
- cultural control – what can be done?
  - before planting
  - during growth
  - after harvest
- resistant varieties
  - these can only be recommended if they are known to be available in the country
- chemical control
  - homemade pesticides
  - commercial pesticides.

Part 4: Completing the Prescription Form

Once they think the problem has been diagnosed and they have thought about a management plan, trainees should now practise completing the plant health clinic Prescription Form. This is the form they will use at the clinics, so it is very important they are familiar with it. Stress that they should fill in ALL parts, using clear handwriting. (They can make up the farmer's details.)

Stress to your trainees that plant doctors should NEVER give advice if they are uncertain. If using a language other than English, an English copy will be needed for record keeping, or use the KoboToolbox app on a smartphone or a tablet.

Make it very clear that the Pacific Pests, Pathogens & Weeds app should be used to check a diagnosis and to guide management strategies ONLY after this process is complete. Suggest to your trainees that they use the mini fact sheets in preference to full fact sheets as they present a summary of problems.

Part 5: Discussion and reflection

Reflection is also a very important part of the process. Discuss the exercise as a whole class, encouraging your trainees to discuss not only what they were able to diagnose easily, but also the unknowns and other difficulties. Ask them what they need to do to give a farmer better advice? What further study do they need to do?

If time, this exercise should be repeated using a sample from a garden or field. Your trainees can never have enough practice!

CHAPTER 6 QUIZ: Test your knowledge

The answers are given in **bold**…

1. Which of the following are all fungicides?

A. Manzate, milk, baking soda, malathion
B. Sundomil, Kotek, Kocide, Talendo
C. Glyphosate, neem, Blitzem, pyrethrum
D. Confidor, Orthene, Bt, Manzate

2. A sprayer nozzle suitable for fungicides should:

A. be an anvil type and the spray should form a light rain
B. be a flat type and the spray should form a mist
C. be a hollow cone type and the spray should form a mist
D. be a flat type and the spray should form a cloud

3. A pesticide label says that it should be made up at a concentration of 10 ml pesticide to 10 L water. The concentration of the pesticide is:

A. 10%
B. 1%
C. 0.1%
D. 0.01%

4. A farmer has 10 ha of a crop to be sprayed. The pesticide label tells her that the spray should be 30 ml pesticide per 20 L water and the crop should receive 400 L per ha. How many ml of the pesticide should she use to make up the spray to spray the whole crop properly?

A. 4000 ml
B. 600 ml
C. 6000 ml
D. 2400 ml

5. Buildup of insecticide resistance in a pest can be prevented by:

A. alternating the spraying between an insecticide and a fungicide
B. spraying early in the morning
C. using the correct type of nozzle for spraying
D. making sure the same type of insecticide is not used all the time

6. Which of these pesticides are not allowed in organic farming?

A. copper fungicides
B. tobacco
C. castor oil
D. Glyphosate

7. Which action should you NOT do if you accidentally spill some pesticide?

A. cover the area with sand
B. make sure you wash yourself and your clothes thoroughly
C. get the dog to lick it up
D. keep children away from the spill

8. Pesticide resistance in insects is caused by:

A. a genetic mutation that is passed on to new generations of the insect
B. a fungicide being used by mistake
C. a virus getting into the insect
D. using the wrong crop rotation

CHAPTER 6 QUIZ: continued...

9. Which of the following information is NOT usually found on a pesticide label?

A. the type of product
B. which pests are resistant to it
C. what it contains
D. what crops it may be used on

10. An emulsifiable concentrate:

A. is the same as a wettable powder
B. is incompatible with all other pesticides
C. cannot be mixed with water
D. forms a milky liquid when mixed with water

11. A pesticide withholding period means:

A. how long before it is safe to enter the crop after spraying
B. the period during which animals are not allowed to graze on the crop at any time
C. the number of days between the last application of a pesticide and crop harvest
D. how long before a pesticide is allowed into a country

12. Copper can be used to control:

A. phytoplasmas and viruses
B. nematodes and mites
C. snails and insects
D. bacteria and fungi

13. Pests in a small farm or garden are best controlled by:

A. ignoring them
B. using pesticides as soon as they are seen
C. encouraging beneficial insects and spiders
D. using insecticides and fungicides weekly

14. Pesticides allowed in organic farming:

A. come only from plants
B. are the same as commercial pesticides only weaker
C. are controlled under organic standards
D. are always safe

CHAPTER 6 QUIZ: answers continued...

9.7 Chapter 7 answers

Chapter 7 brings together everything your trainees have learned in the previous chapters to plan, run and reflect on a PHC, first as a simulation and then a real one for farmers.

EXERCISE 7.1: What do we need to run a successful PHC?

Give your trainees time to think about everything they need to run a PHC successfully. By talking it through from beginning to end and sharing their ideas, they will develop a good understanding of the overall process, and feel more confident as plant health doctors.

Some answers are given below, but check Section 7.2 and Appendix 5 for a full list.

What do we need?		
Before the clinic	**During the clinic**	**After the clinic**
▪ good location for farmers ▪ awareness of the clinic before it is held ▪ tables/chairs ▪ banner ▪ join country social media group for plant health doctors	▪ Pacific Pests, Pathogens & Weeds app ▪ KoboToolbox app ▪ Prescription Forms ▪ pen or pencil ▪ knives ▪ hand lens ▪ camera	▪ samples brought by farmers ▪ Farmers' Feedback Forms ▪ Prescription Forms (copies) ▪ photosheet summary template

Exercise 7.2: WhatsApp — how to use it

The country social groups were discussed in Chapter 4. Here, your trainees learn to send pictures of unknowns or confusing samples to the social media group as part of running a clinic. Trainees should send their phone numbers to the person in charge of the social media groups before the clinic.

You should ask members of the country and other social groups if they can be available when you run this exercise.

Exercise 7.3: Role play — filling out the Prescription Form

This exercise builds on Exercise 6.6 in Chapter 6.
Ask the trainees to go outside and collect a sample of:

- a pest
- a disease
- an unknown problem.

If this is not possible, you need to provide the samples yourself, or use one of the photos in the manual or from the Pacific Pests, Pathogens & Weeds app.

You should carefully model the process of the clinic first, acting as the plant doctor while one of your trainees plays the role of the farmer. Go through the farmer interview process step by step, explaining clearly what you are doing at each step while the trainees observe.

After you have done this and discussed any issues or questions, ask trainees to form pairs. Provide each pair with a Prescription Form to fill in.

Remind the trainees to go through the A,B,C and possible/probable identification and diagnosis steps carefully (see Chapter 2). They should not go straight to the Pacific Pests, Pathogens & Weeds app. When doctors do this at clinics, they often make the wrong diagnosis, something similar to humans self-diagnosing a disease using Google!

The 'doctor' should interview the 'farmer' and fill in the Prescription Form carefully and clearly. The data can also be added to the KoboToolbox app to practise using it.

Sometimes doctors give a farmer incorrect information because they do not want the farmer to think they do not know something. Stress to your trainees that they should not fill in answers if they do not know what the problem is. It is much better to tell a farmer they do not know and they will find out, than give incorrect advice. In this case, they should write on the Prescription Form 'unknown'.

When they have finished, discuss the exercise with the class. It is really important that proper reflection is done at this stage to uncover problems the trainees may have encountered.

Exercise 7.4: Using the KoboToolbox Prescription Form

Demonstrate to the class how the KoboCollect form works. Have the trainees download the KoboCollect app to their smartphone or tablet and open the plant health clinic Prescription Form. Now take any pest or disease sample and fill in the form (offline), as has been done for the hard copy.

Even if we find a way to print out the form, there may still be a need to have the completed form translated into local languages first.

This issue needs to be discussed and resolved by the plant health team in each country.

Exercise 7.5: Fill in the Farmer Feedback Form

The Farmer Feedback Form is an important document to be used after the farmer has seen the plant health doctor at the clinic. The clinic manager or another designated person (especially someone who speaks the farmer's language) interviews each farmer about his/her experience of the clinic and completes the feedback form. The team in each country should ensure translations into their local languages are made available, as well as English.

The manager collects and collates all the feedback forms to present and discuss during the reflection after the clinic. This is an important part of reflection, as well as monitoring and evaluation.

The manager should use the Farmer Feedback Form to provide feedback to plant health doctors at the reflection on processes of diagnosis and make suggestions on improvements, if necessary.

Exercise 7.6: Preparing for many farmers attending the clinic with the same problem

Often, a number of farmers bring the same problems to the clinic if there is an outbreak of an insect pest or disease in the area. If the clinic manager notices this, and if there is time after they have received their prescription from the doctor, it would be very useful to gather the farmers together and ask one of the doctors to give them a short talk about the problem. This will give the farmers the opportunity to talk to each other about the problem and what they are trying to do about it.

Note that it is important that all farmers see the doctor first.

It is very important that you prepare your trainees for the possibility that many farmers will bring the same problem; you can do this by helping them become familiar with plant pests or diseases that they are likely to see at the clinic. Extension staff should already be aware of the major pests and diseases in their area, though sometimes new problems spring up quickly, especially when weather conditions change.

Make sure that trainees have consulted the section of the Pacific Pests, Pathogens & Weeds app where each country has selected 20 mini fact sheets of the most common pests and pathogens in their respective countries. These mini fact sheets have been translated into local languages

For this exercise, give your trainees an example of a pest or disease which is likely to be a problem in the area where the clinic is to be held. If you cannot find a live sample, use a picture or an example from the Pacific Pests, Pathogens & Weeds app. The trainees should prepare a short presentation about the problem for the class covering:

- the symptoms
- the diagnosis
- recommendations for control now and in the future.

Ensure each group presents on a different pest or disease.

Exercise 7.7: Reflection on the clinic process

Exercise 7.8: Farmer feedback data

Exercise 7.9: Reflection on diagnosis and recommendations

These three exercises are critically important for learning and improving the clinics, and should be gone through carefully. Emphasise that being wrong is nothing to be ashamed of, rather it is a vital part of the learning process, and that everyone gains from it, however experienced we may be. It is something we can all share in.

Exercise 7.10: Sending samples for identification

This is an exercise in sending a sample to an expert for examination, locally or overseas, so that an identification can be made. Make sure that you have the equipment needed before starting this exercise.

Set up three tables, with examples of either:

1. A fungal or bacterial disease.
2. A pest.
3. A virus.

Write the instructions for sending away each type of problem and place on the table.

To start, each group should write a label to put inside the parcel containing:

- crop/plant name
- code given at the clinic
- doctor's names and address
- code, same as on the prescription form
- date and location of the clinic
- farmer's name and phone number
- farmer's village
- a short description of the problem and any other useful information they think will be useful.

Trainees should follow the instructions for their pest or disease, and when they have finished, they should unwrap or dismantle the sample for the next group and move to the next table.

Exercise 7.11: Plant health doctor self-evaluation form

Now it is time for your trainees to evaluate themselves as plant health doctors. This is anonymous, but it will help the extension service to monitor how well the program is running and what further training may be needed.

Collate and report the overall results from the class. Discuss what this says about your trainees' confidence and ability to conduct a clinic. Ask:

- What do they think needs to be done to improve?
- How should this take place?

Exercise 7.12: Making a plant health clinic photosheet summary

It is very important to make a summary for the clinic to record the main points and to send it to senior officers, the media and others who are interested in the clinic program. This should be done on the day of the clinic if possible, usually by the clinic manager. The template for this is in Appendix 3.

CHAPTER 7 QUIZ: Test your knowledge

The answers are given in **bold**…

1. Plant health clinics are important parts of:

A. a country's food security
B. a country's plant health system
C. the agricultural extension system
D. all of the above

2. The best place to hold a clinic is:

A. where many farmers gather, e.g. a market
B. at the research station
C. on a farm
D. at the university

3. Important advice for farmers when raising awareness about a forthcoming clinic is:

A. to bring the whole plant, including roots
B. to bring a few leaves
C. to bring a soil sample
D. to bring your phone

4. If you do not know what the problem is, you should:

A. leave that part of the prescription form blank
B. tell the farmer something, even if you are not sure
C. ask if anyone else knows what the problem is
D. send the farmer away

5. Look at the steps below for identifying a disease sample. They are in the wrong order.

1. make a parcel for the specimens with newspaper
2. write a label and put the specimen in a plastic bag with a few drops of water and seal the bag, leav overnight
3. collect samples showing a full range of symptoms

The correct order to do these steps in is:

A. 1, 2, 3
B. 3, 2, 1
C. 2, 1, 3
D. 1, 3, 2

6. Insect samples to be sent away for identification are best preserved in:

A. methanol
B. isopropyl alcohol
C. 70% alcohol
D. beer

7. A plant doctor suspects a farmer's sample has a bacterial wilt. She can test this by:

A. smelling it to see if it smells rotten
B. cutting the stem and dipping the end in water and looking for milky streaming
C. finding the bacteria under a microscope
D. looking for spots on the leaves

CHAPTER 7 QUIZ: answers…

CHAPTER 7 QUIZ: continued...

8. The most important items to take to a clinic are:

A. chairs
B. kava
C. uniforms
D. prescription forms

9. After a clinic, a plant health doctor must always:

A. follow up with a farmer if the farmer has been told that will happen
B. reflect on and review the clinic data and plan to improve next time
C. collect all the samples for looking at later with the other plant health doctors
D. do all of the above

10. A farmer brings yams that have died and gone black. The farmer tells the plant health doctor they have been damaged by lightning. The doctor thinks the problem is anthracnose. The doctor should help the farmer straight away by:

A. agreeing that lightning might be the cause but also offering other ideas of the cause, and suggesting what the farmer could do
B. offering to visit the farm
C. telling the farmer he or she cannot be helped at the clinic
D. asking the farmer to bring in more samples.

THE BIG QUIZ

This should be done at the end of training as a revision exercise, and afterwards, celebrate the end of training! The answers are given in **bold...**

1. A plant health system should include:

A. plant health clinics, extension staff, research staff, ministries of agriculture staff
B. biosecurity staff, research staff, hospital staff, quarantine staff
C. plant health doctors, vets, extension staff, research staff
D. media, tourism, agriculture, horticulture

2. Which of the following are all insecticides?

A. Manzate, milk, baking soda, Taratek
B. Sundomil, Attack, Multiguard, Confidor
C. Glyphosate, neem, Blitzem, pyrethrum
D. Confidor, Orthene, Bt, Taratek

3. A sprayer nozzle suitable for fungicide should:

A. be an anvil type and the spray should form a light rain
B. be a flat type and the spray should form a light rain
C. be a hollow cone type and the spray should form a mist
D. be a flat type and the spray should form a cloud

4. A pesticide label says that it should be made up at a concentration of 1 ml pesticide to 10 L water. The concentration of the pesticide is:

A. 10%
B. 1%
C. 0.1%
D. 0.01%

5. A farmer has 10 ha of a crop to be sprayed. The pesticide label tells her that the spray should be 30 ml pesticide per 20 L water and the crop should receive 500 L per ha. How many ml of the pesticide should she use to make up the spray to cover the whole crop properly?

A. 3000 ml
B. 4000 ml
C. 6000 ml
D. 7500 ml

6. Build-up of pesticide resistance in a pest can be prevented by:

A. alternating the spraying between an insecticide and a fungicide
B. spraying early in the morning
C. using the correct type of nozzle for spraying
D. making sure the same type of pesticide is not used all the time

7. Which action should you NOT do if you accidentally spill some pesticide?

A. cover the area with sand
B. make sure you wash yourself and your clothes thoroughly
C. keep children away from the spill
D. leave it to evaporate away

8. Pesticide resistance in insects is caused by:

A. a genetic mutation that is passed on to new generations of the insect
B. using the wrong crop rotation.
C. a herbicide being used by mistake.
D. a virus getting into the insect

THE BIG QUIZ continued...

9. Which of the following information is NOT usually found on a pesticide label?

A. the type of product
B. which pests are resistant to it
C. what it contains
D. what crops it may be used on

10. A wettable powder:

A. is the same as an emulsifiable concentrate
B. is incompatible with all other pesticides
C. can be mixed with water
D. forms a milky liquid when mixed with water

11. A pesticide withholding period:

A. is the period before it is safe to enter the crop after spraying
B. is the period when animals are not allowed to graze on the crop at any time
C. is the number of days between the last application of a pesticide and crop harvest
D. is the period before a pesticide is allowed into a country from overseas

12. In IPDM, pesticides should be used:

A. always, as a prevention
B. never
C. as a last resort
D. only if the farmer can afford them

13. The adult insect in the picture below is most likely to be:

A. a beetle
B. a wasp
C. a lacewing
D. a fly

14. In order, a companion plant, a biological insecticide and a beneficial organism are:

A. taro, DBM, Trichoderma
B. Chinese cabbage, kocide, ladybird
C. coconut, pyrethrum, trichogramma
D. marigold, metarhizium, spider

15. An example of a good crop rotation would be:

A. lettuce, cabbage, broccoli, bean
B. cucumber, squash, potato, cassava
C. potato, tomato, eggplant, capsicum
D. bean, cabbage, cucumber, cassava

THE BIG QUIZ continued...

16. A plant health doctor is faced with an unknown pest or disease at the clinic. What should s/he do first?

A. send a picture to social media group
B. make up something; it's better than the farmer thinking they don't know
C. see if anyone else in the clinic knows
D. tell the farmer to go away

17. In IPDM, monitoring involves:

A. deciding whether the problem is caused by a pest or a disease
B. using the best pesticide for the pest
C. checking the level of damage and looking for bugs and eggs
D. identifying the pest or disease

18. The correct sequence for applying IPDM is:

A. monitoring, identification of pest or disease, decide amount of damage acceptable, making a plan
B. evaluation, monitoring, identification of pest or disease, making a plan
C. making a plan, identification of pest or disease, monitoring, evaluation
D. identification of pest or disease, monitor, decide amount of damage acceptable, make a plan and action

19. Which plants are all in the same plant family?

A. cabbage, bok choy, broccoli, chilli
B. potato, cassava, taro, sweet potato
C. bitter gourd, pumpkin, cucumber, pineapple
D. capsicum, chilli, eggplant, potato

20. The best way to control a soil borne bacterial infection is:

A. use a resistant variety if it can be obtained
B. spray with a pesticide
C. use a virus that attacks the bacteria
D. add compost to the soil

21. Which of the following is NOT thought to be associated with companion planting:

A. companion plants can provide food for parasitoids
B. companion plants may have a smell that repels pests
C. companion plants always add large amounts of potassium to the soil
D. companion plants may repel root knot nematodes

22. In order, abiotic and biotic factors that cause damage on plants are:

A. fungi and mites
B. birds and drought
C. potassium deficiency and bacteria
D. phytoplasmas and poor soil

23. Typical symptoms on plants caused by bacteria are:

A. leaf spots, angular or round, with or without haloes
B. wilt and yellowing at the edges of leaves
C. rusty spots and mosaics
D. dieback and the leaves go purple

THE BIG QUIZ continued...

24. A common disease of tomatoes in the Pacific region is:

A. witches' broom
B. tobacco mosaic
C. early blight
D. ring spot

25. The smallest of these pathogens is:

A. a virus
B. phytoplasma
C. a bacterium
D. a fungal spore

26. A plant doctor finds a plant with symptoms of wilt. The most unlikely cause would be:

A. bacteria in the soil
B. rust fungus
C. nematodes
D. stalk borers

27. Pests with eight legs are not:

A. mites
B. insects
C. scorpions
D. spiders

28. Which of these diseases is caused by a fungus?

A. bunchy top on banana
B. blossom end rot on tomato
C. scale on sweet potato
D. damping off on cabbage seedlings

29. A plant doctor finds a cabbage with a lot of holes in the leaves. Which are not likely causes?

A. diamondback moth
B. large cabbage moth
C. leaf spot
D. snails

30. A virus can be spread by:

A. bacteria
B. fertiliser
C. rhinoceros beetles' larvae
D. aphids

31. Two insects with simple life cycles are:

A. aphids and katydids
B. butterflies and bugs
C. grasshoppers and ants
D. bees and moths

32. Plant health clinics are important parts of:

A. a country's food security
B. a country's plant health system
C. the agricultural extension system
D. all of the above

33. The best place to hold a clinic is:

A. where many farmers gather e.g. a market
B. at the research station
C. on a farm
D. at the university

THE BIG QUIZ continued...

34. Important advice for farmers when you are raising awareness about a forthcoming clinic is:

A. to bring a whole sample if possible
B. to bring a few leaves
C. to bring a soil sample
D. to bring your phone

35. If you do not know what the problem is, it is best to:

A. leave that part of the prescription form blank
B. tell the farmer something, even if you are not sure
C. end the farmer away
D. ask if anyone else knows what the problem is

36. Look at the steps below for identifying a disease sample.

1. make a parcel for the specimens with newspaper
2. write a label and put the specimen in a plastic bag with a water and seal the bag
3. collect samples showing a full range of symptoms

The correct order to do these steps in is:

A. 1, 2, 3,
B. 3, 2, 1
C. 2, 1, 3
D. 1, 3, 2

37. Insect samples to be sent away for identification are best preserved in:

A. beer
B. methanol
C. isopropyl alcohol
D. 70% alcohol

38. A plant doctor suspects a farmer's sample has a bacterial wilt. She can test this by:

A. smelling it to see if it smells rotten
B. looking for spots on the leaves
C. placing the end of the stem under water and looking for milky streams
D. finding the bacteria under a microscope

39. The most important items to take to a clinic are:

A. chairs
B. kava
C. uniforms
D. prescription forms

40. After a clinic, a plant health doctor must always:

A. follow up with a farmer if the farmer has been told that will happen
B. reflect on and review the clinic data and plan to improve for the next clinic
C. collect all the samples for looking at later with the other plant health doctors
D. do all of the above

THE BIG QUIZ continued...

41. A farmer tells the plant health doctor he thinks his crops have been damaged by an evil spirit. The doctor should help the farmer by:

A. agreeing this might be the case and offering other ideas of what the farmer could do
B. sending the farmer to a priest
C. telling the farmer he cannot be helped at a plant health clinic
D. asking the farmer to bring in more samples

42. Which Pacific countries are thought to have the Guam strain of the rhinoceros beetle?

A. Samoa
B. Guam, Palau, Hawaii, Vanuatu
C. Fiji
D. Guam, Palau, Papua New Guinea, Solomon Islands

43. Good soil is likely to have a pH of around:

A. 1
B. 3
C. 7
D. 9

44. Which of these home-made pesticides is particularly harmful to fish?

A. chilli
B. gliricidia
C. neem
D. derris

45. What are the pests in this photo?

A. rhinoceros beetles on mango
B. green vegetable bugs on tomato
C. black ticks on pumpkin
D. aphids on guava

46. What is the difference between a parasite and a parasitoid?

A. there isn't one: they are the same
B. a parasite does not kill its hosts; a parasitoid does
C. a parasitoid can't be seen with the naked eye; parasites can
D. parasites have complex life cycles whereas those of parasitoids are simple

47. The picture below shows you how:

A. to spray low-growing crops
B. far apart crops should be
C. to use a mist sprayer
D. to water your plants in a drought

THE BIG QUIZ continued...

Multiple choice. Pick one answer only...

48. A farmer brings a plant with large irregular spots on the leaves. It is most likely to be:

A. a wilt
B. a deficiency disease
C. a fungal disease
D. something I know nothing about

49. You want to teach your trainees to think about how plant diseases relate to people going hungry. The best teaching strategy is probably:

A. a cause and effects diagram
B. a picture of a hungry child
C. a role play
D. a concept map

50. Which symptoms are often confused?

A. a powdery mildew and a leaf spot
B. a virus and a deficiency disease
C. a bacterial leaf spot and a bacterial wilt
D. overwatering and copper deficiency.

51. Organic matter in soil is found in:

A. the bedrock
B. humus
C. clay
D. water

52. Which of these are NOT ways in which nitrogen can be made available to plants:

A. nitrogen fixing bacteria
B. using leguminous cover crops
C. drawing in nitrogen from the atmosphere
D. applying fertiliser

53. The plant's rhizosphere includes:

A. roots, root exudates and microbes
B. rhizomes
C. flowers and leaves
D. compost

54. 'One Health' refers to:

A. the health of people in the Pacific
B. the idea that the health of all life forms is interconnected
C. how bacteria affect plant roots
D. the health of soil

55. Which of these are NOT normally found in the soil microbiome:

A. archaea
B. bacteria
C. worms
D. fungi