AHDB
HORTICULTURE

# Grower Summary

## FV 443

Courgettes: Reviews of blossom end rot – causes and potential solutions

Final 2015

## Disclaimer



The results and conclusions in this report may be based on an investigation conducted over one year. Therefore, care must be taken with the interpretation of the results.

## Use of pesticides

Only officially approved pesticides may be used in the UK. Approvals are normally granted only in relation to individual products and for specified uses. It is an offence to use non-approved products or to use approved products in a manner that does not comply with the statutory conditions of use, except where the crop or situation is the subject of an off-label extension of use.

Before using all pesticides check the approval status and conditions of use.

Read the label before use: use pesticides safely.

## Further information

If you would like a copy of the full report, please email the AHDB Horticulture office (hort.info.@ahdb.org.uk), quoting your AHDB Horticulture number, alternatively contact AHDB Horticulture at the address below.

AHDB Horticulture,
AHDB
Stoneleigh Park
Kenilworth
Warwickshire
CV8 2TL

Tel – 0247 669 2051

AHDB Horticulture is a Division of the Agriculture and Horticulture Development Board.

| | |
|---|---|
| **Project title:** | Courgettes: Reviews of blossom end rot – causes and potential solutions |
| **Project number:** | FV 443 |
| **Project leader:** | Sarah Mayne, ADAS |
| **Report:** | Final report, October 2015 |
| **Previous report:** | None |
| **Key staff:** | Sarah Mayne, ADAS UK Ltd |
| **Location of project:** | ADAS Boxworth<br>4 commercial courgette crops |
| **Industry Representative:** | Ellis Luckhurst, PE Simmons & Son Ltd, Higher Trevaskis Farm, Connor Downs, Hayle, Cornwall, TR27 5JQ |
| **Date project commenced:** | 1st April 2015 |
| **Date project completed:** | 31st October 2015 |

# GROWER SUMMARY

## Headlines

- Calcium and boron exhibited negative and positive concentration gradients respectively from the stalk, mid-section and to the blossom end in fruit exhibiting Blossom End Rot.
- Evidence from the literature review suggests that calcium deficiency is linked to restricted growth and yield of courgette.

## Background

A soft, wet rot extending from the flower scar to rot courgettes whilst still on the plant has been termed ‘blossom end rot’ (BER) by growers (HDC Technical update TU-FV 001). Although not a new problem, losses due to BER can be high in wet and damp years. Additionally, the rot may also present to the end customer as internal browning, causing supermarket rejections and creating uncertainty in the courgette industry.

It has been reported that rots from the blossom end typically start with a rot of the flower that has failed to dry up, senesce and detach from the fruit fully. This happens more frequently in wet weather as the flower may adhere to the fruit outer surface, and then act as a bridge for any pathogens to access the mature fruit through the flower scar. Varieties are reported to differ in their susceptibility to BER by many growers, and their differences in timing, flower size, and flower scar size may contribute to this. Certain irrigation methods may avoid water splash and transfer of rot pathogens to the fruit.

A number of microorganisms are known to cause fruit rots in cucurbits, both fungal and bacterial (as detailed in HDC Factsheet 07/13). The majority of fungicide sprays applied to courgette are for the control of powdery mildew, and, especially if the problem is bacterial in nature, it is unlikely these would control the pathogen. If the problem is caused by a fungal pathogen however, it is likely that some of the broader spectrum fungicides approved for use on courgettes would offer some control. The problem in applying plant protection products to courgette lies with harvest intervals, as picking takes place regularly over a long harvesting period.

Traditionally, BER is thought to be caused by localised calcium deficiency, and a similar symptom has been well documented for tomatoes and peppers. Some growers report the problem in early season crops of courgette, at times when they are growing more quickly and under stress as a result. Typically, it is avoided under protection by encouraging water uptake and translocation of calcium into the fruit rather than the leaves of the plant, by management of irrigation and glasshouse humidity. Management of soil nutrients is key to avoiding calcium deficiency and most growers perform soil analyses prior to planting their crop. Some outdoor courgettes are irrigated, and it is likely that improved control of water uptake, for example by using mulches or installing trickle tape, would improve matters. Some growers have already implemented these changes and report less obvious rots in the field. It is likely that soil structure and root health play a role in the development of calcium deficiencies at the growing point of fruit.

There are a number of potential solutions to BER, be it a problem with a pathogen or with crop nutrition. However, the initial cause of the problem must first be identified so that targeted solutions can be trialed. It is likely that nutritional and pathological factors are working in tandem to cause rotting at the blossom end in courgettes when environmental conditions are favorable.

## Summary

Aim: To utilise scientific literature, technical information from both the UK and abroad and specialist grower knowledge to deliver a series of potential solutions to the problem of blossom end rot in courgettes

***Objective 1 - To define the problem of blossom end rot in courgettes and its incidence through grower liaison, review of technical literature and analysis of fruit.***

*Grower liaison*

In total, 14 growers and industry professionals were contacted, primarily by telephone but also via email. The table below (Table 1) summarises some of the opinions and ideas to come out of this liaison. Potential alleviation options suggested by growers have been incorporated into Objective 3.

**Table 1.** Factors that are believed to contribute to the incidence of BER in UK crops

| Factor | Number who believed this affected BER | How? |
|---|---|---|
| Calcium transport | 14 | Classical BER, localised Ca deficiency |
| Wet weather | 14 | Allows pathogens to infect flower, and invade fruit, hinders transpiration stream |
| Grow through plastic | 2 | Water may pool on plastic, and keep fruit damp and in contact with soil |
| Foliar feeds applied | 4 | Difficult to tell, not been applying for long |
| Stored courgettes | 3 | Yes, can develop or worsen in storage |
| Leave waste in field | 1 | Inoculum builds up |
| Overhead irrigation | 1 | Favours pathogen development |
| Variety | 3 | Blossom scar size, uneven flower shape, older varieties worse |
| Ventilation | 1 | Disrupts effective transpiration |
| Soil type | 1 | Avoid leachy soils with too much drainage |
| Late crops/season | 12 | Crops more ‘tired’, under stress |
| Flower detachment | 5 | Allows pathogens entry to fruit more easily |
| Planted through plastic | 1 | Water pools more easily |
| T-tape | 1 | Fertigation provides Ca where it is needed for uptake at the root |

Overall, calcium deficiency and wet weather causing flower rot and retention (Figure 1) were the two most cited factors contributing to blossom end rot by growers.

**Figure 1.** Wet weather causes flowers to hold water, favouring pathogens and prevents the flowers from dropping from set fruit - South West, 2015.

*Technical literature*

- A number of researchers and industry professionals were contacted overseas, and no specific work on this disorder was reported.
- The disorder is not common or viewed as particularly problematic in countries with a drier climate than the UK.
- Where BER was observed, explanations of calcium deficiency and of a wet flower failing to abscise from fruit were given.
- There is an abundance of technical information detailing the various rots courgette fruit are susceptible to, but little in-depth information on blossom end rot specifically.
- Some information is available online, but much is provided by amateur gardeners and as such the solutions suggested are not viable for commercial settings.
- Calcium deficiency is most often cited as the cause in online sources.
- The problem is reported as occurring both late season and early season.
- Abundant technical literature on management of BER in solanaceous crops and tipburn in lettuce could be tested for use in courgette.

The small amount of technical literature that is available comes from state university research stations in the USA, where the disorder is regarded as analogous to that in tomato, pepper and aubergine. Here, the rot is described as brown and dry, and a number of alleviation options are suggested. These options were considered and summarised within Objective 3.

*Fruit analysis*

Fruit was sent to an analytical laboratory for testing and mg/kg dry weight reported back. It was clear that courgettes varied considerably in their content of some nutrients from site to site, and on an individual basis. The calcium levels cited for healthy courgettes in the literature were also extremely variable (ranging from 100 to 5900 mg/kg), and calcium levels reported back for apparently healthy courgette fruit sampled also reflected this (ranging from mean values of 2584 to 5349.5 mg/kg across sites).

When values returned for sampled fruit were averaged, the calcium levels differed between affected and unaffected portions of fruit as illustrated in Figure 2 & Table 2 below. It is notable that sites in the South West and Midlands had a more obvious blossom end rot problem when sampled in comparison to sites in East Anglia and the South East, where the gradient between calcium concentration in different parts of the fruit is less evident. Varieties of courgette grown differed between sites, but it is more likely that regional differences occurred due to the different climatic conditions around the UK.

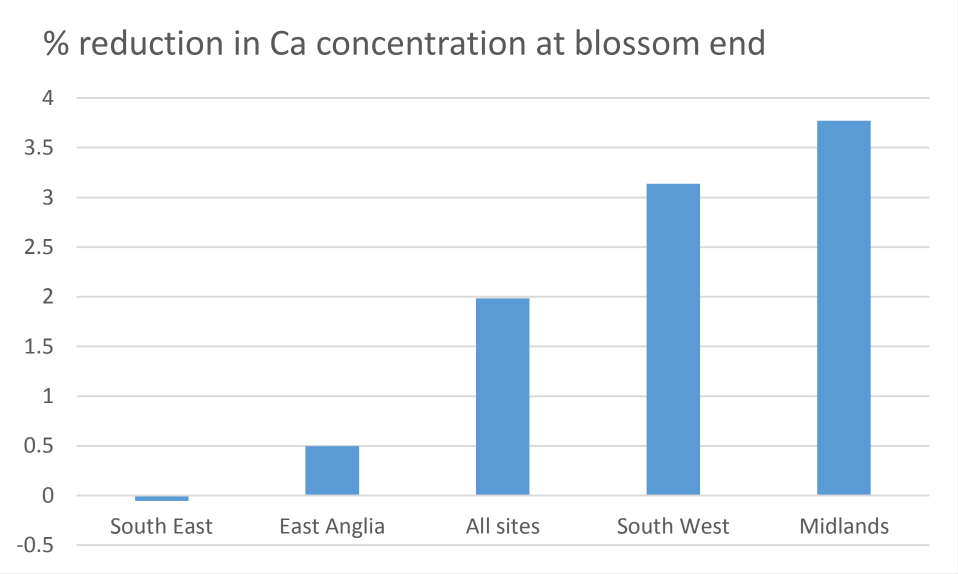


**Figure 2.** Average reduction in Ca concentration (mg/kg) at the blossom end compared to unaffected stalk and mid portions of the fruit for each region individually, and when data from all sites is combined and averaged.

**Table 2.** Mean calcium content of courgette fruit affected by BER, split into 3 sections from stalk to blossom end

| | Calcium (mg/kg dry weight) | | | | % decrease |
|---|---|---|---|---|---|
| | **Stalk end** | **Mid-section** | **Stalk & Mid (average of unaffected tissue)** | **Blossom end** | |
| South West | 3122 | 2479 | 2800 | 2713 | 3.2 |
| East Anglia | 7038 | 5206 | 6122 | 6092 | 0.5 |
| South East | 5665 | 4450 | 5058 | 5061 | 0 |
| Midlands | 9632 | 8490 | 9061 | 8719 | 3.8 |
| Average of all sites | 6364 | 5156 | 5760 | 5646 | 2 |

Another nutrient noted to differ between affected and unaffected tissue was boron, which was reported at generally higher levels in the blossom ends of affected fruit (Table 3). However, this is likely to be due to how boron is accumulated in plants, largely dependent on the transpiration stream and concentrating at leaf/fruit tips.

**Table 3.** Mean boron content of courgette fruit affected by BER, split into 3 sections from stalk to blossom end

| | Boron (mg/kg dry weight) | | | | % increase |
|---|---|---|---|---|---|
| | Stalk end | Mid-section | Stalk & Mid (average of unaffected tissue) | Blossom end | |
| South West | 14.70 | 20.07 | 17.38 | 22.38 | 28.74 |
| East Anglia | 19.13 | 25.63 | 22.38 | 29.43 | 31.51 |
| South Coast | 22.40 | 29.20 | 25.80 | 30.83 | 19.48 |
| Midlands | 24.63 | 29.70 | 27.16 | 29.25 | 7.69 |
| Average of all sites | 20.21 | 26.15 | 23.18 | 27.97 | 20.66 |

Other nutrients did not significantly differ between affected and unaffected tissues, and variability between sites was high. Due to the high variability between fruit sampled, and the differing soil types and crop husbandry between sites, it is envisaged that a high number of samples would have to be taken and tested to gain clearer results using this methodology. However, results certainly seem to add weight to calcium deficiency contributing to BER, and they certainly do not refute this hypothesis.

***Objective 2 - To carry out a literature review covering potential causes of the problem, (covering both nutrition and disease) and exploring treatment/alleviation options from the UK and overseas, which will include information from other crops.***

The full review can be found in the Science Section, but the main points are summarised below.

Blossom end rot in courgette:

- Calcium deficiency in courgette has been found to reduce growth and reduce the plants ability to transport auxins (plant growth hormones), which may have some impact on fruit formation.
- Calcium deficiency in marrow is reported to cause tipburn and concave cupping of very young leaves, as well as patchy chlorosis between veins.
- Boron deficiency in courgettes has been observed to affect cell wall elasticity, but this is not thought to be as severe as in some other crops.
- Traditionally blossom end rot is viewed as being caused in field conditions by rapidly changing weather conditions and uneven irrigation affecting the transpiration stream
- Reduced calcium nutrition and lowered calcium content of tissues is reported to make many crops more susceptible to pathogen attack.

Treatment options:

- Appropriate pH (aiming for 6.5) and salinity levels should be maintained.
- Fertigation with calcium at periods of fruit setting has been utilised in glasshouse crops to successfully mitigate blossom end rot symptoms.
- Yields of summer squash were improved when trickle irrigation was used, although the impact on blossom end rot was not discussed.
- Changes to auxin transport referred to above were observed to be reversed with the addition of calcium ions.
- Altering the nitrogen source may alleviate the problem as calcium uptake was observed to decrease with increasing proportion of ammonium fertiliser used to fulfil nitrogen requirement, and this also increased yield. The authors of this study suggest $NH_4$-N was competing with other cations for uptake.
- Growers may increase fruit yield by using a predominantly $NO_3$-N source fertilizer through the vegetative growth stage and by shifting the $NO_3$:$NH_4$ ratio during the reproductive phase.
- Greater total calcium was found in courgette fruit grown hydroponically with increasing NaCl (up to 120 g/$m^2$ in irrigation water).
- The use of rootstocks in other cucurbits such as melon has been observed to improve uptake of water and nutrients.
- Increasing dry matter content was observed in courgette with use of a sodium silicate top dressing.
- Although use of bio-pesticides proves more difficult in an outdoor environment, use of elicitor/stimulant type products that may induce resistance could reduce the incidence/severity of rots and biocontrol agents may reduce the chances of successful infection by pathogens present.
- Treatment with biological products in storage has been shown to slow development of rots in storage on a variety of fresh produce, although it is unclear if this would be worthwhile in the courgette production system where storage is not utilised for long periods.
- There may be potential for breeding programmes to increase fruit calcium content as traditional courgette morphotypes were found to contain greater concentrations of calcium and other nutrients than pumpkin or vegetable marrow and variation within courgette morphotypes was observed.

***Objective 3 - To critically evaluate potential solutions for immediate uptake by courgette growers***

The potential solutions to come out of this review and the small piece of field work carried out are summarised in Table 4. Options are described and awarded a ranking based on practicalities, costs and potential efficacy. This is based on a combination of factors including the findings of this review and grower consultation. It is important to note that the majority of alleviation options are preventative in nature. Should blossom end rot be observed, removal of affected fruit and the use of foliar sprays containing calcium may have some benefit, but preventing occurrence of the disorder in the first place is preferable.

**Table 4.** The most promising treatment options for blossom end rot in courgette are evaluated

| **Treatment option** | **Current uptake** | **Potential efficacy** | **Ease of implementation e.g. R & D required?** | **Initial cost to grower** | **Ongoing cost to grower** | **Practicality for grower** | **Overall score** |
|---|---|---|---|---|---|---|---|
| **Highest score of 3 awarded** | **High uptake** | **High efficacy** | **Easily implemented** | **Low cost** | **Low cost** | **High practicality** | **out of 18*** |
| Fertigation | Low - 1 | 3 | 2 | 1 | 2 | 1 | 10 |
| Foliar fertiliser | Increasing - 2 | 2 | 2 | 3 | 1 | 3 | 13 |
| Mulching | Common - 3 | 2 | 3 | 1 | 2 | 1 | 12 |
| Flower removal | Low - 0 | 1 | 3 | 2 | 3 | 1 | 10 |
| Removal of waste | Very low - 0 | 1 | 3 | 2 | 3 | 1 | 10 |
| Variety choice | Some - 2 | 2 | 0 | 3 | 3 | 3 | 13 |
| Post-harvest treatments | Very low - 0 | 1 | 1 | 2 | 2 | 1 | 7 |

*Higher score indicates more useful options

## Financial Benefits

- Crop losses to BER vary considerably by location and season.
- Estimates of % loss range from <1% to as high as 20% of a single harvest.
- Assuming a harvest of 6000 kg per acre at 60 pence per kilo, then a 20% loss would represent a financial loss of £720 to the grower per harvest affected.
- Reducing the incidence of this disorder would increase marketable yield and profitability.
- Reducing the disorder could also decrease the number of fruit affected in storage, improving scheduling of product to the supplier.
- Options explored from the growers perspective, ensuring suggested control options are practical and cost effective and can be implemented quickly.

## Action Points

*Analyses*

- Carry out soil analysis annually on fields that are historically badly affected and treat fields appropriately.
- Carry out more in depth soil analysis and amendment at the start of the season to rectify any issues with pH (potentially by liming) or calcium content (a possibility to add gypsum or ulexite, which also contains boron).
- Consider carrying out foliar analysis on crops throughout the season (as in some protected edibles).

*Soil management*

- Use of mulches or adding organic matter may help to slow the loss of soil moisture on quick-draining sites.
- Planting of courgettes on a ridge, as some growers do, rather than on flatter ground may provide better drainage and a more even water supply to roots (except where soils are excessively sandy).
- Evening out the supply of water to the rootzone in this way will ensure transpiration is properly regulated.
- The use of mulches for weed control could have the added benefit of improving soil moisture.

*Fertiliser*

- If fertigation is impractical, targeted and regular application of foliar feeds may offer some benefit.
- Foliar feeds containing calcium may also decrease susceptibility to some foliar diseases.
- Incorporation of additional organic matter may also improve the soil's ability to hold moisture, allowing the crop to uptake calcium more efficiently.

*Irrigation*

- Installation of fertigation may allow a more even irrigation regime, and would also facilitate effective delivery of fertiliser to the root zone of the crop.
- Avoidance of overhead irrigation will prevent the flower becoming wet in drier conditions.

*In the field*

- Wherever possible, clear trash from fields to lower pathogen inoculum.
- Encourage pickers to carefully (and hygienically) remove flowers that remain attached to set fruit when seen, especially if wet weather is forecast.