POTENTIAL AND EVALUATION OF ENVIRONMENTAL EFFECTS OF BIOFUEL PRODUCTION

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2. Education

2003- M. Sc. in Horticulture, University of Life Sciences in Lublin

2008- PhD in Agronomy Institute of Soil Science and Plant Cultivation –State Research Institute - "Miscanthus productivity (miscanthus ssp.) in various habitat and weather conditions"

2010- UE Project Management, research and work development (postgraduate study for researchers), Higher School of Economics and Innovation in Lublin.

2012- Manager of science and business (postgraduate study for researchers), (postgraduate study for researchers), Higher School of Economics and Innovation in Lublin

3. Emploiment history:

2008-2015 - senior research - Institute of Soil Science and Plant Cultivation- State Research Institute

2015.04.01-2015.11.30 – Assistant Professor - Institute of Soil Science and Plant Cultivation- State Research Institute

2015.12.01- independent senior specialist (implementing his own research program)- Institute of Soil Science and Plant Cultivation- State Research Institute

4. Indication of the scientific achievement according to article 16, paragraph 2 of the Law on scientific degrees and scientific title as well as on degrees and title in art from March 14th 2003 (Dz. U. nr. 65, poz. 595).

a. Title of the achievement

POTENTIAL AND EVALUATION OF ENVIRONMENTAL EFFECTS OF BIOFUEL PRODUCTION

b. Publications consisting the mono-thematical cycle being the most important achievement in scientific carrier:

1. **Borzęcka-Walker M*.,** Faber A., Pudełko R., Kozyra J., Syp A., Borek R. 2011. Life Cycle Assessment (LCA) of crops for energy production International Journal of Food, Agriculture & Environment – JFAE Vol.9 (3&4): 698 - 700.
2. **Borzęcka-Walker M*.,** Faber A., Syp A., Pudełko R., 2012 Simulation of greenhouse gasses from miscanthus in Poland using the DNDC model. Journal of Food, Agriculture & Environment Vol.10 (2): 1187-1190
3. **Borzęcka-Walker M*.,** Borek R., Faber A., Pudełko R., Kozyra J., Syp A., Matyka M. 2013. Carbon and nitrogen balances in soil under SRC willow using the DNDC model. Journal of Food, Agriculture & Environment Vol.11 (3&4):1920-1925
4. **Borzęcka-Walker M*.,** Faber A., Kozyra J., Pudełko R., Mizak K., Syp A., 2012 Modelling the impact of climate change on miscanthus and willow for their potential productivity in Poland Journal of Food, Agriculture & Environment Vol.10 (3&4) : 1437 - 1440. 2012
5. Pudełko R., **Borzęcka-Walker M*.,** Faber A, Borek R., Jarosz Z., Syp A. The technical potential of perennial energy crops in Poland. Journal of Food, Agriculture & Environment Vol.10 (2): 781-784. 2012
6. **Borzęcka-Walker M*.,** Faber A., Jarosz Z., Syp A., Pudełko R., 2013 Greenhouse gas emissions from rape seed cultivation for FAME production in Poland. Journal of Food, Agriculture & Environment Vol.11 (1): 1064-1068
7. **Borzecka-Walker M*.**, Faber A., Pudelko R., Jarosz Z., Syp A., Kozyra J. 2013 Optimisation and risk analysis of greenhouse gas emissions depending on yield and nitrogen rates in rapeseed cultivation. Journal of Food, Agriculture & Environment Vol.11 (3&4):1002-1004
8. Rozakis S., Kremmydas D., Pudełko R., **Borzęcka-Walker M*.,** Faber A., 2013 Straw potential for energy purposes in Poland and optimal allocation to major co-firing power plants. Biomass and Bioenergy 58: 275-285
9. Rozakis S, Haque M., Natsis A, **Borzęcka-Walker M*.,** Mizak K. 2013 Cost-effectiveness of bioethanol policies to reduce carbon dioxide emissions in Greece. Int J Life Cycle Assess 18:306–318

*- publications in which I am the correspondending author

The total value of publications documenting scientific achievement according to the last available MNiSW score is: 168 points. Total Impact Factor in the publication according to the Journal Citation Reports is: 10,13. Statements of co-authors of the work along with specifying their individual contribution to the creation of the work constitute an attachment 5.

c. Discussion of the scientific purpose of the works that make up the most important scientific achievement

The society's increasing demand for energy results from the rapid development of the economy. Fossil fuels used so far, such as hard coal, oil and natural gas, belong to the group of non-renewable raw materials, and their use adversely affects the environment and causes its degradation through increased emission of pollutants into the atmosphere, such as nitrogen, carbon and sulfur. Global climate change is the result of increased greenhouse gas (GHG) emissions from the use of fossil fuels.

Agriculture is a branch of the economy also contributing to the emission of greenhouse gases (9%), in particular nitrous oxide (N_2O) and methane (CH_4). These emissions come mainly from the intestinal fermentation of livestock (CH_4), inefficient use of nitrogen by crops (N_2O), the management of natural fertilizers and the combustion of post-harvest residues. The increase in greenhouse gas emissions has incrised interest in these issues by various social groups; starting from politicians, through academia, entrepreneurs and citizens. The strategy of replacing fossil fuels by biomass in the energy production process promoted by the European Union (EU) can have a significant impact on limiting the effects of climate change and diversification of energy sources. This method of acquiring energy has been known for a long time and was based on the use of available resources such as wood, brushwood, peat or other types of biomass. The biggest advantage of biomass of agricultural origin is the zero balance of carbon dioxide (CO_2) emissions released during biomass combustion, as well as the emission of sulfur dioxide (SO_2), nitrogen oxides (NO_x) and carbon monoxide (CO_2) lower than fossil fuels. Fuels produced from biomass can be used for the production of heat, electricity or for the production of transport fuels. The cultivation of energy crops has a positive effect on carbon sequestration in soil from falling leaves and dying roots. These residues are gradually transformed into humus, which enrich the surface layer of the soil profile. In addition, the cultivation of energy crops compared to conventional crops is characterized by a higher efficiency of nitrogen utilization. Due to the ongoing debate in the world of science about the positive and negative impact of biomass on the environment and a small amount of data from Poland, it was decided to investigate this topic.

The aim of the study was to evaluate the potential environmental effects and the production of biofuels from biomass waste, incidental or grown for energy purposes.

Research work focused on assessing the impact of crop cultivation for energy production, organic carbon dynamics in soil, greenhouse gas emissions as well as estimation of the potential yield of selected energy plants. An important part of my work is also an assessment of the life cycle and the possibility of acquiring biomass from long-term crops, by-product biomass and waste biomass for biomass purposes, as well as optimization of plantation location and biomass logistics.

Life Cycle Assessment

In order to estimate the impact of growing energy crops on the environment, the Life Cycle Assessment (LCA) method was used (zał.b 1). It is a management method used to analyze impacts on the environment, including all stages associated with the production process. The guidelines and rules for conducting LCA analyzes are included in the quality and environmental management standards (ISO 14040) introduced by the International Standardization Commission (ISO). In my research, miscanthus, willow, winter wheat, rapeseed and potato were evaluated. These plants differ significantly in terms of soil, climatic and, above all, fertilizer requirements. The analysis confirmed that the highest greenhouse gas emissions in Poland were found in cultivation, which was accompanied by large energy inputs, resulting mainly from the high demand for fertilization. In Poland, the problem is acidification of soils, which adversely affects the yielding of plants. The analysis shows that potato cultivation had the greatest impact on this process, due to high doses of fertilizers used and increased leaching of cations, in particular calcium and magnesium. Despite high doses of fertilizers, less influence on soil acidification was found in the case of rape, which results from high crop density and less leaching of nutrients. The miscanthus cultivation was characterized by the largest net energy production potential, but its impact on the eutrophication of the environment was high. Willow crops were characterized by the lowest emissions, due to low energy expenditure (zał.b 1).

My knowledge about LCA was also used in the work (zał.b 9), in which the LCA method was used to characterize the internal bioethanine production chain, including a set of processes that influence the choice or mode of operation of the tested object. The research was carried out as part of international cooperation (PROFICIENCY) with the Agricultural University of Athens. Our goal was to assess the profitability of bioethanol production in relation to carbon dioxide emissions depending on agricultural policy. The case study concerned the use of a former sugar factory located in the Tesali region in Greece for the production of bioethanol. The work uses a microeconomic model of partial equilibrium of regional supply in the tillage system in Thessaly, coupled with sub-models of industrial processing of bioethanol produced from beets and cereals. The environmental impact of bioethanol production has been determined using the life cycle assessment method. Direct and indirect energy consumption from fossil sources throughout the ethanol production chain has been described as primary energy sources. The energy from fossil sources was calculated on the basis of the amount of fuel and fertilizers used in the biomass production process. In addition, emissions of nitrous oxide were evaluated. The estimates also take into account carbon losses during the transformation of forests and meadows into arable land. It was found that the change in direct land use resulted in lower emissions in agricultural production, because energy crops are a substitute for intensive crops such as cotton and maize. The change in indirect land use affected the reduction of these estimates. The studies showed that the transition from plow cultivation to simplified cultivation had a positive effect on the accumulation of carbon in the soil. The economic and ecological profitability of bioethanol production is clearly influenced by the agricultural policy factors, in this case the area subsidies for cotton. In order to reduce the emission of thermal gases by 1 ton of carbon dioxide, the total production costs of bioethanol ranged between 160 and 212 euro. These costs have decreased if the agricultural policy aims to separate subsidies from production costs.

Modelling

In the studies on energy crops cultivation, a computer simulation model DNDC (called DeNitrification- DeComposition) was used. This model was used to estimate the dynamics of organic carbon content in the soil, the productivity of miscanthus and willows, nitrogen leaching and gas emissions, including nitrous oxide (N_2O), nitric oxide (NO), molecular nitrogen (N_2) ammonia (NH_3), methane (CH_4), and carbon dioxide (CO_2) (zał. b 2, 3, 4). Simulations have been carried out for the most typical types of soils suitable for growing these plants in Poland. The model was calibrated based on the results of field experiments conducted at two experimental stations of the Institute of Soil Science and Plant Cultivation in Osinach and Grabów (Central Poland). A field experiment founded in 2003. At the Experimental Station of Osiny, on the soil of complex 8 (cereal-fodder strong). Experimental Station in Grabów, on soil complex 4 (very good rye). Plants were fertilized with NPK fertilizers. Simulations of greenhouse gas emissions (CO_2, CH_4, N_2O) from cultivation of Miscanthus in Poland were carried out using the DNDC model. The obtained calibration of the model allowed for a 22-year simulation (1986-2007) (zał. b. 2). The modeled miscanthus yield was 15.80 t ha^{-1} $year^{-1}$ on the soil of the complex 8, while 16.82 t ha^{-1} $year^{-1}$ on the soil of complex 4. The difference between the simulated and the measured yield was from 3.09 t ha^{-1} $year^{-1}$ on medium heavy soil up to 1.21 t ha^{-1} r^{-1}. The mean square error RMSE was estimated at 10.3%. The conducted analyzes indicated a high potential for reducing GHG emissions from the cultivation of this plant, due to the high potential of organic carbon sequestration in the analyzed complexes. The greater binding of carbon to soil in complex 4 than to complex 8 resulted from larger simulated crops on soil complex 4. This also resulted in larger nitrogen withdrawals by the plant grown on this soil, while the differences in methane absorption in both habitats were negligible. In the case of willow (zał.b. 3), the model showed a relatively low mean square error (RMSE) of 11.5%.

Production of biofuels in the face of climate change

An important aspect for the future of crops cultivation for energy purposes is the potential impact on these crops of projected climate changes (zał.b 4). To characterize this issue, simulations were carried out using the DNDC model. Simulations for climate change scenarios up to 2030 and 2050 showed a rather slight decrease in the yield of willow and miscanthus in Poland. On the other hand, significant changes were noted in the potential of organic carbon sequestration and reduction of nitric oxide emissions. This was caused by the increase in temperature and the decrease in the amount of rainfall. Differences in biomass yields between scenarios C2050 and C2000 were 5.3 and 3.3% for miscanthus cultivated on soil of complex 8 and soil of complex 4, while for willow, yields decreased by 4.5 and 7.1% on these complexes. Climate change according to scenario C2030 and C2050 contributed to the reduction of N_2O emissions from the cultivation of Miscanthus (both complexes) and willow (complex 4). The reduction of N_2O emissions from these crops was caused by lower precipitation values in the summer months. According to the simulation, climate changes will have a negative impact on the potential of organic carbon sequestration under energy crops in the studied soils.

Scenarios for the development of biofuel production

An important element in the production of biofuels in Poland is the production of biodiesel from rape, for which approximately 553 thousand are allocated. tons of seeds of this plant. Rape in Poland, as well as in Europe, is the basic oily plant. The production of raw materials for fuel purposes is until now the only type of agricultural production in which the EU regulates in detail the requirements for emissions and reduction of greenhouse gas (GHG) emissions and indirectly increasing the sequestration of carbon in the soil as a result of improving agricultural technology. The European Union has defined sustainability criteria for transport biofuels in the Renewable Energy Directive (RED2009 / 28 / EC). The above directive describes the criteria for greenhouse gas (GHG) emissions and the reduction of emissions from the use of biofuels and bioliquids in comparison to fossil fuels. From 1 April 2013, the reduction of greenhouse gas emissions must amount to at least 35% compared to non-renewable fuels. From 2017, these savings must be at least 50%, and 60% for biofuels produced in installations that will start production in 2018 or later. Biofuels that do not meet the sustainability criteria can not be taken into account in order to: (i) calculate the share of energy from renewable energy sources, (ii) check compliance with the objectives set out in the Directive, (iii) eligibility for financial support. The default greenhouse gas emission values throughout the production chain of various biofuels as well as for each part of the chain (cultivation, processing and transport) are included in Annex V, Part D of the RED Directive. At the work (zał. b. 6), the possibilities of reducing greenhouse gas emissions from agriculture, in the full life cycle of biodiesel (FAME), by optimizing nitrogen fertilization, selection of fertilizers with lower emission levels in their production and increase in organic carbon sequestration were undertaken in soils due to the use of simplified tillage or direct sowing. It was found that the optimization of the nitrogen fertilizer dose and manure type manipulation do not guarantee a 50% reduction in greenhouse gas emissions. However, such a limitation was possible to achieve in the simplified cultivation and application of nitrogen fertilization at a dose of 150 kg N ha in the form of urea, urea ammonium nitrate (UAN) solution or mixtures of ammonium nitrate and ammonium sulphate. The increase in the sequestration of organic carbon in the soil as a result of direct sowing have increased reduction of the greenhouse gas emission to 58-63% at a dose of 150 kg N ha^{-1} and 54-59% at a dose of 180 kg N ha^{-1}. Similar analyzes regarding winter wheat and maize are presented in the fifth part of the autoreferat.

The continuation of the oilseed rape work was a publication (zał. b. 7) on the optimization and analysis of the greenhouse gas emission risk depending on yield and doses of fertilization in rapeseed cultivation. The use of nitrogen fertilizers (N) with lower GHG emissions, arising during their production, it is not possible. Attempts to optimize the dose of nitrogen fertilizers, especially their reduction, carry a certain risk of yield reduction.

The paper presents the optimization of agricultural GHG emissions depending on the yield size and N doses, the purposefulness of optimization, risk analysis for the analyzed variables and GHG agricultural emission uncertainty estimates for which the selected optimization goal was met. It was found that the optimization of agricultural GHG emissions, with the allocation to rape meal, through the impact on the volume of yields and N doses can bring about the reduction of emissions found in practice by 2 g of CO2 eq MJ^{-1} FAME. The risk analysis showed that this can only be achieved by an increase in yield by 7.1% in relation to the median data from the agricultural census. There was no possibility of influencing the emission by reducing the N doses. Similar analyzes regarding maize are presented in the fifth part of the autoreferat.

Modeling of biomass potential

The production of energy from biomass can be a significant part of "green" energy. However, food production has a higher priority than biomass production for energy purposes. Therefore, the knowledge of real biomass potentials, not limiting food security, including mainly waste biomass potentials, is a matter of concern (zał. b. 5, 8, 10). In publication (zał. b. 5) the technical potential of agricultural land has been determined, which can be used to grow multi-annual plants intended for energy purposes in Poland. Areas suitable for the location of energy crops have been determined based on four scenarios. The results of these analyzes were presented in the form of maps assuming appropriate conditions for growing energy crops: 1) habitat (agricultural usefulness of soil), 2) availability of groundwater, 3) rainfall 4) protected areas. After taking into account all restrictions on the cultivation of energy crops, the available area in Poland for long-term energy crops is about 1.59 million hectares. The continuation of research on the availability of biomass in Poland was the work on straw potential in the scale of municipalities (NUTS - 5), as well as the needs for local use and the possibility of redistributing excessive quantities to regions with straw deficit (zał. b. 8). Estimated biomass potential concerns only straw surpluses in agriculture, taking into account the needs of soil maintenance (straw fertilization and post-harvest residue). The work was carried out on the basis of data from the Central Statistical Office (GUS), also taking into account the possibility of minimizing transport costs using the original model for optimizing the allocation of straw between main power plants throughout the country, taking into account the technical possibilities and constraints of biomass co-firing with coal. After estimating the amount of straw available for energy at the commune level, the second model was used to allocate biomass for individual power plants, taking into account the straw used by small local boiler houses. According to the presented scenario, the straw technical potential for Poland was estimated at 3.7 million tonnes. Proper straw management ensuring its sustainable use in agriculture and non-agriculture provides redistribution of approximately 2.5 million tonnes between neighboring municipalities. Locally, the excess straw occurs in regions dominated by crop production with a small share of animal production (Greater Poland, Kuyavian-Pomeranian, Pomeranian, and Lower Silesia). There are larger farms in these regions, which facilitates straw transport logistics. A large surplus of straw also occurs in the Lubelskie Voivodeship. However, in this region the farms are much smaller. It should be emphasized that in Poland, the straw potential map was characterized by high variability of straw resources. It has been identified that there are significant deficits of straw in 825 communes (from 2171). In addition, spatial differences in straw availability after the redistribution phase were calculated, which allowed for the identification of straw availability centers. Five major straw surplus clusters have been identified, as well as three smaller straws that are still important due to their location.

Other works on the potential of various types of biomass are discussed in the next chapter on remaining scientific and research achievements.

5. **Remaining achievements of the candidate**

My previous work mainly focused on issues related to the **assessment of the potential and environmental effects of biofuel production**, besides the works presented as "the main scientific achievement" I actively participated in the writing of works largely related to this issue. The total value of these publications according to the last available MNiSW score is: 550 points. Total Impact Factor in the publication according to the Journal Citation Reports list is: 30.16.

1. **Borzęcka-Walker M.,** Pudełko R., 2007. Wstępne badania nad możliwością zastosowania zdjęć lotniczych do oceny przezimowania miskanta. Zeszyty Naukowe Akademii Rolniczej im H. Kołłątaja w Krakowie nr 44
2. **Borzęcka-Walker M.,** Faber A., Mizak K, Pudelko R., Syp A. (2011). Soil Carbon Sequestration Under Bioenergy Crops in Poland, Principles, Application and Assessment in Soil Science, E. Burcu Özkaraova Güngör (Ed.), ISBN: 978-953-307-740-6, InTech,
3. Syp A., Faber A., Kozyra J., Borek R., Pudełko R., **Borzęcka-Walker M.,** Jarosz Z. 2011. Modelling Impact of Climate Changes and Management Practices on Greenhouse Gas Emissions from Arable Soils. Pol.J. Environ. Stud. Vol. 20 6:1593-1602
4. Faber A., Pudełko R, Borek R, **Borzecka-Walker M.**, Syp A., Krasuska E., Mathiou P. 2012, Economic potential of perennial energy crops in Poland. Journal of Food, Agriculture & Environment Vol.10 (3&4): 1178 – 1182
5. Faber A., Łopatka A., Kaczyński R., Pudełko R., Kozyra J., **Borzecka-Walker M.**, Syp A. 2012. Assessment of existing soil organic carbon stocks and changes at a national and regional level in Poland Journal of Food, Agriculture & Environment Vol.10 (3&4): 1210 – 1213
6. Syp A., Faber A., **Borzęcka-Walker M.** (2012). Simulation of soil organic carbon in long-term experiments in Poland using the DNDC model". Journal of Food, Agriculture & Environment Vol. 10 (3&4): 1224-1229
7. Syp A., Jarosz Z., Faber A., **Borzecka-Walker M.**, Pudelko R., (2012). Greenhouse gas emissions from winter wheat cultivation for bioethanol production in Poland. Journal of Food, Agriculture & Environment Vol. 10 (3&4): 1169-1172.
8. Pudełko R., Stuczyński T., **Borzęcka-Walker M**. 2012: The suitability of an unmanned aerial vehicle (UAV) for the evaluation of experimental fields and crops. Žemdirbyste Agriculture, vol. 99, No. 4 (2012), p. 431 8211;436,

9. Syp A., Faber A., **Borzęcka-Walker M**. 2013. An assessment of biomass production potential in Poland and impacts on food security Journal of Food, Agriculture & Environment Vol.11 (3&4) : 1721-1725.
10. Krasuska E., Faber A., Pudełko R., Jarosz Z., **Borzęcka-Walker M**., Kozyra J. Syp A., 2013a. Emission saving opportunities for corn cultivation for ethanol in Poland Journal of Food, Agriculture & Environment Vol.11 (3&4) :2050-2053.
11. Krasuska E., Pudełko R., Faber A., Jarosz Z., **Borzęcka-Walker M**., Syp A., Kozyra J. Optimization and risk analysis of greenhouse gas emissions depending on yield and nitrogen rates in winter wheat cultivation Journal of Food, Agriculture & Environment Vol.11 (3&4) : 2 2 1 7 - 2 2 1 9 . 2 0 1 3b
12. Faber A., **Borzęcka-Walker M.**, Krasuska E., Jarosz Z., Pudełko R., Kozyra J., Syp A., Nieróbca A., Smagacz J. 2014. Indirect land-use change effects of biodiesel production: A case study for Poland. Journal of Food, Agriculture & Environment. Vol.12 (2) :1353-1355
13. Gerssen-Gondelach S.J., Wicke B., **Borzęcka-Walker M.,** Pudełko R., Faaij A.P.C. 2016 Bioethanol potential from miscanthus with low ILUC risk in the province of Lublin, Poland. GCB Bioenergy doi: 10.1111/gcbb.12306
14. Baker P., Chartier O., Haffner R., Heidecke L., Van Hussen K., Meindert L., Pia Oberč B., Ryszka K.(Ecorys), Capros P., De Vita A., Fragkiadakis K., Fragkos P., Paroussos L., Petropoulos A., Zazias G. (E3MLab), Ball I., Dzene I., Janssen R., Michel J., Rutz D. (WIP Renewable Energies), Lindner M., Moiseyev A., Verkerk H. (EFI), Witzke P. (Eurocare), **Walker M. (IUNG)**. Research and Innovation perspective of the mid – and long-term Potential for Advanced Biofuels in Europe 2017, PDF ISBN 978-92-79-70565-6, Print ISBN 978-92-79-70572-4 doi:10.2777/37969, Luxembourg: Publications Office of the European Union. DOI: 10.2777/05471
15. Borzęcki K., Pudełko R., Kozak M., **Borzęcka M.,** Faber A. Przestrzenne rozmieszczenie odpadów drzewnych w Europie. Sylwan 162 (7): 563−571, 2018
16. Bartoli A., Hamelin L., Rozakis S., **Borzęcka M.**, Brandão M. 2019 Coupling economic and GHG emission accounting models to evaluate the sustainability of biogas policies Renewable and Sustainable Energy Reviews 106 (2019) 133–148
17. Hamelin L., **Borzęcka M**., Kozak M., Pudelko R., A spatial approach to bioeconomy: Quantifying the residual biomass potential in the EU-27. 2019, Renewable and Sustainable Energy Reviews, 100: 127-142

5.1. Modelling

I have continue research into the use of the DNDC model and the possibility of limiting emissions from GHG from maize and wheat crops intended for the production of liquid biofuels (zał. c. 7, 10). Corn and wheat are the main raw materials for the production of ethanol in the European Union. Conventional maize cultivation, which is typical for Polish farms, guarantees that maize-based ethanol will meet the requirements of sustainable development standards for the reduction of greenhouse gas emissions at the current level of at least 35%. The future required reduction in greenhouse gas emissions by 50-60% in the production of ethanol from maize can be achieved in Poland by improving the cultivation technology by optimizing the nitrogen fertilization rate, selecting the N fertilizer range and by applying simplified cultivation or using no-tillage cultivation. In the case of winter wheat, 50% GHG emission reduction is possible when using 90 kg N fertilizer without taking into account the type of fertilizer. Improvement of cultivation technique through the introduction of simplified or ploughless cultivation enables emission reduction by 53-69%.

The next stage of works on the use of annual energy crops such as winter wheat was the optimization of nitrogen fertilization of these plants depending on the obtained yield (zał. c 11). Annex V of the RED directive specifies the standard amount of reduction of greenhouse gas emissions for a given wheat production path is 23 g CO2 eq. MJ-1 produced ethanol. The analyzes show that when fertilizing 90-160 kg of N^{-1}, the estimated emission reduction is 1.7 g CO2 eq MJ^{-1}.

5.2. Carbon sequestration in soil

Agricultural land management has a significant impact on the resources of organic carbon in soil, and sustainable management may lead to increased sequestration. It is important to apply and promote practices that have a positive impact on carbon sequestration in soil, such as the transition from the tillage system to non-tillage farming, the inclusion of cover crops for crop rotation, the use of post harvest residues. The potential for carbon sequestration in the European Union (EU) is around 90-120 Mt C/yr, in the US at 75-208 Mt C/yr, in Canada around 24 Mt C/yr, to achieve this potential, one need to implement optimal land management practices (Hutchinson et al., 2007).

In the paper (zał. c. 2), knowledge about carbon sequestration is presented and the potential of bioenergy crops for carbon sequestration in Poland. However, the assessment of existing organic carbon resources in soil and changes at the national and regional levels in Poland was also carried out (zał. c. 5). The model DNDC was often used for modeling work zał. c 6. This model was used to assess the impact of different cultivation systems on carbon sequestration (C) and greenhouse gas emissions: methane (CH_4) and nitrous oxide (N_2O). Two cultivation systems were analyzed. The first one included potatoes, winter wheat, spring barley and fodder corn (P-W-B-M). The second one is potato, winter wheat, spring barley with a mixture of clover and grass (P-W-B-C). The results of the analyzes indicated a positive effect of the higher dose of manure used on the increase of SOC, but there was a negative impact of the increase in N_2O emissions.

5.3. Land use change (LUC)

The land use change aspect also known as LUC is becoming more and more important in the production of biofuels. Changes in land use can be divided into direct (dLUC - direct land use change) or indirect (iLUC - indirect land use change). Direct land use changes relate to changes in the current land use, eg of a forest to arable land intended for the production of additional raw material for energy purposes. Indirect land use change refers, among other things, to the transformation of land previously allocated for other food purposes to the production of energy crops. Such activities lead to the release of additional CO_2 emissions, especially if the land rich in organic carbon is transformed. In addition, such activities may have a negative impact on biodiversity. According to the European Commission, the proposed value for the coefficient for oilseed crops is 55 g CO2 eq. MJ^{-1} biofuels and should be included in the calculation of greenhouse gas emissions from biofuels from 2021.

In the work zał. c. 12, six GHG reduction scenarios were analyzed with or without organic carbon sequestration, taking into account different cultivation techniques. The inclusion of iLUC in the production of biodiesel in Poland results in a reduction of greenhouse gas emissions lower than the required 50% from January 2018. However, in some regions of rapeseed cultivation, at least 50% of the emission threshold can be achieved using simplified cultivation (Małopolskie, Opolskie, Pomorskie and Zachodniopomorskie) or no no-tillage cultivation (małopolskie, opolskie, podkarpackie, pomorskie, śląskie and zachodniopomorskie).

In the work on zał. c. 13, the amount of additional biofuel that can be produced in 2020, taking into account the iLUC principles, was assessed. The parameters required to monitor the iLUC risk and the possibilities of implementing iLUC mitigation measures were also determined. The case study focuses on the production of bioethanol from miscanthus in the

Lublin region. Depending on the efficiency of the bioethanol production chain, the production potential of bioethanol with low risk iLUC varies from 12 to 35 PJ per year (522 to 1479 million liters per year). The agricultural sector in the Lublin region is characterized by a large number of small farms in relation to regions such as western Poland or Germany. In the Lublin region, several factors have been identified that could have a significant impact on changes in land use, land cover or annual yields. However, the availability and quality of data necessary for monitoring is different for different parameters. In particular, data on losses in the food supply chain and unused land should be improved. The assessment of iLUC mitigation measures and the potential for bioethanol production from miscanthus with low iLUC risk in the Lubelskie voivodeship shows that mitigation or prevention of iLUC from bioenergy is possible only when there is a close link between the agricultural and bioenergy sectors. Therefore, an integrated view of these sectors in the planning and implementation of iLUC prevention policies is essential. This will allow a significant bioenergy potential to be realized with a low risk of causing iLUC while increasing the productivity of the agricultural sector as a whole.

5.4. Aerial photography

My research also involved the use of aerial photographs to acquire spatial information about the environment. Spatial methods are widely used in agricultural research. Their advantage is that they are non-invasive, fast and cheap methods and allow spatial analysis of the variability of the studied phenomenon. I started my work with remote sensing while I was still a PhD student. I used aerial photographs to assess the wintering of miscanthus plants (zał. c. 1). Monitoring agricultural crops can be mainly used in precision farming, or in various types of experimental stations. It allows to obtain detailed information on spatial variability, often invisible to terrestrial observers. Aerial photographs obtained at low altitudes (eg thanks to BSL platforms) can be combined with high-resolution terrestrial measurements. Data obtained from remote sensing are processed by the geographic information system thanks to which it is possible to obtain spatial variation maps (zał. c. 8).

5.5. The biomass potential

The biomass potential has been described as the main achievement. In addition, the assessment of biomass production potential in Poland and its impact on food security was undertaken (zał. c. 9). It was found that 79% (2020) and 73% (2030) of agricultural land inPoland are necessary for the production of food and feed. Knowing from previous research that it is possible to cultivate perennial energy crops on 1.59 million hectares of arable land, an assessment was made of the economic potential of these crops. In Poland, the area of perennial plantations reached only 10,000 ha and began to decrease. It is influenced by low competitiveness compared to traditional agriculture and high risk related to biomass production. The average estimated biomass prices for Poland should not be lower than those estimated for Western Europe. The price for biomass at the level of 6 € GJ^{-1} should ensure satisfaction of biomass demand for heat and power plants in Poland, which is estimated at 4 million tonnes per year in the 2020 perspective.

I also carried out additional work to update biomass potential data and modeling as part of the order „Research and Innovation perspective of the mid- and long-term Potential for Advanced Biofuels in Europe" project ordered by the European Commission. The result of this work was a published monograph (zał. c. 14).

The demand for biomass acquisition is increasing. There is also growing public awareness of biomass recovery or the use of waste biomass. In work zał. c. 15 the spatial distribution of wood waste in Europe was assessed.

I also took part in research carried out on a European scale as part of the BioBoost project. In the work (zał. b 17), the methodology for determining the total (theoretical) biomass potential for NUTS-3 in EU-27 and Switzerland was presented. The work focused on estimating biomass, which can be considered as waste. The biomass residues from 4 main sources were estimated: i) agriculture (straw, manure, crop residues, perennial plantations); ii) forestry (forest remnants); iii) management of urban green areas (residues from the development of urban green areas and roadside vegetation); and iv) food waste (agri-food waste from the food industry and biodegradable municipal waste). The total theoretical biomass potential from eight key biomass sources at the NUTS-3 level for EU-27 is 8,500 PJ y^{-1}. Regions with the highest concentration of biomass, among others Paris (France) from 25 TJ km^{-2}, were also designated, mainly due to biodegradable municipal waste or Jaen (Spain), which is the main region producing olive oil. Similar regions with high concentrations of biomass (above 20 PJ y^{-1}) were determined in 13 countries: in the Czech Republic (5 regions), Denmark (5 regions), Spain (6 regions), Finland (11 regions), France (25 regions), Hungary (2 regions), Italy (2 regions), Latvia (2 regions), Poland (5 regions), Romania (1 region), Sweden (11 regions), Slovakia (1 region) and Great Britain (1 region).

6. List of published scientific works or creative professional work and information on didactic achievements, scientific cooperation and popularization of science

6.1. Scientific publications in journals included in the JCR database

The sum of scientific publications in the SCOPUS database is **24**

6.2 Sumaryczny impact factor

The total Impact Factor (IF) according to the SCOPUS database is in line with the year of publication of the work **41.88**

6.3 Monographs, scientific publications in international or national magazines other than those in the JCR database

Total point for monographs scientific publications in international or national journals other than those in the JCR database according to the list of scientific journals of the Ministry of Science and Higher Education in accordance with the year of publication of the work –**194** pkt.

6.4 Number of publications citation

The number of publications cited according to the SCOPUS database is **132**

6.5 Hirsch Indeks

The Hirsch index according to the SCOPUS database is **7**

6.6 Number of points MNiSW

Total point for publications according to the MNiSW current list of scientific journals **718** pkt.

Table 1. Synthetic summary of scientific achievements

No.	Publication type	Language	Post-doctoral
1	Original works published in journals from JCR list	EN	24
2	Monography	EN/PL	1
3	Monography chapters	EN/PL	8/7
	Total I		**39**
4	Reports	EN/PL	20/1
5	Expertise	EN/PL	4
6	Papers at international conferences	EN/PL	20/8
7	Papers at the workshops	EN/PL	14/4
8	Posters	EN/PL	27/4
	Total II		**102**

Table 2. List of achievements including the point score of magazines according to MNiSW and IF for the year of publication.

Lp.	Journal title	Number of publications	Number of points for publication	Total impact factor for the year of issue	Total number of points
A. Scientific publications in journals in the Journal Citation Reports database (JRC)					
1	Pol.J. Environ. Stud.	2	15	1.38	30
2	Journal of Food, Agriculture & Environment JFAE	15	13-15	6.16	224
3	Žemdirbyste Agriculture	1	20	0.57	20
4	Biomass and Bioenergy	1	40	3.41	40
5	Int J Life Cycle Assess	1	40	3.09	40
6	GCB Bioenergy	1	45	4.88	45
7	Sylwan	1	15	0.62	15
8	Renewable and Sustainable Energy Reviews	2	45	20.18	90
	Total A	24		41.88	504
B. Scientific publications in international or national journals other than those in the database referred in point A					
1	Electronic Journal of Polish Agricultural Universities (EJPAU)	1	6	-	6
2	Post. Nauk Rol.	1	6	-	6
3	Journal of Food, Agriculture & Environment	1	10	-	10
4	Rozdziały w monogrfi w języku polskim	7	2-8	-	34
5	Rozdziały w monogrfi w języku angielskim	8	1-10	-	33
6	Autorstwo monografii naukowej	1	125	2	125
Total B		18			214
Total A+B		42		41.88	718