UNIVERSITAS
GADJAH MADA
Evaluation of a Plant Fisiology Monitoring System Performance Based on Visible-Near Infrared Spectroscopy in a Controlled Environment
Arifa Haryani, Andri Prima Nugroho, S.T.P., M.Sc., Ph.D. ; Prof. Dr. Nazmi Mat Nawi
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

REFERENCES

Acosta, M., Quiñones, A., Munera, S., De Paz, J. M., & Blasco, J. (2023). Rapid Prediction of Nutrient Concentration in Citrus Leaves Using Vis-NIR Spectroscopy. *Sensors*, *23*(14), 6530. https://doi.org/10.3390/s23146530

Anum, H., Li, K., Tabusam, J., Saleh, S. A. A., Cheng, R., & Tong, Y. (2024). Regulation of anthocyanin synthesis in red lettuce in plant factory conditions: A review. *Food Chemistry*, *458*, 140111. https://doi.org/10.1016/j.foodchem.2024.140111

Arachchige, C. N. P. G., Prendergast, L. A., & Staudte, R. G. (2022). Robust analogs to the coefficient of variation. *Journal of Applied Statistics*, *49*(2), 268–290. https://doi.org/10.1080/02664763.2020.1808599

Atanassova, S., Petrova, A., Yorgov, D., Mineva, R., & Veleva, P. (2025). Visible and Near-Infrared Spectroscopy for Investigation of Water and Nitrogen Stress in Tomato Plants. *AgriEngineering*, *7*(5), 155. https://doi.org/10.3390/agriengineering7050155

Badura, M., Batog, P., Drzeniecka-Osiadacz, A., & Modzel, P. (2019). Regression methods in the calibration of low-cost sensors for ambient particulate matter measurements. *SN Applied Sciences*, *1*(6), 622. https://doi.org/10.1007/s42452-019-0630-1

Bai, Y., Liao, Z., Shang, J., Gan, W., Kong, X., & Wei, X. (2025). A review on real-time plant monitoring sensors for smart agriculture. *Chemical Engineering Journal*, *523*, 168868. https://doi.org/10.1016/j.cej.2025.168868

UNIVERSITAS
GADJAH MADA
Evaluation of a Plant Fisiology Monitoring System Performance Based on Visible-Near Infrared Spectroscopy in a Controlled Environment
Arifa Haryani, Andri Prima Nugroho, S.T.P., M.Sc., Ph.D. ; Prof. Dr. Nazmi Mat Nawi
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Banik, S., Kibria, B. M. G., & Sharma, D. (2012). Testing the Population Coefficient of Variation. *Journal of Modern Applied Statistical Methods*, *11*(2), 325–335. https://doi.org/10.22237/jmasm/1351742640

Bilal, S., Khan, T., Asaf, S., Khan, N. A., Saad Jan, S., Imran, M., Al-Rawahi, A., Khan, A. L., Lee, I.-J., & Al-Harrasi, A. (2023). Silicon-Induced Morphological, Biochemical and Molecular Regulation in Phoenix dactylifera L. under Low-Temperature Stress. *International Journal of Molecular Sciences*, *24*(7), 6036. https://doi.org/10.3390/ijms24076036

Buljubašić, I., & Delalić, S. (2008). *IMPROVEMENT OF STEAM BOILER PLANT EFFICIENCY BASED ON RESULTS OF ON-LINE PERFORMANCE MONITORING*.

Centore, Paul. (2015). *The coefficient of variation as a measure of spectrophotometric repeatability*. *571–579*. https://doi.org/doi-org.ezproxy.ugm.ac.id/10.1002/col.22002

Chen, F., Zhao, G., Shen, Y., Li, Z., Tan, B., Zhu, H., Wang, Q., & Fu, X. (2022). Shading Gradients Drive Differential Responses of Leaf Traits in an Early Community Germinated by Forest Topsoil. *Diversity*, *14*(8), 600. https://doi.org/10.3390/d14080600

Chen, H.-Y., & Chen, C. (2022). Evaluation of Calibration Equations by Using Regression Analysis: An Example of Chemical Analysis. *Sensors*, *22*(2), 447. https://doi.org/10.3390/s22020447

Chi, Haoran, Li, Yingxue, Wu, Fang, & Zou, Xiaochen. (2025). *Spectral scale effects on the optical estimation of winter wheat leaf SPAD value*.

UNIVERSITAS
GADJAH MADA
Evaluation of a Plant Fisiology Monitoring System Performance Based on Visible-Near Infrared Spectroscopy in a Controlled Environment
Arifa Haryani, Andri Prima Nugroho, S.T.P., M.Sc., Ph.D. ; Prof. Dr. Nazmi Mat Nawi
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Cotrozzi, L., Peron, R., Tuinstra, M. R., Mickelbart, M. V., & Couture, J. J. (2020). Spectral Phenotyping of Physiological and Anatomical Leaf Traits Related with Maize Water Status. *Plant Physiology*, *184*(3), 1363–1377. https://doi.org/10.1104/pp.20.00577

Dabek, A., Mantovani, L., Mirabella, S., Vignati, M., & Cinquemani, S. (2025). Advancements in Non-Destructive Detection of Biochemical Traits in Plants Through Spectral Imaging-Based Algorithms: A Systematic Review. *Algorithms*, *18*(5), 255. https://doi.org/10.3390/a18050255

Data, M., Yahya, W., & Kurniawan, A. (2020). Implementasi Teknologi Virtualisasi Berbasis Kontainer untuk Perangkat Internet of Things pada Pertanian Presisi. *CYBERNETICS*, *3*(01), 1. https://doi.org/10.29406/cbn.v3i01.1448

Daurai, B., Ramchiary, S. S., & Gogoi, M. (2023a). Comparison of Sparkfun TRIAD AS7265x spectroscopy sensor device with a Spectrophotometer for qualitative and quantitative analysis. *2023 4th International Conference on Computing and Communication Systems (I3CS)*, 1–3. https://doi.org/10.1109/I3CS58314.2023.10127282

Daurai, B., Ramchiary, S. S., & Gogoi, M. (2023b). Comparison of Sparkfun TRIAD AS7265x spectroscopy sensor device with a Spectrophotometer for qualitative and quantitative analysis. *2023 4th International Conference on Computing and Communication Systems (I3CS)*, 1–3. https://doi.org/10.1109/I3CS58314.2023.10127282

Dey, B., & Ahmed, R. (2025). A comprehensive review of AI-driven plant stress monitoring and embedded sensor technology: Agriculture 5.0. *Journal of*

UNIVERSITAS
GADJAH MADA
Evaluation of a Plant Fisiology Monitoring System Performance Based on Visible-Near Infrared Spectroscopy in a Controlled Environment
Arifa Haryani, Andri Prima Nugroho, S.T.P., M.Sc., Ph.D. ; Prof. Dr. Nazmi Mat Nawi
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Industrial Information Integration, *47*, 100931. https://doi.org/10.1016/j.jii.2025.100931

Dias, D. P., & Marenco, R. A. (2025). Carbon uptake in response to climatic seasonality and time of day in Amazonian trees from different forest strata: The effect of shading on morning photosynthesis. *Ciência Rural*, *55*(10), e20240240. https://doi.org/10.1590/0103-8478cr20240240

Dinneny, J. R. (2015). A developmental biologist's journey to rediscover the Zen of plant physiology. *F1000Research*, *4*, 264. https://doi.org/10.12688/f1000research.6167.1

Dsouza, A., Newman, L., Graham, T., & Fraser, E. D. G. (2023). Exploring the landscape of controlled environment agriculture research: A systematic scoping review of trends and topics. *Agricultural Systems*, *209*, 103673. https://doi.org/10.1016/j.agsy.2023.103673

Engler, N., & Krarti, M. (2021). Review of energy efficiency in controlled environment agriculture. *Renewable and Sustainable Energy Reviews*, *141*, 110786. https://doi.org/10.1016/j.rser.2021.110786

Eskandarzade, P., Zare Mehrjerdi, M., Didaran, F., Gruda, N. S., & Aliniaeifard, S. (2023). Shading Level and Harvest Time Affect the Photosynthetic and Physiological Properties of Basil Varieties. *Agronomy*, *13*(10), 2478. https://doi.org/10.3390/agronomy13102478

Falcioni, R., Antunes, W. C., Demattê, J. A. M., & Nanni, M. R. (2023). A Novel Method for Estimating Chlorophyll and Carotenoid Concentrations in Leaves:

UNIVERSITAS
GADJAH MADA
Evaluation of a Plant Fisiology Monitoring System Performance Based on Visible-Near Infrared Spectroscopy in a Controlled Environment
Arifa Haryani, Andri Prima Nugroho, S.T.P., M.Sc., Ph.D. ; Prof. Dr. Nazmi Mat Nawi
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

A Two Hyperspectral Sensor Approach. *Sensors*, *23*(8), 3843. https://doi.org/10.3390/s23083843

Gan, C. I., Soukoutou, R., & Conroy, D. M. (2022). Sustainability Framing of Controlled Environment Agriculture and Consumer Perceptions: A Review. *Sustainability*, *15*(1), 304. https://doi.org/10.3390/su15010304

Gardiner-Piggott, A., McAinsh, M., Toledo-Ortiz, G., & Orr, D. J. (2025). The Effects of High Temperature Stress and Its Mitigation Through the Application of Biostimulants in Controlled Environment Agriculture. *Agronomy*, *15*(12), 2742. https://doi.org/10.3390/agronomy15122742

Ge, Y., Atefi, A., Zhang, H., Miao, C., Ramamurthy, R. K., Sigmon, B., Yang, J., & Schnable, J. C. (2019). High-throughput analysis of leaf physiological and chemical traits with VIS–NIR–SWIR spectroscopy: A case study with a maize diversity panel. *Plant Methods*, *15*(1), 66. https://doi.org/10.1186/s13007-019-0450-8

Gorretta, N., & Gowen, A. A. (2020). Visible and Near Infrared Optical Spectroscopic Sensors for Biosystems Engineering. *In N. M. Holden, M. L. Wolfe, J. A. O. Ogejo, & E. J. Cummins (Eds.)Introduction to Biosystems Engineering.*

Graamans, L., Baeza, E., Van Den Dobbelsteen, A., Tsafaras, I., & Stanghellini, C. (2018). Plant factories versus greenhouses: Comparison of resource use efficiency. *Agricultural Systems*, *160*, 31–43. https://doi.org/10.1016/j.agsy.2017.11.003

UNIVERSITAS
GADJAH MADA
Evaluation of a Plant Fisiology Monitoring System Performance Based on Visible-Near Infrared Spectroscopy in a Controlled Environment
Arifa Haryani, Andri Prima Nugroho, S.T.P., M.Sc., Ph.D. ; Prof. Dr. Nazmi Mat Nawi
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Hakkim, V., Joseph, E., Gokul, A., & Mufeedha, K. (2016). Precision Farming: The Future of Indian Agriculture. *Journal of Applied Biology and Biotechnology*, 068–072. https://doi.org/10.7324/JABB.2016.40609

Heusinkveld, B. G., Mol, W. B., & Van Heerwaarden, C. C. (2023). A new accurate low-cost instrument for fast synchronized spatial measurements of light spectra. *Atmospheric Measurement Techniques*, *16*(15), 3767–3785. https://doi.org/10.5194/amt-16-3767-2023

Hu, C., Zhao, T., Duan, Y., Zhang, Y., Wang, X., Li, J., & Zhang, G. (2025). Visible-near infrared hyperspectral imaging for non-destructive estimation of leaf nitrogen content under water-saving irrigation in protected tomato cultivation. *Frontiers in Plant Science*, *16*, 1676457. https://doi.org/10.3389/fpls.2025.1676457

Humberto E, G., Lin, W.-C., Meerkov, S. M., & Ravichandran, M. T. (2013). Resilient plant monitoring system: Design, analysis, and performance evaluation. *United States*. https://doi.org/10.1109/CDC.2013.6760671

Inoue, Y., Guérif, M., Baret, F., Skidmore, A., Gitelson, A., Schlerf, M., Darvishzadeh, R., & Olioso, A. (2016). Simple and robust methods for remote sensing of canopy chlorophyll content: A comparative analysis of hyperspectral data for different types of vegetation. *Plant, Cell & Environment*, *39*(12), 2609–2623. https://doi.org/10.1111/pce.12815

Jiang, J., Zhang, Q., & Gao, S. (2025). Enhancing Multi-Flight Unmanned-Aerial-Vehicle-Based Detection of Wheat Canopy Chlorophyll Content Using

UNIVERSITAS
GADJAH MADA
Evaluation of a Plant Fisiology Monitoring System Performance Based on Visible-Near Infrared Spectroscopy in a Controlled Environment
Arifa Haryani, Andri Prima Nugroho, S.T.P., M.Sc., Ph.D. ; Prof. Dr. Nazmi Mat Nawi
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Relative Radiometric Correction. *Remote Sensing*, *17*(9), 1557. https://doi.org/10.3390/rs17091557

Jin, D., Su, X., Li, Y., Shi, M., Yang, B., Wan, W., Wen, X., Yang, S., Ding, X., & Zou, J. (2023). Effect of Red and Blue Light on Cucumber Seedlings Grown in a Plant Factory. *Horticulturae*, *9*(2), 124. https://doi.org/10.3390/horticulturae9020124

Johnson, M. A., & Thakur, S. (2025). Sprouts, microgreens, and baby leaves cultivation in controlled environment agriculture- a panacea for global food and nutritional security. *Food Bioscience*, *73*, 107579. https://doi.org/10.1016/j.fbio.2025.107579

Jung, C., & Arar, M. (2023). Natural vs. Artificial Light: A Study on the Influence of Light Source on Chlorophyll Content and Photosynthetic Rates on Indoor Plants. *Buildings*, *13*(6), 1482. https://doi.org/10.3390/buildings13061482

Karim, M. R., Haque, M. A., Ahmed, S., Reza, M. N., Lee, K.-D., Kang, Y. H., & Chung, S.-O. (2025). Effects of Sensor Speed and Height on Proximal Canopy Reflectance Data Variation for Rice Vegetation Monitoring. *Agronomy*, *15*(3), 618. https://doi.org/10.3390/agronomy15030618

Khaled, A. Y., Abd Aziz, S., Bejo, S. K., Nawi, N. M., & Abu Seman, I. (2018). Spectral features selection and classification of oil palm leaves infected by Basal stem rot (BSR) disease using dielectric spectroscopy. *Computers and Electronics in Agriculture*, *144*, 297–309. https://doi.org/10.1016/j.compag.2017.11.012

UNIVERSITAS
GADJAH MADA
Evaluation of a Plant Fisiology Monitoring System Performance Based on Visible-Near Infrared Spectroscopy in a Controlled Environment
Arifa Haryani, Andri Prima Nugroho, S.T.P., M.Sc., Ph.D. ; Prof. Dr. Nazmi Mat Nawi
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Kumar, A., Naroju, S. P., Kumari, N., Arsey, S., Kumar, D., Gubre, D. F., Roychowdhury, A., Tyagi, S., & Saini, P. (2024). The role of drought response genes and plant growth promoting bacteria on plant growth promotion under sustainable agriculture: A review. *Microbiological Research, 286,* 127827. https://doi.org/10.1016/j.micres.2024.127827

Kutschera, A., & Lamb, J. J. (2018). Light Meter for Measuring Photosynthetically Active Radiation. *American Journal of Plant Sciences*, *09*(12), 2420–2428. https://doi.org/10.4236/ajps.2018.912175

Lazim, S. M., Nawi, N. M., Sulaiman, Z., Mustafah, A. M., Soyoye, B. O., & Abdullah, N. (2023a). *Prediction and Classification of Chlorophyll Contents to Determine the Severity Levels of White Root Disease Infection on Rubber Leaves*. *54*(12).

Lazim, S. M., Nawi, N. M., Sulaiman, Z., Mustafah, A. M., Soyoye, B. O., & Abdullah, N. (2023b). *Prediction and Classification of Chlorophyll Contents to Determine the Severity Levels of White Root Disease Infection on Rubber Leaves*. *54*(12).

Li, Fenling, Wang, Li, Liu, Jing, & Chang, Qingrui. (2015). Remote sensing estimation of SPAD value for wheat leaf based on GF-1 data. *College of Resources and Environment, Northwest A&F University, Yangling, 712100, Shaanxi, China*. https://doi.org/DOI:%2010.6041/j.issn.1000-1298.2015.09.040

Lolitasya, A. Y., Hadi, M. Z. S., & Sa'adah, N. (2025a). Development of a Real-Time Soil NPK Prediction System Using AS7265X Spectral Sensor and Random Forest Regression. *2025 International Electronics Symposium (IES)*, 133–139. https://doi.org/10.1109/IES67184.2025.11161478

UNIVERSITAS
GADJAH MADA
Evaluation of a Plant Fisiology Monitoring System Performance Based on Visible-Near Infrared Spectroscopy in a Controlled Environment
Arifa Haryani, Andri Prima Nugroho, S.T.P., M.Sc., Ph.D. ; Prof. Dr. Nazmi Mat Nawi
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Lolitasya, A. Y., Hadi, M. Z. S., & Sa'adah, N. (2025b). Development of a Real-Time Soil NPK Prediction System Using AS7265X Spectral Sensor and Random Forest Regression. *2025 International Electronics Symposium (IES)*, 133–139. https://doi.org/10.1109/IES67184.2025.11161478

Lopin, P., Nawsang, P., Laywisadkul, S., & Lopin, K. V. (2025). *Evaluation of Low-Cost Multi-Spectral Sensors for Measuring Chlorophyll Levels Across Diverse Leaf Types*. Physical Sciences. https://doi.org/10.20944/preprints202503.1183.v1

maria, c, & csaba, c. (2002). Fundamentals of Spectroscopy', in Environmental Sampling and Analysis for Metals. *Lewis Publishers, p., 408.* https://doi.org/https://doi.org/https://doi.org/10.1201/9781420032345

Melo, P. H. R., Costa, E., Silva, G. P. V., Bortolheiro, F. P. A. P., Dantas, T., Binotti, F. F. S., Vendruscolo, E. P., Vieira, G. H. C., Andrade, L. H. C., & Lima, S. M. (2025). Direct and indirect blue light supplementation on growth, pigments, and gas exchange of young arugula plants. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, *53*(4), 14730. https://doi.org/10.15835/nbha53414730

Milton, E. J., Schaepman, M. E., Anderson, K., Kneubühler, M., & Fox, N. (2009). Progress in field spectroscopy. *Remote Sensing of Environment*, *113*, S92–S109. https://doi.org/10.1016/j.rse.2007.08.001

Muhammad, I., Shalmani, A., Ali, M., Yang, Q.-H., Ahmad, H., & Li, F. B. (2021). Mechanisms Regulating the Dynamics of Photosynthesis Under Abiotic Stresses. *Frontiers in Plant Science*, *11*, 615942. https://doi.org/10.3389/fpls.2020.615942

UNIVERSITAS
GADJAH MADA
Evaluation of a Plant Fisiology Monitoring System Performance Based on Visible-Near Infrared Spectroscopy in a Controlled Environment
Arifa Haryani, Andri Prima Nugroho, S.T.P., M.Sc., Ph.D. ; Prof. Dr. Nazmi Mat Nawi
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Naaz, S., Kumar, G. R., Sharma, M., & Pant, M. (2025). Advanced GPS Navigation Systems for Intelligent Transportation: Reliability Analysis and Cost Optimization. *2025 14th International Conference on System Modeling & Advancement in Research Trends (SMART)*, 407–412. https://doi.org/10.1109/SMART66937.2025.11389647

Nazara, R. V., Aini, N., Roviq, M., & Maghfoer, Moch. D. (2026). Stage-specific nutrient solution strength modulates fruit yield and biomass partitioning in cherry tomato (*Solanum lycopersicum* var. *Cerasiforme*) grown in wick hydroponics. *Journal of Plant Nutrition*, *49*(7), 1187–1201. https://doi.org/10.1080/01904167.2025.2606979

Nguyen, T. N. P., & Sung, J. (2024). Light Spectral-Ranged Specific Metabolisms of Plant Pigments. *Metabolites*, *15*(1), 1. https://doi.org/10.3390/metabo15010001

Padhiary, M., Kumar, A., & Sethi, L. N. (2025). Emerging technologies for smart and sustainable precision agriculture. *Discover Robotics*, *1*(1), 6. https://doi.org/10.1007/s44430-025-00006-0

Peter, H., Josef, P., Peter, P., & Patrick, H. (2005). *Model-based data reconciliation to improve accuracy and reliability of performance evaluation of thermal power plants*. https://doi.org/10.1115/GT2005-68937

Qamar, F., & Dobler, G. (2023). Atmospheric correction of vegetation reflectance with simulation-trained deep learning for ground-based hyperspectral remote sensing. *Plant Methods*, *19*(1), 74. https://doi.org/10.1186/s13007-023-01046-6

UNIVERSITAS
GADJAH MADA
Evaluation of a Plant Fisiology Monitoring System Performance Based on Visible-Near Infrared Spectroscopy in a Controlled Environment
Arifa Haryani, Andri Prima Nugroho, S.T.P., M.Sc., Ph.D. ; Prof. Dr. Nazmi Mat Nawi
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Rawal, A., Hartemink, A., Zhang, Y., Wang, Y., Lankau, R. A., & Ruark, M. D. (2024). Visible and near-infrared spectroscopy predicted leaf nitrogen contents of potato varieties under different growth and management conditions. *Precision Agriculture*, *25*(2), 751–770. https://doi.org/10.1007/s11119-023-10091-z

Rodrigues, J. A., & Correia, J. H. (2022). Enhanced Photodynamic Therapy: A Review of Combined Energy Sources. *Cells*, *11*(24), 3995. https://doi.org/10.3390/cells11243995

Rosyida, Karno, K., Putra, F. P., & Limantara, J. C. (2022). Efek cahaya LED merah dan biru pada pertumbuhan, hasil dan kandungan klorofil tanaman pakcoy (Brassica chinensis L.) dalam Growbox. *AGROMIX*, *13*(2), 168–174. https://doi.org/10.35891/agx.v13i2.3028

Ryu, D. K. (2012). Construction and operational test of a plant factory', American Society of Agricultural and Biological Engineers Annual International Meeting 2012. *Https://Doi.Org/10.13031/2013.42051*, *7(12)*, 5497–5505.

Sanyaolu, M., & Sadowski, A. (2024). The Role of Precision Agriculture Technologies in Enhancing Sustainable Agriculture. *Sustainability*, *16*(15), 6668. https://doi.org/10.3390/su16156668

Sharma, P., Jha, A. B., & Dubey, R. S. (2024). Strigolactones: Coordination with other phytohormones and enhancement of abiotic stress responses. *Environmental and Experimental Botany*, *223*, 105782. https://doi.org/10.1016/j.envexpbot.2024.105782

Siddiqui, M. A., Baig, M. H., & Yousuf, M. U. (2025). Performance and data acquisition from low-cost air quality sensors: A comprehensive review. *Air*

UNIVERSITAS
GADJAH MADA
Evaluation of a Plant Fisiology Monitoring System Performance Based on Visible-Near Infrared Spectroscopy in a Controlled Environment
Arifa Haryani, Andri Prima Nugroho, S.T.P., M.Sc., Ph.D. ; Prof. Dr. Nazmi Mat Nawi
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Quality, Atmosphere & Health, *18*(4), 1183–1203. https://doi.org/10.1007/s11869-024-01683-3

Sithiyopasakul, J., Archevapanich, T., Sithiyopasakul, S., Lasakul, A., Purahong, B., & Benjangkaprasert, C. (2024). Implementation of Cloud Computing and Internet of Things (IoT) by Performance Evaluation. *2024 12th International Electrical Engineering Congress (iEECON)*, 1–6. https://doi.org/10.1109/iEECON60677.2024.10537945

Swinton, S. M., Lupi, frank, & Robertson, G. P. (2007). *Ecosystem services and agriculture: Cultivating agricultural ecosystems for diverse benefits*. *64(2), pp*, 245–252. https://doi.org/https://doi.org/10.1016/j.ecolecon.2007.09.02

Syarovy, M., Nugroho, A. P., & Sutiarso, L. (2023). PEMANFAATAN MODEL NEURAL NETWORK DALAM GENERASI BARU PERTANIAN PRESISI DI PERKEBUNAN KELAPA SAWIT. *WARTA Pusat Penelitian Kelapa Sawit*, *28*(1), 39–54. https://doi.org/10.22302/iopri.war.warta.v28i1.97

Villagran, E., Espitia, J. J., Rodriguez, J., Gomez, L., Amado, G., Baeza, E., Aguilar-Rodríguez, C. E., Flores-Velazquez, J., Akrami, M., Gil, R., & Arias, L. A. (2025). Use of Lighting Technology in Controlled and Semi-Controlled Agriculture in Greenhouses and Protected Agriculture Systems—Part 1: Scientific and Bibliometric Analysis. *Sustainability*, *17*(4), 1712. https://doi.org/10.3390/su17041712

Wang, Li, Lei, Shao-Gang, Bian, Zheng-Fu, Peng, Jian, & Wang, Kai. (2019). *Hyperspectral Features of Typical Plants in Different Mining Disturbance Zones Caused by Coal Mining Collapse in Semi-Arid Areas*.

UNIVERSITAS
GADJAH MADA
Evaluation of a Plant Fisiology Monitoring System Performance Based on Visible-Near Infrared Spectroscopy in a Controlled Environment
Arifa Haryani, Andri Prima Nugroho, S.T.P., M.Sc., Ph.D. ; Prof. Dr. Nazmi Mat Nawi
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Xia, Y., Liu, W., Meng, J., Hu, J., Liu, W., Kang, J., Luo, B., Zhang, H., & Tang, W. (2024). Principles, developments, and applications of spatially resolved spectroscopy in agriculture: A review. *Frontiers in Plant Science*, *14*, 1324881. https://doi.org/10.3389/fpls.2023.1324881

Yudono, B. (2017). *Spektroskopi*. SIMETRI.

Zahir, S. A. D. M., Jamlos, M. F., Omar, A. F., Nordin, M. A. H., Raypah, M. E. A., Mamat, R., Jamlos, M. A., & Muncan, J. (2025). Quantifying the impact of varied NPK fertilizer levels on oil palm plants during the nursery stage: A Vis-NIR spectral reflectance analysis. *Smart Agricultural Technology*, *11*, 100864. https://doi.org/10.1016/j.atech.2025.100864

Zahir, S. A. D. M., Omar, A. F., Jamlos, M. F., Azmi, M. A. M., & Muncan, J. (2022). A review of visible and near-infrared (Vis-NIR) spectroscopy application in plant stress detection. *Sensors and Actuators A: Physical*, *338*, 113468. https://doi.org/10.1016/j.sna.2022.113468

Zhang, L., Jin, J., Wang, L., Rehman, T. U., & Gee, M. T. (2022). Elimination of Leaf Angle Impacts on Plant Reflectance Spectra Using Fusion of Hyperspectral Images and 3D Point Clouds. *Sensors*, *23*(1), 44. https://doi.org/10.3390/s23010044

Zhen, S., & Van Iersel, M. W. (2017). Far-red light is needed for efficient photochemistry and photosynthesis. *Journal of Plant Physiology*, *209*, 115–122. https://doi.org/10.1016/j.jplph.2016.12.004

Zhou, L., Wu, H., Jing, T., Li, T., Li, J., Kong, L., & Zhou, L. (2024). Estimation of Relative Chlorophyll Content in Lettuce (Lactuca sativa L.) Leaves under

UNIVERSITAS
GADJAH MADA
Evaluation of a Plant Fisiology Monitoring System Performance Based on Visible-Near Infrared Spectroscopy in a Controlled Environment
Arifa Haryani, Andri Prima Nugroho, S.T.P., M.Sc., Ph.D. ; Prof. Dr. Nazmi Mat Nawi
Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Cadmium Stress Using Visible—Near-Infrared Reflectance and Machine-Learning Models. *Agronomy*, *14*(3), 427. https://doi.org/10.3390/agronomy14030427

Zou, L., Li, H., Ding, X., Liu, Z., He, D., Kowah, J. A. H., Wang, L., Yuan, M., & Liu, X. (2022). A Review of The Application of Spectroscopy to Flavonoids from Medicine and Food Homology Materials. *Molecules*, *27*(22), 7766. https://doi.org/10.3390/molecules27227766