Optical Caliper for Tomato Head Thickness

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Gewasgroei Goed Gemeten

Partners: 2Grow bvba, 2Harvest, AVAG Greenhouse Technology, Axia Vegetables Seeds BV, Duijvestijn Tomaten BV, Greenport West Holland, GRN Consultancy BV, Horti-Tech BV, LetsGrow.com, Van der Knaap Group of Companies, Tomatoworld, Vertify, V.O.F. Reijm en Zn Komkommerkwekerij

Project 'Gewasgroei Goed Gemeten'

Measuring plant health and status is key for growers in the Dutch greenhouse horticulture industry to create optimal conditions for plant growth and predictability and optimization of yield with minimal energy cost. Within the **'Gewasgroei Goed Gemeten'** project led by The Hague University of Applied Sciences (project leader dr. John Bolte), plant data plays a key role. The consortium of researchers and entrepreneurs aims to pave the way towards large-scale application of sensor technology to record plant growth. Such a large-scale application asks for accurate, but low-cost sensors to be developed. Results of this project's research and development, together with suppliers, growers and breeders, will advance the technology for Dutch horticulture and abroad, where there is a growing demand for Dutch knowledge and expertise.

Optical Caliper

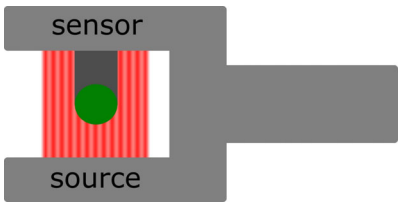
The most important parameters to be measured are the *Head Thickness* and the *Leaf Area Index* of the crop. Both parameters are related to the sap flow which is indicative for vegetative and reproductive growth.
For tomato growers Head Thickness is defined as the thickness of the stem about 25 cm to 30 cm below the top. Currently, head thickness is measured manually with a caliper, which is labor-intensive and has the disadvantage that the plant is touched, which has negative impact on its growth. We are developing an optical caliper allowing for contactless measurement of head thickness.

Requirements Optical Caliper

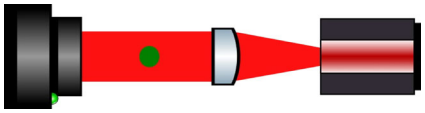
- Handheld contactless head thickness measurement
- Range up to 15 mm (nominal size 10 mm)
- Accuracy 0.1 mm
- Highly reproducible results
- Real time measurement

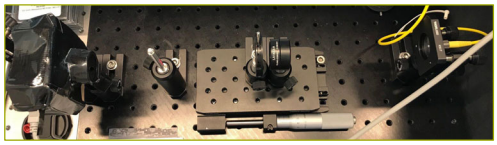
Design / Setup

Simple measurement principle:
measure the shadow cast by the stem



Current setup:
- 635 nm laser source, expanded and collimated to about 30 mm to create a parallel light beam
- Detection of the stem shadow with a line scan camera (14 µm pixel width), with a 625 nm filter to be able to work in well lighted conditions.





First results

Tests were performed with cylinders with diameters in the range 6 to 13 mm. An example intensity profile is shown in figure 1.

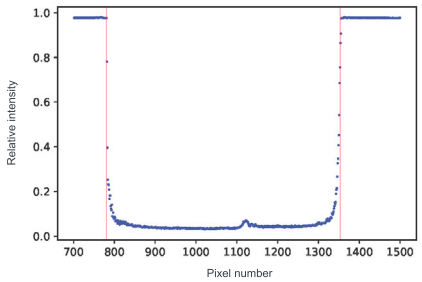


Figure 1: Relative intensity profile of the line scan camera showing the shadow cast by an 8 mm cylinder.

Results from the optical caliper agree within 0.01 - 0.08 mm with the conventional digital caliper contact measurement, as seen in table 1. The accuracy of the method fulfills the requirement of 0.1 mm.

Table 1: Results from the optical caliper compared to a conventional digital caliper for cylinders of different width.

Diameter [mm]	Digital caliper [mm]	Optical caliper [mm]
6	6.00	5.922
8	7.97	7.952
10	9.97	9.982
12,7	12.65	12.684

Measurements with the cylinder placed at different distances from the line array show that the laser light is well collimated resulting in insensitivity to position within the required accuracy, as seen in table 2.

Table 2: Results from the optical caliper for cylinders of different width at different distances to the sensor.

Diameter [mm]\ position [a.u.]	1	2	3
6	6.006	5.978	5.866
8	8.008	8.008	7.994
10	10.038	10.010	10.010
12,7	12.656	12.740	12.656

Conclusion

The **measurement principle is proven** with the first measurements. The next step is to translate this principle into a user friendly, compact, cost effective, handheld devise that can be used in the greenhouse directly.

Future setup:
- Reduce the setup size by applying two reflection gratings in the optical path, redirecting and expanding the light beam in one direction, allowing for a smaller sensor area.