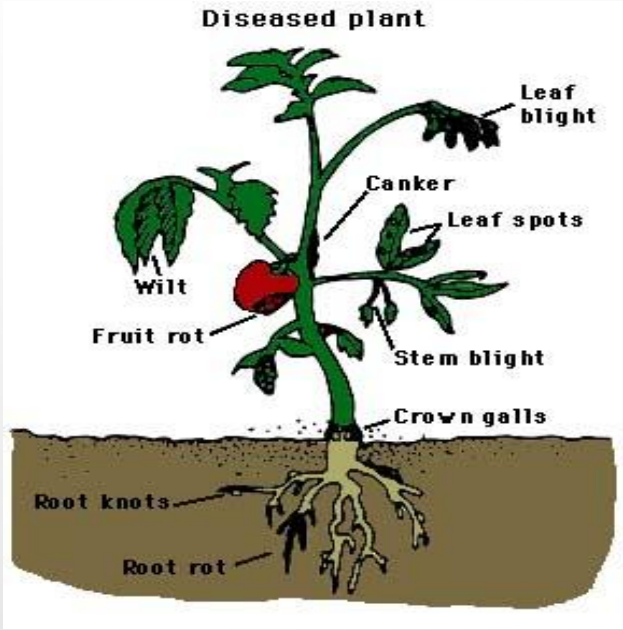
Plant diseases and what we can do about them

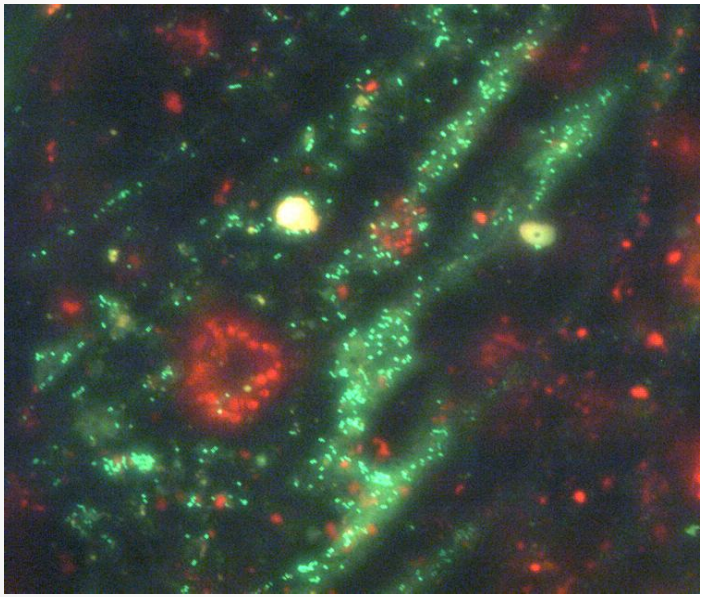
Matt Dickinson

- **Importance**
- **Causes (Viruses, Bacteria, Fungi / Oomycetes)**
- **How to diagnose the cause**
- **Control**



PLANTS ARE COVERED IN BACTERIA AND FUNGI

- Fluorescent microscopy on lettuce leaf surface – green dots are bacteria
- Fungi isolated from lettuce leaves
- Most of these microbes are harmless to animals and plants



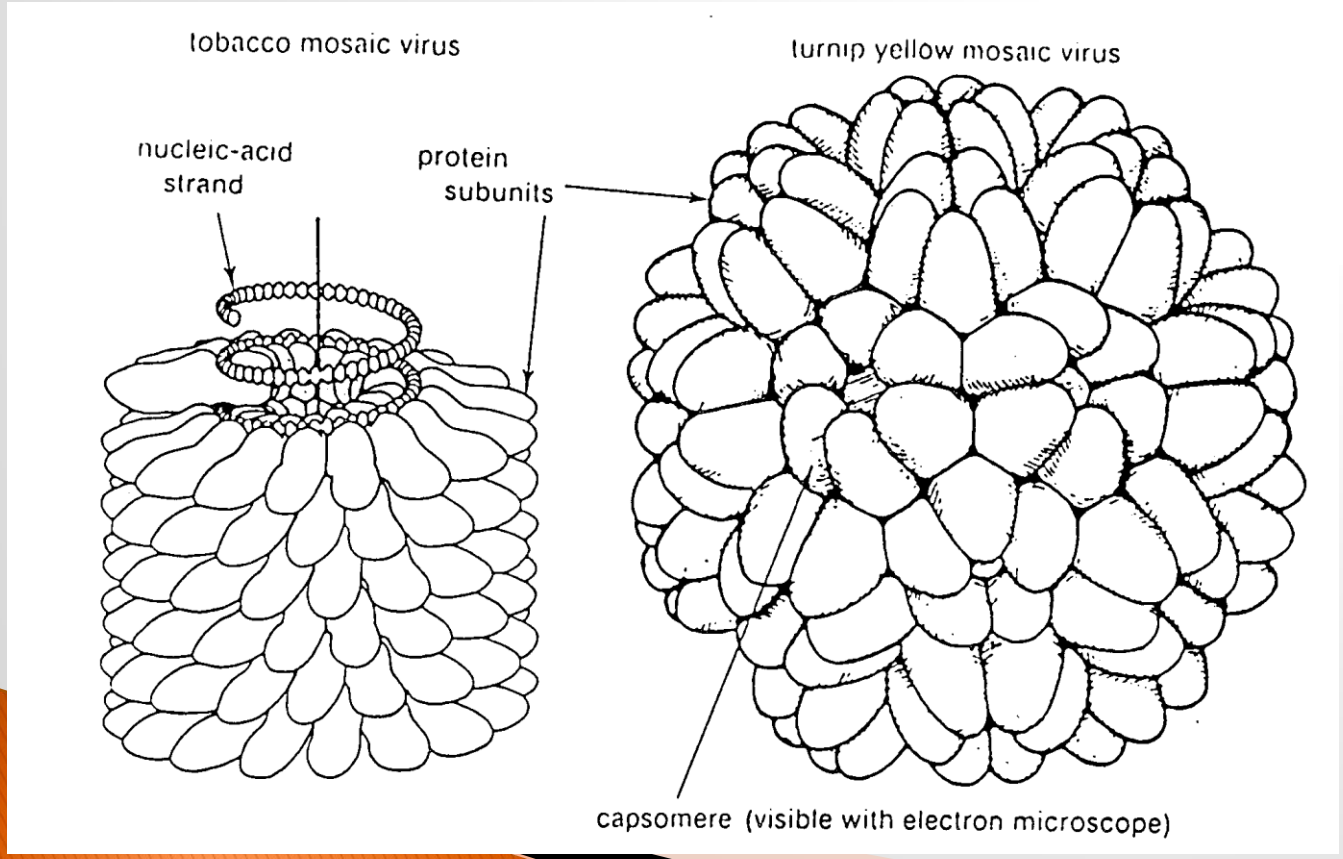
However, some are pathogenic and can cause major crop losses

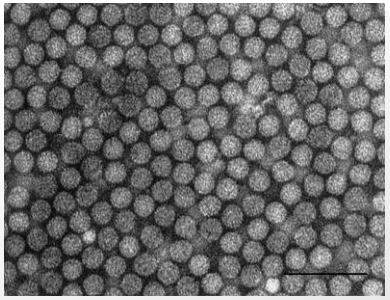
	Actual production	Estimated losses to dis-ins-w	Potential production	Estimated losses to diseases	% of crop lost to			Total % of crop lost
					Diseases	Insects	Weeds	
	Millions of Tons				%	%	%	%
Cereals	1,695	893	2,588	238	9.2	13.9	11.4	34.5
Potatoes	255	121	376	82	21.8	6.5	4.0	32.3
Other root crops	556	420	976	163	16.7	13.6	12.7	43.0
Sugarbeets	319	104	423	44	10.4	8.3	5.8	24.5
Sugarcane	811	991	1,802	346	19.2	20.1	15.7	55.0
Legumes	45	22	67	8	11.3	13.3	8.7	33.3
Vegetables	368	141	509	51	10.1	8.7	8.9	27.7
Fruits	302	92	394	50	12.6	7.8	3.0	23.4
Coffee-cocoa-tea	8	7	15	3	17.7	12.1	13.2	42.4
Oil crops	240	106	346	34	9.8	10.5	10.4	30.7
Fiber crops	40	18	58	6	11.0	12.9	6.9	30.8
Tobacco	6	3	9	1	12.3	10.4	8.1	30.8
Natural rubber	4	1	5	0.6	15.0	5.0	5.0	25.0
			Average percentages lost		11.8	12.2	9.7	33.7

PLANT VIRUSES

Particles are very simple structures – a single strand of RNA is encapsidated in multiple copies of a single polypeptide.

Rod shaped **Isometric**





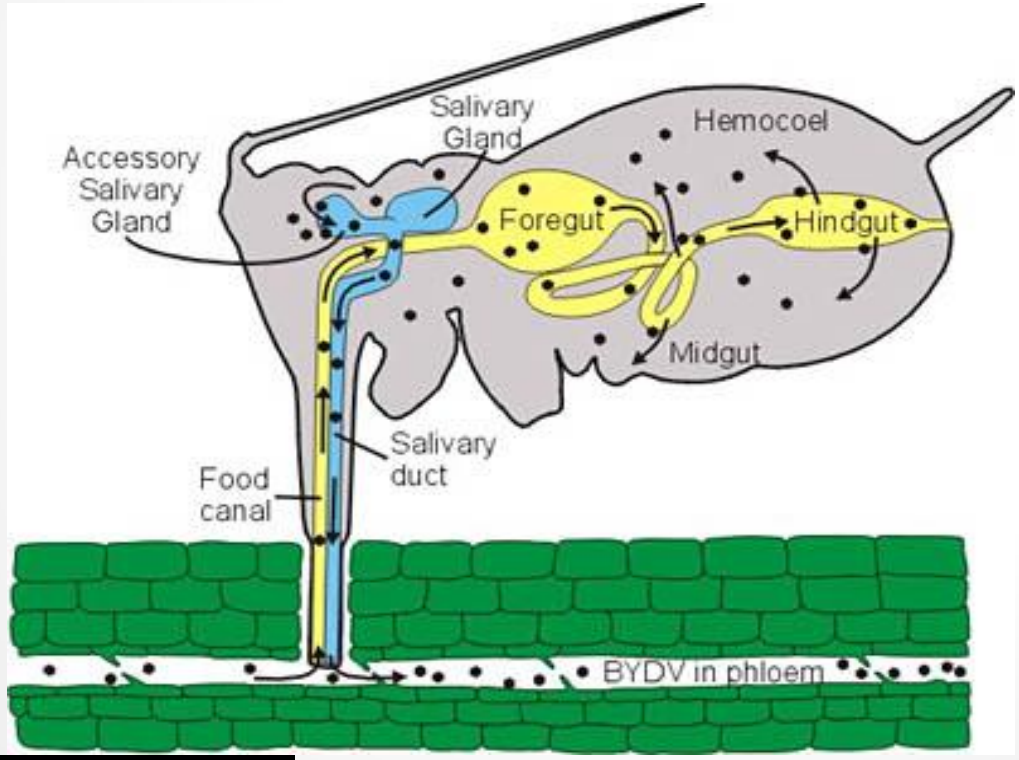
Virus transmission between plants

By sucking insects e.g. aphids and leafhoppers.

By biting insects and nematodes.

By contact.

By seed.



What do they do to plants?

Classical symptoms are colour deviations - Mosaics / striping in leaves and stunting.

Presence of virus ‘taxes’ the plant.

Tomato mosaic virus

Barley yellow dwarf virus

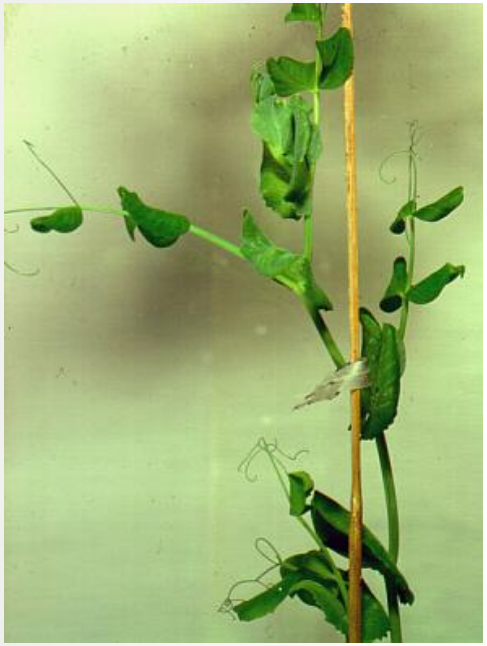
Tulip break virus

May cause malformations such as leaf curls or tumours

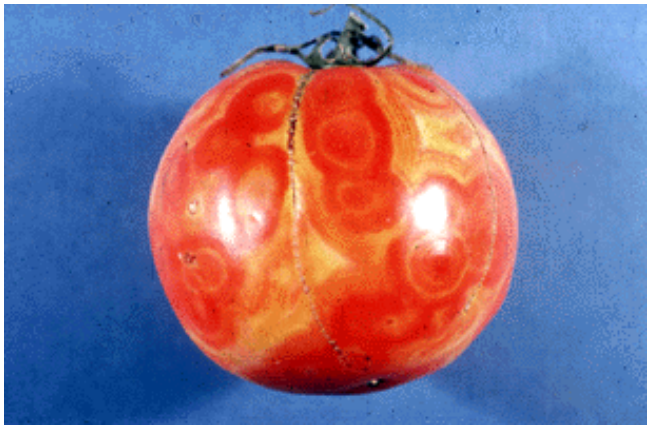
In annual plants, main problems are yield loss

In trees, problems are more severe

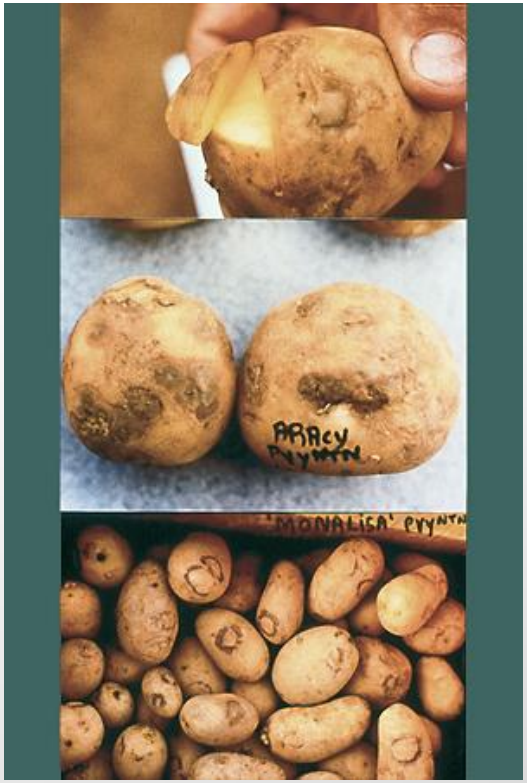
Pea leaf roll



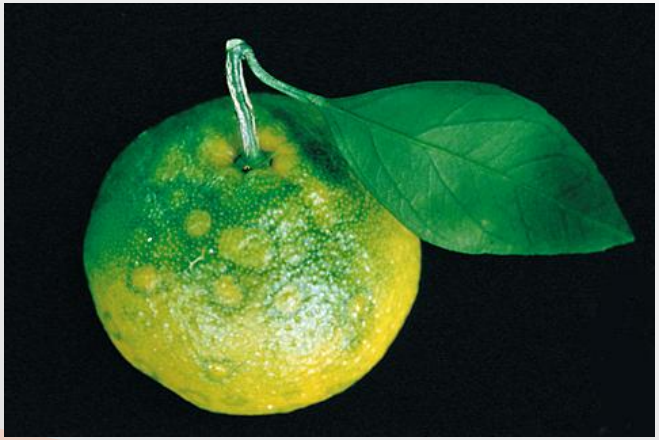
Tomato spotted wilt



Potato virus Y



Citrus mosaic



Bacterial diseases

- Wilts - bacteria colonise plants from soil through wounds and block water movement in the xylem, causing wilting.

Soft rots

- Often occur as secondary invaders and as post-harvest infections for example on potatoes.
- Produce cell-wall degrading enzymes that break down host cells.

Leaf spots / bacterial blights

Bacteria often produce toxins in the plant that cause foliar damage.

Bacterial blight

Halo blight on beans

Fireblight on apples

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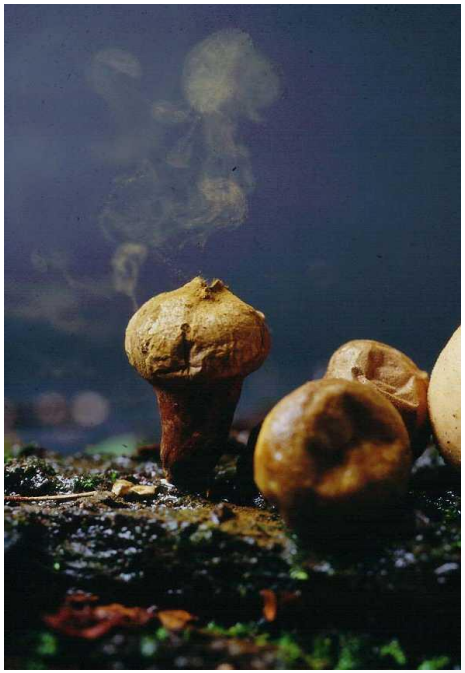
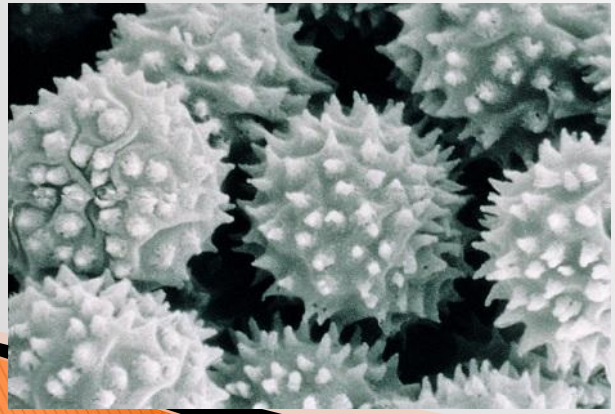
FUNGI / OOMYCETES

Transmitted between plants as spores either in the soil or through the air.

Spores germinate on plants and fungus invades the plant tissue.





Powdery mildews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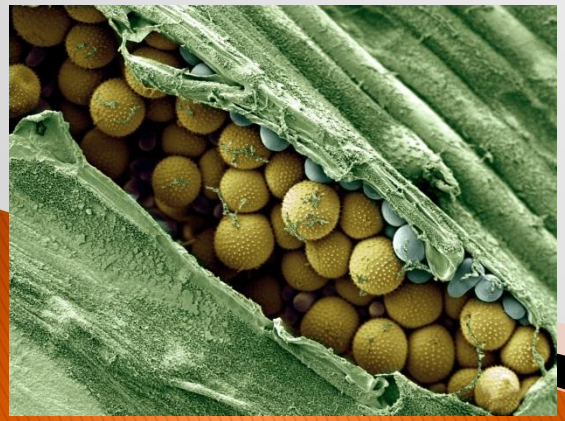
Rusts

- Diseases can spread rapidly and over great distances.
- Many different species of rust occur on wide range of plant species.

Wheat black (stem) rust



Wheat yellow (stripe) rust

Wheat brown (leaf) rust

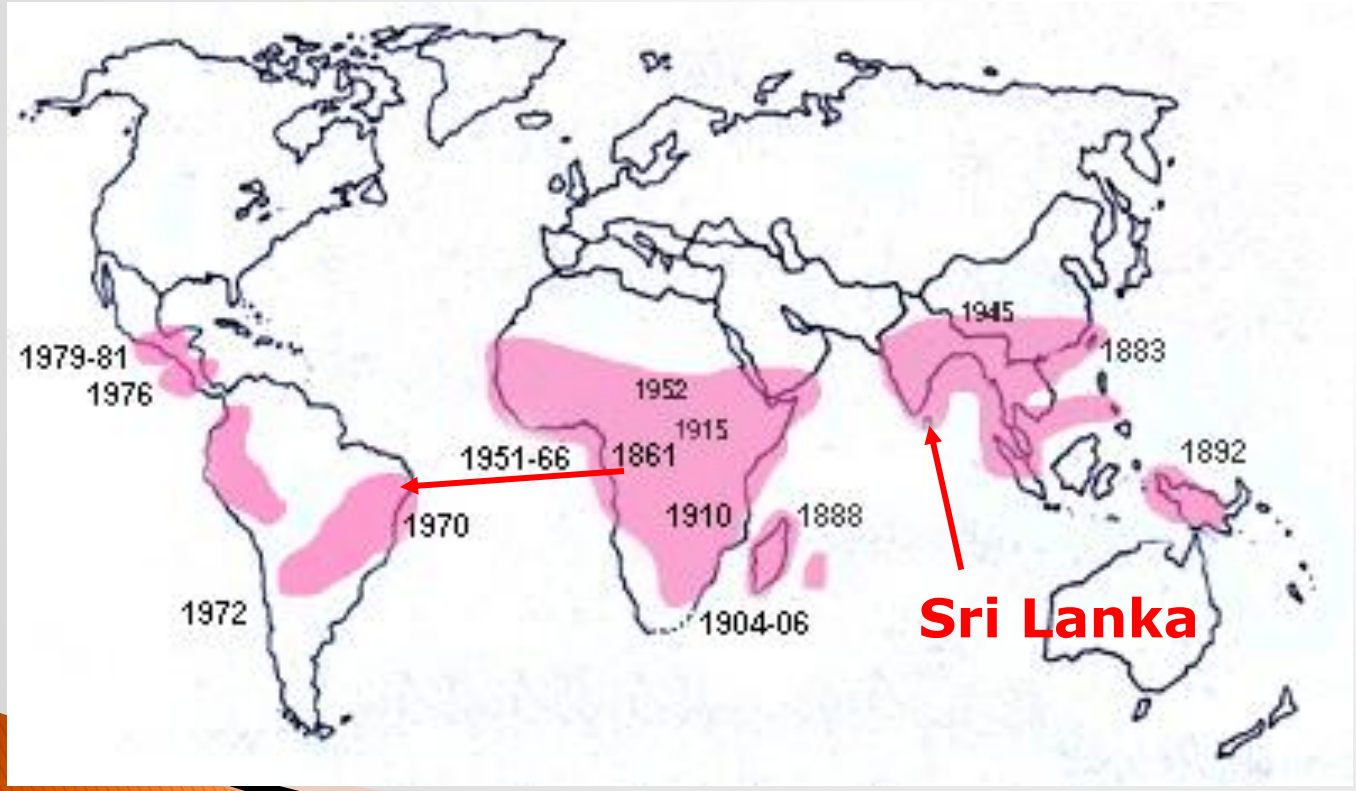
Rose rust

Hawthorn rust

Coffee rust

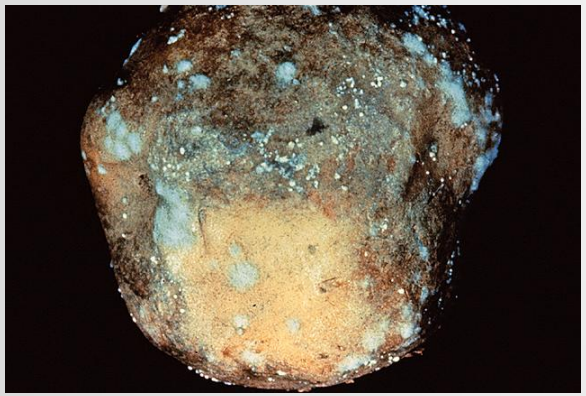
Epidemic started in Sri Lanka in 1870s and has since spread worldwide.

In 1970s it is believed to have crossed the Atlantic to S. America in Tradewinds.



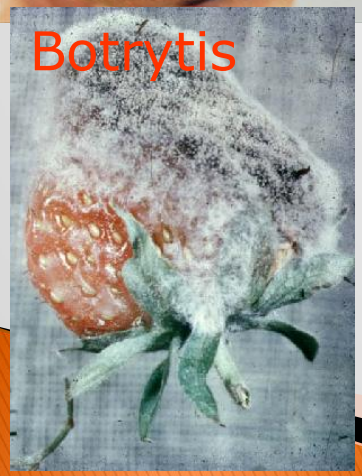
Potato blight

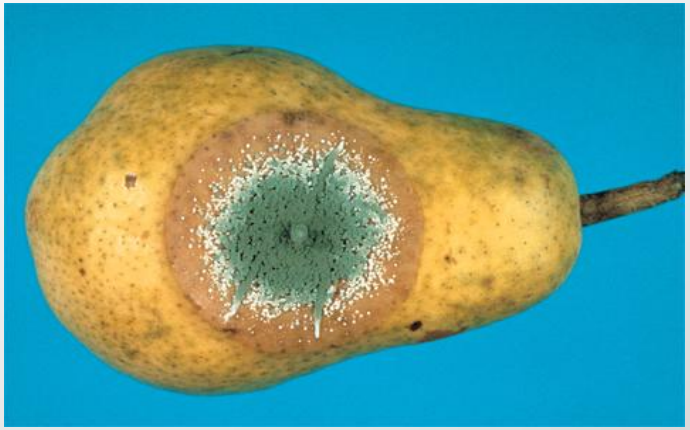
- Responsible for Irish potato famine (1840s)
- Overwinters in infected tubers
- Splashes onto leaves and stems
- Forms lesions which inhibit photosynthesis
- Also infects tubers
- Costs potato industry £3 billion/year



Postharvest diseases

This can be a serious problem for import of many tropical fruits such as mangoes / bananas, which may be carrying infections that only develop when the fungus ripens on the supermarket shelf.





Tree Diseases

Sudden oak death

California and Oregon 1000's tree deaths native oaks

Has been found in 14 European countries – largely in nurseries but some woodlands and gardens - Larch

Dutch Elm

Ash Dieback

Not all plant pathogens are bad

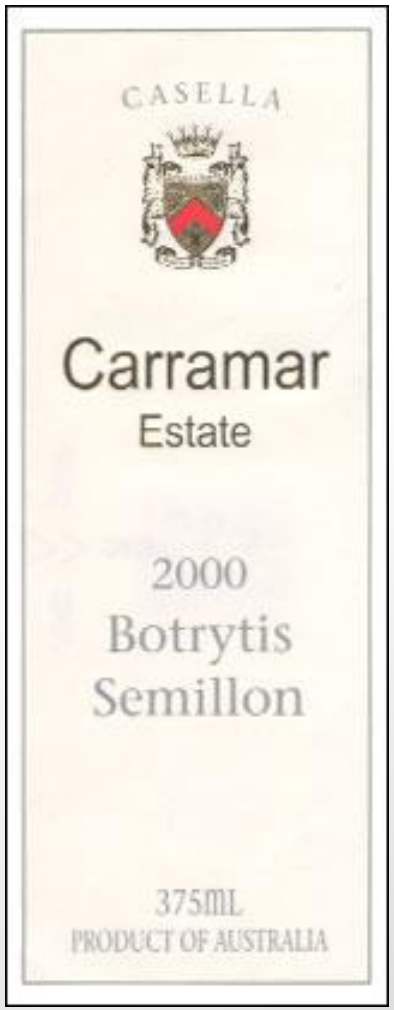
Maize smut

In parts of central America, maize is deliberately infected with smut, and the galls are considered a delicacy, conferring health benefits.

Huitlacoche / Mexican truffle

Some grapes are deliberately infected with *Botrytis* – noble rot.

Result is distinctly flavoured premium sweet white wines



Diagnostics

Classical methods

- Visual symptoms/ reference books can be used for many common pathogens.
- However, sometimes more than one organism or environmental factors cause the same symptoms.
- The disease may be novel or unusual.
- Often control measures are only effective prior to symptom development.

We have been undertaking a number of projects on developing molecular diagnostics e.g. for coconut diseases

- Often referred to as the 'Tree of Life'.
- Grows in poor coastal soils with minimal capital outlay.
- Source of food, drink, building materials, fuel, and income.
- Coconut oil is regarded as one of the healthiest dietary oils.

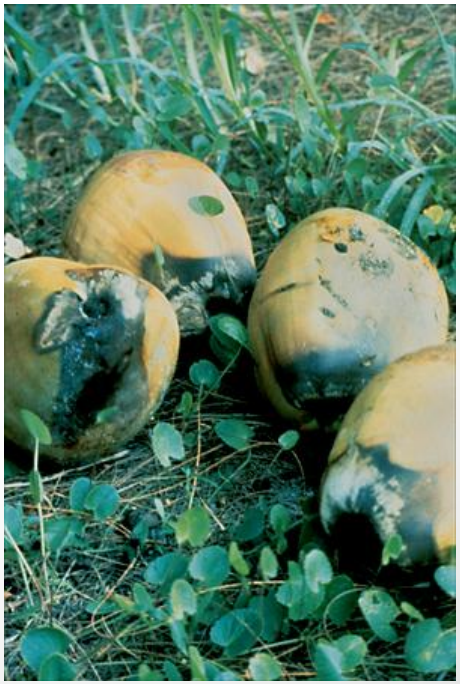
Lethal yellowing type diseases in Africa and the Caribbean

- Phytoplasma disease widespread in Florida, Mexico, numerous Caribbean Islands, and has spread to Belize, Honduras and Guatemala.

- Also in much of East and West Africa

Lethal yellowing - Jamaica

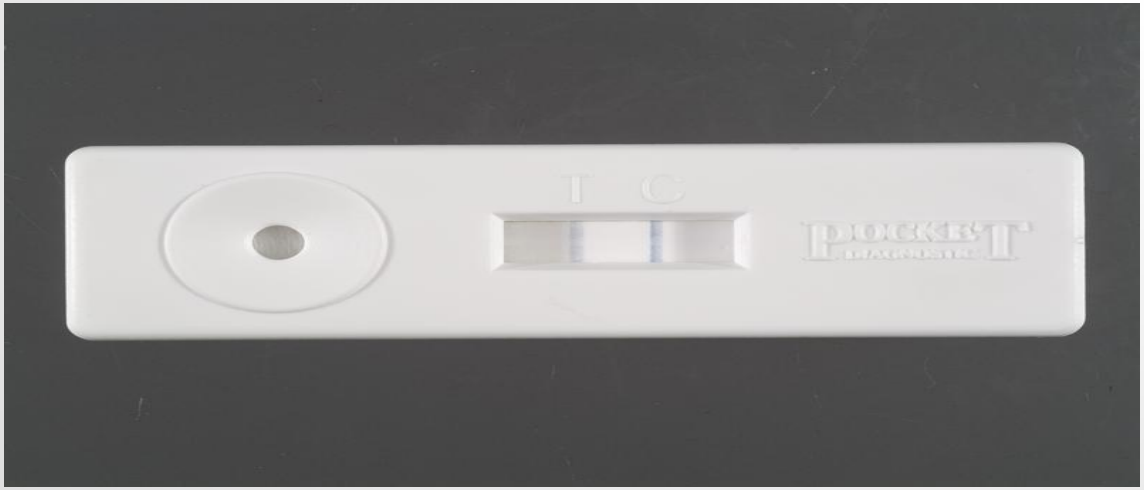
Cape St Paul wilt - Ghana



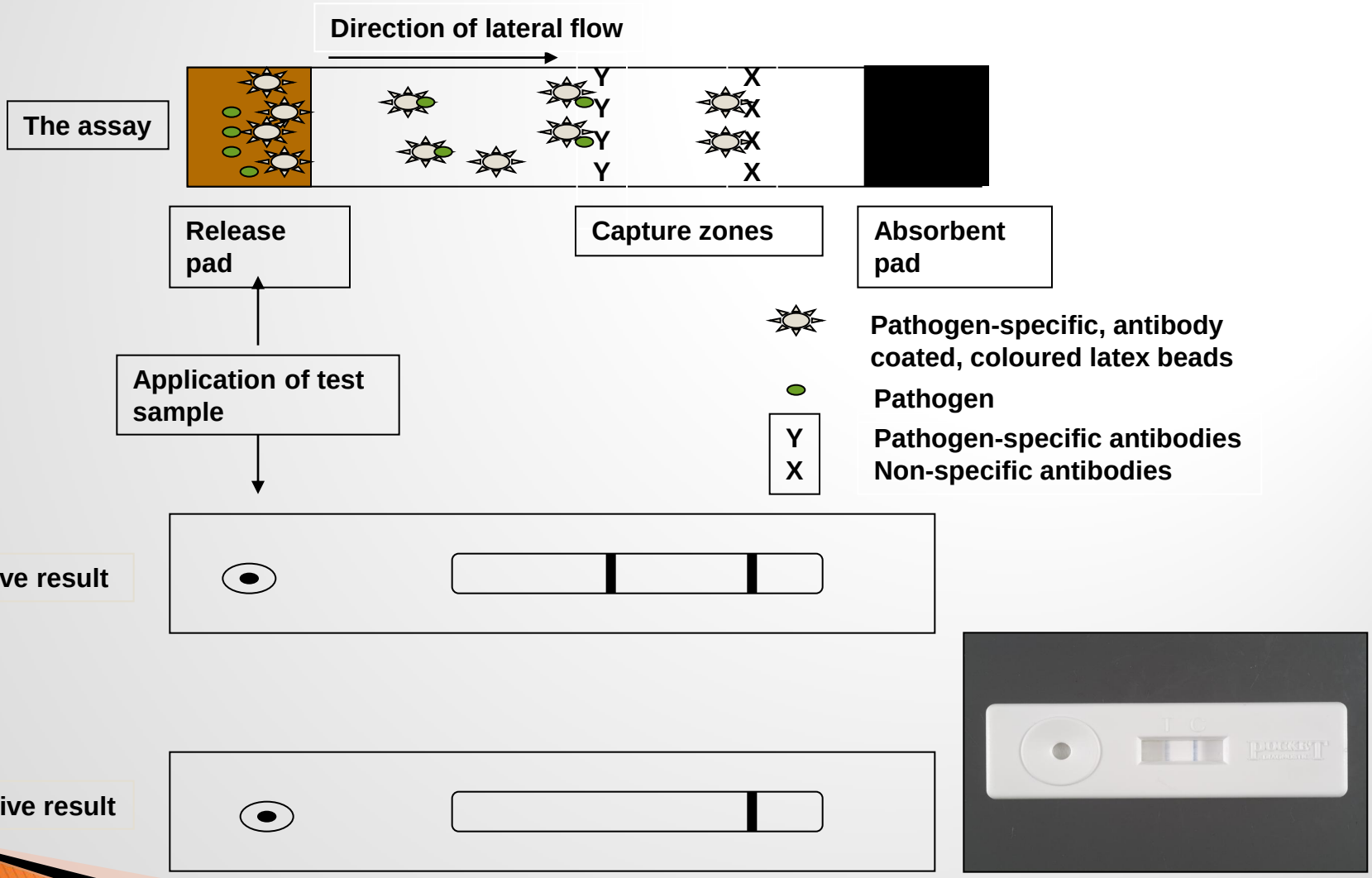
Diagnostics kits

The lateral flow device:

- Based on antibodies against the particular target you are trying to detect.
- Can be difficult to develop and can lack sensitivity.

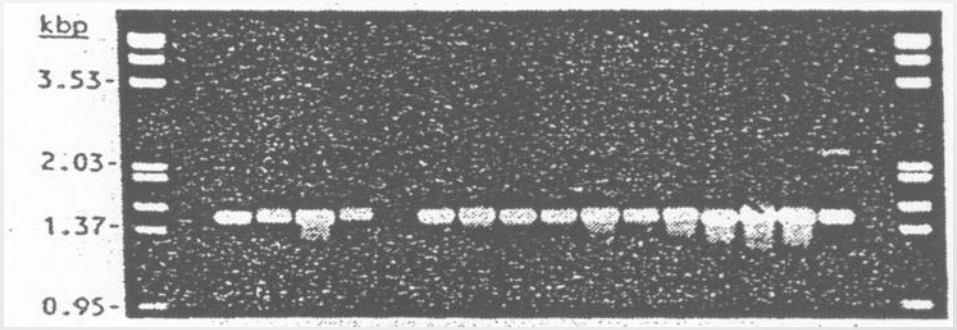


Lateral flow ‘dipstick’ detection. The upper diagram shows the assay principle, whilst the lower diagrams indicate what positive and negative results would look like in a commercial assay strip.



DNA-BASED DIAGNOSTICS

- PCR (polymerase chain reaction).
- Extract total DNA from test plants.
- Use DNA primers that recognise a specific sequence to amplify a portion of the genome of the target organism.
- But can run into problems with contamination of materials – false positives.

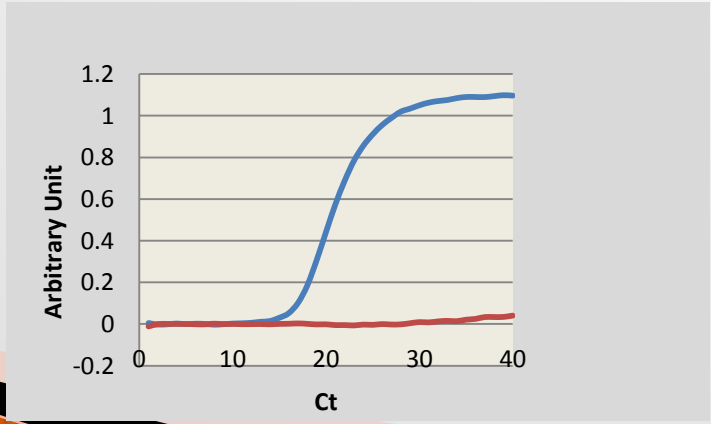


Possible improvements

- Real-time PCR provides improved reliability since it is a closed diagnostic system – once samples have been set up, the tubes don't have to be reopened.

- It is rapid, providing results within 1-2 hours, sensitive, and assays have been developed for many plant pathogens.

- However, the equipment is expensive and not very portable, so it is not appropriate for 'in field' diagnostics.



LOOP MEDIATED ISOTHERMAL AMPLIFICATION (LAMP)

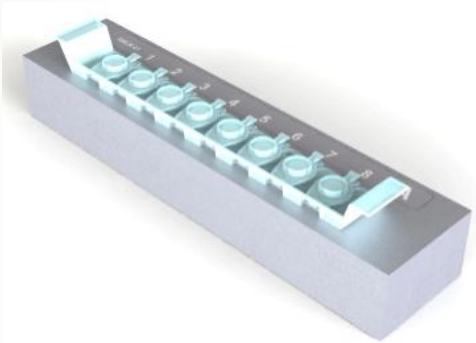
- A rapid DNA amplification technique that takes about 30 minutes to get a positive reaction.

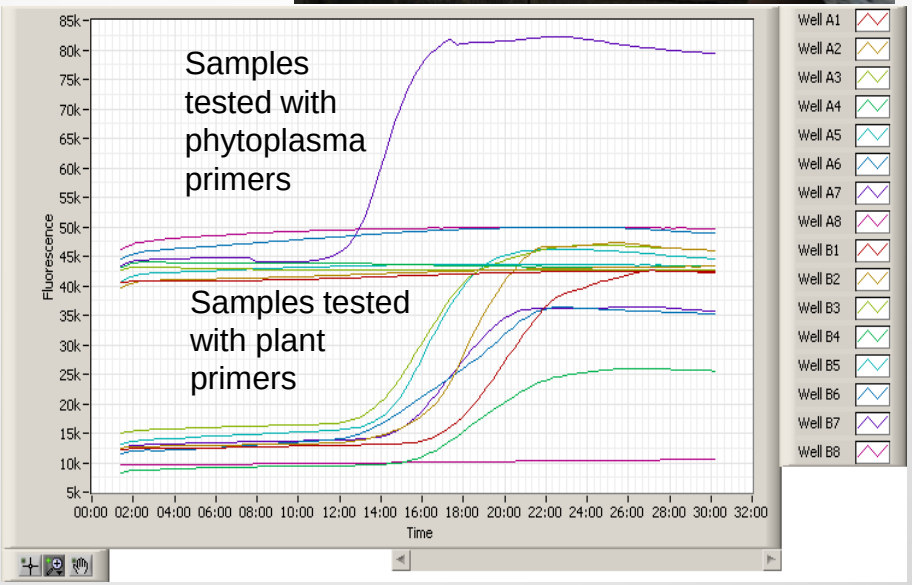
- Can be combined with a portable detection machine and a rapid DNA extraction method that takes 2 minutes.

- Place approx 0.5 g plant material into extraction bottles (contain buffer and steel beads) and shake for 2 mins. Use 2 microlitres of the solution directly in the LAMP reaction mixes.

Setting up LAMP reactions in the field

- Strips of 8 tubes can be purchased from Optigene, UK, along with reagent mixes that contain the enzyme, buffer, fluorescent dye etc.
- The only additional reagent required is the primers for the particular organism to be detected.
- The reaction mixes are stable at room temperature – therefore mixes can be prepared in the lab and transported out to the field for on-site field work.





- Assays have been developed for *Phytophthora ramorum* (Sudden Oak Death), *Botrytis cinerea* and numerous other diseases such as cassava brown streak virus and ash dieback.

- The system can be used not just for plant pathogens, but also for human and animal pathogens and authenticating food products – all that is required is design of suitable primers for a particular assay and validation.

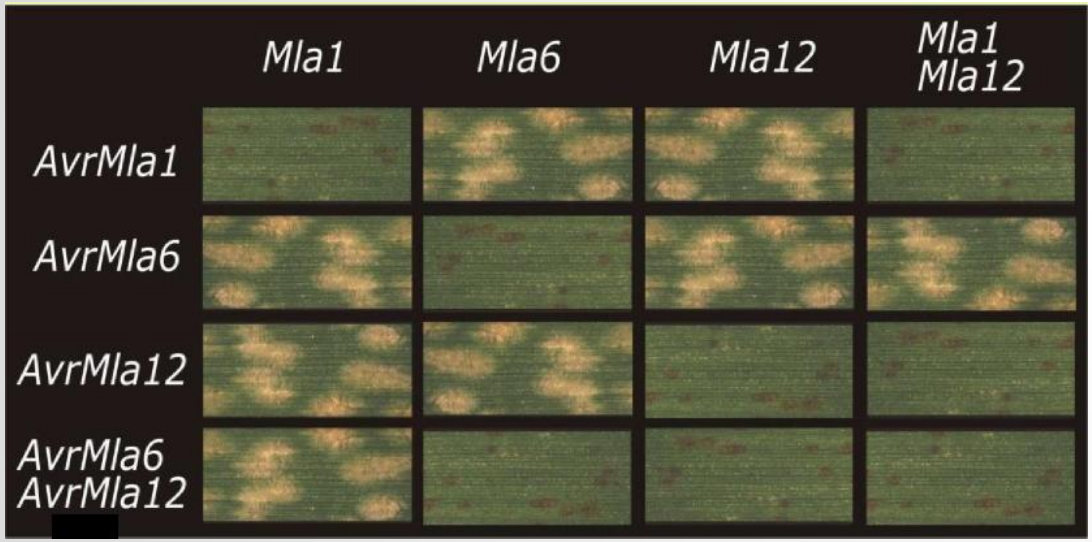
CONTROL OF PLANT DISEASE

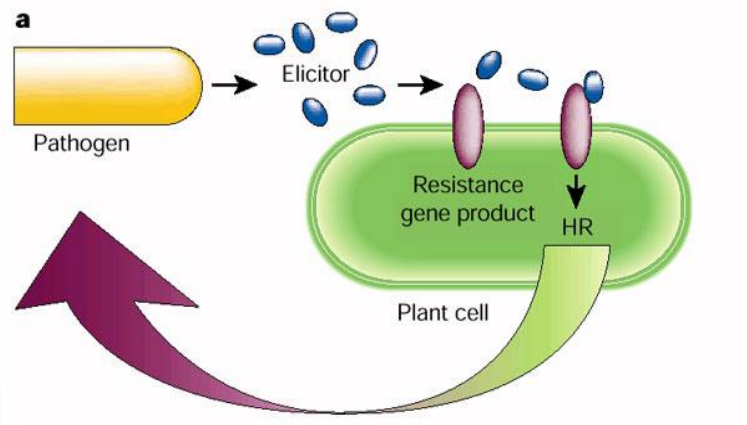
- Cultural practices
- Chemicals
- Biological control
- Resistance genes

RootShield® PLUS+

Resistance genes

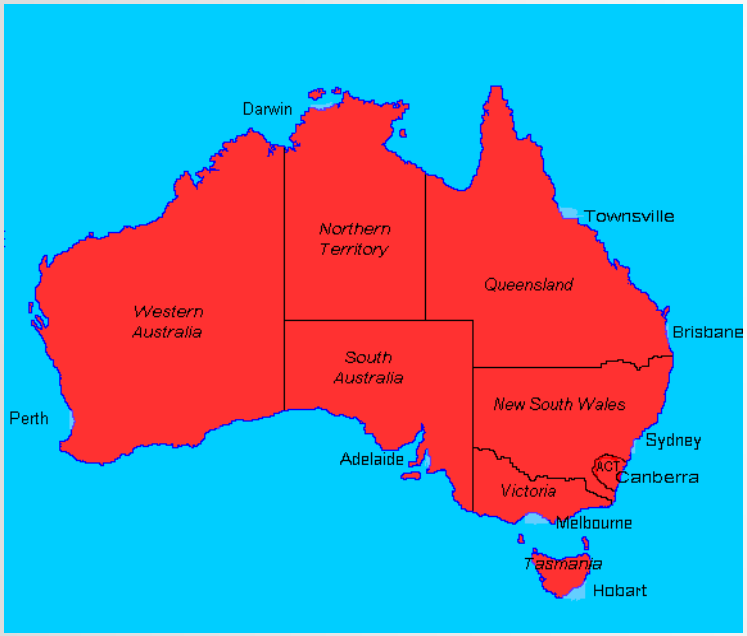
Can breed resistance genes into commercial cultivars

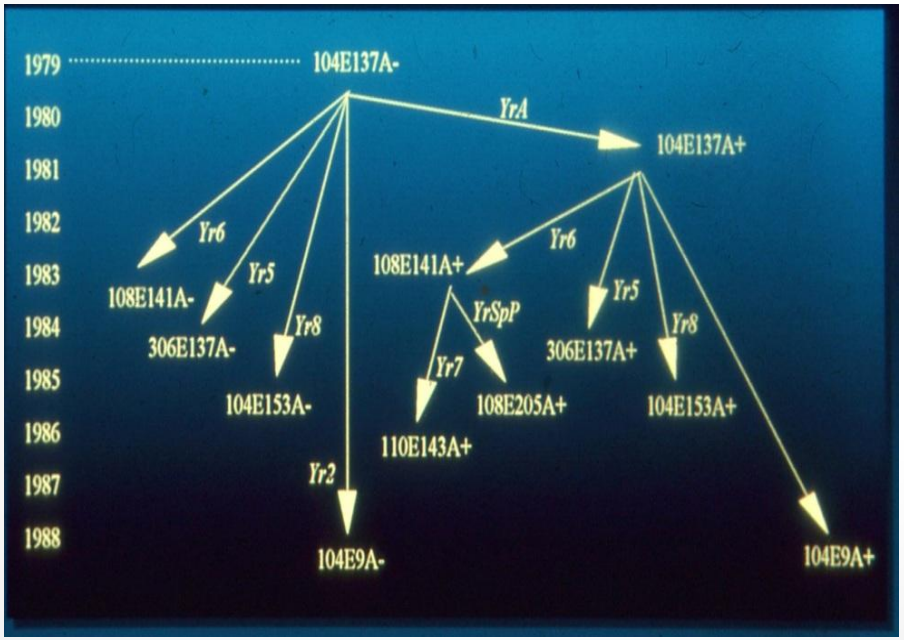




But pathogen populations keep evolving and changing

e.g. yellow rust of wheat in Australia





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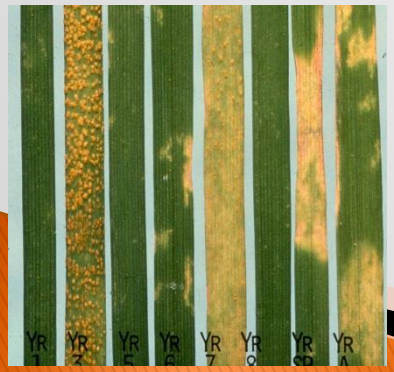
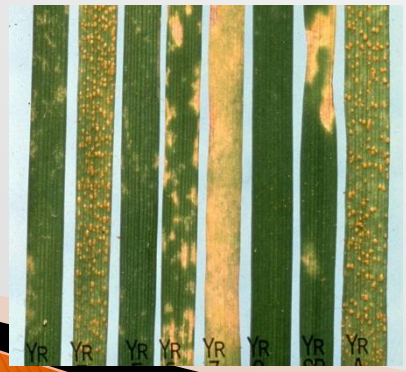
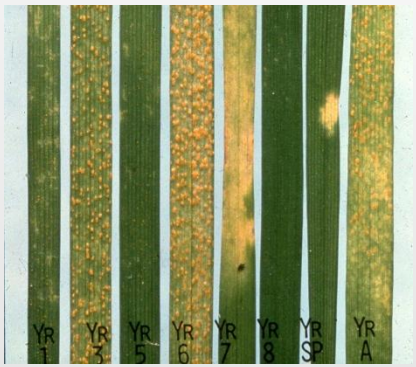


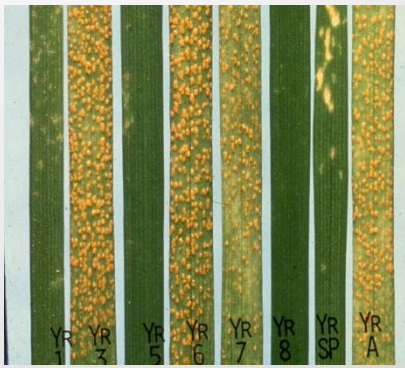
1981



1983



1986



FUTURE PERSPECTIVE

Rather than breeding resistance genes into plants, it will be possible to introduce them through genetic engineering.

Chemicals are being developed that mimic activators of defence responses.

There is also evidence that sometimes natural populations of non-pathogenic microbes can help protect plants against pathogens.

But, pathogens will continue to evolve in response to selection pressure.

Therefore integrate different control strategies.

Thankyou