

Cabbage

Project No. FV 160 & 160a (HortLINK HL0114LFV)

Internal disorders of stored white cabbage

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This factsheet provides growers of white cabbage with new information on the identification of the principal internal disorders of white cabbage, the causes of the problems, including the important link between viruses and internal disorders, and the actions needed to minimise their economic impact.

Background

Internal storage disorders regularly account for losses of 10% in UK stored cabbage crops, though on occasions individual growers may suffer more significant losses of 80% or even total loss.

When storage problems arise, the cabbage may need to be replaced by more expensive imported cabbage to

ensure that customer contracts are met. Improved harvest management is required to select the optimal crops for short, medium and long-term storage.

Cigar burn and tipburn are the two principal causes of internal disorders. Pepper spot and veinal streak are less prevalent problems.

Until recently, 'tipburn' (a term previously used for all internal

disorders) had been wholly attributed to calcium deficiency but the results from a recent HortLink project (HL0114LFV) have highlighted the role of plant viruses as a cause.

Correct identification of the disorder, information on their extent, timing and location in the crop will assist in devising strategies to avoid losses.

Tipburn

The primary cause of tipburn is Beet Western Yellows Virus (BWYV). Symptoms are exacerbated when Cauliflower Mosaic Virus (CaMV) is present in combination with BWYV.

In addition, the lack of calcium during periods of rapid growth has been implicated in the disorder. This may be associated with various stress factors that affect the crop. Periods of rapid growth combined with high humidity conditions are unfavourable for the uptake of calcium and may lead to classic tipburn symptoms. Such severe, early cases are probably due to an inadequate supply of calcium during the growing season.



1 Characteristic Tiburn symptom on leaf edge of stored cabbage head

Symptoms

Tipburn is characterised by a collapse or discoloration of tissue at the leaf margins throughout the head (Figure 1). Externally, the heads look normal but when cut open, breakdown of the leaf margin is apparent. This is characterised initially by grey papery coloured tissue, becoming brown as it develops.

In the growing crop, plants infected with BWYV may be symptomless or produce a very mild yellowing of leaves. Internal tipburn symptoms can sometimes be seen if affected heads are cut open before harvest. In addition to the storage disorders, BWYV also reduces growth in the field and this can result in up to 25% reduction in harvest tonnage.

When cabbages infected by BWYV are put in to store, the severity of tipburn symptoms will increase with time.

Source and spread of BWYV

Oilseed rape crops often harbour BWYV during the winter months, with aphids spreading the virus on to adjoining vegetable brassica crops in the spring. Other sources of the virus include horticultural brassicas, weeds and garden plants.

The peach potato aphid (*Myzus persicae*) is the most common aphid

vector of BWYV. The virus is held deep in the aphid's digestive tract, only being transmitted to the plant, after several hours feeding. Aphids retain the ability to transmit the virus for life. This delay in passing on the virus means that insecticides may reduce the spread of BWYV by killing the aphid before virus transmission.

Detection

It is possible for laboratories to detect BWYV in infected cabbage heads during the growing season. However, only 50% of virus-infected heads go on to develop symptoms. This is not considered a reliable enough indication on which to base store management decisions.

Monitoring should therefore be based on cutting open heads both pre-harvest and in store. If the symptoms start to appear, growers should be aware that these would get worse with time, so should consider shortening the period the heads are in store.

Varietal susceptibility

Cultivars vary in susceptibility to BWYV infection and also calcium-induced susceptibility to tipburn (see 'Varietal resistance' section).



2 Cut cabbage head from plant infected with BWYV showing surface view of tipburn symptoms

Cigar burn

Cigar burn symptoms (Figure 3) are caused by the aphid-borne Turnip Mosaic Virus (TuMV). Symptoms are exacerbated when Cauliflower Mosaic Virus (CaMV) is present in combination with TuMV.

Symptoms

Severe TuMV infection of the cabbage leaves can occasionally be seen in the growing crop, prior to harvest, as black rings and necrotic spots on the older leaves (Figures 6 and 7). In addition to leaf quality problems, yield losses of up to 20% (head weight) can also be experienced when virus infection has occurred.

The classic symptom of Cigar burn is characterised by the presence of internal sunken necrotic spots in stored heads. These are mainly 5-10 mm in diameter and closely resemble the burn mark left by a cigar (Figure 4).



3 Section of head showing extent of cigar burn through a head infected by TuMV

Such large symptoms on the inner leaves of the cabbage, even in small amounts, can render a cabbage unmarketable. Cigar burn can appear on any internal leaf and rarely is the disorder limited to the outer leaves.

If the cabbage has mixed infection by CaMV as well as TuMV, the internal disorders are more severe and losses can be as high as 65%.

The severity of cigar burn symptoms did not significantly increase during a 4-month storage period. Knowing that the severity of the disorder may not increase over time aids its management.

Spread and incidence

The peach potato aphid (*Myzus persicae*) and the cabbage aphid (*Brevicoryne brassicae*) are thought to be the main aphid species that spread TuMV. The virus is transferred in seconds from the mouthparts of an infective aphid to the plant leaves. This rapid rate of transfer from aphid to plant renders both systemic and contact insecticides ineffective. Aphids only retain the ability to transmit the virus for a few hours.

Plants that become infected with virus in June, will have a higher incidence of cigar burn in stored heads than those infected during propagation in April.

Detection

Severe TuMV infections can be seen by eye in the field (Figures 6 and 7). Random sampling of heads close to harvest and testing at Warwick HRI has shown that cigar burn symptoms developed in 70% of cases where TuMV was positively identified. Pre-storage virus testing therefore provides a useful indicator of potential cigar burn problems, aids decisions on variety and batch management (for in-store monitoring, sampling or immediate processing).

Varietal susceptibility

There are differences in varietal susceptibility to TuMV and CaMV infection and consequential yield losses. Seed companies may be able to offer information about resistant varieties both for fresh market use and processing in which there can be large differences (see 'Varietal resistance' section).



4 Cigar burn symptoms on stored cabbage head



5 Field symptoms of cigar burn on cabbage head



6 Cabbage plant in the field infected by TuMV showing necrotic symptoms



7 TuMV infected cabbage plant from LINK project showing external necrotic symptoms whilst growing

Cauliflower mosaic virus (CaMV)

CaMV causes vein-banding and mosaic symptoms in the leaves and should be visible during crop walking (Figure 8). Where these field

symptoms have been seen crops are likely to develop some storage disorders, as other viruses are also likely to be present in the affected crop.

Though CaMV does not cause any major internal disorders on its own, it does increase the losses caused by other viruses.

CaMV can be confirmed in individual plants but the costs of monitoring and laboratory testing commercial crops will be prohibitive.

Further investigations are required to develop better 'in field' predictions and understandings for CaMV exacerbation of disorders.



8 Distorted brassica leaf caused by CaMV

Mixed infections

TuMV, CaMV and BWYV are all considered economically important because of the potential to reduce yield and cause or exacerbate internal disorders. Symptoms of tipburn will increase in severity if BWYV is found in combination with other viruses such as CaMV and TuMV.

Disorder	Cause	Aphid Transmission	Storage
Tipburn	BWYV	Slow	Continues to develop in store
Cigar burn	TuMV	Rapid	Does not get worse after 4 months in store
Cigar burn (severe)	TuMV + CaMV	Rapid	Does not get worse after 4 months in store

Pepper spot

Pepper spot is considered to be a physiological, non-disease disorder. The disorder is characterised by very small black spots less than 1 mm in diameter, randomly distributed, on either or both sides of the outer leaves as well as the inner leaves of the cabbage (Figure 9). It is rarely seen in the field in early harvested crops, but is often first seen when cabbage heads are cut open in store. The spotting can spread inwards, whilst becoming increasingly severe on the outer leaf layers.

The occurrence of this disorder has declined in recent years, possibly due to the growing of less susceptible varieties, reductions in the amount of nitrogen fertilisers and improved management of the store environment.



9 Pepper spot disorder on cabbage leaf

Veinal streak

Veinal streak is also thought to be a physiological disorder. Unlike pepper spot, the black lesions are larger, often coalesce and are confined only to the mid-rib of the cabbage (Figure 10). Like Pepper spot, it is only seen infrequently, but is highly visible when the cabbage is cut open.



10 Characteristics pepper spot disorder on mid-rib of cabbage

Control

Site selection

Cabbage crops intended for short, medium and long term storage should not be grown in fields close to over-wintering brassicas, especially oilseed rape, as these can be important sources of viruses, through aphid transmission.

Similarly, avoid fields prone to water-logging as they will lead to conditions that disrupt root functioning and deficiencies in calcium uptake may occur leading to tipburn symptoms.

Varietal resistance

It is possible to select varieties with some known resistance to the major storage disorders and virus diseases. Guidance on varietal resistance should be sought from the various seed companies.

Past National Institute of Agricultural Botany (NIAB) Descriptive Lists have rated winter white cabbage varieties for resistance to TuMV and

CaMV. However, there are no independent trials data available for the full spectrum of current varieties used in the industry.

Monitoring and avoidance

Field inspections should be made for the symptoms of the more severe viruses i.e. TuMV and CaMV, by cutting open and inspecting cabbage heads.

Laboratory testing cabbage for TuMV in the field pre-storage will provide a good indication of the likelihood of cigar burn developing in store. However, there is currently no protocol to indicate the sample number to provide an accurate indication of virus level.

Testing cabbage for BWYV in the field pre-storage by ELISA does not accurately estimate level of tipburn symptoms in the crop.

Aphid control

Control of aphids with insecticides is important to prevent aphid infestations causing direct feeding

damage to crops. Despite, BWYV transmission by aphids being relatively slow, insecticides will not completely control virus spread (both Gaucho *imidacloprid* and Aztec *triazamate* were tested in the HDC/HortLINK project and gave no control). As timing of infection is not related to severity of tipburn it is important to avoid virus infection for the whole season.

Additionally, aphids with resistance i.e. modified acetylcholinesterase (MACE) are becoming more common and this will reduce the effectiveness of insecticidal control, if products with different modes of actions are not alternated.

Action points

Pre-harvest

- Use the weekly HDC aphid monitoring report issued in the spring and summer to provide some warning of aphid species active in your local area.
- Monitor crops regularly and maintain good aphid control throughout the growing season to minimise infection of all aphid-borne viruses implicated in internal disorders.
- After periods of significant aphid activity, look out for the visible symptoms of the virus in the growing crop and laboratory test cabbage heads at random towards the end of the season for the presence of TuMV.
- Monitor crops for internal disorders by cutting heads open both in the field pre-harvest and after the crop has been stored. If a major problem is anticipated in a batch before harvest, do not harvest the batch. If a minor problem is found, ensure

that the boxes from this particular batch are clearly marked, made easily accessible for removal and marketing, and undergo further in-store monitoring to assess if the internal disorder increases in severity.

- Market infected crops early in order to avoid losses.
- ELISA testing prior to harvest for BWYV will not provide a reliable indication of severity of subsequent tipburn symptoms.
- Areas of the field where water has been standing during the growing season warrant special attention before harvesting the cabbage, as root development and function is likely to have been impaired, reducing uptake of nutrients and water. Levels of internal disorders found during monitoring can then help decide whether to harvest or store the crop.

Post-harvest

- If latent tipburn symptoms are found in cabbage heads shortly

after filling the store, it is most likely that the problem will get worse.

Remove cabbage from store as soon as possible. Do not attempt to hold on to such crops as high losses will result.

- Store any high-risk crops in 'high grade' sealed stores. This should significantly reduce secondary infections, such as grey mould (*Botrytis cinerea*), resulting from virus infection.
- The environmental controls and management of all stores should always be of the highest standard. Temperature and airflow are of paramount importance in maintaining the cabbage in best condition and reducing storage losses.
- Growers are advised to record incidences of tipburn and cigar burn in different varieties, to aid variety selection in future.

Laboratory testing facilities

Samples can be sent to:

John Walsh
Warwick HRI
Wellesbourne
Warwick
CV35 9EF
T 0247 657 5028

Central Science Laboratory
Sand Hutton
York
YO41 1LZ
T 01904 462000

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Further information: A full copy of the final reports for HDC projects FV 160 & FV 160a (HortLINK HL0114LFV) are available from the HDC office (01732 848383).

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