Project Title:	The Causes & Prevention of Lesions (Oedema) in Herbs
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PART 1

GROWER SUMMARY

OEDEMA OF CORIANDER IS UNLIKELY TO BE DUE SOLELY TO HIGH HUMIDITY

1.1 PROJECT BACKGROUND

A number of salad and herb crops, including coriander, suffer from a condition that manifests itself as water-soaked lesions on the leaves. This disease is known in the herb trade as 'oedema' (US spelling edema). It appears very quickly, often emerging throughout an apparently healthy crop within twenty-four hours. Retailers will not accept any cosmetic damage to leaf crops, so this disease can make the crop unsaleable and can cause losses as high as £200,000.

In herb and salad crops, it is not currently known whether oedema is:

- A physiological disorder (the favoured theory being weakness of cells under turgid conditions, related to weather conditions).
- Caused by insect damage.
- Caused by pathogen damage.

According to growers, the condition occurs when the air is humid and the ground is wet. This is consistent with the theory that lack of transpiration, but continuing root water pressure causes cells to burst. However, there is currently no data to support this hypothesis.

A further theory involves the disturbance in calcium transportation, similar to the condition 'blossom-end rot' of tomato.

In the literature, oedema is generally described as the over-development of cells, both in number and size, resulting in the formation of swellings or galls, often corky in texture.

Anecdotally, oedema in coriander is seen as a greying of the leaf, which can then develop into yellow-brown necrosed spots. If kept in a humid environment (e.g. having been packaged for sale), the coriander leaves disintegrate into a black, liquid mush.

1.2 AIMS OF THE PROJECT

The aim of this project is to understand the physiology and causes of oedema, in order to allow preventative measures to be investigated; e.g. selection of less susceptible varieties, use of plant protectant products (insecticides, fungicides etc.), more appropriate management of irrigation schedules. Previously, almost no work has been done on the condition, particularly in herbs.

Two strategies have been proposed: working with growers in the field and setting up controlled experiments in the laboratory.

A network of growers has been set up who will log incidences of oedema in their crop and provide samples of diseased plants for investigation in the laboratory. Logging their anecdotal evidence is also likely to provide significant clues as to the causes of the condition. As it is thought that oedema occurs in humid conditions, weather data (primarily soil and air temperatures, wind speed and direction and relative humidity) will be collected. Many of the growers collect this data for their own use, so will also be able to provide it for the project.

In the laboratory, the symptoms of the condition will be investigated and recorded. Certain experiments, based on those mentioned in the literature and from anecdotal evidence will also be set up. Conditions can be monitored closely and factors changed with relative ease. Any significant results can then be transferred to field experiments.

1.3 SUMMARY OF CURRENT PROGRESS

1.3.1 GROWER NETWORK, QUESTIONNAIRES & WEATHER DATA

Thirteen growers have agreed to participate in the project and contacts with crop advisors and seed merchants have also been made.

Questionnaires have been created to log the site details (aspect, soil type and pH), cropping regime (date of sowing, irrigation regimen, fertiliser and protectant chemical applications) and incidence of oedema. Gathering this information throughout the season, for crops which may or may not have been affected by the condition, will allow a potential correlation between environmental conditions and incidence of the disease to be identified. The questionnaires have been sent out, along with a guidance sheet explaining how the questionnaire should be filled in.

Most growers collect weather data on their property, which they have agreed to share with the project. Those that do not, happen to be situated close to larger organisations which do - e.g. the Scottish Agricultural Research Institute. The weather data is generally kept on the growers' computer systems, so it will be simple to collect it at the end of the growing season.

1.3.2 ANECDOTAL EVIDENCE

There appears to be some confusion as to the nature of oedema. Some growers are affected by slate-blue, water-soaked symptoms, whilst others by the greying, paperiness, although both are termed oedema.

On interviewing a number of herb growers, a number of hypotheses as to the causes of oedema emerged. The most common, was that the condition arose in periods of 'thundery' (humid) weather, particularly after periods of rain. Further questioning resulted in a slight divergence of opinion - some felt that the oedema was due to the humidity itself, while others believed it was the *change* in humidity.

Other growers claimed not to get oedema, but to get blight caused by the bacterium *Pseudomonas syringae*. Again, opinions varied as to whether the *Pseudomonas* was directly responsible for the disease, or was a secondary infection, resulting in the crop losses seen.

These hypotheses would support causes gleaned from previous research on other plant species, so provide a starting point in my research on coriander.

Soil type was also mentioned as having a contributory effect, since coriander requires a continuous water supply and this may not be maintained in light, sandy soils.

The fact that the condition appears in a crop generally between May and July then possibly in September, when the growing season is from late March/April to October, has also led to the thought that day length is a contributory factor. However, at these times of the year, day temperature tends to be high and night temperatures low, so a change in temperature could also be a possibility.

One grower commented that the symptoms of oedema were similar to those seen on herbs after Linuron (a fungicide) burn.

1.3.3 SYMPTOMS OF OEDEMA

1.3.3.1 Visible Symptoms

Oedema appears as a slight greying of the leaf lamina, between veins on the upper side of the leaf. Once formed, the patches do not seem to increase in size. A pinprick indentation generally develops within this area, usually one per grey patch, which also remains a constant size. If the leaves are cut and left in the open air, the patch dries out, turning papery and necrotic, before the whole leaf withers and dies.

1.3.3.2 Under Binocular Zoom Microscope

Under x90 magnification, the greyness is not particularly distinguishable. The indentation is revealed as a pale brown-beige sunken lesion, with a slimey, water-soaked appearance. In the samples currently obtained, the indentation measures approximately 0.08mm in diameter.

1.3.3.3 Cellular Study Of Oedema Lesions

The hypothesis that, in oedema, cells burst and result in the symptomatic lesions and indentations, can be studied by looking at affected areas under a light microscope.

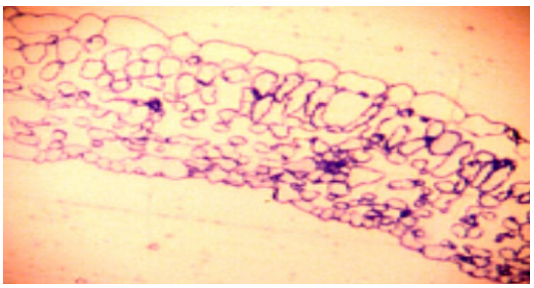


Figure 1: Transverse section through a healthy coriander leaf (mag x400).

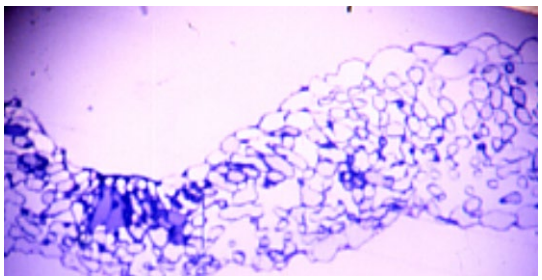


Figure 2: Transverse section through the indentation in a coriander leaf with oedema (mag x400).

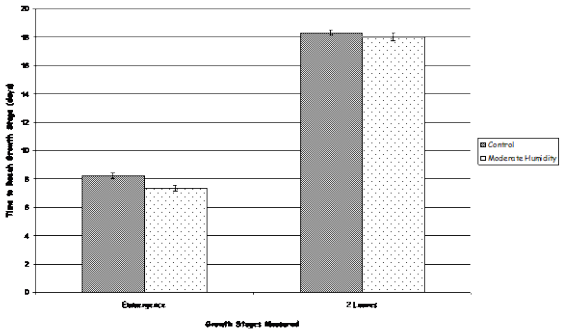
Figures 1 and 2 show sections of affected and unaffected coriander leaf tissue. The sections of affected coriander were taken through the indentaion previously seen with the naked eye and under the zoom microscope. In this tissue, the cells appear to be intact, but the *intercellular spaces* have collapsed, which means that the cell-cell structure of the leaf has broken down. Further study of the sections under a transmission electron microscope may also aid diagnosis.

1.3.4 INVESTIGATION INTO THE EFFECTS OF HUMIDITY

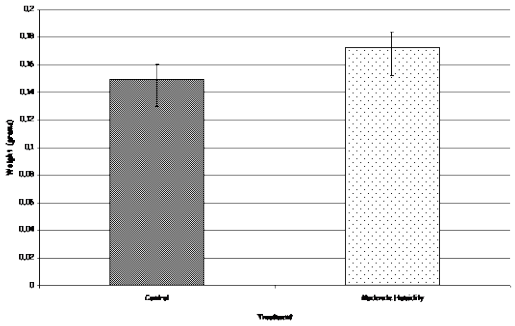
Following the findings of a preliminary investigation into humidity and oedema, that coriander does not grow well in high humidity, it was decided to only use low and moderate humidity treatments. Although the primary aim was to produce the symptoms of oedema, growth and developmental stages were also logged, as a means of monitoring the growth conditions.

The average relative humidity of the control treatments was 61%, whilst that of the moderate humidity treatments was 84%.

No conditions of oedema were seen on any of the plants in any treatment.



Graph 3: Time Taken for Coriander to Reach Two Growth Stages Under Different Levels of Humidity



Graph 4: Dry Weights of Coriander 35 Days After Sowing, Under Different Levels of Humidity

Plants grown under moderate humidity took 0.88 days less to emerge than those grown as the control (Graph 3). There is also a difference of 0.28 days in plants in each treatment reaching the 2 leaf stage.

Graph 4 shows that plants grown in moderate humidity are marginally larger (i.e. have a greater dry weight).

This results of this experiment show that a constant humidity does not automatically trigger oedema. However, it could be that a *change* in humidity may trigger oedema. Therefore, to support or rule out this hypothesis, further work would still need to be carried out, growing plants in high humidity, then reducing it, or growing them in low humidity and increasing it.

1.3.5 USE OF A PRESSURE BOMB TO REPRODUCE SYMPTOMS OF OEDEMA

If high environmental humidity causes water pressure inside the plant to increase to such an extent that the cells burst, which in turn causes the symptoms of oedema, then theoretically the symptoms should be able to be mimicked if the leaf is put under pressure along the transpiration stream.

A pressure bomb is a piece of equipment usually used to measure the water potential (ψ) of a leaf, although it can also be used to force pressure up the stem along the transpiration stream. If oedema is due to an increase in root pressure, then symptoms will be produced when the pressure inside the bomb vessel is increased.

However no leaves pressurised in this way showed oedema symptoms , even under considerable pressures.

1.4 PRELIMINARY CONCLUSIONS

These preliminary results would suggest that neither hypotheses linked to transpiration (i.e. 1) that humidity causes oedema and 2) during the condition, cells burst)- is correct. When grown in humid conditions, the condition does not develop. When the transpiration stream is subjected to high pressures, the symptoms are not induced. When studied under a light microscope, the cells have not burst. Instead, the cell-cell structure has broken down, resulting in a collapsing of the intercellular spaces.