OPTI-SCIENCES, INC.

CCM-300 - The Chlorophyll Content Meter proven for *very small* leaves & difficult to measure samples

The CCM-300 Uses a proven fluorescence ratio technique for chlorophyll content measurement from Gittelson (1999).

Unlike absorption chlorophyll content measuring systems, samples do not have to fill the measuring aperture for reliable measurement.

Applications

***Published References* for:**

Scots Pine Seedlings

Spruce Seedlings

2 week old Arabidopsis

17 day old Rice seedlings

7-42-day old Transgenic Barley

Moss on Rocks in Antarctica

CAM plants - Prickly Pear Cactus

Peat Moss

Chlorolichens

Golf Green Grass & Silvery-Thread Moss

Orchard Grass

also for... Corn, Soybeans, Sugar Cane Maple trees, Potatoes, Wheat & Poison Ivy

Advantages

- Direct readout of chlorophyll content in mg m^{-2} .
- Much larger reliable measuring range than absorption style meters. Get better results at higher chlorophyll content levels.
- Provides reliable results regardless of leaf or sample size, thickness, and shape. Offers a high degree of correlation with chemical tests.
- Measurement modes include discrete single measurement and sample averaging from 2-30 samples. Software allows either mean or median option selections.
- Almost unlimited measurement storage up to 1 gigabyte of non volatile flash memory.
- USB output: files are comma delineated & may be opened directly in Excel® or other spread sheet software.
- Graphic Color touch screen & data display.

Tel: (603) 883-4400 Fax: (603) 883-4410 Web: www.optisci.com Email:sales@optisci.com

CCM-300 Chlorophyll Content Meter

CAM Plants, Conifers, Grasses, Moss, Chlorolichens

Measures chlorophyll content reliably from 41 mg m^{-2} to 675 mg m^{-2}

Gitelson 1999

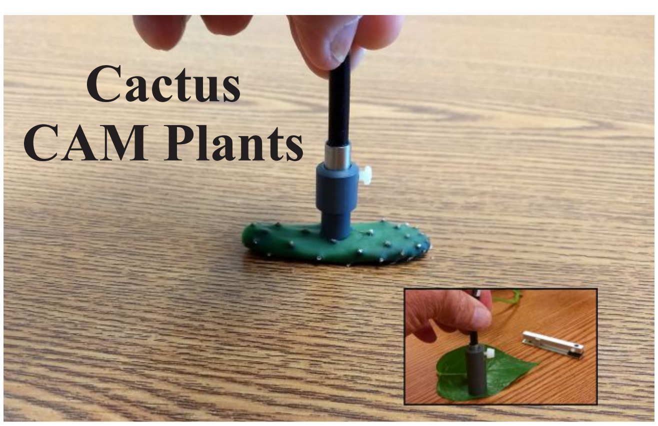
Leaf absorption based chlorophyll content technology has been shown to provide reliable measurements up to only about 400 mg m^{-2} , where the technology saturates. However, well fertilized healthy plants can have significantly higher chlorophyll content values.

Gitelson's ratio fluorescence method has been shown to measure reliably up to 675 mg m^{-2}, providing better measurements of well fertilized plants and earlier plant stress measurement sensitivity.

More examples of difficult samples

Measuring immature rice

Measuring Arabidopsis thalia the same day as germination.



Accessories: Optional optical probes

Cylindrical probes allow fiberoptic placement in a perpendicular position to the sample for more repeatable results on samples that are difficult for the standard leaf clip. They should be considered for measuring samples like moss on rocks, CAM plants or very short grasses.

They are not part of the standard equipment.

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Published CCM-300 References

Difficult to measure sample references -

17-day old rice seedling chlorophyll content measurement

Chia-Cheng Kan, Tsui-Yun Chung, Yan-An Juo Ming-Hsiun Hsieh (2015) Glutamine rapidly induces the expression of key transcription factor genes involved in nitrogen and stress responses in rice roots BMC Genomics201516:731 https://doi.org/10.1186/s12864-015-1892-7

2 week-old Arabidopsis thaliana seedlings

Jasmina Kurepa, Timothy E. Shull, Jan A. Smalle (2016) Quercetin feeding protects plants against oxidative stress. F1000Research 2016, 5:2430 Last updated: 25 DEC 2016) Latest published: 03 October 2016, 5:2430 (doi: 10.12688/f1000research.9659.1)

Spruce saplings

O Krišāns, Ā Jansons, G Ievinsh (2016) Effect of decreased precipitation events on primary growth and photosynthesis-related characteristics of spruce (Picea abies) saplings grown in different substrates - THE 74th SCIENTIFIC CONFERENCE OF THE UNIVERSITY OF LATVIA 2016 - eeb.lu.lv

Moss in Antarctica

Erin E. Shortlidge, Sarah M. Eppley, Hans Kohler, Todd N. Rosenstiel, Gustavo E. Zúñiga, Angélica Casanova-Katny, (2017) Passive warming reduces stress and shifts reproductive effort in the Antarctic moss, Polytrichastrum alpinum Annals of Botany, Volume 119, Issue 1, 1 January 2017, Pages 27–38, https://doi.org/10.1093/aob/mcw201

Coral - wave motion & nutrient stress

Dana Riddle (2015) Coral Nutrition Part 4: Can Nutrient Deficiency Related to Water Motion Induce Coral Bleaching? Advanced Aquarist Volume XVI › June 2015 https://www.advancedaquarist.com/2015/6/aafeature

Chlorolichens

Shuai Liu, Su Li, Xiao-Yang Fan, Guo-Di Yuan, Tao Hu, Xian-Meng Shi, Jun-Biao Huang, Xiao-Yan Pu, Chuan-Sheng Wu (2019) Comparison of **two** noninvasive methods for measuring the pigment content in foliose macrolichens. et al. Photosynth Res (2019). https://doi.org/10.1007/s11120-019-00624-x

Difficult to measure sample references -

Orchard grass

Gordon B. Jones, Jasper B. Alpuerto, Benjamin F. Tracy, and Takeshi Fukao (2017) Physiological Effect of Cutting Height and High Temperature on Regrowth Vigor in Orchard grass. Front Plant Sci. 2017; 8: 805. Published online 2017 May 19. doi: 10.3389/fpls.2017.00805 PMCID: PMC5437204

7-42-day old transgenic barley

PetrVojta, FilipKokáš, Alexandra Husičková, JiříGrúz, VeroniqueBergougnoux, Cintia F. Marchetti, Eliška Ježilová, Václav Mik, Yoshihisa Ikeda, Petr Galuszka, (2016) Whole transcriptome analysis of transgenic barley with altered cytokinin homeostasis and increased tolerance to drought stress. New Biotechnology Volume 33, Issue 5, Part B, 25 September 2016, Pages 676-691 https://doi.org/10.1016/j.nbt.2016.01.010

Scots pine seedlings

Tapani Repo, Samuli Launiainen, Tarja Lehto, Sirkka Sutinen, Hanna Ruhanen, Juha Heiskanen, Ari Laurén, Raimo Silvennoinen, Elina Vapaavuori, Leena Finér (2016) The responses of Scots pine seedlings to waterlogging during the growing season   Canadian Journal of Forest Research 2016, 46(12): 1439-1450, https://doi.org/10.1139/cjfr-2015-0447

Norway spruce and Scots pine seedings

Johanna Riikonen, Nelli Kettunen, Maria Gritsevich, Teemu Hakala, Liisa Särkkä, Risto Tahvonen, (2016) Growth and development of Norway spruce and Scots pine seedlings under different light spectra Environmental and Experimental Botany Volume 121, January 2016, Pages 112-

Peatland vegetation sphagnum moss and other Peatland plants

Anshu Rastogi, Marcin Stróżeckia, Hazem M. Kalaji, Dominika Łuców de Mariusz, Lamentowicz, Radosław Juszczak (2019) Impact of warming and reduced precipitation on photosynthetic and remote sensing properties of peatland vegetation Environmental and Experimental Botany Volume 160, April 2019, Pages 71-80 https://doi.org/10.1016/j.envexpbot.2019.01.005

Published CCM-300 References

Difficult to measure sample references -

CAM plants – Prickly Pear Cactus -Opuntia humifusa & Opuntia stricta

Kudakwashe Musengi (2018) THE BIOLOGICAL CONTROL OF CACTI (CACTACEAE: OPUNTIOIDEAE) IN SOUTH AFRICA: BASIS OF HOST SELECTION IN THE 'STRICTA' BIOTYPE OF DACTYLOPIUS OPUNTIAE (COCKERELL) (HEMIPTERA: DACTYLOPIIDAE). University of the Witwatersrand, South Africa. May 2018. file:///C:/Users/Sales/Desktop/CCM-300%20on%20cactus.pdf

Golf green grass & Silvery-Thread Moss

ZRaudenbush Z.T, Greenwood J.L., McLetchie D.N., Eppley D.N. (2018) Divergence in Life-History and Developmental Traits in Silvery-Thread Moss (Bryum argenteum Hedw.) Genotypes between Golf Course Putting Greens and Native Habitats. Cambridge University Press: 11 September 2018, Volume 66, Issue 5 , September 2018 , pp. 642-650 , DOI: https://doi.org/10.1017/wsc.2018.37

Easier plants -

Corn

Thomas R. Butts, Joshua J. Miller, J. Derek Pruitt, Bruno C. Vieira, Maxwel C. Oliveira, Salvador Ramirez II, John L. Lindquist (2017) Light Quality Effect on Corn Growth as Influenced by Weed Species and Nitrogen Rate. Journal of Agricultural Science Vol 9, No 1 (2017) DOI: http://dx.doi.org/10.5539/jas.v9n1p15

Nursery nitrogen status

MJ Clark, Y Zheng (2017) Effect of Top-dressed Controlled-release Fertilizer Rates on Nursery Crop Quality and Growth and Growing Substrate Nutrient Status in the Niagara Region, Ontario, Canada. doi: 10.21273/HORTSCI11309-16 HortScience January 2017 vol. 52 no. 1 167-173

Soybean

Pradeep Wagle, Prasanna H. Gowda, Saseendran S. Anapalli, Krishna N. Reddy, Brian K. Northup, (2017) Growing season variability in carbon dioxide exchange of irrigated and rainfed soybean in the southern United States. Science of The Total Environment,–Volumes 593594, 1 September 2017, Pages 263-273 https://doi.org/10.1016/j.scitotenv.2017.03.163

Easier plants -

Potato

Maropeng Vellry Nemutanzhela, David Mxolisi Modise, Kotose Joseph Siyoko, Sheku Alfred Kanu (2017) Assessment of Growth, Tuber Elemental Composition, Stomatal Conductance and Chlorophyll Content of Two Potato Cultivars Under Irrigation with Fly Ash-Treated Acid Mine Drainage. American Journal of Potato Researc August 2017, Volume 94, Issue4, pp 367–378

Noccaea Brassicaceae - flowering plant

Soledad Martos, Berta Gallego, Llorenç Sáez, Javier López-Alvarado, Catalina Cabot, and Charlotte Poschenrieder (2016) Characterization of Zinc and Cadmium Hyperaccumulation in Three Noccaea (Brassicaceae) Populations from Non-metalliferous Sites in the Eastern Pyrenees Front Plant Sci. 2016; 7: 128. Published online 2016 Feb 9. doi: 10.3389/fpls.2016.00128

Poison Ivy

John G. Jelesko, Elise B. Benhase, Jacob N. Barney (2017) Differential Responses to Light and Nutrient Availability by Geographically Isolated Poison Ivy Accessions. Northeastern Naturalist 24(2):191-200. 2017 https://doi.org/10.1656/045.024.0210

Sugar Maple

Amritpal S. Singh, A. Maxwell P. Jones, Mukund R. Shukla, Praveen K. Saxena (2017) High light intensity stress as the limiting factor in micropropagation of sugar maple (Acer saccharum Marsh.) Plant Cell, Tissue and Organ Culture (PCTOC), May 2017, Volume 129, Issue2, pp 209–221, doi:10.1007/s11240-017-1170-2

Cd and Cu stress in road side plants

Margita Kuklová, Helena Hniličková, František Hnilička, Ivica Pivková, Ján Kukla (2019) Impact of expressway on physiology of plants and accumulation of risk elements in forest ecosystems Plant Soil Environ., 65: 46 53. https://doi.org/10.17221/585/2018-PSE

CCM-300 Chlorophyll Content Meter

CAM Plants, Conifers, Grasses, Moss, Chlorolichens

The science for measuring chlorophyll content using ratio chlorophyll fluorescence has been well established. The cost for such systems, however, has been much higher than for the more popular light absorption instruments available. As a result, the ability to measure very small samples, curved samples and very thick samples has been out of reach for most budgets.

With the CCM 300, Opti-Sciences has engineered a ratio fluorescence solution that is much closer to the cost of absorption techniques.

While it is still more cost effective to use the CCM-200plus for medium size and larger leaves on most wheat or corn plants, the CCM-300 is in an affordable price range to allow cost effective measurement of chlorophyll content in *very* small leaves, and other difficult to measure samples.

Unlike absorption techniques that require full coverage of the measuring aperture, and a relatively flat surface for reliable measurement, this fluorescence technique does not. Instead, the sample absorbs light at one wavelength, and it is re-emitted as fluorescence at longer wavelengths.

This allows measurement of curved samples like individual conifer needles, leaves that are too thick for absorption techniques found in CAM plants, and samples that are too small for reliable absorption technique measurements such as moss, turf grasses, Arabidopsis, and immature rice.

Furthermore, the correlation with chemical measuring techniques is excellent, even at higher chlorophyll content levels.

The design of this instrument was based on the science from Gitelson A. A., Buschmann C., Lichtenthaler H. K. (1999)

The fluorescence emission and excitation wavelengths used in this test were designed to provide the maximum chlorophyl measuring range, and minimize possible measuring errors.

Measurement method reference:

Gitelson A. A., Buschmann C., Lichtenthaler H. K. (1999) "The Chlorophyll Fluorescence Ratio F735/F700 as an Accurate Measure of Chlorophyll Content in Plants" Remote Sens. Enviro. 69:296-302 (1999)

Technical Specifications

Measured Parameters: Chlorophyll content in mg m^{-2} and CFR or Chlorophyll Fluorescence Ratio - fluorescence emission ratio of intensity at 735nm / 700nm.

Measurement Area: 3 mm diameter circle, external diameter of 4 mm. However, the instrument will reliably measure samples that are much smaller than 3 mm.

Resolution: Ratio 0.01 or 1 mg m^{-2}.

Repeatability: is dependent on signal strength. For samples with low signal strength, averaging of multiple measurements is recommended. for samples with good signal strength, ratio values of +- 0.03 or better, are common.

Noise: <+/- 2%

Source: (1) LED 460 nm blue diode half band width 15 nm.

Detector: Two solid state, high sensitivity detectors. Band limiting filter sets provided. Dual wavelength detection at the same time. 700nn to 710nm, and 730 nm to 740 nm.

Detection: Modulated light digitally controlled to minimize background detection. Temperature compensation included for light source and detector

Storage Capacity: Up to 1 gigabyte of non-volatile flash memory

Modes: Single point measurement, & measurement averaging for 2- 30 samples, averaging with 2 sigma outlier removal, or median determination.

User Interface: 240 x 320 pixel Color touch screen

Output: USB 1.1

Temperature Range: 0-50 Deg C

Power Source: 2 Rechargeable AA batteries. Charger supplied with instrument.

Auto Off Interval: (no key press or download) programable from 0 to 20 minutes.

Size: 12cm x 9cm x 3 cm

Weigh: 0.6 lbs 275g

Measuring time: 5 seconds

Components included: CCM 300 Chlorophyll content meter, fiberoptic, sample clip, battery charger, 4 AA NiMH rechargeable batteries, USB cable, carrying case and manual.

Optional probe tips: for CAM plants, moss on rocks, & samples that do not work with a leaf clip. - not included.