RETASTE Conference Abstracts
Vol. 3 RETASTE-LCA-553-Poster
Athens, Greece, 27-29 September, 2023

rethink food resources, losses, and waste 2023

Environmental Assessment of Integrated Robotic Cultivation System for Greenhouse Tomato Production

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Abstract

Modern agriculture contributes to a wide range of environmental impacts (i.e. climate change, acidification, eutrophication etc.), therefore, new cultivation soilless systems have emerged as a promising alternative over traditional agricultural techniques, enabling food production with substantially reduced environmental footprint (Bringezu, 2019; Horion et al., 2016). However, vegetable fruit harvesting and plant protection spraying treatments are still mainly manual with high labor costs and labor intensity (Villa-Henriksen et al., 2021). Thus, automated and intelligent harvesting and spaying of greenhouse cultivations, using robots is receiving increasing attention (e.g., Kounalakis et al., 2021). Even though several scientific reports evaluate the production efficiency of the recently introduced agri-robots integrated in existing cropping systems, their environmental impact in comparison to conventional hydroponic cultivation is still not addressed (Pons et al., 2015). Here we assess and compare the environmental footprint of automated agri-robot as part of the general assessment of hydroponic cultivation of tomato process (RTM) and that of the existing soilless tomato cultivation model (CTM), using Life Cycle Assessment (LCA). Consequently, a total of 18 environmental impact categories were examined separately, namely, (i) fine particulate matter formation, (ii) fossil recourse scarcity, (iii) freshwater eutrophication, (iv) fresh water ecotoxicity, (v) global warming, (vi) human carginogenic toxicity, (vii) human non-carcinogenic toxicity, (viii) ionizing radiation, (ix) land use, (x) marine ecotoxicity, (xi) mineral recourse scarcity, (xii) ozone formation - human health, (xiii) ozone formation – terrestrial ecosystems, (xiv) stratospheric ozone depletion, (xv) terrestrial acidification, (xvi) terrestrial ecotoxicity, and (xvii) water consumption. Information on CTM and RTM LCA variables were documented during the SOilless culture UPgrade (SOUP) Project which designed, developed, and tested a multi-functional greenhouse robot for hydroponic tomato cultivation. The assessment was conducted in Open-LCA. LCA results, indicate that CTM emits 685.20 kg CO_2 eq per 1 ton of produced tomato, whereas RTM emits 537.97 kg CO_2 eq per 1 ton of produced tomato, i.e. 21% less. Approximately 75% of this impact is mainly due to the energy subsystem attributable to the emission of greenhouse

gases for electricity production. Concomitantly, the CO_2 eq difference, between the two evaluated production systems, is 147.23 kg CO_2 per year. It is indicative that a car in Greece emits approximately 1.157,34 kg CO_2/year. Interpreting the results becomes evident that the reduction in CO_2 emission of a 1 ha SOUP production system equals to 3 cars annual CO_2 emission (3,535.44 CO_2/year) in Greece. Additionally, tomato production in RTM have 19.5% reduced non-carcinogenic human toxicity compared to CTM cultivation model. At the same time, the reduction of fertilizers and pesticides impact by 30% and 20%, respectively, demonstrate the significant contribution of RTM technology to the workforce health and safety during the cultivation practices. These results highlight the importance of RTM technology for reducing environmental impact of greenhouse tomato production and, at the same time, improve yield and quality characteristics of the end product.

Keywords: LCA, robotics, greenhouse, tomato, hydroponic

References

Bringezu, S., 2019. Toward Science-Based and Knowledge-Based Targets for Global Sustainable Resource Use. Resour. 2019, Vol. 8, Page 140 8, 140. https://doi.org/10.3390/RESOURCES8030140

Horion, S., Prishchepov, A. V., Verbesselt, J., de Beurs, K., Tagesson, T., Fensholt, R., 2016. Revealing turning points in ecosystem functioning over the Northern Eurasian agricultural frontier. Glob. Chang. Biol. 22, 2801–2817. https://doi.org/10.1111/GCB.13267

Kounalakis, N., Kalykakis, E., Pettas, M., Makris, A., Kavoussanos, M.M., Sfakiotakis, M., Fasoulas, J., 2021. Development of a Tomato Harvesting Robot: Peduncle Recognition and Approaching. HORA 2021 - 3rd Int. Congr. Human-Computer Interact. Optim. Robot. Appl. Proc. https://doi.org/10.1109/HORA52670.2021.9461281

Pons, O., Nadal, A., Sanyé-Mengual, E., Llorach-Massana, P., Cuerva, E., Sanjuan-Delmàs, D., Muñoz, P., Oliver-Solà, J., Planas, C., Rovira, M.R., 2015. Roofs of the Future: Rooftop Greenhouses to Improve Buildings Metabolism. Procedia Eng. 123, 441–448. https://doi.org/10.1016/J.PROENG.2015.10.084

Villa-Henriksen, A., Skou-Nielsen, N., Munkholm, L.J., Sørensen, C.A.G., Green, O., Edwards, G.T.C., 2021. Infield optimized route planning in harvesting operations for risk of soil compaction reduction. Soil Use Manag. 37, 810–821. https://doi.org/10.1111/SUM.12654

Acknowledgments: This work has received funding from the Project "Laboratory of Solid Waste and Liquid Waste Management"