Research
Based
Curricula

How do plants fight against diseases and pests?

Key Stage 4 Biology

Resource 6

2019

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Resource Six Overview

Topic	Methods to assess how well a pesticide/adjuvant works
GCSE Modules	Detection and identification of plant diseases

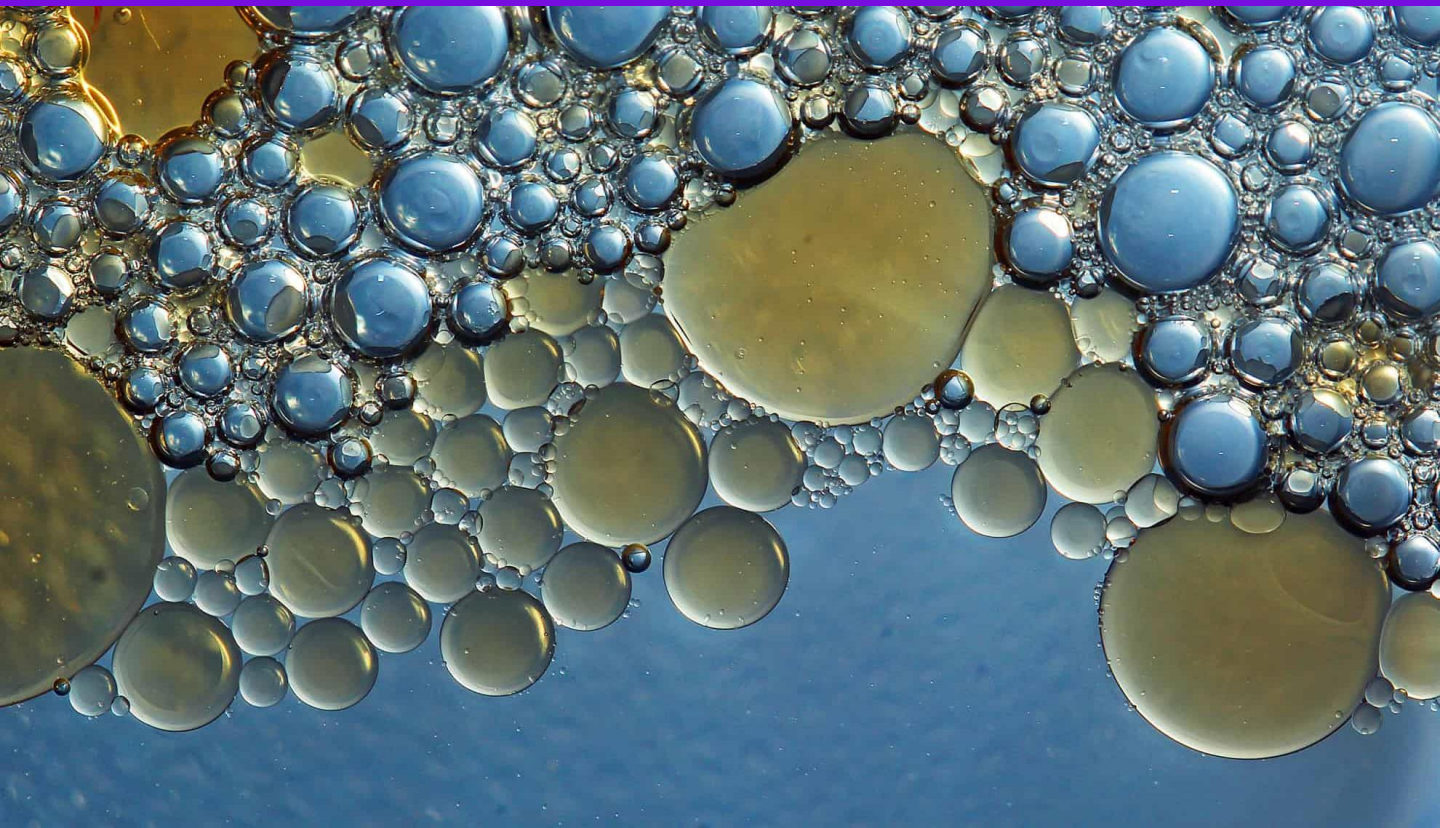
Objectives

After completing this resource, you should be able to:

- ✓ Understand that adjuvants are specific to the type of pesticide and infestation on the crop.
- ✓ Understand the use of thermal cameras and droplet drying time as a measure of time pesticides/adjuvants spend on the surface of the leaf.
- ✓ Understand the limitations of these techniques and why fluorescent molecules tell us more.
- ✓ Reinforce the idea of using insect counts and measuring damage on the leaf to tell us how well a pesticide treatment worked.

Instructions

1. Read the data source
2. Complete the activities
3. Explore the further reading



Resource Six
Data Source

Section A

Pesticides and adjuvants

Active Reading

Pesticides are used to target pests and pathogens which cause damage or disease to a plant, especially food and commodity crops. These can be sprayed chemicals (pesticides) or sprayed biological organisms which defend the plant, these are called biopesticides. In resource 5 you will have learnt some examples of harmless fungi and bacteria that can be used to fight off pathogenic bacteria and fungi. You will have also been introduced to adjuvants which can be chemicals or biological products which are used to help the sprayed pesticide or biopesticide to reach its target location or function better or for longer. If a farmer wants to spray a biopesticide, a live biological organism, they would use an adjuvant which might help the cells stay alive for longer or stop them drying out. The adjuvant would have to not be harsh enough to kill the cells and would have to be organic if used in organic farming.

Section B

Droplets on a leaf

Different chemicals/biological products behave differently on the leaf surface and some basic Chemistry knowledge is needed to understand the absorption process. The waxy cuticle is the surface on the outside of the leaf and is a thick wax layer. Water cannot easily pass through a layer of wax because wax is a lipid and is hydrophobic (water hating) and water is hydrophilic (water loving). Therefore the wax and water don't mix and form two separate layers.

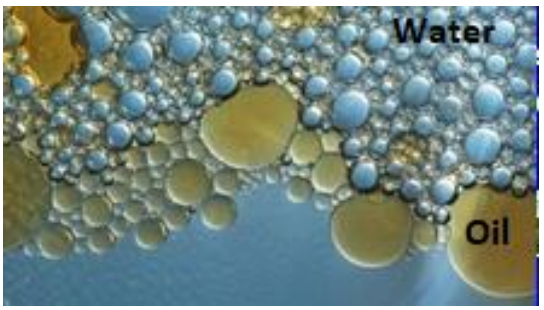


Figure 16

Left: Oil and water separated layers

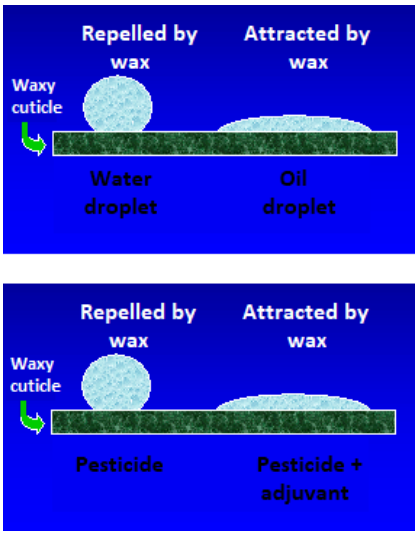
Right: A succulent plant which is adapted for dry conditions. The waxy cuticle layer is even thicker than any food crop and the leaves look wetter for longer

Resource Six
Data Source

The cuticle is designed to keep water in so this is what the plant has become adapted to do. Rain droplets of water stay as a droplet on the surface of the leaf until they evaporate or run off the leaf. Oil/lipid products are absorbed through the waxy cuticle more easily. Therefore if we want the adjuvant/pesticide to get inside the leaf we might use a lipid or oily adjuvant. If we want our pesticide/biopesticide to stay on the leaf for longer we might use an adjuvant which contains water or can take on water from the atmosphere.

Figure 18

Droplet behaviour on a leaf



Section C

Droplet drying time

To understand how well a droplet can get into the plant leaf we need to measure how long the droplet stays on the leaf. This can be done easily with a microscope, by watching the droplet dry and timing how long it takes. We can also use thermal cameras to visualise the droplet on the leaf surface and see how long it takes to become the same temperature as a leaf, an indication that the droplet has disappeared.

Neither of these methods can tell us how much is being absorbed or how much is being evaporated however so we still don't know how much is getting into the leaf. This only tells us the behaviour of the droplets on the leaf cuticle.

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Data Source

Figure 19

Observing a drying droplet with a microscope

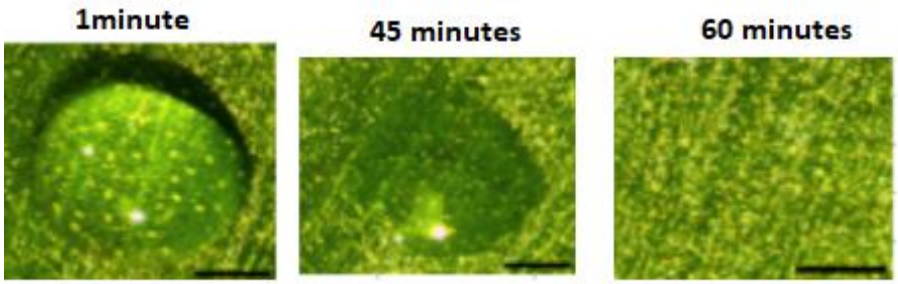
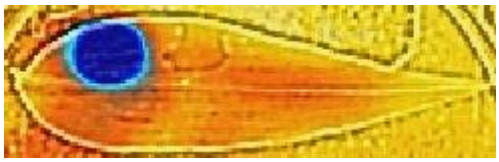


Figure 20

Observing a drying droplet using a thermal camera



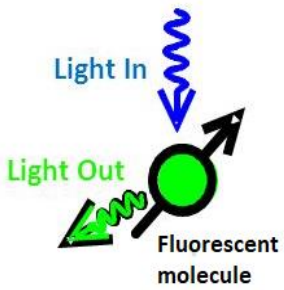
Section C

Droplet drying time

To be able to see how much is inside a leaf we need to use fluorescent molecules as we can't normally see chemicals when they're inside cells. This requires some basic Physics knowledge. To be able to see the pesticides/adjuvants, the pesticide or adjuvant need to either be fluorescent themselves or be used with a dye which is fluorescent. If using a dye it is a good idea to use a dye which doesn't normally go inside cells, and then if it does go inside we can say this is because of the adjuvant that has helped it. A fluorescent molecule is defined as a molecule which absorbs light at one wavelength and emits it at another wavelength giving us a visible colour we can see.

Figure 21

A fluorescent molecule in action



We can use fluorescence to tell us how well products can be absorbed by a leaf. Figure 22 shows the lower epidermis of the leaf. In the leaf on the left it is not fluorescent which means the adjuvant/dye could not pass through to the bottom surface. In the image in the right we can see that the cell walls of all the epidermal cells and the guard cells and

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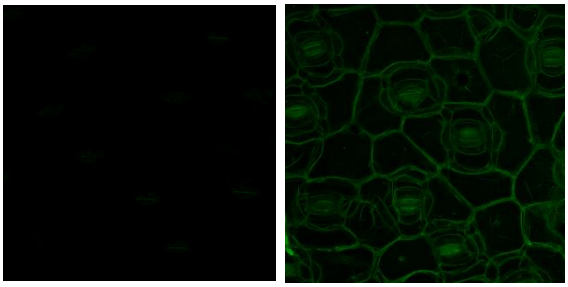
Data Source

Figure 22

Fluorescence study of a leaf



also the stomata all appear fluorescent so the fluorescent molecule must be present at the bottom of the leaf in these areas. The pesticide/adjuvant/dye must have moved from the top of the leaf where it was placed as a droplet, to the bottom of the leaf where it is being visualised here.

Section D

Checking that the pesticide/adjuvant works

The final step is to check if the adjuvant and pesticide help improve plant health and see whether they should be recommended to farmers for certain infestations. This can be done in the lab by spraying leaves with different adjuvant/pesticide products and then putting insects or fungi onto a plant leaf and seeing how many are killed or by measuring how much damage we can see on the leaf. In previous resources in this pack, you have already used these methods when you measured lesions on tomato leaves to compare a fungal infection, and you have counted insects before and after an insecticide treatment to see how successful the treatment was.

Resource Six Activities

Activities

1. What is meant by the terms hydrophobic and hydrophilic?

2. Which boundaries of a plant leaf are hydrophobic?

3. Explain why plants such as aloe vera or a jade plant appear to have wet leaves.

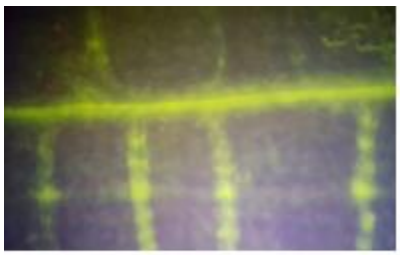
4. What can a thermal camera tell us about a chemical droplet on the leaf surface?

5. If a farmer had a problem with powdery mildew what type of pesticide would you recommend for the problem? Insecticide, fungicide, bactericide, herbicide or virucide?

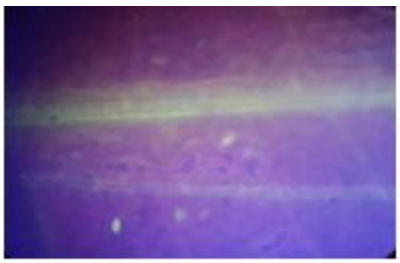
6. What are the limitations of watching droplets with a thermal camera or measuring droplet drying time on a leaf?

7. What advantage does using a fluorescent molecule give?

8. The images below are from the spongy mesophyll tissue of two leaves. You can see the vascular tissue (or veins) made up of the xylem and phloem. The leaves have been treated on the top surface with different adjuvants and a fluorescent dye which is not normally able to penetrate the leaf. The dye appears yellow when viewed with a microscope. Which adjuvant helped the dye penetrate the leaf tissue the best?



Adjuvant B



Adjuvant D

9. If a farmer had an aphid infestation and wanted to use an insecticide to kill the aphids by getting the insecticide into the phloem so that aphids were poisoned when feeding from the plant phloem. Explain which adjuvant, B or D, is best for the farmer to use?

10. How could you check that an insecticide had worked successfully for an aphid infestation?

Resource Six
Further Reading

Explore

- Sygenta is an industrial agrochemical company which has a branch based in the U.K. Take a look at some of the products they make and some of the species of vegetable and cereal crops they sell. Some of these are developed to be grown at different times of the year and have resistance against certain damaging pests/pathogens.

https://www.syngenta.co.uk/

- excellent place for lesson resources and practical ideas specifically for Plant biology in schools.

http://www.saps.org.uk/

- A good website to start learning about growing your plants.

https://www.rhs.org.uk/science

- There is talk that they may be bringing a new Eden project to the Morecambe region in the near future. Read this article to find out more!

https://www.independent.co.uk/news/uk/home-news/morecambe-eden-project-morecambe-bay-mussl-david-harland-cornwall-a8537126.html

This botanical garden in London and others across England inspired me to work in Plant science. Looking around at the amazing plant variety that exists really gets you thinking how wonderful the world of Plants can be and makes you wonder why each plant has evolved the way it has. I recommend visiting as many botanical gardens as you can!

https://www.kew.org/

Resource Six
Further Reading

Explore

Optional practical activities:

1. Take leaves from a succulent plant from your school collection and some other leaf types, maybe collect some from around the school grounds. Use a thin pipette to put the smallest droplets of water that you can on each leaf and time how long they take to disappear (you will probably need at least an hour to do this). On which leaves did the water stay on the longest and on which leaf did it disappear the quickest?

2. You could try adding different food colourings to the water (Kopykake red and blue dyes work well) then add the droplets to the leaves and leave them for 24 hours. After 24 hours you could turn the leaves over and see if you can see any dye from the food dye on the bottom surfaces.

3. Instead of using water use different chemicals to get an idea of which chemicals take longer to dry which is a combination of both evaporation and absorption. Perhaps try water, glycerol and sunflower oil and time how long the droplets take to disappear using a microscope. You could add three different colour dyes to these different chemicals and again after 24hours turn the leaves over and see if they have moved through to the bottom of the leaf. These results will vary with the types of chemicals, dyes and leaves used.

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