Grower Summary

FV 425

Application of chlorophyll fluorescence for prediction of harvest maturity in broccoli

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<td>Application of chlorophyll fluorescence for prediction of harvest maturity in broccoli</td>
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GROWER SUMMARY

Headline
A non-destructive measurement of broccoli heads using chlorophyll fluorescence has been identified that has potential to assess consignments of broccoli at the point of harvest and to predict the storage potential.

Background
It is difficult to pinpoint exactly when broccoli is at the right harvest maturity for good storage behaviour and shelf-life. Areas of a crop with seemingly identical heads, harvested at the same time, can show widely differing keeping qualities – which creates an obvious problem for managing the schedule of a crop that, due to variability in weather and consumer demand through the season, may need to be stored for up to three weeks to balance supply and demand. However, the technology of chlorophyll fluorescence could potentially be used to monitor the maturity and health of broccoli heads. This project is investigating two key questions: can chlorophyll fluorescence be used to assess heads at harvest for their subsequent keeping quality; and can the technology be used to inform crop management decisions in the field and after harvest?

Chlorophyll fluorescence
Green plant tissues contain chloroplasts, the microscopic organs within the cells where photosynthesis takes place. The chlorophyll molecules in the chloroplasts absorb sunlight. Most of the energy received is used to drive photosynthesis which in turn supplies energy to the plant, but a portion is unused and re-emitted by the chlorophyll as fluorescence. The more active the chloroplasts the more energy is released as fluorescence.

For decades scientists have used this as a tool to study some fundamental aspects of photosynthesis, for example, it can indicate both the concentration and the activity or health of chloroplasts within plant tissue. Chloroplasts are very sensitive, rapidly losing activity if the tissues become stressed, so measuring chlorophyll fluorescence has been used to assess crop health in the field and, in particular, disease load for arable crops. Changes in fruit and vegetable maturity are also associated with changes in chloroplast function and concentration. The ripening of most fruit involves very significant loss of green colour and that’s down to a loss of chloroplasts. It is already known, for example from work in project TF 142, that chlorophyll fluorescence can be a valuable tool to assess maturity of tree fruit.
Summary

As a technique that can measure both the concentration and the activity/health of chloroplasts within plant tissues, chlorophyll fluorescence has been used to assess maturity and health for a wide range of crops. Specifically, chlorophyll fluorescence has been used to map changes in the health of broccoli during storage and shelf-life (FV395) where a decline in the number of active chloroplasts is correlated with a reduction in head quality leading to senescence.

The overall objectives of this project are:

1) To optimise an existing chlorophyll fluorimeter for use on broccoli heads in collaboration with the manufacturer (Hansatech Instruments Limited)

2) To relate chlorophyll fluorescence profiles of broccoli to maturation in the field as estimated by the effective day degrees after transplant and morphological characteristics

3) To identify biochemical changes (antioxidants and isothiocyanates) during broccoli head maturation

4) To determine the optimum harvest window to extend the storage/shelf-life of broccoli

5) To model broccoli head maturity, including biochemical and morphological changes in terms of chlorophyll fluorescence profile.

The specific objective for the first year of the project was to identify a measurement using chlorophyll fluorescence at harvest that could predict the subsequent keeping quality of broccoli heads.

Broccoli heads with a range of maturity were harvested from five field trials (three with cv. Steel, and two with cv. Iron Man) between July and October 2014. The quality of the heads was followed over two weeks of low temperature storage, followed by shelf-life determination at 18°C. A full range of quality assessments were measured at each stage including head diameter, weight, colour by machine measurement, visual scoring of colour, stem turgor, head colour, bud compactness, bud elongation, floret loosening.

On the basis that the main changes associated with quality that we were observing were colour and floret loosening, an overall Maturity Index was developed by combining these observations (Maturity Index score = Head colour score + floret loosening score). An increase in Maturity Index indicated loss of quality.

Figure A shows the data for a trial on cv. Steel carried out in July, with the Maturity Index for
individual heads. It is notable that at harvest the heads were indistinguishable in terms of Maturity Index, but as storage progressed they exhibited a range of keeping qualities, indicated by an increasingly wide range in Maturity Index.

In order to achieve the objectives of the overall project, the specific objective of these trials was to identify a measurement at harvest that could predict the subsequent keeping qualities of broccoli heads. For practical reasons we chose to relate characteristics measured at harvest to the Maturity Index after four days of shelf-life (indicated by an arrow in Figure A).

![Figure A](image)

**Figure A**: The maturity index of individual heads of broccoli during 14 days storage at 1°C followed by shelf-life determination at 18°C, showing how heads that appear to have identical maturity at harvest deteriorate at very different rates. An increase in Maturity Index indicates loss of quality.

A wide range of characteristics measured at harvest were tested for their ability to predict deterioration of heads, including head diameter, colour by machine measurement and a range of chlorophyll fluorescence characteristics. As expected, head diameter was quite a good predictor of maturity index after four days of shelf-life – it is well known that larger, more mature heads have a shorter storage life, a rule of thumb that growers use to some extent to control stocks.
We found no useful relationship between colour measurement at harvest and subsequent keeping quality but we identified one particular chlorophyll fluorescence characteristic that we found correlates consistently with Maturity Index after four days of shelf-life and we used this to produce a simple predictive model. The data indicates that the two cultivars we have tested follow the same or very similar models, but the model can be improved by including head size to make more accurate predictions of storage and shelf-life behaviour.

The indications so far are that measurement of this particular chlorophyll fluorescence characteristic may prove to be a practical method to assess broccoli storage potential. The evidence is not yet strong enough to suggest that it could be used to grade individual heads, but it could be used to predict the overall behaviour of consignments. As an illustration of this, Figure B shows a plot between the predicted and actual Maturity Index for four consignments of broccoli.

There may also be potential to use this technology as a tool to help growers make decisions on changes to crop management in the field which will improve a crop’s keeping qualities.

![Figure B. Actual v predicted Maturity Index after 4 days shelf-life using the model developed using head diameter and chlorophyll fluorescence](image)
Priorities for the next phase of this project will be:

- Design a specialised sensor head, increase accuracy and speed up measurement
- Test the ability of chlorophyll fluorescence in a commercial situation to distinguish storability of consignments at harvest and during storage in order to improve crop scheduling. This will include refining the measurement practices, such as stage of measurement (before/after harvest), time of day, number of heads.
- Test the use of chlorophyll fluorescence measurements during head development as a means to optimise growing practices for improved quality/storability.

Financial Benefits

The potential financial benefits from this project will arise as a result of growers being able to predict the storage potential of consignments, so that they can optimise scheduling of harvesting and the order of distribution of consignments.

Action Points

No specific change in practices is recommended at this stage of the project. However, in order to ensure that the technology development is focused as effectively as possible to industry needs, the researchers welcome input from growers on the way in which they would envisage using the technology.