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Assessment of technical efficiency and carbon footprint of spring barley cultivation in Poland

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Introduction: Ensuring food security while reducing adverse environmental impact is the main goal of sustainable agriculture. Effective use of agricultural inputs, such as: fertilizers, biocides, fuel, seeds can reduce the impact of cultivation on the environment by limiting greenhouse gases (GHG) emissions. The purpose of this study is to evaluate the efficiency of spring barley cultivation in Poland to indicate the reasons for its inefficiency and to assess the possibility of the carbon footprint (CF) reduction potential.

Methodology & Theoretical Orientation: Survey data from 113 farms cultivating spring barley in season 2015/2016 were used. The joint application of CF and Data Envelopment Analysis (CF+DEA) 5-step method was applied to assess eco-efficiency. The carbon footprint of the crop cultivation and its reduction potential for inefficient farms were estimated. Fractional Regression Model (FRM) was used to explain how farm specific variables (structural and environmental factors) influence efficiency of spring barley cultivation.

Findings: The results revealed that the average values of technical, pure technical and scale efficiency scores were 0.72 (± 0.20), 0.80 (± 0.19), 0.91 (± 0.13), respectively. The fully effective farms consume less mineral fertilizers (N–43%, P–10%, K–21%) and fuel (15%) than inefficient farms having 19% higher yield level. The cultivation of spring barley results with average CF of 2484 (± 1516) kg CO_2e ha^{-1} The economic size of farm, cultivated area, soil quality and annual rainfall significantly affect the results of technical efficiency.

Conclusion & Significance: The results indicate that the improvement of spring barley cultivation technology through the effective use of inputs, especially mineral fertilizers, could lead to reduction of carbon footprint in its cultivation by an average of 32%, which leads to reduction of greenhouse gas emissions by 744 kg CO_2e ha^{-1}.

Recent Publications

1. Biograce (2015) Biograce – complete list of standard values, Version 4 public to harmonise European GHG calculations,
2. IPCC (2006) 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4. Agriculture, Forestry and Other Land Use,
3. Ramalho E. A., Ramalho J.S., Henriques P. D. (2010) Fractional regression models for second stage DEA efficiency analyses. Journal of Productivity Analysis 34 (3): 239-255. DOI: 10.1007/s11123-010-0184-0.

4. Rebolledo-Leiva R, Angulo-Meza L, Iriarte A, González-Araya MC., Vásquez-Ibarra L (2019) Comparing Two CF+DEA Methods for Assessing Eco-Efficiency from Theoretical and Practical Points of View. Science of The Total Environment 659(IV): 1266–82.

5. Mangala R (red.), Reeves TG., Pandey S, Collette L (2011) Food and Agriculture Organization of the United Nations, Save and Grow: A Policymaker's Guide to Sustainable Intensification of Smallholder Crop Production. Rome: Food and Agriculture Organization of the United Nations

Biography

Tomasz Żyłowski is a researcher at Department of Bioeconomy and System Analysis (Institute of Soil Science and Plant Cultivation – State Research Institute) in Pulawy, Poland.

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