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DETERMINATION OF THE ENVIRONMENTAL IMPACT OF A NEW BIOMASS LOGISTICS CHAIN

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ABSTRACT

Agricultural residues (prunings) coming from permanent plantations and orchards constitute a significant and largely unused potential for renewable energy. The EuroPruning project, respecting the impact on the environment, aims to turn prunings into a valuable fuel source by developing solutions for their harvesting, transportation and storage that will create growth in the European biofuels market. To determine the environmental consequences of the Pruning-to-Energy (PtE) logistics chain, a Life Cycle Assessment study will be conducted. In this study the PtE scenarios will be compared to three current practices: open field burning, mulching and use for domestic heating. In the paper an outline of the assessment methodology and consequent challenges are provided.

Introduction

There is a wide variety of different kinds of biomass that could potentially be used for the production of renewable energy. Agricultural residues (prunings) coming from permanent plantations and orchards constitute a significant and largely unused potential for renewable energy. The EuroPruning project aims to turn prunings into a valuable fuel source by developing solutions for their harvesting, transportation and storage that will create growth in the European biofuels market. At three demonstration sites the developed solution will be tested and demonstrated. The sites cover plantations of apples and cherries in Germany, peaches, almonds and olives in Spain and grapes in France. Whether or not a given biomass flow is suitable for energy production does not only depend on the technological possibilities and the potential economic feasibility of the conversion process, but as well of the whole of the impacts on the environment and society. To determine the environmental consequences of the Pruning-to-Energy (PtE) logistics chain, a Life Cycle Assessment study will be conducted. In this study the PtE scenarios will be compared to three current practices: (open field burning, mulching and use for domestic heating). In this article an outline of the assessment methodology and consequent challenges are provided.

Sustainability assessment

The European Union considered Sustainable Development as a vital objective for European policies, incorporating it in the Amsterdam treaty of 1997. Sustainable Development consists of three pillars: Economic Prosperity (i), Environmental Protection (ii) and Social Equity and Cohesion (iii). Within the EuroPruning project the three pillars of sustainability are considered in a Life Cycle Thinking approach to enable a founded choice for a sustainable utilisation scenario for orchard prunings. In this paper the initial approach for the assessment of the environmental impacts by application of a Life Cycle Assessment (LCA) is presented.

Environmental assessment: LCA according to the ISO Norm

According to the ISO 14040:2006 Norm LCA is defined as "the compilation and evaluation of the inputs, outputs and potential environmental impacts of a product system throughout its life cycle." (ISO 2006a)

The technique examines every stage of a product life cycle, from raw materials extraction, through manufacture, distribution, use, possible re-use/recycling and final disposal. The phases of LCA, according to ISO 14040:2006 are presented in Figure 1.

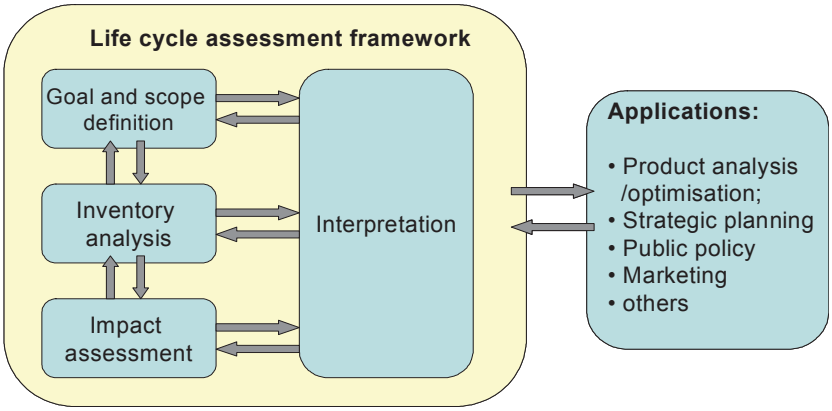

Figure 1. Phases of LCA, according to ISO 14040:2006 (adapted from ISO 2006a)

Goal and scope definition

A goal and scope definition is the phase in which the initial choices, that will determine the working plan of the entire LCA, are made. The goal of the study is formulated in terms of the exact question, target audience and intended application. The scope of the study is defined in terms of temporal, geographical and technological coverage, and the level of sophistication of the study in relation to its goal (Guinée et al., 2002).

Life Cycle Inventory

Within the phase of inventory analysis for each "life stage": (i) the inputs (in terms of raw materials and energy) and (ii) outputs (in terms of emissions to air, water and solid waste) are calculated. The results of the inventory are aggregated over the entire life cycle.

Allocation of flows and releases

In many systems, including pruning to energy (PtE) not only one product of service is generated. For example PtE's main function is produce electricity/heat, however at the same time a co-production of wastes and gas-exhaust may take place (generation of ash, NO_x, CO_2 or SO_2 from combustion processes). Thus the material and energy flows as well as associated environmental releases should be allocated to the different products according to clearly stated procedures (ISO 14044:2006). The ISO norm prescribes that the allocation should be wherever possible avoided by dividing the unit processes to be allocated into two or more sub processes and collecting the input and output data related to these sub processes as well as by expanding the product system to include the additional functions related to the co-products.

Life Cycle Impact Assessment and Results Interpretation

Life cycle impact assessment (LCIA) is the phase in which the inventory analysis output is further processed and interpreted in terms of environmental impacts and social preferences. LCIA requires the comparative evaluation and aggregation of various emissions, resources and other disturbances such as land use and noise. An aggregation of these "stressors" inevitably contains apples-and-oranges comparisons (Hertwich and Hammitt, 2001). Figure 2 summarises the overall framework of LCIA. It shows the relation between life cycle inventory results, impact categories, category indicators and category end point(s). The impact category Acidification is used to illustrate this concept.

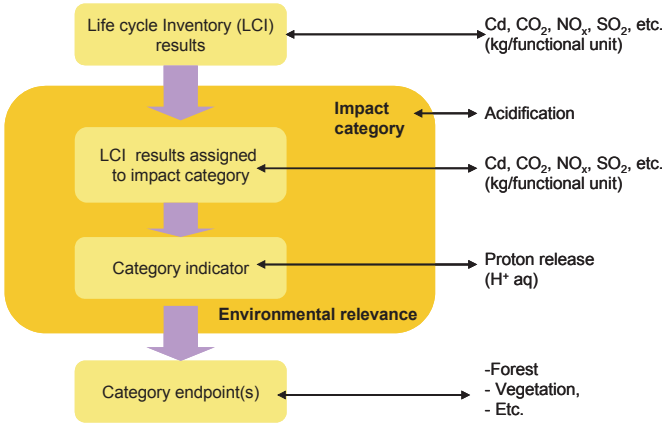

Figure 2. The conceptual framework for defining category indicators (adapted from ISO 2006b)

ISO 14044:2006 defines also the term “environmental mechanism”, which is “a system of physical, chemical and biological processes for a given impact category, linking the LCI results to category indicators and to category endpoints” (ISO 2006b).

Endpoints, according to ISO, there are physical elements in the environmental mechanism of an impact category of direct concern to society. Udo de Haes and Lindeijer (2002) define Areas of Protection as classes of endpoints. The midpoints are all elements in an environmental mechanism of an impact category between interventions and endpoints. Four areas of protection (valuable in themselves or to humans) were identified according to JRC (2011): human health, man-made environment, natural environment and natural resources.

The difficulty of an LCIA lies in the fact that stressors (such as emitted substances) cause unequal effects to different people and ecosystems according to different mechanisms of action and different times. Even if the mechanisms of action are the same as for the greenhouse gases their dynamic behaviour and therefore time horizon differs (Hertwich and Hammitt 2001). The determination of the comparative significance of one environmental impact relative to another is hence not primarily question of measurement, it is one of judgement.

LCA approach and methodology for EuroPruning and accompanying dilemmas

Goal

The goal of the study is, according to the Description of Work (DOW) of the EuroPruning project: “to assess the environmental impacts potentially derived from the utilization of agricultural wood pruning biomass as energy feedstock.”

Scope: cradle-to-gate or cradle-to-grave?

Within the DOW it is specified, that the environmental assessment will concentrate on the value chain until the distribution to the final user (will not incorporate the assessment of all the impacts related to the final use of the fuel). This seems to be a valid specification for the economic assessment, where the price that is paid for the final solid fuel produced replaces all the economic impacts of the various options of energy production later on in the value chain. Specific costs of investment and operation of installations ‘after the gate’ are not relevant for the comparison of various options of the utilisation of agricultural wood pruning biomass. For the social assessment a limitation to the logistic chain up unto the energy production facility gate is valid as well. The direct social impacts of the various options of what to do with the generated prunings are relevant, whereas the social impacts of energy production is out of the scope of the EuroPruning project.

However, as for the environmental assessment, the picture is more complex. The sole reason for thinking about the energetic use of agricultural prunings is the potential substitution of conventional energy. Therefore, this environmental gain of substituting currently produced energy should also be reflected within the environmental assessment. There is not such a thing as market price in environmental terms. For the environmental assessment therefore a standard, generally applied energy transformation process will be considered. This approach is followed as well in similar, more limited studies (Boschiero et al., 2013;

Picchi et al., 2013). In the first place the scope of the LCA will be the comparison of current practices of agricultural prunings use with the improved logistics chain for energy purposes that will be developed within the EuroPruning project. For this purpose, as explained above, the incorporation of the energy transformation process is unavoidable. However, it is likely, that prunings as a fuel will be compared to other biomass fuels, such as forest residues or biofuels from energy plantations. In that case a comparison of the production and logistic chain of the biomass fuels up unto the gate of the energy transformation process could be considered, thus excluding the impacts during the combustion (or gasification, pyrolysis etc.) process.

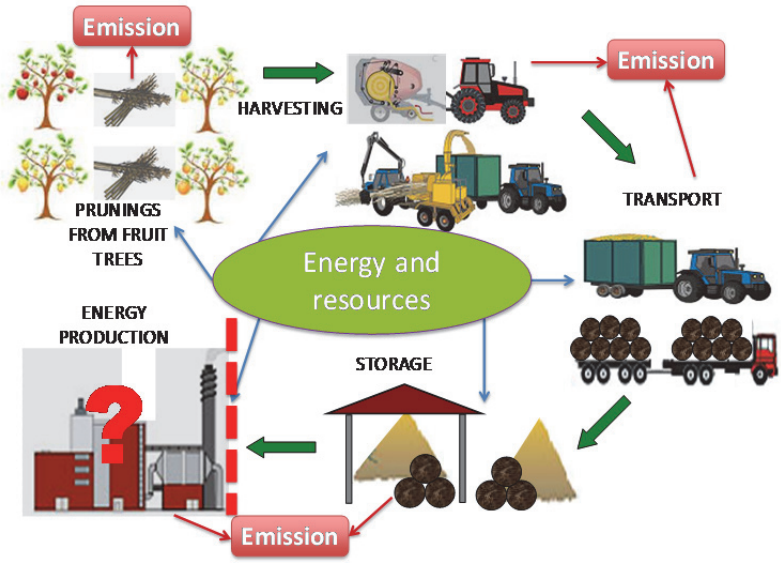

Figure 3. The life cycle scope within the EuroPruning project (Dyjakon et al., 2014)

All scenarios to be compared have then the same environmental gain: energy production, thus substituting conventional energy sources. A study comparing various sources of solid biofuels could end at the delivery of a certain amount of contained energy to the gate of the final user.

Scope: Europe wide?

Within the EuroPruning project a number of project deliverables will clearly lead to results reflecting the European Union as a whole. Detailed estimates for prunings generation in the entire Union will be provided. However, as the project intention is to developed a new logistic chain for pruning biomass, data deriving from field studies will only reflect the specific cases studies (e.g. soil GHG emissions from mulching test in German apple orchards). To overcome this discrepancy, in a first approach detailed LCA investigations based on the project demonstration sites will be undertaken as a kind of indicator studies.

The demonstration sites cover plantations of apples and cherries in Germany, peaches, almonds and olives in Spain and grapes in France. Based on these Europe wide estimated and conclusions will be drawn.

Inventory analysis

In the inventory analysis for all life cycle stages the resource consumption and emissions will be determined and consequently aggregated (see Figure 3). For the following stages data stemming from the project case studies will be used:

– effects of mulching. Both greenhouse gas emissions, the introduction of organic carbon and nutrients to the soil as well as the leaching thereof will be considered.
– prunings harvesting. The construction and use of the developed harvesting machinery will be considered.
– storage. During the storage the pruning material will be subject to various decomposition processes. The effects thereof will be determined during field trials.
– biomass composition. The composition and other parameters of both fresh (before mulching) and stored (before energetic use) pruning biomass will be determined. The heavy metal content however, will be taken from literature sources, as a thorough analysis cannot be afforded from the project budget.

Interviews amongst farmers and farmer unions about the growing and pruning of permanent crops will provide additional information for the LCA modeling. The remaining necessary data will be taken from standard processes contained in the applied LCA software as well as from literature sources.

Impact assessment methodology

The Life Cycle Impact Assessment (LCIA) methodology to be applied within the EuroPruning project will be a mid-term assessment due to the reasons described above. The JRC recommends a number of methods in its Handbook (JRC 2011). Within the EuroPruning project the methods CML2002 and IMPACT2002+ will be compared, after which one will be chosen for the entire environmental assessment (Guinée et al., 2002; Jolliet et al., 2003).

Interpretation: crediting

When comparing various systems in an LCA, some of them may have by-products or services as an output that others lack. The additional function related to the by-products can be accounted for as credits in form of negative energy and material flows equivalent to the quantities of replaced primary products are assigned to respective processes. The production of those products is accounted for as a positive effect, the called “credit”. Alternatively, a ‘basket of services’ can be created, in which all by-products are contained. Every scenario that does not provide with the by-product or service within the scenario itself, needs to account for the environmental burdens of the supplementary production of the by-product externally (outside the actual scenario). In Figure 4 the basket of services for the considered scenarios in the EuroPruning project is shown.

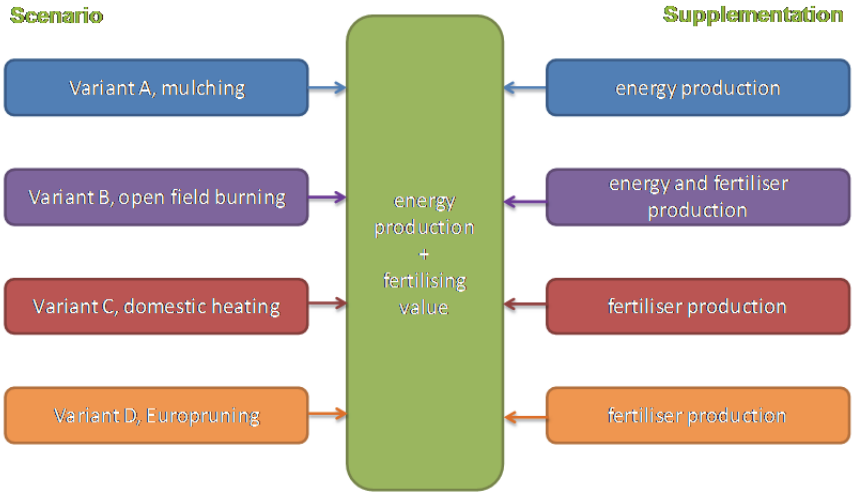

Figure 4. Basket of services for the EuroPruning project scenarios

The scenario of using agricultural woody prunings for energy purposes (variant D in Figure 4) produces energy, but lack the fertilising value of the prunings (which are not applied to the soil). Therefore additionally to the other environmental impacts, the burdens of the production of an amount of fertilisers equal to the value in the mulching scenario are to be added to the EuroPruning scenario.

Interpretation: soil depletion

Currently, LCIA methodologies consider the introduction of biomass matter into soil as a positive effect in terms of carbon sequestration and nutrient enrichment. However, taking away prunings for energy purposes could imply a further soil depletion, especially when the soil is sandy or poor in organic matter. Current LCIA methods do not consider the risk of soil fertility depletion (Cherubini et al., 2009; Milá et al., 2007; Boschiero et al., 2013), as this effect depends on the actual state of the soil. In general, LCA refers only to potential impacts, not considering the actual state of the environment. Within the EuroPruning project, a handbook for farmers that produce prunings will be published. In this handbook amongst other things, the danger of soil depletion will be considered, likely leading to guidance to remain the prunings on the fields in case of soils poor in organic carbon.

Interpretation: waste or product

Farmers grow permanent crops to produce fruits, olives, grapes etc. The pruning biomass is generated as waste, which is consequently mulched or burned. In current practice, pruning residues do not have a market value yet, their disposal rather poses costs to the farmers. This implies, that all environmental impacts related to the growth of the trees should be solely allocated to the agricultural products and not to the pruning residues. When comparing alternative uses of the pruning residues, the environmental burden of the

tree growing could be neglected anyway, as it is identical for all scenarios. However, when comparing prunings as a fuel to other fuels, the pre-chain is relevant. At the moment the Pruning-to-Energy alternative becomes economically interesting for the farmers, pruning residues will have a positive value. The latter would imply, that part of the burden for the growing of the permanent crops should be allocated to the prunings residues. For the Euro-Pruning project this implies, that at first the fruit growing impacts can be neglected, but in later stages of the project may become relevant.

Conclusions

Within the EuroPruning project Life Cycle Assessment will be applied to determine the environmental impacts potentially derived from the utilisation of agricultural wood pruning biomass as energy feedstock. For this purpose data from literature, LCA software processes and from the planned field studies within the project will be used. The latter will comply: harvesting, storage, pruning composition and mulching. The LCA study will initially encompass the entire 'cradle-to-grave' of agricultural pruning residues, including a standardised energy production module. Part of the impact related to the growing of the fruits will be allocated to the produced prunings. Four scenarios will be compared: three current practices (open field burning, mulching and use for domestic heating) with the Pruning-to-Energy scenario. Energy produced or fertilising value achieved by soil application will be accounted for as environmental gains. The CML2002 or IMPACT 2002+ impact assessment method will be applied to determine the impacts of the use of prunings for energy purposes in three indicator studies: apples and cherries in Germany, peaches, almonds and olives in Spain and grapes in France.

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References

Boschiero, M.; Neri, P.; Zerbe, S. (2013). *Apple orchard pruning residues as a potential bioenergy source in South Tyrol: a LCA case study*, 15th International Conference RAMIRAN 2013, 3-5 June 2013,Versailles, France.

Cherubini, F.; Bird, N.D.; Cowie, A.; Jungmeier, G.; Schlamadinger, B. and Woess-Gallasch, S. (2009). *Energy- and greenhouse gas-bases LCA of biofuel and bioenergy systems: key issues, ranges and recommendations.* Resources, Conservation and Recycling 53, 434-447.

Dyjakon, A.; den Boer, J.; Bukowski, P. (2014) *Europruning – a new direction for energy production from biomass. Agricultural Engineering, 3*(151), 29-40.

European Commission Directorate for Research & Innovation (2012). *FP7-KBBE-2012-6-singlestage Grant Agreement Number 312078 Europruning - Development and implementation of a new, and non existent, logistic chain on biomass from pruning*. Annex I – "Description of Work".

Guinée, J.B. (Ed.) (2002). *Handbook on Life Cycle Assessment: Operational Guide to the ISO Standards*. Series: Eco-efficiency in industry and science. Kluwer Academic Publishers. Dordrecht.

Hertwich, E.G.; and Hammitt, J.K. (2001). A Decision-Analytic framework for Impact Assessment Part 2: Midpoints, Endpoints and Criteria for Method Development. In: International Journal of LCA 6 (1), 5-12.

ISO (2006a). *International Standard 14040:2006 Environmental Management – Life cycle assessment – Principles and framework.* International Organisation for Standardisation (ISO), Geneva.

ISO (2006b). *International Standard 14044:2006 Environmental management – Life cycle assessment – Requirements and guidelines*. International Organisation for Standardisation (ISO), Geneva.

Joint Research Centre (2011). *International Reference Life Cycle Data System (ILCD) Handbook-Recommendations for Life Cycle Impact Assessment in the European context.* First edition November 2011. EUR 24571 EN. Luxemburg. Publications Office of the European Union.

Jolliet, O.; Margni, M.; Charles, R.; Humbert, S.; Payet, J.; Rebitzer, G. and Rosenbaum, R. (2003). IMPACT 2002+: a new life cycle impact assessment methodology. *International Journal of LCA 8*(6), 324-330.

Milá, I.; Canals, L.; Romanyá, J.; Cowell S.J. (2007). Method for assessing impacts on life support functions (LSF) related to the use of "fertile land" in Life Cycle Assessment (LCA). *Journal of Cleaner Production 15*, 1426-1440.

Picchi, G.; Silvestri, S. and Cristoforetti A. (2013). *Vineyard residues as a fuel for domestic boilers in Trento Province (Italy): Comparison to wood chips and means of polluting emissions control.* Fuel, Volume 113, November 2013, Pages 43-49, ISSN 0016-2361, http://dx.doi.org/10.1016/j.fuel.2013.05.058

Udo de Haes, H.A.; Lindeijer, E. (2002). *Areas of Protection,* Second Draft, December 22, 2000. In: Gate to EHS: global LCA village, March 2002, 1-5.

OKREŚLENIE WPŁYWU NOWEGO ŁAŃCUCHA LOGISTYCZNEGO BIOMASY NA ŚRODOWISKO NATURALNE

Streszczenie. Odpady rolnicze (ścinki gałęzi) pochodzące z winnic i sadów stanowią duży potencjał jako odnawialne źródło energii. W artykule przedstawiono cel projektu EuroPruning, jakim jest przekształcenie tego typu odpadów w wartościowe paliwo na europejskim rynku energetycznym poprzez poprawę i rozwój technologii ich pozyskiwania, zbioru, transportu i magazynowania. Aby określić środowiskowe konsekwencje opisanej strategii wykorzystania ścinek gałęzi z drzew owocowych do celów energetycznych, zaproponowano metodologię opierającą się na tzw. analizie cyklu życia. Do analizy przyjęto różne warianty, które zostaną porównane z aktualnymi sposobami zagospodarowania gałęzi z drzew owocowych (spalanie na uboczu, rozdrabnianie i pozostawianie na miejscu, wykorzystanie w domowych systemach grzewczych). Omówiono zagadnienia związane z analizą cyklu życia oraz problematykę wyboru odpowiednich założeń przy przyjętej ocenie środowiskowej.

Słowa kluczowe: ocena cyklu życia, wpływ na środowisko, biomasa z sadów, energia z biomasy, ścinki gałęzi

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INTERNET MARKET OF SPARE PARTS FOR AGRICULTURAL MACHINES

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ABSTRACT

The objective of the paper was to analyse and assess the internet market of spare parts for agricultural machines. The research was carried out in the group of the selected servicing centres, which offer sale of spare parts on the web sites. Differences in the assortment of specific on-line shops and the manner of presenting information concerning sale in the Internet was analysed. Assortment offer of on-line shops is varied. Possibility of selling spare parts through the Internet constitutes an asset of an enterprise. On this basis, present directions of development of the web site department and sale of spare parts for farm tractors in Poland were determined.

Introduction

Technical service of farm tractors aims at maintenance of machines in an up-state for use so that it can correctly fulfil tasks; it should be constantly improved and extended (Rybacki, 2011). One of possible and applied changes within this system is facilitation of the contact with customers through the use of web sites.

Increase of IT awareness of consumers and development of the telecommunication market, which enables access to the Internet, results in formation of new trade possibilities. Knowledge and experience of entrepreneurs and recognition of needs of the agricultural machines branch induce technical services to introduce innovative solutions, including sale of spare parts through the Internet. At the same time it is an evidence of social changes, which determine direction and pace of development of the entire economy in Poland and around the world. Presently, competitive advantage plays a significant role and the advanced technical infrastructure favours dynamic development of the market (Babuchowska and Marks-Bielska, 2010).

Creation of enterprises web sites, which deal with technical service of farm tractors, constitutes a chance for obtaining new customers, even from distant regions of the country. On-line shops are so constructed that although a client has no physical contact with a product, he or she may obtain all essential informations.

Data bases are a basic IT tool used in e-shops. The biggest asset is a possibility of access of many people in real time (Sojak et al., 2007).

Despite existing barriers, resulting from individual beliefs concerning purchases in the Internet or due to the lack of proper telecommunication infrastructure, which enables access to the assortment in internet catalogues of spare parts, growing interest of such services among farmers is visible (Sieczko and Sieczko, 2010). Creation of the sale system of parts in the Internet constitutes an integral part of the decision taking process made by a client. Possibility of browsing through the catalogue of parts on the web site is a great simplification of traditional procedures related to the purchase. Each year sale through services of the web site increases by few dozens percent in comparison to the previous year. Moreover, number of servicing centres, which offer internet sale of spare parts, increases (Cupiał and Szeląg-Sikora, 2013).

A farmer, who buys a farm tractor, must take economic effects into account, which in future will be generated by technical service of a machine, inter alia, replacement of parts (Durczak and Rzeźnik, 2011). Immediate availability of spare parts on the web site influences shaping positive relations between a servicing agency and clients. Possibility of performing some activities through the Internet related to servicing machines results in better assessment of a servicing centre by farmers (Durczak et al., 2011). Logistic activity of enterprises which carry out an e-shop depends on appropriate cooperation of the following departments: trade, sale and maintenance. Success guarantees their mutual completion in order to ensure the best possible customer service (Juściński and Piekarski, 2009b). Presently, web sites which offer sale of parts for farm tractors are conducted by dealers and importers and smaller business entities (Rybacki and Durczak, 2010). Seasonal nature in agriculture with the use of farm tractors causes fluctuations of demand for spare parts. The third quarter of a year is a period, where demand is the highest (Juściński and Piekarski, 2009a).

The objective of the paper

The objective of the paper was to anlayse the use of the Internet for trade of spare parts for farm tractors in terms of available assortment and advancement of the e-sale system by an enterprise. Having analysis results will allow determination of present directions of development of the web site and sale of spare parts for farm tractors in Poland.

Materials and methods

In order to carry out the objective of the paper, market offers of spare parts for farm tractors, presented on the web sites of enterprises which deal with technical service of farm tractors, were analysed. All web sites are modern and enable sale of spare parts with the use of the Internet. On this basis, actual state related to present internet offer of spare parts was presented. Web sites of servicemen and bookmarks related to the sale of parts were the object of the research. During research, availability and prices of parts selected from a catalogue offer were compared. The scope of the paper included also a manner of placing information concerning sale of parts in the Internet. Customers may shop on-line directly on the web site of the servicing centre on the independent web site of an e-shop selling spare parts or ordering a part by calling a shop to a telephone number provided on the web site. A manner of purchasing parts in servicing centres was investigated through analysis of 15

servicing enterprises from around Poland, which declare possibility of sale of spare parts through the Internet. The selected enterprises took part in the competition "Serwis na medal" ["The best servicing centre"] in 2013. Servicing agencies from around Poland entered for the contest, which was organized by the Polish Economic Chamber of Farming Machines and Devices in Toruń, held under the patronage of the Poznań University of Life Sciences.

Results and analysis

Research on e-sale of spare parts for farm tractors was carried out based on information included on the web sites of servicing agencies. Each of them has a working web site with bookmarks, among which, there is one related to sale of spare parts. Names of bookmarks used by servicing agencies are presented in figure 1.

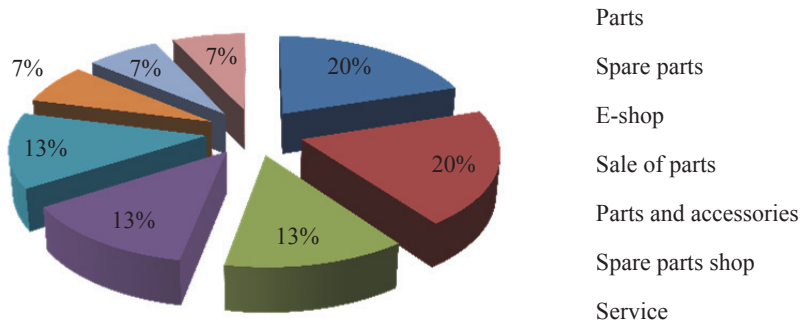

Figure 1. Name of a bookmark on the web site of a servicing agency, which provides information concerning sale of spare parts

The most frequent names of bookmarks, which indicate a place, where information on sale of spare parts is included, are: "parts" and "spare parts". Servicing centres use such names as: "e-shop", "shop", "sale of parts". Rarely are used: "parts and accessories", "spare parts shop" and "service". The names used, through closeness of meaning, facilitate the use of the web site and finding information which are interesting for a user. These are communicative definitions; however in future one should aim at unification of names using for example the name "e-shop".

When analysing web sites of servicemen selected for the research, four manners of placing information on the sale of spare parts for farm tractors may be distinguished. They were collected and presented in figure 2.

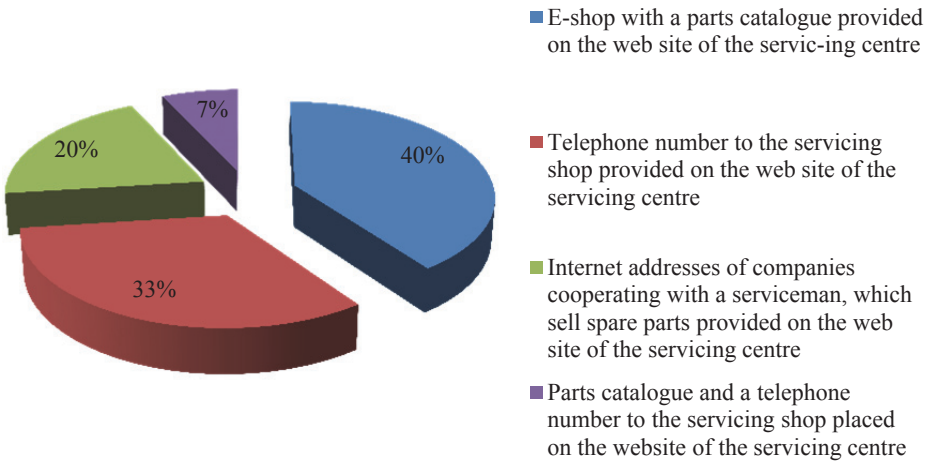

Figure 2. Manner of placing information on sale of parts through the Internet by a servicing centre

Having an e-shop, which provides a catalogue of parts offered for sale, is a manner of sale of parts through the Internet used by the highest number of technical service centres. However, manners of sale are varied. Providing a telephone number of a service shop is also a popular solution but less advanced. It enables direct conversation with a shop employee. Some servicing centres place on its website, an Internet address of a company which cooperates with a serviceman, which sells spare parts. A catalogue of spare parts and options related to the purchase of the selected assortment are in this case on the company's website. These usually are Internet addresses of the agricultural machines producers known and functioning on the territory of the entire country. The lowest number of servicing centres uses a manner, which consists in providing a telephone number to a serviceman shop and catalogue of sold parts without the possibility of buying through the Internet.

An e-shop with available catalogue of parts is the most appropriate solution. All enterprises which offer spare parts should aim at such solution. Opportunity to complete a request form on spare parts by a client on the web site of the selected farm machines servicing centres is an additional solution.

Research on the internet sale of spare parts for farm tractors allowed noticing that depending on the analysed service, the offered assortment is varied. Information on the assortment was presented in table 1.

Data included in table 1 show that despite carrying out activity in the same branch, assortment offer of e-shops is varied. Some e-shops enable only purchase of spare parts for agricultural machines, other also sell operational liquids and tools. Spare parts and operational liquids, for which demand is the highest during a year, occur the most frequently in the e-shops offer. At the same time, these are operational materials used in farm tractors, which require to be exchanged with determined frequency during operation. Filters in farm tractors, which are exchanged during the planned technical inspections are an example. Sale

offer should be the widest. The analysis shows that operational materials and other basic tools for performance of technical inspections prevail.

Table 1
Selected assortment offered by e-shops of service establishments of agricultural machines

Item number	Selected assortment of e-shops	Participation of the assortment in e-shops (%)
1	Batteries	20
2	Oil pressure sensors	60
3	Fuel level sensors	20
4	Tubes	20
5	Engine block nozzles	20
6	Filters of hydraulic oil	80
7	Filters of motor oil	80
8	Fuel filters	60
9	Air filters	80
10	Universal agricultural foils	60
11	Draw hooks	20
12	Driving wheels	20
13	Cross wrenches	20
14	Bearing	60
15	Manometers	40
16	Oil gauges	20
17	Hydraulic oils	60
18	Gear oil	40
19	Gear and hydraulic oils	60
20	Engine oils	80
21	V-belts	60
21	Piston ring	20
22	Coolants	40
23	Front covers of a timing gear	20
24	Hydraulic pumps	20
25	Fuel pumps	20
26	Potentiometers	40
27	Reflector	40
28	Ball studs	40
29	Cab panes	20
30	Clutch plates	80
31	Tape measures	20
32	Transmission main shaft	60
33	Fuel filter elements	60
34	Air filter elements	60
35	Cross screwdrivers	20
36	Flat screwdrivers	20
37	Sets of socket wrenches	40
38	Bulbs	20

Research on the e-sale of spare parts for farm tractors showed that there is no assortment, which would be sold by all services through web sites. Even in case, when an offer includes the same type of a spare part, not necessarily it comes from the same manufacturer. Tables 2 and 3 presents the selected assortment of e-shops stating also prices.

Table 2
Price of the selected products in e-shop of the service enterprise A

Item number	Selected assortment of e-shop A	Gross price (PLN)
1	Oil pressure sensor New Holland	60.00
2	Filter of motor oil Steyr	45.00
3	Fuel filter New Holland	75.00
4	Air filter New Holland	154.00
5	Ball bearings of BR series	249.12
6	Hydraulic oil Ambra Hydrosystem 46 HV, 51	120.00
7	Motor oil Aral Traktoral 10W 40, 201	335.00
8	Grooved V-belt Case IH JX 60,70	140.00
9	Clutch disc New Holland	700.00
10	Fuel filter element New Holland	45.00

Table 3
Price of the selected products in e-shop of the service establishment B

Item number	Selected assortment of e-shop B	Gross price (PLN)
1	Oil pressure sensor Same Deutz-Fahr	98.00
2	Motor oil filter Same Deutz-Fahr	50.00
3	Fule filter Zetor Proxima	39.00
4	Air filter Donaldson	140.00
5	Ball bearing 2RS Same Deutz-Fahr	149.64
6	Hydraulic oil Akcela HY-TRAN, 5 l	125.00
7	Motor oil Ambra Mastergold 15W 40, 20 l	450.00
8	V-belt AV 15 x 1465 Same Deutz-Fahr	90.00
9	Clutch disc Zetor Proxima	480.00
10	Fuel filter element Same Deutz-Fahr	75.00

Spare parts and operational materials available in the internet catalogue of the servicing centre A in majority are designated for New Holland and Case farm tractors. The second e-shop offers, on the other hand, assortment of Same-Deuts Fahr and Zetor manufacturers. It is, inter alia related to cooperation of technical services of farm tractors with manufacturers. It proves relations which take place between a manufacturer and a serviceman. Some of servicing agencies are of a factory service centre nature; some function based on franchise principles.

Data included in tables 2 and 3 prove diversification of spare parts and operational materials offered in the e-sale system. Price of the same spare part may differ depending on the service. For example, the same sensor of oil pressure Same Deuts Fahr is available in three e-shops. Depending on the shop offer it costs PLN 63.06, 74.00 and 98.00. Thus, it is important at the moment of purchase to compare offered prices and check whether the select-

ed spare part is of appropriate make. These activities are easy to perform, because internet catalogues include descriptions of parameters of spare parts and operational materials. Because all internet catalogues of parts include prices, a potential client may compare assortment and prices of the selected e-shops.

Conclusion

Review of the activity carried out in servicing agencies allowed noticing a common tendency for enabling purchase of spare parts through the Internet. It proves, inter alia, a progress within the scope of rendering services in the Polish agriculture. It also proves that the society is more aware of the meaning of the technical service. Thus, enterprises should prepare suitable service offers and invest in equipment and adjustment to growing customers' requirements, by inter alia, opening e-shops. The research also confirmed that each service establishment offers parts of other companies. Most frequently these are materials coming from the agricultural machines manufacturer, with which the service centre cooperates, which constitutes a link of distribution logistic of the manufacturer on the market.

References

Babuchowska, K.; Marks-Bielska, R. (2010). Wspieranie przedsiębiorczości na obszarach wiejskich ze środków PROW 2007-2013. *Acta Scientiarium Polonorum Oeconomia, 9*(2), 5-15.

Cupiał, M.; Szeląg-Sikora, A. (2013). Koncepcja internetowego systemu wspomagania zarządzania w przedsiębiorstwie rolniczym w zakresie decyzji o zakupie sprzętu. *Zarządzanie i finanse. Zeszyty Naukowe Nr 1 - Tom 1*, 93-102. Pozyskano z: http://zif.wzr.pl/pim/2013_1_1_7.pdf.

Durczak, K.; Rybacki, P.; Staszak, Ż. (2011). Wyniki badań jakości obsługi posprzedażnej maszyn rolniczych. *Inżynieria Rolnicza, 8*(133), 101-108.

Durczak, K.; Rzeźnik, C. (2001). Badania procesu zakupu maszyn rolniczych. *Inżynieria Rolnicza, 11*(31), 53-59.

Juściński, S.; Piekarski, W. (2009a). Naprawy pogwarancyjne ciągników rolniczych jako element autoryzowanego systemu dystrybucji. *Inżynieria Rolnicza, 8*(117), 23-30.

Juściński, S.; Piekarski, W. (2009b). Systemy zarządzania logistycznego w przedsiębiorstwie prowadzącym autoryzowaną dystrybucję pojazdów i maszyn rolniczych. *Zarządzanie Przedsiębiorstwem, 2*, 42-48.

Rybacki, P. (2011). Badania jakości serwisu technicznego maszyn rolniczych metodą SERVQUAL. *Journal of Research and Applications in Agricultural Engineering, Vol 56(2)*, 122-125.

Rybacki, P.; Durczak, K. (2010). Badania wykorzystania Internetu w dystrybucji części wymiennych maszyn rolniczych. *Journal of Research and Applications in Agricultural Engineering, Vol 55(2)*, 85-87.

Sieczko, A.; Sieczko, L. (2010). Wykorzystanie portalu Allegro w e-biznesie skierowanym do rolników. *Acta Scientiarium Polonorum Oeconomia, 9*(2), 211-222.

Sojak, M.; Głowacki, S.; Krawcewicz, M. (2007). Zastosowanie internetowej platformy wymiany ogłoszeń z wykorzystaniem baz danych w inżynierii rolniczej. *Inżynieria Rolnicza, 2*(90), 287-292.

INTERNETOWY RYNEK CZĘŚCI WYMIENNYCH DO MASZYN ROLNICZYCH

Streszczenie. Celem pracy była analiza i ocena internetowego rynku części wymiennych do maszyn rolniczych. Badania przeprowadzone zostały w grupie wybranych zakładów serwisowych, oferujących sprzedaż części wymiennych za pośrednictwem stron internetowych. Analizowano różnice w asortymencie poszczególnych sklepów internetowych oraz sposób zamieszczania informacji dotyczących sprzedaży w Internecie. Oferta asortymentowa sklepów internetowych jest zróżnicowana. Możliwość sprzedaży części wymiennych za pośrednictwem Internetu stanowi atut przedsiębiorstwa. Na tej podstawie określono aktualne kierunki rozwoju działu serwisu internetowego i sprzedaży części do ciągników rolniczych w Polsce.

Słowa kluczowe: części wymienne, ciągnik rolniczy, serwis techniczny, sprzedaż internetowa, sklep internetowy

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ORCHARDS BIOMASS FOR ENERGY PURPOSES: AN APPROACH FOR THE ASSESSMENT OF THE IMPACT ON SOCIETY

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ABSTRACT

Analysis and evaluation of the impact on the social aspects and the social value of a given investment are still not a popular analysis applied in Poland. However, EU legislation and the practice of developed countries (including the U.S.) support the implementation of these analyzes. They are important from the point of view of the local community and that is why they are incorporated into the EuroPruning project. This article presents two types of analyzes: SLCA and SROI, which take into account in their methodologies the social aspects, i.e. impact on the condition and the satisfaction of the local community (social impact).

Introduction

Orchard biomass coming from apple, cherry, almond, grape or olive plantations is a significant and largely unused potential for renewable energy. The EuroPruning project aims at turning prunings into a valuable fuel source by developing solutions for their harvesting, transportation and storage that will create growth in the European biofuels market (Den Boer et. al, 2014). Usually, the legitimacy of the project/investment in Poland is considered mainly from the economic point of view. If required by legislation, an environmental analysis is performed, as well. Unfortunately, the social aspects connected with a venture are very often neglected and are not taken into consideration. It arises from the marginalization of this aspect, whereas the acceptance by local society (and the rest of stakeholders) seems to be crucial in terms of sustainable development of the region.

There are different analyses taking into consideration social aspects. To the most important belongs: Social Return On Investment (SROI) and Social Life Cycle Assessment (SLCA). In the project both analyses will be done: to determine the validity and added value of the Pruning-to-Energy (PtE) logistics chain, apart from economic and environmental aspects, social assessment studies will be performed. In this study, the PtE scenario will be compared to three current practices: open field burning, mulching and use for domestic heating.

The aim of this paper is to present the strategy of the EuroPruning project focusing on the main assumptions, the methodology to be applied and final targets which should allow choosing the best way of pruning treatment in terms of environmental, economic and especially social aspects.

Social aspects in the EuroPruning project

All elements of the logistics chain may be analyzed also in terms of social aspects. For example: almost every element of logistics chain can create new jobs by orchards biomass collection, by servicing of machinery, by energy production etc. There are also negative aspects as well, for instance a danger of accidents or pollutants emission increase by the machineries. Social outputs are all transactions and activities coming from logistic chain implementation (negative like injuries, and positive like job creation) which value can be measured and expressed in Euro. According to the SROI analysis there are also other effects coming from outputs, called as "social outcomes" (see fig. 1). Social outcomes are indirect benefits from enterprise like: integration of society among the new project, increase of local society's environmental awareness, improved welfare thanks to new jobs, rise of practical skills of local community (by involving the society to new tasks and responsibilities), better health (lower GHG emission), or finally higher responsibility of consumers health and safety, because consumers and producers belong to the same local community.

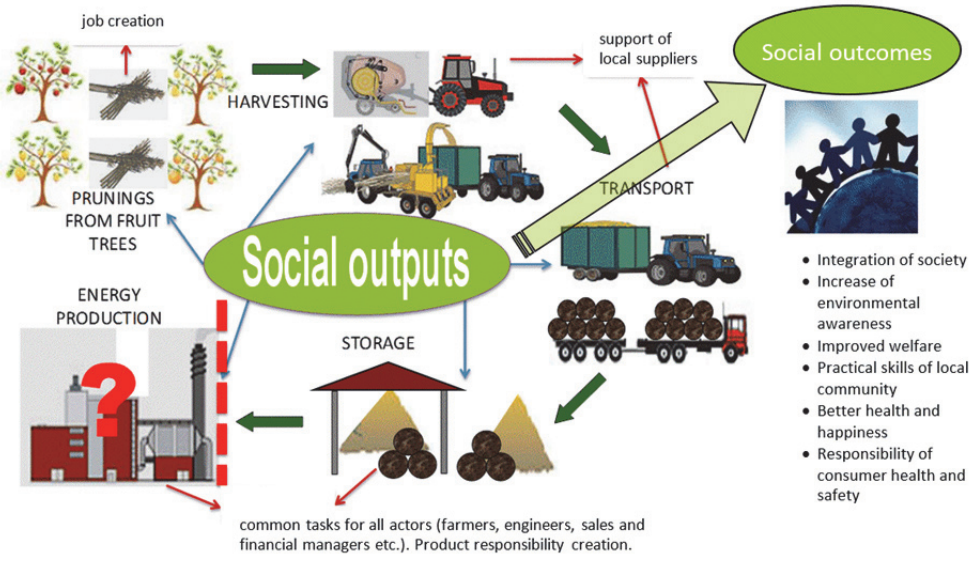

Figure 1. The social scope within the EuroPruning project (adapted from Dyjakon et al., 2014)

Social aspects in the EuroPruning project will be taken into consideration within two kinds of analysis: SROI and SLCA.

Social Return on Investment (SROI)

The SROI analysis means the Social Return On Investment and it grew up from ROI analysis (Return On Investment), which are quite straightforward and commonplaces within many organizations all around the world. The SROI analysis adds to typical financial analysis another, new activities evaluated as "social value". Social value refers to social, environmental and economic costs and benefits taken into consideration simultaneously. By taking these values into consideration the social impacts may be evaluated, which result from positive or negative pressures on social endpoints (i.e. well-being of stakeholders).

The term "social impact" is defined as the consequences to human populations of any public or private actions that alter the ways in which people live, work, play, relate to one another, organize to meet their needs and generally cope as members of society (The Interorganizational Committee, 2003). The origin of Social Impact Assessment (SIA) comes from the environmental impact assessment (EIA) model, which were first implemented in the 1970's in the U.S, as a method to assess the impacts on society of different projects (Barrow, 2000). The term also includes "cultural impacts involving changes to the norms, values, and beliefs that guide and rationalize their cognition of themselves and their society" (The Interorganizational Committee, 2003). The common opinion about SROI is, that this analysis could be ambiguous, while it is basing on social value, which refers to social, environmental and economic costs and benefits. To collect all important data for a project the impact value chain should be defined.

Based on the "Impact value chain in The Double Bottom Line" (Clark et al., 2008) the value chain for EuroPruning was proposed and presented in figure 2.

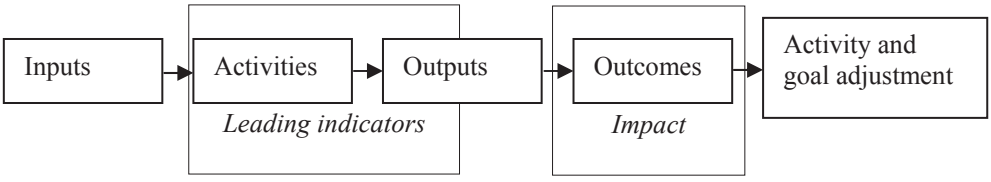

Figure 2. EuroPruning impact value chain (based on Clark et al., 2008)

Inputs includes all the elements which are put into venture (for example, machinery, logistics and know – how). Activities are venture's primary activities, means pruning acquisition, utilisation and energy production.

Impact value chain allows to differentiate between outputs and outcomes. Outputs are results that a company, or a project manager can measure or assess directly. Outputs could include the number of workplaces created, saved energy or benefits of the use of renewables, associated with green energy production. Social impact indicators are specific operational outputs that can be measured by meeting their social benefit objectives.

Outcomes are the changes in society. For the EuroPruning project, desired outcomes could be increasing i.e. the society benefits, including family support for basic commodities and workforce facilities.

Impact refers to the portion of the total outcome as a result of the farmers and energy producers activity. It should answer the question "what would have happened anyway" by the alternative solution.

Social Life Cycle Assessment (SLCA)

Social life cycle assessment is a social impact (and potential impact) assessment technique that aims to assess the social and socio-economic aspects of products and their potential positive and negative impacts along their life cycle encompassing extraction and processing of raw materials, manufacturing, distribution, use, re-use, maintenance, recycling, and its final disposal (Benoit and Mazijn, 2009).

There are many methodologies taking into consideration different criteria. A reasonable and prudent choice of methodology and criteria is very important. The most popular or the most compatible to EuroPruning project methodologies are:

1. Life Cycle Sustainability methodology proposed by Barthel et al. (2005),
2. Methodology presented by Dreyer et al. (2006),
3. Corporate Social and Environmental Performance described by Gauthier (2005),
4. Societal LCA methodology by Hunkeler (2006),
5. Social impacts of the production of notebook PCs by Manhart & Grieshammer (2006),
6. Venture capital fund by Méthot (2005),
7. Label 'Sustainable Development' by Spillemaeckers et al. (2004),
8. Sustainability SWOTs by Pesonen (2007),
9. The integration of economic and social aspects by Weidema (2006),
10. Methodologies used for ZeroWIN (ZEROWIN 2010),
11. Methodology applied by TransWaste (Transwaste 2012).

The first methodology contains a method to assess social impacts on people caused by the activities in the life cycle of a product (Barthel at al. 2006). The next methodologies (no. 2-5) come from development of LCA analysis, enriched by social aspects, which is a popular method recently. An interesting position is also the sustainability SWOTs by Pesonen basing on the popular SWOT analysis, but the most accurate methodology to the EuroPruning project were published in TransWaste final report (TransWaste 2012). In this work the societal Life Cycle Assessment and analysis of social impacts were studied in order to come up with an approach to assess the social impacts of the informal collection, transport and trade of used items. The most important step in SLCA is a proper choice of social criteria. The social criteria are concerned with the ways in which society (and particularly farmers) would use the new logistics and renewable energy as part of their everyday lifestyles. In described above methodologies the main groups of social criteria are:

1. Human rights.
2. Labour practices and decent work conditions.
3. Social.
1. Product responsibility.

The first group of criteria seems unimportant in EuroPruning project. Human rights are taking into consideration problems like: non-discrimination (composition of employees according to gender, age, disabled, part-time workers), freedom of association and collective bargaining or child labour threat, including hazardous child labour. In the project this threats are negligible – all scenarios take place in Europe, so human rights respecting will not change.

Much more important is the second group of criteria: labour practices and decent work conditions. Wages, including equal remuneration on diverse groups, regular payment, length and seasonality of work and minimum wages, benefits, including family support for

basic commodities and workforce facilities, and finally physical working conditions, including rates of injury and fatalities, nuisances, basal facilities and distance to workplace will highly affect the impact.

To the social aspects evaluated during the EuroPruning project belong: development support and positive actions towards society, including job creation, support of local suppliers, general support of developing countries, investments in research and development, infrastructure, and local community education programmes. Additionally, the local community acceptance (such as complaints from society, and presence of communication channels) and ensuring of commitment to sustainability issues from and towards business partners seems to be vital, as well.

The product responsibility is hard to estimate, but it influences the social impact definitely. It is important to society the integration of costumer health and safety concerns in product, such as content of contaminants, other threats/benefits to human health due to product use. Fuel from biomass (prunings) should be introduced to users as a product, with all marketing activities such as labelling, information about ingredients, origin, use, potential dangers, and side effects.

Conclusions

The increase of renewable energy production from biomass is a very important task for European Countries in the coming years. For an reliable assessment of a new logistic chain for the biomass from pruning residues the SROI and SLCA analysis is required. Biomass harvesting methods, the transport, storage, and utilisation for energetic purposes influences the society, and the main task of SROI analysis is social impact evaluation, made by impact value chain creation.

The SLCA methodology comes from development of LCA analysis, and applies the criteria in the three main groups: labour practices and decent work conditions, social, and product responsibility.

For the project the SLCA methodology was assumed, and the most important criteria were chosen. The next step is collection of data from evaluated localisations (Potsdam, Bordeaux and Zaragoza) and social impact elaboration according to adopted methodology, criteria and assumptions.

To the most important social indicators include: employment and job creation (in man-hour per GJ of acquired energy), influence on health of the society, and product responsibility. They should refer to energy production (GWh per 1 person or GWh per hectare), to the LCA (Life Cycle Assessment) like climate impact (GHG emissions), bioenergy policy and finally to the micro-scale changes. The final value of all comparisons should be calculated and expressed in Euro.

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References

Barrow, C.J. (2000). *Social impact assessment: an introduction*. Arnold, London, and Oxford University Press Inc., New York.

Benoit, C.; Mazijn, B. (2009). *Guidelines for social life cycle assessment of products*. UNEP/SETAC Life Cycle Initiative at UNEP, CIRAIG, FAQDD and the Belgium Federal Public Planning Service Sustainable Development.

Clark, Rosenzweig, Long, Olsen (2008). *Double Bottom Line Project Report: Assessing Social Impact in Double Bottom Line Ventures*. Rockefeller Foundation. Jan 2004. 25 Sept 2008 <http://www.riseproject.org/DBL_Methods_Catalog.pdf>.

Den Boer J., Bukowski P. and Dyjakon A. (2014). Determination of the environmental impact of a new biomass logistics chain. *Agricultural Engineering, 3*(151), 5-14.

Dreyer, L.; Hauschild, M.; Schierbeck, J. (2006). A Framework for Social Life Cycle Impact Assessment. *Int J LCA, 11*(2), 88-97.

Dyjakon, A.; den Boer, J.; Bukowski P. (2014). Europruning – a new direction for energy production from biomass. *Agricultural Engineering, 3*(151), 29-40.

European Commission. (2010). *Biomass potential. Chapter in "Agriculture and Bioenergy" website of the Department of Agriculture and Rural Development of European Commission*. Available in: http://ec.europa.eu/agriculture/bioenergy/potential/index_en.htm.

The Interorganizational Committee on Principles and Guidelines for Social Impact Assessment (2003). *Principles and guidelines for social impact assessment in the USA*, in: Impact Assessment and Project Appraisal, volume 21, number 3, September 2003, pages 231–250, Beech Tree Publishing, 10 Watford Close, Guildford, Surrey GU1 2EP, UK

TransWaste (2012). *Social effects informal collection & formalisation strategies*. Final report of the project TransWaste funded by Central Europe.

Zerowin, G.; Obersteiner, P.; Beigl, A.; Pertl, S. (2010). *Scherhaufer Institute of Waste Management*. BOKU Wien. Grant Agreement number: 226752. Work package number: 7.

BIOMASA Z SADU NA CELE ENERGETYCZNE: SPOSÓB PODEJŚCIA PRZY OCENIE WPŁYWU NA SPOŁECZEŃSTWO

Streszczenie. Analiza i ocena wpływu społecznych aspektów na wartość inwestycji wciąż nie należy do popularnych analiz stosowanych w Polsce. Jednak ustawodawstwo Unii Europejskiej oraz praktyki z krajów wysoko rozwiniętych (w tym USA) wskazują na zasadność przeprowadzania także tych analiz. Aspekty społeczne są ważne z punktu widzenia rozwoju gospodarczego regionu (także w obszarze rolniczym) i stanowią istotne uzupełnienie analiz ekonomicznych oraz środowiskowych. Z tego względu, wskaźniki społeczne są także przedmiotem rozważań realizowanego projektu EuroPruning, którego zadaniem jest opracowanie nowej metody logistycznej pozyskiwania, transportowania, magazynowania i wykorzystania ścinek gałęzi z drzew owocowych dla celów energetycznych. W artykule przedstawiono dwa typy analiz uwzględniających wpływ aspektów społecznych na analizę cyklu życia (SLCA) oraz zwrot inwestycji (SROI). Omówiono metodykę badawczą oraz problematykę oceny i wyboru odpowiednich wskaźników opisujących aspekty społeczne w zadanych warunkach.

Słowa kluczowe: biomasa, gałęzie drzew owocowych, produkcja energii, aspekt społeczny, SROI, SLCA

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EUROPRUNING – A NEW DIRECTION FOR ENERGY PRODUCTION FROM BIOMASS

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ABSTRACT

One of the possibilities of biomass potential increase on the energy market is the utilisation of agricultural residues in the form of prunings coming from orchards and permanent plantations (fruit tree, vineyards and olive grove prunings and branches from up-rooted trees). The issue of such biomass acquisition for energy purposes in Europe is not fully developed and several aspects still require investigation and/or solutions. The result of that unsolved subject is EuroPruning project realised in the frame of FP7 which is focused on the development of new improved logistics for pruning residues. The paper presents the main goals and assumptions of the EuroPruning project. The methodology and the range of the research works related to harvesting, transport and storage of prunings is described, as well. Attention was paid as well to the environmental, economic and social aspects that are going to be analysed during the project realisation.

Introduction

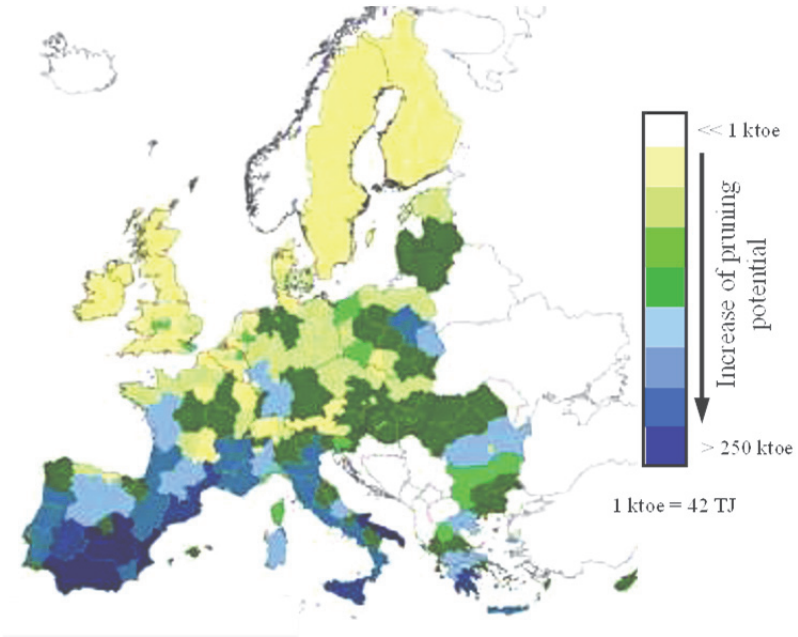
Many of the biomass fuels used today for energy production come from various sectors (agriculture, forestry, industry, waste etc.) and are in the form of e.g. wood products, dried vegetation, crop residues or aquatic plants. Biomass belongs to the one of the most commonly used renewable sources of energy in the last years. It is caused by its relatively low cost, high availability, indigenous nature and positive influence on the environment.

The most common biomass used in households for heating and cooking is wood from conifer and leafy trees. It leads to a considerable reduction in net carbon dioxide emissions that contribute to the greenhouse effect. However, the intensive use of fire wood as an alternative fuel may result in deforestation. The problems associated with denuding forests, and widespread clear cutting can lead to groundwater contamination and irreversible erosion patterns that could literally change the structure of the world ecology.

Therefore, other sources of wood for energetic purposes are searched that are abundant in a wide-scale yet non-disruptive manner, since they could be implemented at a local level by the society.

Moreover, it is crucial that biomass, during the whole chain of its route, could be converted to usable energy in ways that are more efficient, less polluting, and at least as economical as today's practices (EU White Paper, 1997).

One of the options, beside the straw residues, is the use of agricultural residues (prunings) coming from permanent plantations and orchards (Magagnotti et al., 2013; Spinelli and Picchi, 2010; Spinelli et al., 2010): olive trees, vineyards, fruit trees etc.. The European Union currently creates more than 25 million Mg of agricultural wood prunings each year (Nikolaou et al., 2003), but only a marginal percentage is used as solid biofuel. It should be mentioned, that in certain regions of the EU, the plantations with soft fruit, citrus, olives but also vineyards cover a significant surface delivering theoretically a large energetic potential. The energy potential from pruning and cuttings in permanent crops across a Europe is shown in figure 1.



Source: www.biomassfutures.eu

Figure 1. Energy potential from pruning

As the practical utilisation of pruning from permanent plantations and orchards for heat and/or electricity production is still not well recognised, an international Consortium (fig. 2) and finally European project EuroPruning has been created. The EuroPruning project aims to turn prunings into a valuable fuel source by developing solutions for their harvesting, transportation and storage that will create growth in the European biofuels market.

Spain
CIRCE (Centre of Research for Energy Resources and Consumption), University of Zaragoza, Zaragoza
GRUYSER, Fraga
MITRAFOR, Zaragoza
AGRI-FOOD COOPERATIVES SPAIN, Madrid
Sweden
*SLU (*Swedish University of Agricultural Sciences), Uppsala
MOBITRON, Huksvarna
Germany
ATB (Leibniz Institute of Agricultural Technology), Potsdam
TERRAQUAT, Nurtingen
OBSTGUT MARQUARDT GbR, Potsdam
Italy
CRA-ING (Agriculture Research Council, The Agricultural Engineering Research Unit), Rome
ONG, Castelbolognese
Poland
WUELS (Wroclaw University of Environmental and Life Sciences), Wroclaw
PIMR (The Industrial Institute of Agricultural Machineries), Poznan
Belgium
GREENOVATE EUROPE, Brussels
France
COOP de FRANCE (National federation of agriculture and forestry cooperatives), Paris
UNI-MEDOC. Gaillan En Medoc

Figure 2. EuroPruning Consortium: (17 partners from 7 EU-countries: 6 research institutes, 8 small and medium enterprises, 3 other institutions, total budget: 4.6 million Euros, duration: 38 months).

The objective of this paper is to present the strategy of the EuroPruning project focusing on the main assumptions, the methodology to be applied and final targets which should lead to the increase of knowledge about the possible ways of pruning treatment in terms of environmental, economic and social aspects.

Motivation and the main objective of EuroPruning project

Agricultural residues are a potential source of renewable energy. There is already an implemented and developed logistic chain for straw residues from annual crops (Hahn and Herrmann, 2009; Sambra et al., 2008). Currently, in many countries, straw is a widely used biofuel for households heating as well as for heat/electricity generation in commercial plants. The straw market is well recognised and reached a level of stabilisation and acceptance in power engineering.

A high potential is also to be found in pruning residues from fruit tree / plant branches and twigs. The pruning yield depends on the kind of a fruit tree, geographical location and many other factors, but may reach even 7-8 $Mg \cdot ha^{-1}$ of dry biomass having lower caloric value of ca. 17-18 $MJ \cdot kg^{-1}$ (Velazquez-Marti et al., 2012; Bilandzija et al., 2012; Boschiero et al., 2013). Unfortunately, prunings are still an almost unexploited biomass resource. Usually, farmers along Europe chop the branches to incorporate them to soil as organic

supplement (which involves significant costs) or pile the branches and burn them on an open field (to avoid costs and get rid of the biomass). There are also other constraints limiting the utilisation of biomass for energy purposes. As compared to herbaceous crops, fields are more scattered in the territory and the size of plantations is smaller (imply more complicated logistics), harvesting of prunings from the soil in very dense plantations (distance between trees less than 1.7 m) is also complex and machinery cannot adapt to differential crop layouts. Finally, there is no procedure or proven technology of prunings treatment in terms of their use as a primary source of bioenergy.

As a result, EuroPruning project aims to take-off for an extensive utilisation of the agricultural prunings for energy in Europe. The main objective of EuroPruning, therefore, is to develop a new logistic chain including harvesting, transport and storage for woody residues from the fruit tree cuttings (fig. 3).

Figure 3. EuroPruning concept

To fulfil the EU requirements (European Commission, 2010) and insure the sustainable use of prunings, the economic, environmental and social aspects will be analysed, as well. Additionally, the project will develop new machinery for harvesting and on-site treatment of the prunings which will fill a technology gap in the market: a modular prototype (to be mounted on regular agricultural tractors) adaptable to different crop layouts able to pick-up the branches, chip and store them into a trailer or to wrap them; and a baler capable to produce large bales, similar to hay and straw bales. Machinery will be able to reduce costs and pre-treat the biomass so that the product is compatible with standard transport means. Furthermore, the achieved results and findings will be supported by the demonstrations performed on the permanent plantations in three different regions in Europe: Spain (Zaragoza

region), France (Médoc) and Germany (Brandenburg region), where newly developed machines for automated pruning collection (baling) and chopping will be tested.

Research methodology and work packages in EuroPruning project

To obtain the expected targets, the project has been divided into nine work packages (fig. 4). In addition, due to the complexity of the project there have been assessed two modules including several related work packages (WPs).

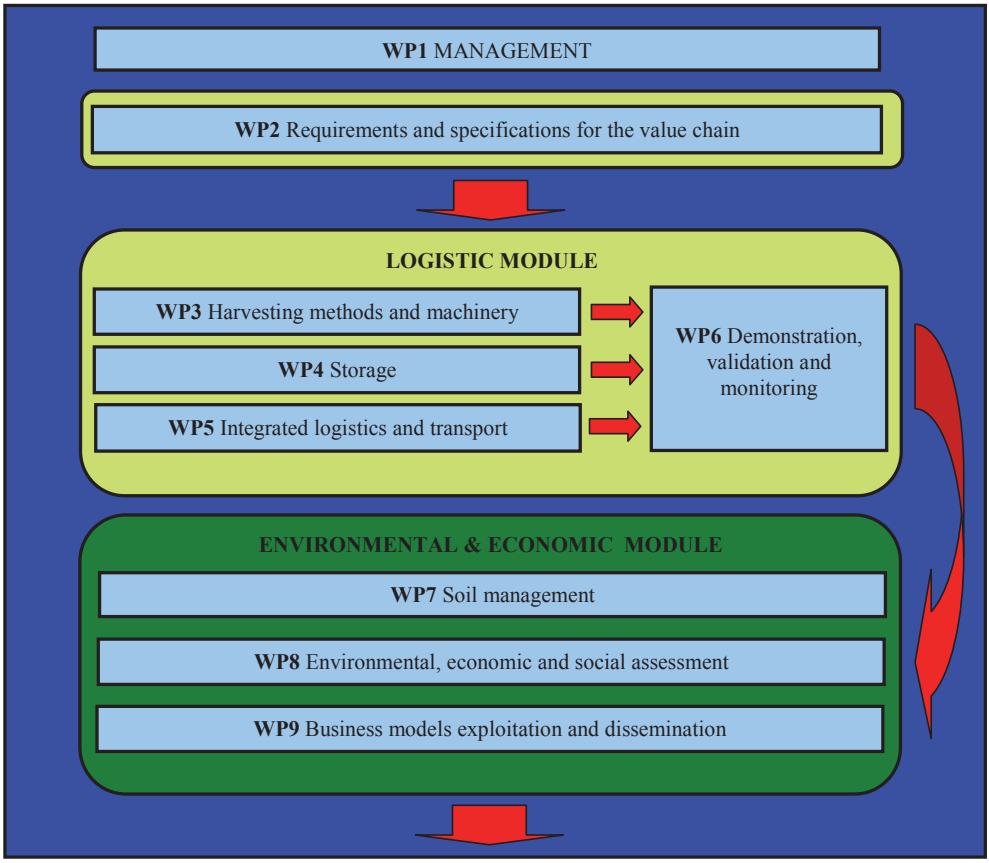


Figure 4. Distribution of the work packages in the EuroPruning project

The management issues are defined and developed in WP1 (Management) in order to ensure the project runs in the most efficient way.

Within the WP2 the analysis is focused on the assessment of the quality of agricultural pruning residues as feedstock for energy production at each step of the supply chain using defined criteria, like: physical-chemical properties including particles size, proximate and ultimate analysis, ash composition, impurities content etc. (fig. 5). Quality criteria, together

with other specifications (for example, consumer expectations) will be employed to evaluate the biomass across the demonstration activities of the supply chain: harvesting, pretreatment, storage and transport.

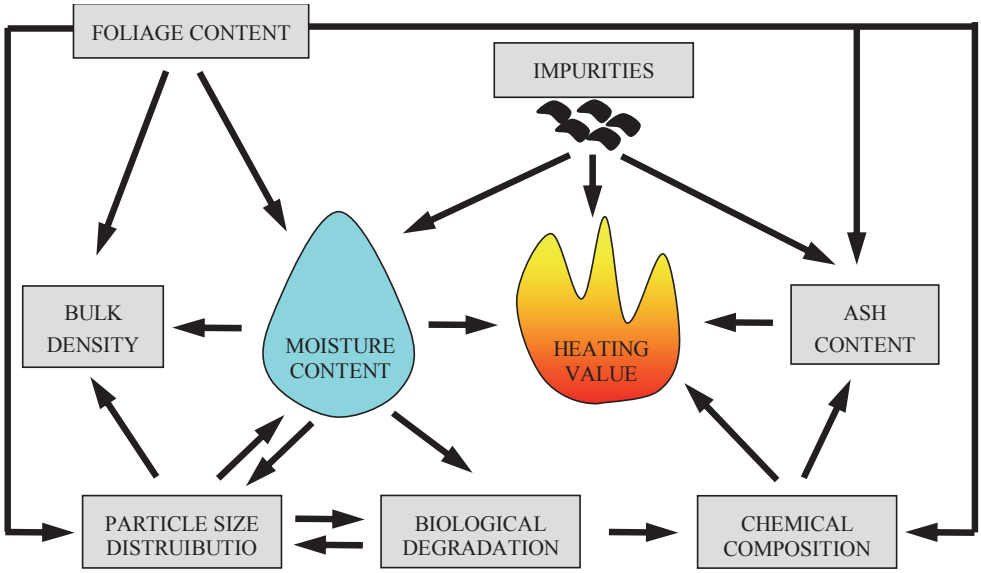


Figure 5. The quality criteria and the relations between the exemplified parameters of biomass

The procedure of the prunings quality control will be also applied during the demonstrations activities. Finally, the data will be implemented in the logistics module considered in the following WPs.

Next three work packages (WP3, WP4 and WP5) are the RTD type (Research and Technology Development) investigating different steps of the logistic chain: harvesting, storage and integrated logistic focused on the prunings' transport.

WP3 seeks to design, develop and build new prototypes for a sustainable and feasible large or small scale wood pruning logistics. In this task, particular attention is paid on the wide range of the requirements which should be fulfilled by the innovative machineries working in the fruit trees plantations.

WP4 contains the assessment of proper management of agricultural prunings storage and proposition of best practices regarding length of windrowing and adequate particle size under certain climate conditions. This data will encourage possible market players of the logistic chain to enter the bioenergy market with a product of high quality.

Based partially on the results obtained during the earlier steps of the investigated process, in WP5 the development and implementation of innovative logistics tools in order to optimise environmentally and economically efficient and effective handling of prunings along the whole value chain will be elaborated. It should be marked that the organisation, management, handlings, storage, packaging, transport, and other associated information

will flow in both directions (from producer to consumer and the other way). In addition, the financial flow will be implemented in that phase of the project. The traceability for monitoring from the fruit tree orchard (or other permanent plantation) to the final consumer will be performed to control and guarantee the quality of the prunings.

A substantial part of the project is WP6 including the demonstration phase. The role of this practical demonstration is to validate and monitor the processes of prunings harvesting, treatment as well as prototype machineries operation in real conditions. Moreover, in order to measure the different impacts of the new logistic, an economic and environmental module will be implemented (see fig. 4). The demonstration will take place in three areas across the Europe which are distinguished by varying local climates: Oceanic, Continental and Mediterranean (fig. 6).

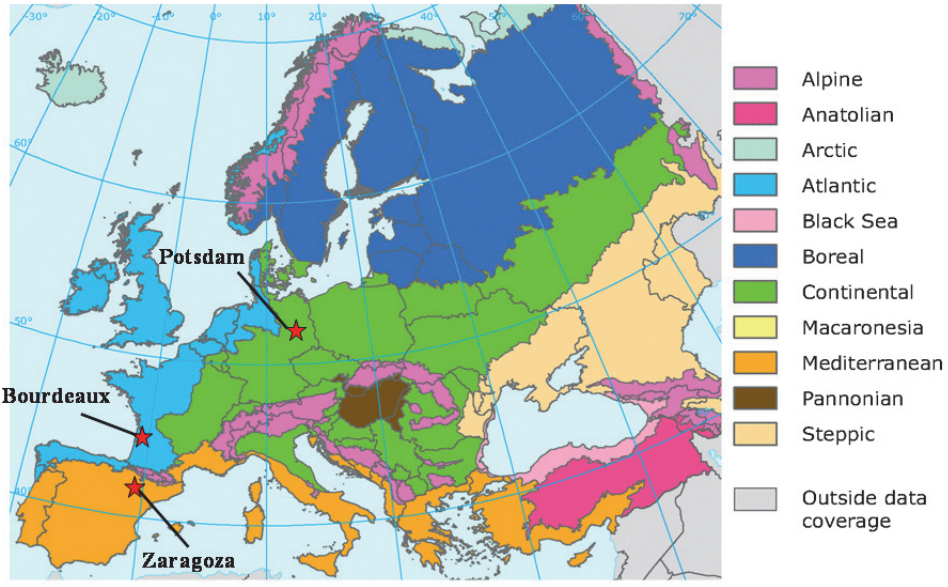


Figure 6. Biogeographic regions in Europe (EEA, 2011)

The selected site is the area of Médoc, near Bordeaux, in South-West France is an Oceanic climate. The area of Postdam, in North-East Germany, represents the continental climate prevailing in countries of Central Europe (Czech Republic, Poland, Hungary, etc.). The third location (Zaragoza in North-East Spain) represents the Mediterranean dry climate (typical of inlands in Spain). The practical results, the pilot-scale real operation demonstrations of EuroPruning are intended to show to farmers, logistic operators and companies of the energy sector along Europe that the use of the agricultural prunings is feasible, economic viable and profitable for large scale (Spanish demo site) and small scale (French and German demo sites) supply chains.

WP7 concerns soil management. The research to be performed in the demonstration areas are focused on the analysis of the influence of wood prunings on the composition of soil organic matter. It is important to determine, how much pruning should be left on the soil as

a source of mineral matter. It helps to avoid the need of extra fertilisation and to maintain the mineral balance in the agricultural system. If there is an excess of the prunings, they may be collected and allocated for energy purposes.

The results obtained in previous work packages will be subsequently analysed in terms of the environmental, economic and social aspects (WP8). It enables to evaluate the potential of the whole logistic chains investigated in the project and their application in Europe. The positive and negative effects or implications of the logistic chain will be identified in WP8. Moreover, the best logistic chains in terms of economics and environmental issues will be proposed, as well as their adaptability to different social contexts. Finally, the capacity of prunings to promote sustainable practices and development in rural areas will be discussed. By using different tools, LCA (Life Cycle Assessment), LCC (Life Cycle Costing) and SROI (Social Return of Investment) analysis will be performed.

Finally WP9 is oriented to dissemination actions towards the key players of the value chain and the general public as well as development of business plans for all major typical logistics supply chains. At the end, WP9 will provide recommendations for market uptake for each stakeholder as part of the exploitation plan.

Expected results and specific outcomes

The project outcomes (grouped into certain issues) are expected to be:

a) prunings properties as a fuel:
   – identification and assessment of the specifications and properties of biomass from agricultural pruning residues,
   – selection of the appropriate methodology for sampling and testing of quality parameters, and its implementation on the demo sites,
   – assessment of the quality of pruning residues as feedstock for energy production at each step of the supply chain,
   – identification and definition of the specifications of the final users at each demonstration site,
   – elaboration of the guidelines and best practices for evaluating pruning residues along the whole value chain, taking into consideration geographical variations and end user demands.
b) harvesting methods and machinery:
   – costs reduction for prunings harvesting up to 50% without affecting the quality and life cycle of the plant,
   – analysis and evaluation of the current harvesting methods according to the guidelines and specifications for the biomass quality for harvesting,
   – mapping of the EU27 pruning potential,
   – improvement of the current harvesting methods regarding environmental impacts, prunings quality and economics,
   – design and construction of a tested prototype of a complete new baler machine for branches from pruning residues,
c) transport and integrated logistics:
   – reduction of prunings transport costs up to 30% by providing decision making tools to logistic operators,

- design and implementation of logistics tools in order to optimise environmentally and economically the transport of the pruning among the whole value chain,
- definition and development of the traceability systems on the pruning logistic to assure the quality,
- development and testing of a new Smart Box tool under real conditions for optimising logistics,

d) storage of biomass from prunings:
- testing and monitoring of the storage of prunings under real conditions in large piles,
- definition of best practices for open air storage regarding to environmental, economic, safety and biomass quality concerns,

e) soil management:
- definition, depending on the soil conditions and crop requirements, the amount of pruning to be left on the field as amendment,
- development and definition of a protocol and methodology for soil management analysis,
- monitor the impact on the soil of the demo-sites,

f) demonstration on the field and validation:
- testing under real conditions the developments and results of the project,
- analysis of samples obtained during the test on field to validate and optimise the developments of the project,

g) impacts assessment:
- definition of a methodology and measurements of the economic impact of the implementation of the results in the market,
- determination of logistics cost in the whole value chain of biomass,
- definition of a methodology and measurement of the environmental impact of the implementation of the results,
- assessment of the social impact of the results of the project,

h) business models and exploitation:
- review of the current market trends on biomass,
- development of the exploitation plan including: valorisation, SWOT analysis, exploitation roadmaps and value innovation analysis of individual projects results,
- definition of business models for market take-up and safeguard the value of the project results,

i) dissemination:
- assurance of the effective branding of EuroPruning and dissemination of key results targeting farmers, policy makers, authorities, non-governmental organisations (NGOs), investors, professionals, land owners and researchers,
- dissemination of results including advices for policy makers, focusing on measures to implement the improved new logistic chain of prunings,
- dissemination of results of an environmental, social and economic analysis among stakeholders and users,
- creation of the possibility for EuroPruning continuity beyond the end of the project, in order to attain the full potential impact.

Final conclusions

The increase of biomass potential allocated for decentralised and local energy production, especially amongst the agricultural residues, is still a very important task and challenge for European Countries in the coming years. Therefore, more and more attention is paid to the agricultural sectors that have not been yet investigated in respect of their utilisation as a source of solid biofuels. The prunings coming from orchards and permanent plantation are good example of this strategy. It led to the creation of the EuroPruning project supported by the European Commission.

The overall objective of the EuroPruning project is to develop and demonstrate a non-existent, new logistic chain for the biomass from pruning residues. The logistic chain includes the harvesting methods, the transport and the storage of the biomass. Furthermore, the quality of the biomass, the cost effectiveness of the processes as well as the environmental and social impacts will be taken into account.

To achieve this global objective, the following main specific targets were defined:

- assessment of fuel quality properties for pruning biomass related to the final consumer expectations and energy production,
- improvement of the harvesting methods and machinery development,
- transport and integrated logistics development,
- determination of optimal storage conditions of prunings,
- soil management analysis to define the optimal amount of prunings for energy purposes,
- demonstration and validation of the prunings-to-energy strategy under real conditions,
- impacts analysis of the whole logistic chains in terms of environmental, economic and social aspects,
- structure and definition of business models and other supporting tools introducing prunings to the biomass energy market.

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References

Bilandzija, N.; Voca, N.; Kricka, T.; Matin, A.; Jurisic, V. (2012). Energy potential of fruit tree pruned biomass in Croatia, *Spanish Journal of Agricultural Research, 10*(2), 292-298. (ISSN: 1695-971-X), http://dx.doi.org/10.5424/sjar/2012102-126-11.

Boschiero, M.; Neri, P.; Zerbe, S. (2013). *Apple orchard pruning residues as a potential bioenergy source in South Tyrol: a LCA case study*, 15th International Conference RAMIRAN 2013, 3-5

June 2013, Versailles, France, Available in: http://www.ramiran.net/doc13/Proceeding_2013 /documents/S10.15.pdf.
EU White Paper: COM(97) 599 final. *Energy for the future - renewable sources of energy*. Available in: http://europa.eu/documents/comm/white_papers/pdf/com97_599_en.pdf.
European Commission, (2010). *Biomass potential. Chapter in "Agriculture and Bioenergy"* website of the Department of Agriculture and Rural Development of European Commission. Available in: http://ec.europa.eu/agriculture/bioenergy/potential/index_en.htm.
European Environment Agency (EEA). (2011). *Biogeographic regions in Europe*. Available in: http://www.eea.europa.eu/data-and-maps/figures/biogeographical-regions-in-europe-1.
Hahn, J.; Herrmann, A. (2009). *Baling, transportation, and storage of straw*, In: Agricultural Mechanization and Automation, Edited by McNulty P., Grace P.M., Volume II, 292-308. ISBN: 978-1-84826-097-9 (eBook), ISBN: 978-1-84826-547-9 (Print Volume).
Magagnotti, N.; Pari, L.; Picchi, G.; Spinelli, R. (2013). Technology alternatives for tapping the pruning residue resource. *Bioresources Technology, Volume 128*, 697-702. (ISSN: 0960-8524), http://dx.doi.org/10.1016/j.biortech.2012.10.149
Nikolaou, A.; Remrova, M.; Jeliazkov, I. (2003). *Biomass availability in Europe*. Available in: http://ec.europa.eu/energy/res/sectors/doc/bioenergy/cres_final_report_annex.pdf
Sambra, A.; Sorensen, C.A.G.; Kristensen, E.F. (2008). *Optimized harvest and logistics for biomass supply chain*. Proceedings of European Biomass Conference and Exhibition, Valencia, Spain. (DVD), ISBN-10: 8889407581, ISBN-13: 978-8889407585
Spinelli, R.; Magagnotti, N.; Nati, C. (2010). Harvesting vineyard pruning residues for energy use. *Biosyst Eng,* Volume 105, 316-322. (ISSN: 1537-5110), http://doi:10.1016/j.biosystemseng .2009.11.011
Spinelli, R.; Picchi, G. (2010). Industrial harvesting of olive tree pruning residue for energy biomass. *Bioresources Technology*, *Volume 101,* 730-735. (ISSN: 0960-8524), http://doi:10.1016/ j.biortech.2009.08.039
Velazquez-Marti, B.; Fernandez-Gonzalez, E.; Callejon-Ferre, A.J.; Estornell-Cremades, J. (2012). Mechanized methods for harvesting residual biomass from Mediterranean fruit tree cultivations, *Scientia Agricola*. *Volume 69, No. 3*, 180-188, May/June 2012 (ISSN 0103-9016), access on 05 Jan. 2014. http://dx.doi.org/10.1590/S0103-90162012000300002.

EUROPRUNING – NOWY KIERUNEK WYTWARZANIA ENERGII Z BIOMASY

Streszczenie. Jedną z możliwości zwiększenia potencjału biomasy na rynku energetycznym jest wykorzystanie odpadów rolniczych w postaci gałęzi ze ścinek drzew sadowniczych (drzew owocowych, winnic, drzew oliwnych i innych roślin korzennych). Zagadnienie pozyskiwania tego typu biomasy dla celów energetycznych w Europie nie jest w pełni rozwinięte i wiele aspektów wymaga nadal zbadania i/lub rozwiązania. Efektem tego jest projekt EuroPruning realizowany w ramach 7 Programu Ramowego ukierunkowany na rozwój nowej i ulepszonej metody logistycznej dla tego typu biomasy. W artykule przedstawiono główne cele i założenia projektu EuroPruning. Omówiono metodologię oraz zakres prac badawczych związanych z pozyskiwaniem, transportem i magazynowaniem takich odpadów rolniczych i uwzględniających aspekty środowiskowe, ekonomiczne i społeczne.

Słowa kluczowe: biomasa, ścinki gałęzi, sad, produkcja energii

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ANALYSIS OF STUDENTS' MOTIVATION AND PREDISPOSITION TO INTRODUCE CES EDUPACK SOFTWARE FOR TEACHING MATERIALS SCIENCE

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ABSTRACT

The aim of the study was to examine the motivation and predispositions of students of the Faculty of Production Engineering at the University of Life Sciences in Lublin to attend laboratory classes in Materials Science supported with a computer program Cambridge Engineering Selector – CES EduPack in English. Determinants of the desirability of its use for first-year students were: the level of computer skills, interests of students in the issues of materials selection and knowledge of the English language, which supports the program. The survey consisted of 17 questions. The questionnaire was filled in by 81 students. The results confirmed the positive opinion of the respondents about the advisability of using a computer program for education purposes. Moreover,half of the respondents believe that during laboratory classes various forms of knowledge transfer should be combined. Students in a large majority show interest in the choice of materials for the products of everyday use. In contrast, they are afraid of or do not have an opinion on using software in English.

Introduction

Motivation to undertake actions aiming at increasing the attractiveness and improvement of knowledge acquisition on engineering materials included reduction in the number of teaching hours and deteriorating teaching results in the subject "Materials Science" among the students majoring in Agricultural and Forestry Technique and Production Management and Engineering of the University of Life Sciences in Lublin. The actions of previous authors while teaching students Materials Science at various majors of the Univeristy of Life Sciences allowed developing a specific, different than the one applied on technical universities, methodology of teaching, adjusted to present conditions, to the level of students and time possibilities (Grudziński, 2006). Research carried out by Kozielska and Kern (2011) proved that computer-assisted education on the university level develops imagination and creativity of students of technical universities. It was recognized that according to the trend prevailing in teaching, which consists in teaching many perception channels of a human being (sight, hearing, kinesthetic) (Kozielska, 2012) enabling students the use as

a supplementation of laboratory lessons, information technologies based on computer simulations, would be purposeful. Garcia et al. (2007) think that teachers' attempts aiming at making lessons more attractive along with development of information technologies offer new, more attractive and effective form of learning. Students who can choose between a traditional blackboard and chalk, a multimedia presentation and animation, prefer combining two or three media. Interactivity is the most important asset of multimedia teaching (Lieu, 1999).

Cambridge Engineering Selector – CES EduPack developed in the University in Cambridge is the most popular program which supports teaching material engineering worldwide including 12 universities in Poland. This program is based on the hierarchical manner of selection of material to specific applications, enables learning on various levels of educating material engineering (Granta Materials Intelligence, 2014). Using it requires basic skill of computer operation and English knowledge on the beginners' level.

Research methodology

The objective of the paper was to check students' motivation and predisposition to laboratory classes during which the source of knowledge on materials was a computer program CES EduPack in English.

Investigation carried out with a guided survey in 2013 included the group of 81 students of the 2nd semester of the regular first degree studies at the Agricultural and Forestry Technique [AFT] (21% of the investigated persons) and Production Management and Engineering [PME] (79% of the investigated) majors at the University of Life Sciences in Lublin.

An anonymous questionnaire comprised 17 closed, half-open and directed questions. The questions concerned students' motivation to learning on engineering materials, their acceptance to the use of information technologies during classes, subjective assessment of English knowledge and computer skills, some personal data and verification of knowledge on basic computer skills.

Research results

In the respondents group women constituted 24% at the AFT major and 45% at the PME major. While choosing the major, 47% of AFT students took into consideration their interests. Bzowska-Baklarz and Pieczykolan (2006) as well as Falińska and Bieniek (2009) obtained similar results. Among the remaining part of respondents not being qualified to the originally chosen major the possibility of finding attractive job after graduation was decisive in the selection of the major. Among the AFT students, 8% were guided by their interests and 52% by the possibility of finding attractive workplace after graduation.

After the educational reform, the number of students graduating from vocational schools, particularly technical secondary schools, decreased; mostly they are graduates of general secondary schools (Falińska and Bieniek, 2009). The investigation which was carried out proves these relations, because over 76% of the investigated persons completed a general secondary school.

Each year, the number of students of life sciences universities, who have access to a computer with Internet raises (Sołowiej et al., 2007; Lorencowicz and Kocira, 2009,

2010, 2012). Among the AFTstudents - 100% and among the PME students - 97% of the investigated in 2013 had access to computers and the Internet in the place of residence.

The AFT students (70%) and PME students (64%) assess their computer skills within the scale 1-5 as 4 or 5 respectively (fig.1).

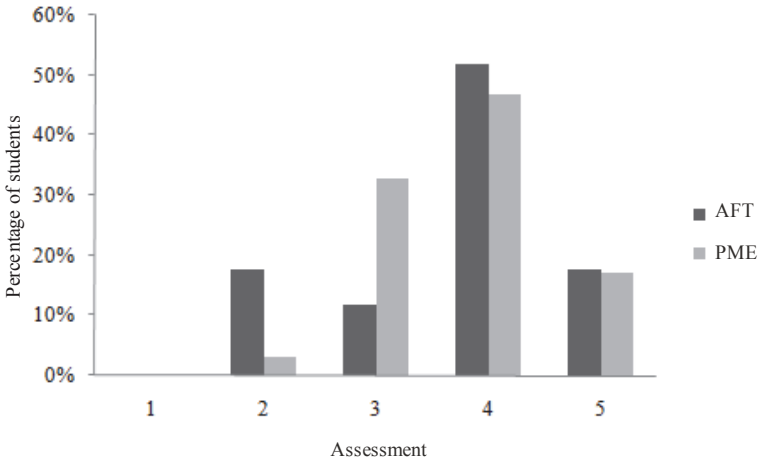

Figure 1. Assessment of computer skills declared by the students.

Verification of declarations of the questioned persons on computer skills degree, was carried out based on answers to the following questions:

1.Which set of file types is characteristic for computer graphics files?

2.Which address of the Internet website is incorrect?

3.How to change a font for the text fragment into a bold one?

Four answers: a, b, c, d could be chosen. The lower number of correct answers was given to the question 3-13% of students of the AFT major and 38% of the PME major (fig. 2). These results are surprising, because 91% of the investigated persons (Lorencowicz and Kocira, 2009) uses MS Office packet in studying and 83% assesses their word processor skills as very good (Sołowiej et al., 2007). As much as 75% of the questioned answered correctly to the remaining questions, which cannot be recognized as a satisfactory result in the light of common use of the Internet and computer graphics by adolescents.

Majority of the questioned students (78% of respondents) thinks that using computer in laboratory lessons raised their activity (fig. 3). Additionally, over half of the investigated persons thinks that the most attractive form of carrying out laboratory lessons on the Materials Science is combining various activity forms, i.e. own work, group work, presentation of educational films, joined calculations, copying micro-structures presented by a lecturer.

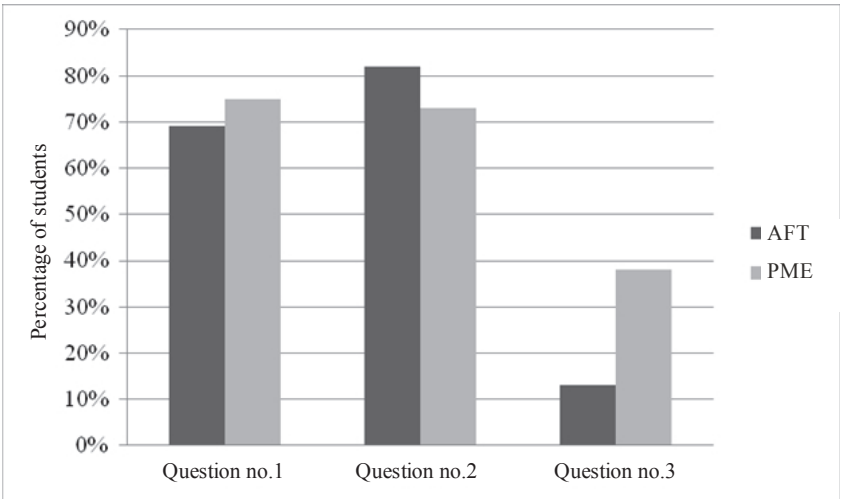

Figure 2. The correct answers to the questions concerning computer skills

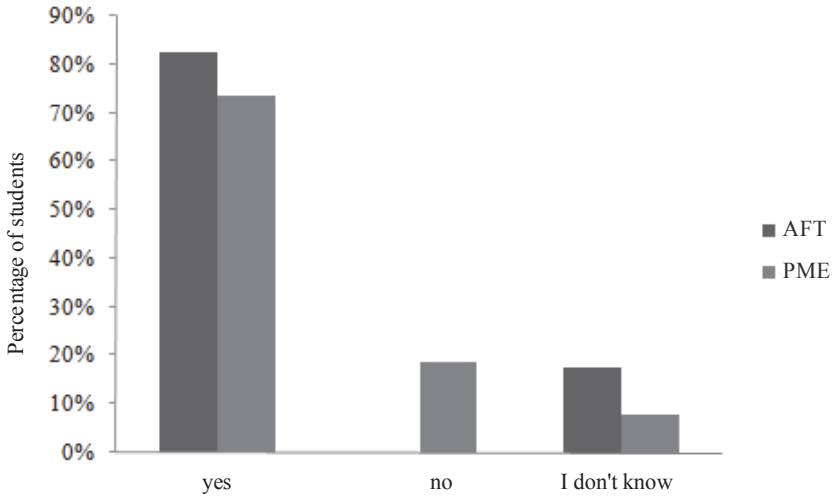

Figure 3. The positive impact of computer use in the laboratory classes for their attractiveness in respondents' opinions

It was found out that students show interest in issues related to selection of materials, especially to goods, which they use or which are related to their hobby. For example, over 80% of respondents would like to know with the use of a computer program, which factors decide on the selection of materials for cell phones casings (fig. 4).

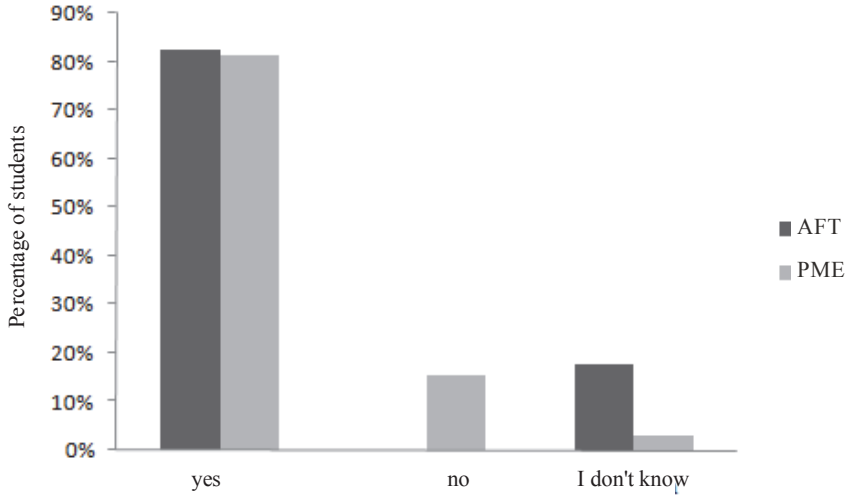

Figure 4. The results of students interest of the choice of materials for the casing of mobile phones with the help of a computer program

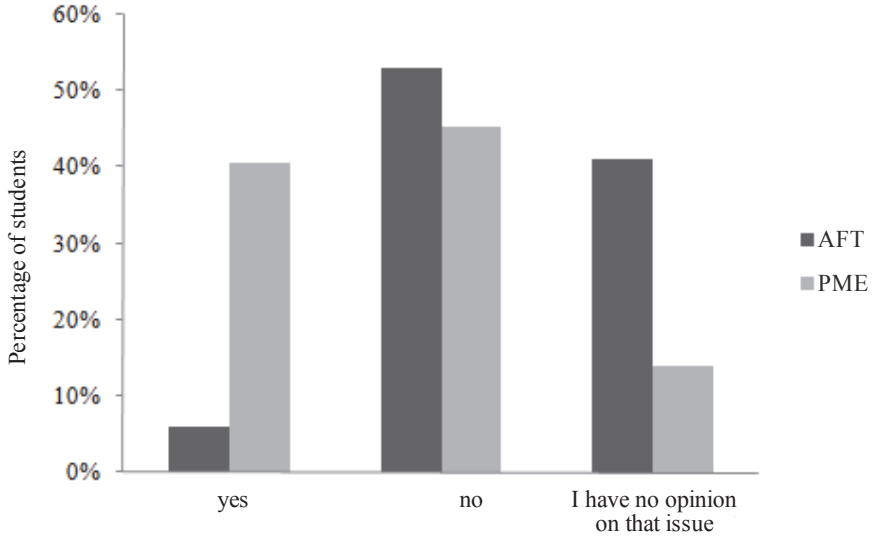

Figure. 5. Declaration of desire to participate in activities in which the source of knowledge about materials would be a computer program in English

Only 1 student of the AFT major would wish to take part in lessons, during which a computer program in English would be a source of knowledge. Among the PME students, 41% respondents expressed their wish to participate in lessons and 45% - would not like to take part in such lessons (fig.5).

Students' fears are related to poor, in their opinion, English skills. The AFT students (65%) and the PME students (77%) assess their English skills as 1 to 3 (fig. 6).

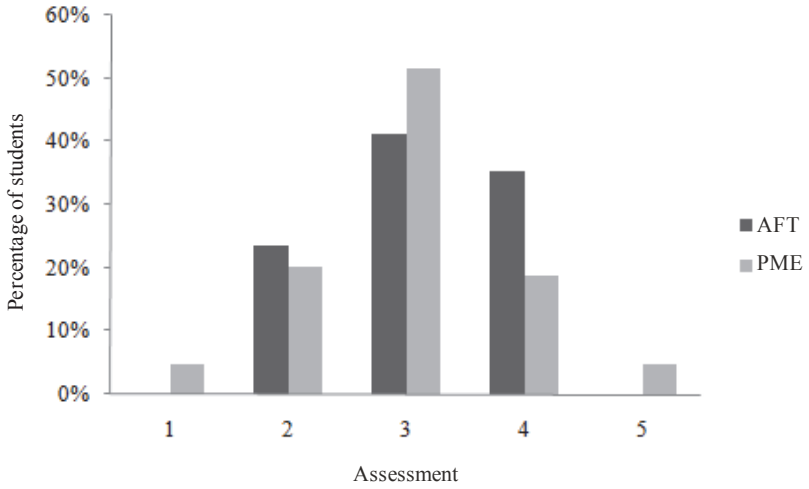

Figure 6. Subjective assessment of English language proficiency

Conclusions

The analysis of answers to the questionnaire shows that students of the first year of the AFT and PME majors of the Faculty of Production Engineering feel the need to use IT as a supplementary means for the knowledge acquisition on laboratory lessons on the Materials Science. They are interested in engineering materials properties and possibilities of their application to modern uses.

Results of a survey compared with results of such research carried out a few years ago prove the increase of availability of computers with Internet access; however, the answers to the questions that verify the abilities to use the program by students were not satisfactory. It proves the necessity to implement changes in teaching programmes, which aim at increasing the number of activities in informatics and foreign languages, which had been alarmed earlier in the research on opinions of graduates of the University of Life Sciences in Lublin (Bzowska-Baklarz and Pieczykolan, 2005).

Students fears mostly concern their English skills and working on a computer program in foreign language. It concerns mainly AFT students. The questionnaire did not include questions verifying English skills of respondents, therefore it is difficult to verify students' opinions on a low level of this skill. Previous authors' experience related to demonstration of a film in English prove their full teaching usefulness, but only after informing students

on the subject of a film, providing the meaning of more important technical definitions, pausing a film in more important places and explaining phenomena presented in these moments. Thus, before implementation of teaching software it is very important to properly prepare students for lessons and use detailed activity instructions. On account of very poor results of the questionnaire on English skills, next research among respondents is planned with the use of a demonstration program CES EduPack.

References

Bzowska-Bakalarz, M.; Pieczykolan, E. (2005). Jakość kształcenia w ocenie absolwentów wydziału techniki rolniczej. *Inżynieria Rolnicza, 6*(66), 65-74.

Falińska, K.; Bieniek, J. (2010). Jakość kształcenia na kierunku Technika Rolnicza i Leśna Uniwersytetu Przyrodniczego we Wrocławiu według jego absolwentów. *Inżynieria Rolnicza, 5*(123), 15-23.

García, R. R.; Quirós, J. S.; Santos, R. Z.; González, S. M.; Fernanz, S. M. (2007). Interactive multimedia animation with Macromedia Flash in Descriptive Geometry teaching. *Computers & Education, 49*(3), 615-639.

Granta Materials Intelligence, Granta Design Ltd., Cambridge, 2014. Pozyskano z: www.grantadesign.com.

Grudziński, J. (2006). System ekspertowy identyfikacji tworzyw sztucznych stosowanych w rolnictwie. *Inżynieria Rolnicza, 5*(80), 215-221.

Kozielska, M.; Kern, T. (2011). Application of Information Technology by Students of Technical Sciences in the Context of Their Studying Styles. *The New Educational Review, 25*(3), 151-159.

Kozielska, M. (2012). Rola technologii Informacyjnych w akademickim kształceniu technicznym. 22. Ogólnopolskie Sympozjum Naukowe: Człowiek – Media – Edukacja, Uniwersytet Pedagogiczny w Krakowie, Kraków. Pozyskano z: www.ktime.up.krakow.pl/symp2012/referaty_2012_10 /kozielsk.pdf.

Lieu, D. (1999). Using interactive multimedia computer tutorials for engineering graphics education. *Journal for Geometry and Graphics, 3*(1), 85-91

Lorencowicz, E.; Kocira, S. (2009). Wykorzystanie komputerów i Internetu przez studentów studiów o profilu rolniczym. *Inżynieria Rolnicza, 9*(118), 121-129.

Lorencowicz, E.; Kocira, S. (2010). Ocena wykorzystania technologii informacyjnych w procesie kształcenia studentów. *Inżynieria Rolnicza, 7*(125), 119-124.

Lorencowicz, E.; Kocira, S. (2012). Ocena wykorzystania Internetu przez studentów studiów inżynierskich. *Postęp Nauki i Techniki, 15*, 238-245.

Sołowiej, P.; Nalepa, K.; Neugebauer, M. (2007). Poziom umiejętności wykorzystania sprzętu komputerowego i znajomość oprogramowania użytkowego studentów kierunku technika rolnicza i leśna. *Inżynieria Rolnicza, 2*(90), 293-299.

ANALIZA MOTYWACJI I PREDYSPOZYCJI STUDENTÓW DO WPROWADZENIA OPROGRAMOWANIA EDUKACYJNEGO CES EDUPACK PRZY NAUCZANIU NAUKI O MATERIAŁACH

Streszczenie. Celem pracy było sprawdzenie motywacji i predyspozycji studentów Wydziału Inżynierii Produkcji Uniwersytetu Przyrodniczego w Lublinie do uczestniczenia w zajęciach laboratoryjnych z przedmiotu Nauka o Materiałach wspomaganych programem komputerowym Cambridge Engineering Selector – CES EduPack w języku angielskim. Czynnikami warunkującymi celowość jego zastosowania dla studentów pierwszego roku studiów były: poziom umiejętności obsługi komputera, zainteresowanie studentów problematyką doboru materiałów oraz znajomość języka angielskiego, w którym obsługuje się program. Badanie ankietowe zawierało 17 pytań. Ankietę wypełniało 81 studentów. Wyniki badań potwierdziły pozytywną opinię respondentów o celowości wykorzystania programu komputerowego do zajęć dydaktycznych. Ponad połowa badanych uważa, że w trakcie ćwiczeń należy łączyć różne formy przekazu wiedzy. Studenci w dużej większości wykazują zainteresowanie doborem materiałów na wyroby codziennego użytku. Natomiast obawiają się lub nie mają wyrobionej opinii na temat wykorzystania programu w języku angielskim.

Słowa kluczowe: materiałoznawstwo, oprogramowanie edukacyjne, ankieta

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FACTORS THAT INFLUENCE SOLID PARTICLES EMISSION AND METHODS OF THEIR LIMITATION

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ABSTRACT

Renewable energy constitutes an effective tool in the struggle with a danger of global climate warming. The next solution in this fight is development of the construction of combustion engines and exhaust gas purification systems such as new catalysts and particulate filters (DPF). The paper presents the author's own research results of the measurement of toxic components of exhaust gas emission, in particular (NOx and PM) in delivery trucks which meet the requirements of environmental protection Euro 4, which were propelled with diesel oil – petroleum – derived and with biofuel B10. The above vehicles were operated in a horticultural farm. Measurement of toxic components emission NOx and PM from the operated vehicles was carried out pursuant to the European standards i.e. the New European Driving Cycle with the use of a dynamometer Schenck 500G S60. The obtained results proved that the efficiency of the particulate filter and the operation of the catalytic converter for both types of fuels were comparable

Introduction

Significant changes of the structure of combustion engines of the automotive industry and agricultural sector within the last decade is an aspect which is related to natural environment protection. At the constant increase of the number of vehicles and farm tractors, the process of consequent and intelligent purification of exhaust gases seems to be indispensable. The EURO standards introduced by the European Union force taking up more and more radical steps in order to limit emission of toxic components of exhaust gases, in particular particulate matter (PM) by drive units equipped with the self-ignition engines.

Meeting the future requirements of EURO 6 (presented in table 1) will require the use of new technologies and modern solutions concerning construction of drive units, including advanced methods of controlling the combustion process and modern fuels and additional packets, which refine these products (Jakóbiec et al., 2008a; Jakóbiec et al., 2008b.) In case of engines of non-road vehicles, which include machines and farm tractors, diversification of operational conditions and limits of emission of toxic components of fumes determined with standards Stage IIIA and Stage IIIB is significant. Diversification of approval tests,

during which measurements of emissivity of road vehicles are carried out. Emission standards for non-road vehicles refer to the regulations included in the Tier standards (EPA Non-road Regulation USA): 40 CFR 89; 40CFR1039; 40 CFR 1068) with the European references in the EU directive - EU-Nonroad Directive 97/68/EC (2004/26/EC). In case of farm tractors, measurements of emissivity are carried out in the determined steady state cycles (WOM) as ISO 8178, ECE R49, ESSC (European Steady State Cycle).

Table 1
Border values of emission of Euro standards for self-ignition engines

C	Date:	Test	CO ($g \cdot kWh^{-1}$)	HC ($g \cdot kWh^{-1}$)	NOx ($g \cdot kWh^{-1}$)	PM ($g \cdot kWh^{-1}$)	Exhaust smoke (m^{-1})	NH_3 ($mg \cdot kg^{-1}$)
Euro I	1992, <85 kW	ECE R-29	4.5	1.1	8.0	0.612		
	1992, >85 kW		4.5	1.1	8.0	0.36		
Euro II	1996.10	ESC & ELR	4.0	1.1	7.0	0.25		
	1998.10		4.0	1.1	7.0	0.15		
Euro III	1999.10, tylko EEV		1.5	0.25	2.0	0.02	0.15	
	2000.10		2.1	0.66	5.0	0.10 0.13*	0.8	
Euro IV 0.02	2005.10	ESC & ELR	1.5	0.46	3.5	0.02	0.5	
Euro V	2008.10		1.5	0.46	2.0	0.02	0.5	
Euro VI	2013.01		1.5	0.13	0.5	0.01		10

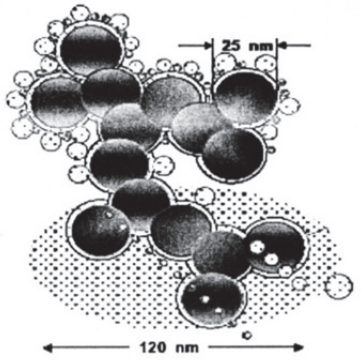
*For engines of swirl volume per a cylinder below 0.75 dm^3 and rated speed exceeding 3000 m^{-1}

Source: Stanik and Jakóbiec, 2012

Mechanism of formation of particulate matter emission

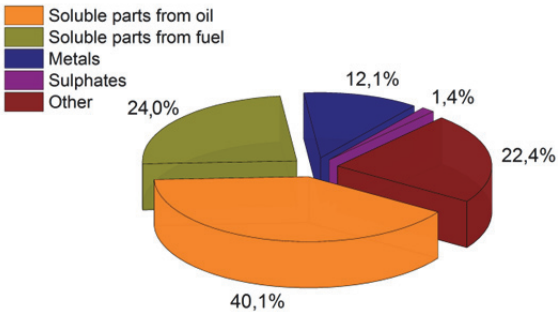
Particulate matter means products coming out of the exhaust system of the engine (self-ignition) of liquid or solid state which include particular number of carbon particles, sulphur and nitrogen, metals and heavy hydrocarbons. A typical form of the particulate matter was presented in figure 1, whereas a percentage participation of various components which form particles and their agglomerates are presented in figure 2.

The increased participation of light fractions in the diesel oil influences the decrease of its viscosity, affecting thus the improvement of the combustion process effectiveness. Presence of fractions with a high temperature of boiling (value of temperature of de-distillation of 90 and 95% fuel and temperature at the end of distillation) causes the increase in the emission of particulate matter and increase in the exhaust smoke, but does not decrease the content of nitric oxide.



Source: Jakóbiec, 2012

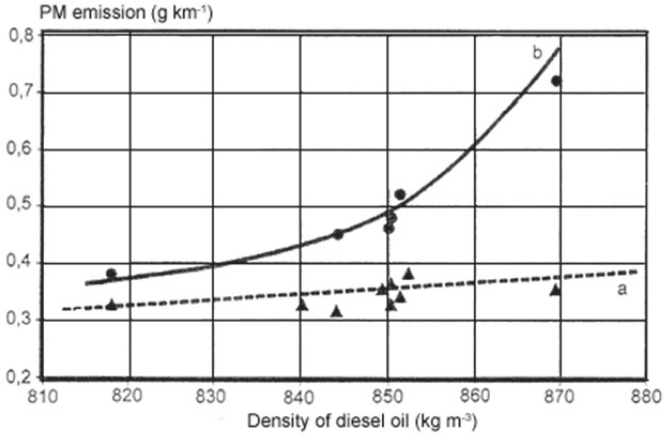
Figure 1. Typical particulate matter of PM emission



Source: Jakóbiec, 2012

Figure 2. Percentage share of various components of particulate matter emission (PM)

Presence of the heavy fractions also indirectly influences emission, because carbon deposit is more easily formed on sprayers' ends and the combustion chamber. The carbon deposit changes the course of the combustion process leading to deterioration of its effectiveness, increase of the emission of the non-combusted hydrocarbons, carbon monoxides and the particulate matter. Density of diesel oil plays a significant role in shaping the emission of the particulate matter (fig. 3).



Source: Jakóbiec, 2012

Figure 3. Relation of emission of particulate matter to density of diesel oil - a self-ignition engine direct injection charged with cooled air

It should be emphasised that emission of particulate matter is related to the combustion of hydrocarbon fuels and FAME biofuels in varied conditions determined with the injection process and phases of fuel combustion. Intense works tend in the direction of knowing the mechanism of formation of the particulate matter emission and their limitation. Motor oil, in particular a type of the base (physical and chemical properties) and the use of performance chemicals play a significant role in the process of formation and composition of the PM. Moreover, conditions of the engine operation play a significant role, where at low rotational speed and low load, non-combusted engine oil constitutes high percentage participation in the composition of the formed PM (Dowling, 1992). It is related to a low temperature of combustion of the load in the engine chamber, which influences incomplete combustion of oil which gets there. With the increase of the engine load, and thus the increase of the temperature in the combustion chamber of the engine, combustion of oil takes place in a more complete manner and participation of oil in the composition of the formed PM decreases (Stępień and Oleksiak, 1992). The increase of the rotational speed shortens the time of oil formation in the combustion zone of the engine, which caused incomplete combustion of oil and increase of the participation in the composition of the formed particulate matter (PM).

Methods of reduction of the particulate matter (PM) emission

Reduction of the particulate matter emission from self-ignition engines is one of the most difficult problems which lead to development of the particulate matter filter (DPF) (Mayer, 2001; Blanchard et al., 2002). Considerable progress has been made concerning improvement of the construction solutions on various planes of the DPF regeneration processes due to the advanced systems of Common rail fuel injection and also through development and spreading of new materials for filtration monoliths such as silicon carbide, ceramic metals (including aluminium - titanic filters) along with development of additives for FBC fuels (Stępień and Oleksiak, 2009).

The most popular solution of passive regeneration of the DPF filter is electronic control of fuel injection at the use of the Common Rail system (Rokosch, 2007). The concept of natural regeneration (without catalytic support) of the particulate matter filter (DPF) may be carried out within temperatures ranging from 600 to 700ºC of initiation of the carbon black oxidization process. Support of regeneration with the use of covering walls of the filtration monolith with the layer of catalyst - usually a platinum one, decreases temperature of carbon black oxidization to approx. 400ºC, whereas by the use of the additives FBC (Fuel Born Catalyst) type, the temperature may be reduced to approx. 300-500ºC. Catalytic impact of ash additives (organic in particular) on oxidization (afterburning of particulate matter) PM is very well documented in the literature (Eastwood, 2000; Novel-Cattin, 2000).

The basic assumption of passive regeneration of the DPF filters is lowering the temperature of carbon black oxidization to the level, which is obtained by exhaust gases in conditions of operation. Additives for fuels, which contain metals, constitute catalytic structure for carbon black oxidization (Bllom et al., 1997; Daly et al., 1993). Presently, the most popular additives for fuels which are used for support of the regeneration process DPF are: Fe, Ce, Mn, Zn, Pt and Cu. To sum up the issue of the FBC additives with catalytic activity, the basic requirements, which have to be met, should be emphasised:

– initiation of the DPF regeneration must include the temperature of exhaust fumes in the exhaust system of an engine which results from the engine structure as well as from the manner of its operation;
– regeneration of the filter must take place completely and evenly in its full volume - too high local increase of the temperature will cause defects of materials, of which the filter is made;
– ashes from burning of the additive should not chemically damage the material, of which DPF monolyth is constructed i.e. ceramic body and its metal casing;
– products of the combustion process of the FBC additives and ashes accumulated in the DPF filters should not generate secondary emission of exhaust fumes components i.e. NO_2, furans, dioxines, PAH (polycyclic aromatic hydrocarbons) and other gas components.

Evaluation of the process of passive regeneration of the DPF filter of a delivery vehicle

Research included measurement of the particulate matter emission and concentration of nitric oxides (NOx) in delivery trucks used in the horticultural farm. The vehicles had the same type of an engine of 2.0 dm^3 displacement equipped with the Common Rail injection system and the particulate matter filter (DPF) of the exhaust gases purification system which meets the requirements of Euro 4. Three vehicles were used in the research including one which was propelled by diesel oil and the remaining two with B10 biofuel. Measurements were carried out after the following mileage: 10,40, 80 thousand km with the use of a dynamometer SCHENCK 500g s60 according to the European NEDC (UDC+EUDC) presented in figure 4.

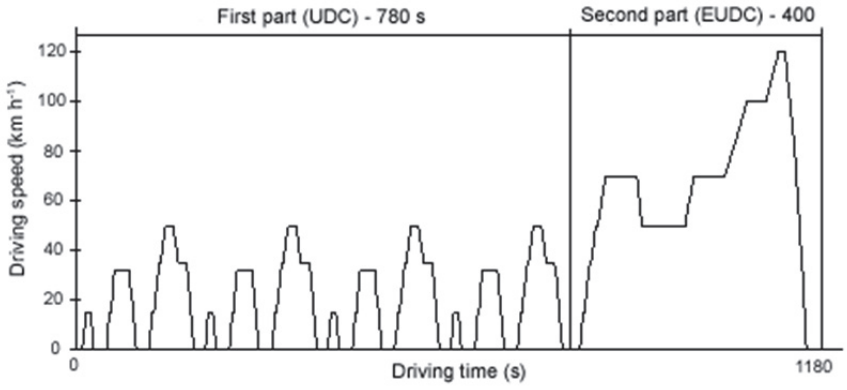


Figure 4. European driving cycle NEDC (UDC + EUDC)

During the research each time the analysis of the operational parameters of the engine with a diagnostic device was carried out, mainly in order to check a degree of regeneration of the particulate matter filter (DPF) and changes of of correction of fuel doses in the CR system for the needs of determination of the technical condition features change of particular engine cylinders and technical condition of the electromechanical injectors of the 2nd generation. An exemplary list of the selected working parameters (table 2) for the correct

scope of the Smooth Running Control - SRC along with the record of the regeneration condition DPF can be read out with the use of the external diagnostic testing device. Modern filters of the particulate matter which use ceramic filtration monoliths of Cordieryt type, SiC or Sintermetal characterize with efficiency reaching 95-99% in the scope of total mass of stopped PM, including 95-99.9% concerning stopping particles of elementary carbon (carbon black) and 60-90% concerning decrease of SOF emission (Soluble Organic Fraction) and 50-70% of limitation of the WWA amount (Automotive Division, 1999).

Table 2
Exemplary list of the selected working parameters of the engine during the diagnostic process OBD II

Control parameter	Measured value	Nominal value
Rotational speed	830 rot·min^{-1}	The scope of rotations: up to 1,500 rot·min^{-1}
Correction of a dose	96% 104% 109% 92%	Admissible deviation 20%
Cylinders injectors 1, 2, 3, 4		
Difference of pressures for DPF	34 hPa	230 hPa
Atmospheric pressure	980 hPa	600-1080 hPa
Mass intensification of air flow	280 mg·cycle^{-1}	300 mg·cycle^{-1}
Charging pressure	106 kPa	Value of reference 100 kPa
Dose of injection	7.2 mg·cycle^{-1}	6.8 mg·cycle^{-1}

Research results acc. to the European test NEDC (UDC + EUDC) was presented in figure 5 and 6.

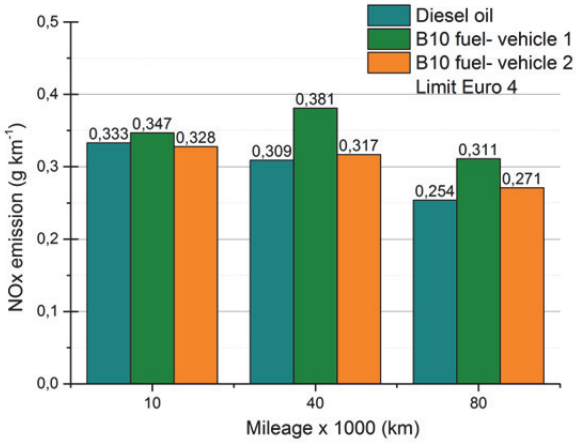


Figure 5. Average concentration of nitric oxide (NOx) in the European test NEDC (UDC + EUDC) for the researched delivery trucks propelled with diesel oil and biofuel B10 during operation

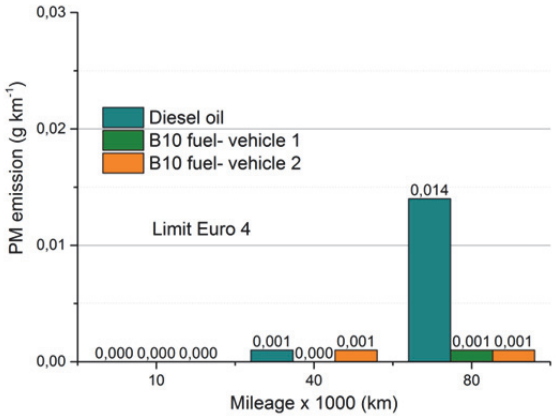


Figure 6. Average concentration of particulate matter emission in the European test NEDC (UDC+EUDC) for the researched delivery trucks propelled with diesel oil and biofuel B10

Conclusions

The obtained results allow formulation of the following conclusions:

1. Deterioration of catalytic converter operation efficiency with regard to the concentration of nitric oxide (NOx) for both fuels was reported, where in case an engine was propelled with diesel oil it was approx. 19.5%, whereas for B10 biofuel it was respectively approx. 38.5% and 22.1%.
2. Results obtained in vehicles propelled with biofuel B10 were comparable and slight difference may be assigned to slightly different conditions of operation.
3. Efficiency of the particulate matter filter for both fuels was comparable and was on a high level above 95%.
4. In the vehicle propelled with diesel oil after mileage of 80 thousand km, blockage of particulate matter filter caused by human factor (exceeding the conditions of vehicle operation) was reported.

References

3M Automotive Division (1999). 3M Diesel Filter Cartridges for Particulate Emission Control. *3M Innovation Technical Bulletin*.

Blanchard, D.; Colignion C.; Griard C.; Rigaudeau C.; Salvat O.; Sequelong T. (2002) *Passenger Car Series Application of a New Diesel Particulate Filter System Using a New Caria-Basel Fuel-Born Catalyst: From the Engine Test Bench to European Vehicle CCertification*. SAE Paper 2002-01-2781.

Bloom, R.; Brunner, N.; Schroeer, S. (1997). Fiber Wound Diesel Particulate Filter Durability Experience with Metal Based Additives. *SAE Paper 970180*.

Daly, D.; McKinnon, D.; Pavlich, D. (1993). A Diesel Particulate Regeneration System Using a Copper Additive. *SAE Paper 930131*.

Dowling, M. (1992). The impact of Oil Formulation on Emissions from Diesel Engines. *SAE Paper 922198*.

Eastwood, P. (2000) *Critical Topics in Exhaust Gas Aftertreatment*. Ford Motor Company. Research Studies Press Ltd.

Jakóbiec, J.; Urzędowska, W.; Mazanek, A.; Lubowicz, J. (2008) Badania eksploatacyjne biopaliwa B10 zawierającego 10% (V/V) FAME w nowoczesnych silnikach o zapłonie samoczynnym z bezpośrednim, wysokociśnieniowym wtryskiem paliwa w układzie Common Rail, uwzględniając aspekt współdziałania z olejem silnikowym. *Dokumentacja INiG*.

Jakóbiec, J; Baranik, M; Duda, A. (2008). Wysoka jakość estrów metylowych kwasów tłuszczowych oleju rzepakowego to promocja transportu samochodowego. *Archiwum Motoryzacji, 1*, 3-18.

Mayer, A. (2001) *Verified particulate trap systems for Diesel engines*. Version 1.

Novel-Cattin, F.; Rincon, F.; Trohel, O. (2000) Evaluation Method for Diesel Particulate Trap Regeneration Addititives: Application to Fire Additives. *SAE Paper 2000-01-1914*.

Rokosch, U. (2007) *Układy oczyszczania spalin i pokładowe systemy diagnostyczne samochodów OBD*. Wydawnictwo Komunikacji i Łączności, Warszawa.

Stanik, W.; Jakóbiec, J. (2012) Europejska legislacja emisji spalin z pojazdów samochodowych. *Autobusy-Technika-Eksploatacja-Systemy transportowe*, *10*, 30-33.

Stępień, Z.; Oleksiak, S. (2009) Zagadnienia współdziałania pasywnej i aktywnej regeneracji filtrów cząstek stałych silników z ZS do autobusów miejskich. *Nafta-Gaz, R.65, 11*, 875-882.

CZYNNIKI WPŁYWAJĄCE NA EMISJĘ CZĄSTEK STAŁYCH ORAZ METODY ICH OGRANICZENIA

Streszczenie. Energia odnawialna stanowi skuteczne narzędzie w walce z niebezpieczeństwem globalnego ocieplania klimatu. Kolejnym rozwiązaniem w tej walce to rozwój konstrukcji silników spalinowych i układów oczyszczania spalin jak nowe katalizatory i filtry cząstek stałych (DPF). W pracy zamieszczono własne wyniki badań pomiaru emisji toksycznych składników spalin zwłaszcza (NOx i PM) w samochodach dostawczych spełniających wymagania ochrony środowiska Euro 4, które były napędzane olejem napędowym (ON)- paliwo ropopochodne i biopaliwem B10. Powyższe pojazdy eksploatowano w gospodarstwie sadowniczym. Pomiar emisji toksycznych składników NOx i PM z eksploatowanych pojazdów przeprowadzono według standardów europejskich tj. europejskiego cyklu jezdnego NEDC z wykorzystaniem hamowni podwoziowej typu Schenck 500G S60. Uzyskane wyniki wykazały, że sprawność filtra cząstek stałych oraz pracy reaktora katalitycznego dla obu rodzajów paliw były porównywalne.

Słowa kluczowe: silnik, paliwo, filtr DPF, test NEDC

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IMPACT OF LASER BEAMS TREATMENT ON THE BIOMASS YIELD AND ENERGY VALUE OF MULTIFLORA ROSE

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multiflora rose

ABSTRACT

The object of the paper was to determine the impact of laser beams treatment of the cuttings of multiflora rose on the yield of fresh and dry mass and the energy value. A one-factor field experiment was carried out in 2009-2013 in Mydlniki near Cracow. The impact of two doses of radiation of cuttings with laser beams on the yield, chemical composition and energy value of multiflora rose was investigated. As a result it was found out that radiation with laser beams did not influence the size of fresh yield of multiflora rose. However, bigger dose of laser radiation caused higher increase of dry mass concentration in the above-ground parts and a higher yield of dry mass. No significant impact of bio-stimulation of laser radiation of cuttings on the combustion heat and calorific value of multiflora rose was reported. A considerable content of sulphur in the multiflora rose biomass was reported.

Introduction

Combustion of fossil raw materials is a basic energy source in the modern world. Resources of these raw materials are limited and, according to the estimations, petroleum will suffice for approx. 50 years, whereas hard coal for 200 years (Szecówka, 2009). Thus, undertaking research on biomass from agricultural land as a renewable energy source is justified. Perennial energy crops in our country in 2010 occupied only 0.05% of the area of agricultural lands i.e. approx. 10,200 ha. Shrubby willow prevailed on the area of approx. 6,160 ha. According to the forecasts in 2020, in Poland, from 1.0 to 4.3 million ha of mainly poor soils of rye complexes will be designated under the crops of perennial energy plants (Czarnocka et al., 2012). Also multiflora rose, which does not react with a significant decrease of the crop-yield at the cultivation on light soils, is predisposed for plantings on these soils (Kieć et al., 2011). One of the forms of adjusting a multiflora rose to stress conditions which occur on light soils is a bio-stimulation of cuttings with a laser beam. Laser stimulation as well as magnetic field stimulation (Podleśny, 2004) or microwaves stimulation (Jakubowski, 2007) or an electric field stimulation (Marks, 2005) belong to the group of physical methods of stimulating seeds and germination material to better growth and as a consequence better yield. Works on the use of laser stimulation for the increase of cultivation plants yield was started in the 60s of the last century in the University in Almaty

(Injuszin et al., 1981). Koper (1994) and Koper et.al. (1997) have started a pre-sowing stimulation of seeds with laser beams. In the contemporary publications, results indicating a positive impact of radiation with laser beams on the potato tubers yield and flax seeds yield may be found (Dobrowolski et al., 1996). The review of the national and world literature shows that so far no research over the use of laser beams on the biomass yield of the above-ground parts of multiflora rose used for energy purposes have been undertaken.

The objective of the paper was determination of the impact of laser beams radiation of cuttings on the yield of fresh and dry mass of the above-ground parts of multiflora rose.

Material and methods

A one-factor field experiment in four replications was carried out in 2009-2013 in the randomised-blocks design in the Experimental Station of the Department of Agrotechnology and Agricultural Ecology of the University of Agriculture in Cracow located in Mydlniki next to Cracow (50°05` N, 19°51` E). A single experimental plot had the area of 10 m^2. The impact of two doses of radiation of cuttings with laser beams on the yield of fresh and dry mass of multiflora rose of Jatar variety was researched.

Irradiation of multiflora rose cuttings was carried out in 2009. Medical Laser D 68-1 emitting red light with the waves length of λ 672 nm and power 20 mW was used. Two times of interrupted exposition a) 3x3 seconds, and b) 3x9 s. were applied. The radiated cuttings were planted in spring 2009 in the spacing of 70x70 cm on the fluvioglacial brown soil of classified based onj the particle size-as loamy sands. The content of available forms of phosphorus and potassium was low, reaction was slightly acid (pH in KCl 5.93). No mineral, organic or natural fertilization nor chemical plant protection was applied. Due to weak growth of the rose biomass, the the first yield was harvested in winter 2013 for 4-year growths.

A fresh mass yield and the content of dry mass were determined (in 105°C), and heat of combustion and the calorific value were measured according to Polish Norm PN 81/G 04513 pursuant to DIN 51731 in the calorimetric bomb AC-350. The ash content was determined with a weight method – Polish Norm PN-G-04512. The carbon and hydrogen content was carried out with the Shefield method – Polish Norm PN-G-04521, the total sulphur content was determined with the combustion method in high temperature – Polish Norm PN-ISO 351.

The obtained results were statistically analysed with the use one-factorial analysis of variance (ANOVA) for the design of randomised blocks, where the period of irradiation was a factor (two levels). Significance of differences between the mean values was estimated with Tukey's test at the level of significance P=0.05.

Results and discussion

Treatment with laser beams did not cause differentiation of fresh mass yield of multiflora rose. Only tendency to higher by 4% yielding at a higher dose of irradiation with laser beams occurred (fig. 1a). The analysis of variance proved simultaneously significantly higher yield of dry mass on objects (plots) treated with laser radiation (fig. 1b) in comparison to control, by 0.66 t ha^{-1} for a lower radiation dose and by 1.42 t·ha^{-1} for a higher radiation dose. It was caused by a higher accumulation of dry mass per unit and simultaneously by lower water content in biomass formed from cuttings radiated with a laser in comparison

to the control object (field) (fig. 2). Rose shoots treated with a longer time of laser beams radiation were characterized by significantly higher dry mass content (by 3.1%) compared to the control.

The results obtained in the research are similar to the results of laser radiation of energy willow cuttings, where the increase of dry mass content in the willow leaves was reported (Jakubiak and Śliwka, 2009). According to Karu (1990) bio-simulation of plants with laser light results in absorption of radiation energy quantum by photoreceptots, which consist in cell organelles and active biological compounds. Laser radiation particularly stimulates enzymes which are responsible for cycles of energy changes in cells, which influence the synthesis and utilization of ATP (Cenian et. al., 2005). In the development cycle of plants, it shows usually in the form of speeding earlier growth stages and with the increased resistance to stress factors such as e.g. salinity (Dobrowolski et al., 2012; Jakubiak and Śliwka, 2006). A positive effect of physical stimulation may be observed in the later growth stages – plants are higher, have a higher yield of vegetative and generative parts (Podleśny and Pietruszewski 2006). In the research average dry mass content in multiflora rose biomass amounting to 54.7% (fig. 2) was similar to analogous value for energy willow (Stolarski et al., 2008). Average yield of multiflora rose dry mass in the fourth year after planting was 21.43 $t \cdot ha^{-1}$ (fig. 1b). It resulted from the fact that fertilization and plant protection was not applied and the field soil, on which radiated cuttings were planted, was of low agronomic category. Such an approach to agrotechnology of multiflora rose followed from the assumption that this plant was predisposed to be cultivated in sandy soils, which prevail in Poland and which possibly may be used in future for cultivation of energy plants. Assuming harvesting of rose in a two-year cycle, it is justified to decrease the obtained dry mass yield by half that is to 10.7 $t \cdot ha^{-1}$. Assuming this value for comparative purposes, it should be stated that such yield is similar to an average dry mass yield of energy willow harvested annually (Dubas, 2004). However, it is almost two times lower than average yield of Virginia mallow *Sida hermaphrodita* (Kalembasa and Wiśniewska, 2006) and by average of 20% lower than yields of Manitoba maple *Acer negundo* (Frączek, 2009). However, it should be emphasised that yields of mentioned plants were obtained on better soils and with fertilization. Thus, comparison should include economic indexes e.g. costs of production 1 GJ of thermal energy, which are decisive for use in the practice of research results (Bieniek and Żołnierz-Rusinek, 2008).

The analysis of variance did not prove a significant impact of laser irradiation of cuttings on the heat of combustion, calorific value and chemical composition of multiflora rose biomass (Table 1). Thus, a result part of the paper presents average values. Average value of the heat of combustion was 18, 573 $kJ \cdot kg^{-1}$and the calorific value 17,078 $kJ \cdot kg^{-1}$. Similar values of the heat of combustion and the calorific value for multiflora rose are presented by Stolarski et al. (2008). Presented parameters are similar to analogous data of energy willow (Stolarski et al., 2008). Average ash content in multiflora rose biomass was 2.4%, volatile parts 6.28%, carbon 46.2%, hydrogen 5.79% and sulphur 0.08%. These values, except for sulphur, are similar to analogous data of energy willow (Stolarski et al., 2008). Sulphur content in multiflora rose biomass was almost two times higher than in the quoted research.

In the available literature there is no research results concerning production efficiency of bio-stimulation with a laser of multiflora rose cuttings. One should thus assume, that the presented results are one of the first ones, which quantify the impact of laser beams irradiation of multiflora rose cuttings on the content of dry mass and cropping of this energy plant.

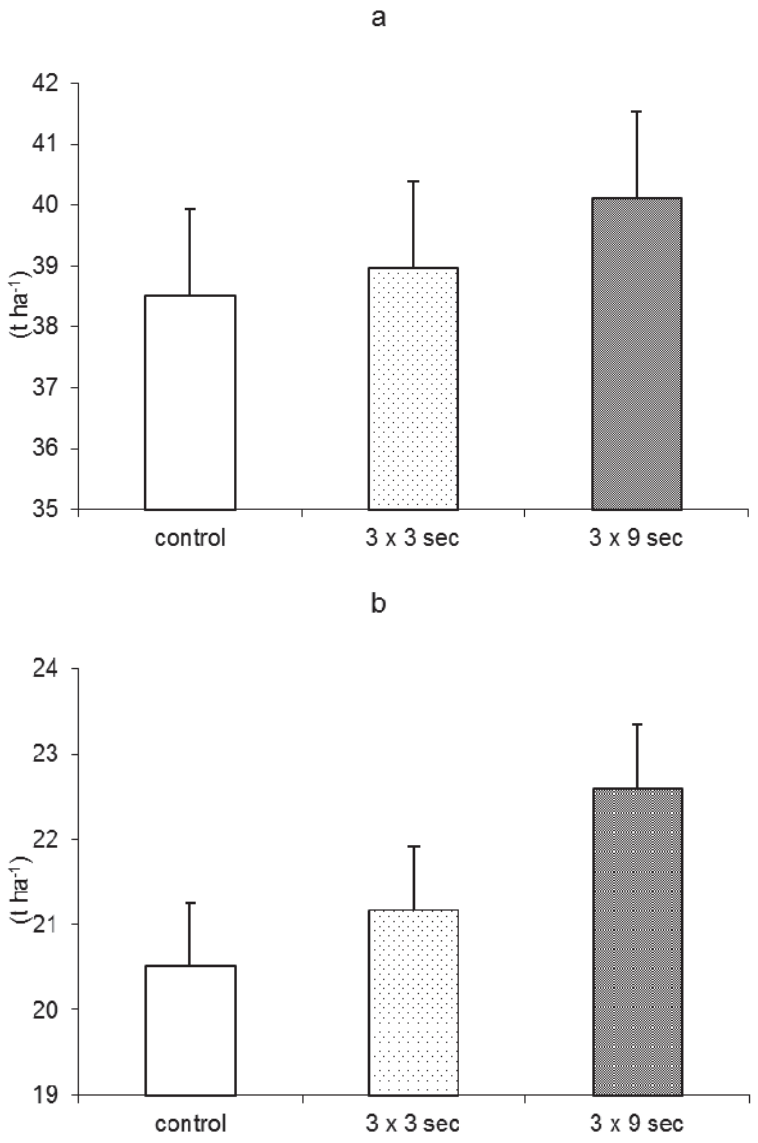

Figure 1. Yield of multiflora rose biomass treated with laser irradiation (average + SD): a) fresh mass yield (t·ha^{-1}), insignificant difference, b) yield: dry mass (t·ha^{-1}); P=0.05; LSD = 0.737

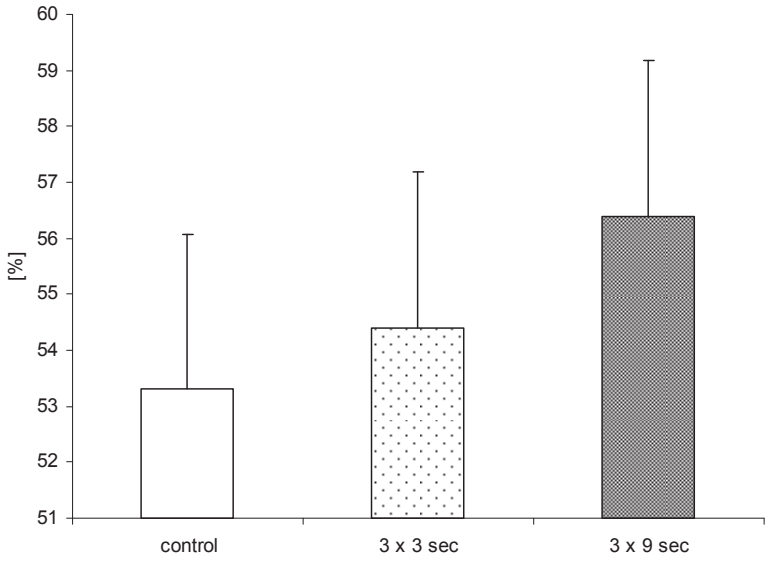

Figure 2. Dry mass content (%) in multiflora rose shoots (average +SD); P=0.05; LSD = 2.78

Table 1
Heat of combustion, calorific value and composition of multiflora rose

Item	Control	Laser beam treatment		Mean
		3 x 3 seconds	3 x 9 seconds	
Heat of combustion, (kJ·kg^{-1})	18568	18.574	18.577	18.573
LSD $_{\alpha=0,05}$		n.s.		
Calorific value, (kJ·kg^{-1})	17068	17.081	17.085	17.078
LSD $_{\alpha=0,05}$		n.s		
Ash content, (%)	2.4	2.4	2.5	2.4
LSD $_{\alpha=0,05}$		n.s		
Volatiles content, (%)	6.26	6.30	6.29	6.28
LSD $_{\alpha=0,05}$		n.s		
Carbon content, (%)	46.2	46.2	46.3	46.2
LSD $_{\alpha=0,05}$		n.s		
Hydrogen content, (%)	5.78	5.78	5.81	5.79
LSD $_{\alpha=0,05}$		n.s		
Sulphur content %	0.07	0.09	0.08	0.08
LSD $_{\alpha=0,05}$		n.s		

LSD – Least significant difference; n.s. – non significant

Conclusions

1. Laser beams treatment of multiflora rose cuttings did not cause significant diversity of yielding of multiflora rose fresh mass.
2. Cuttings treated with a higher dose of laser radiation caused higher content of dry mass in the above-ground parts and the increase of multiflora dry mass yield.
3. Laser beams treatment of multiflora rose cuttings did not influence significantly the heat of combustion and calorific value of multiflora rose.

References

Bieniek, J.; Żołnierz-Rusinek, A. (2008). Wierzba Salix viminalis jako źródło energii odnawialnej na przykładzie platacji założonych na terenie Kotliny Kłodzkiej. *Inżynieria Rolnicza, 4*(102), 111-118.

Cenian, A.; Zaremba, E.; Frankowski, M. (2005). *Biostymulacyjne oddziaływanie promieniowania laserowego*. Instytut Maszyn Przepływowych PAN, Gdańsk

Czarnocka, A.; Szczukowski, S.; Tworkowski, J.; Stolarski, M. (2012). *Wieloletnie rośliny energetyczne*, MULTICO Oficyna Wydawnicza, Warszawa. ISBN 978-83-7763-182-9

Dobrowolski, J.W.; Śliwka, M.; Mazur, R.; (2012). Laser biotechnology for more efficient bioremediation, protection of aquatic ecosystems and reclamation of contaminated areas. *Journal of Chemical Technology and Biotechnology, 87*, 1354-1359.

Dobrowolski, J.W.; Wącholewski, T.; Smyk, B.; Barabasz, W.; Różycki. E. (1996). Experiments on the influence of laser light on some biological elements of natural environment. *Environmental Managnement and Health, 8/4*, 36-43.

Dubas, J. (2004). *Wierzba*. W: Rośliny energetyczne. Kościk B. (red.). Wyd. AR Lublin, 56–77.

Frączek, J. (red.). (2010). *Produkcja biomasy na cele energetyczne*. Kraków, PITR, 15-54.

Injuszin, W.T.; Iliasow, T.U.; Fiedorowa, N.N. (1981). *Łuć laziera i urażaj*. Wyd. Uniwersytet w Ałma-Acie.

Jakubiak, M., Śliwka, M. (2006). The application of laser biostimulation for more efficient phytoremediation of soil and waste water. *Polish Journal of Environmental Studies*, *15*, 176-178.

Jakubiak, M.; Śliwka, M. (2009). Wpływ fotostymulacji na zawartość wybranych pierwiastków w liściach wierzb energetycznych. *Ochrona Środowiska i Zasobów Naturalnych, 40*, 411-418.

Jakubowski, T. (2007). Wpływ mikrofalowej stymulacji sadzeniaków ziemniaka na wzrost i rozwój roślin potomnych. *Inżynieria Rolnicza*, *11*, 49-56.

Kalembasa. S.; Wiśniewska, B. (2006). Wpływ dawek azotu na plon biomasy ślazowca pensylwańskiego (Sida hermaphrodita Rusby) oraz zawartość w niej makroelementów. *Acta Agrophysica, 8*(1), 127-138.

Karu, T.J. (1990). Effects of visible radiation on cultured cells. J. Photochem. Photobiol., 52, 1089-1098.

Kieć, J. (2011). *Agrotechnika roślin energetycznych*. Wyd. Doln. WSTP Polkowice, 18-26.

Kieć, J.; Łabza, T.; Wieczorek, D. (2011). Róża wielokwiatowa (Rosa multiflora) odmiany Jatar na cele energetyczne. *Fragmenta Agronomica, 28*(3), 35-41.

Koper, R. (1994). Pre-sowing laser bio-stimulation of seeds of cultivated plants and its results in agrotechnics. *International Agrophysics, 8*, 593-596.

Koper, R.; Łasiak, S.; Woźniak, Z. (1997). Urządzenie do przedsiewnej laserowej biostymulacji nasion wybranych roślin uprawnych oraz efekty jego stosowania. *Inżynieria Rolnicza, 1*(1), 63-96.

Marks, N. (2005). Wpływ impulsowego pola elektrycznego na straty przechowalnicze bulw ziemniaka. *Inżynieria Rolnicza*, *10*(70), 303-309.

Podleśny, J. (2004). Wpływ stymulacji magnetycznej nasion na wzrost, rozwój i plonowanie roślin uprawnych. *Acta Agrophysica*, *4*(2), 459-473.
Podleśny, J., Pietruszewski, S. (2006). Wpływ traktowania nasion polem magnetycznym na wzrost, rozwój i dynamikę gromadzenia masy łubinu białego (Lupinus albus L.). *Inżynieria Rolnicza*, *10*, 169-176.
Stolarski, M., Szczukowski, S., Tworkowski, J. (2008). Biopaliwa z biomasy wieloletnich roślin energetycznych. *Energetyka*, *1*, 77-80.
Szecówka, L. (2009). *Ekologiczny efekt energetyczny wykorzystania biopaliw*. Wydawnictwo Politechniki Częstochowskiej, Częstochowa.

WPŁYW NAŚWIETLANIA PROMIENIAMI LASERA NA PLON BIOMASY I WARTOŚĆ ENERGETYCZNĄ RÓŻY WIELOKWIATOWEJ

Streszczenie. Celem pracy było określenie oddziaływania naświetlania promieniami lasera sadzonek róży wielokwiatowej na plon świeżej i suchej masy oraz wartość energetyczną. Przedmiotem badań było jednoczynnikowe doświadczenie polowe przeprowadzone w latach 2009-2013 w Mydlnikach k. Krakowa. Badano wpływ dwóch dawek naświetlania sadzonek promieniami lasera na plon, skład chemiczny i wartość energetyczną róży wielokwiatowej. W wyniku badań stwierdzono, iż naświetlanie promieniami lasera nie wpłynęło na wielkość plonu świeżej masy róży wielokwiatowej, jednakże większa dawka promieniowania laserowego spowodowała wyższy przyrost suchej masy części nadziemnych oraz większy plon suchej masy. Nie stwierdzono istotnego wpływu biostymulacji promieniowaniem laserowym sadzonek na ciepło spalania i wartość opałową róży wielokwiatowej. Stwierdzono znaczną zawartość siarki w biomasie róży wielokwiatowej.

Słowa kluczowe: biostymulacja laserowa, ciepło spalania, skład chemiczny, róża wielokwiatowa

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LEVEL AND EFFECTIVENESS OF USE OF DELIVERY TRUCKS AND TRUCKS IN THE SELECTED HORTICULTURAL FARMS

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ABSTRACT

The objective of the paper was to analyse the level and effectiveness of using delivery trucks and trucks in horticultural farms. The scope of the paper covers delivery trucks and trucks, which constitute the equipment of 60 agricultural farms, which produce vegetables and fruit, located on the territory of Świętokrzyskie and Małopolskie Voivodeship. The following, inter alia, was determined: annual use, yield, structure of transport works and the use of capacity. It was determined, inter alia, that in the vegetable farms there are more both delivery trucks and trucks per one farm than in the horticultural farms. The transport efficiency of vehicles in the vegetable farms is lower in comparison to vehicles in the horticultural farms.

Introduction

According to the estimations in agriculture, annually 800-1000 million tonnes of loads are transported which in relation to the structure and intensity of production gives an index from 20 to 70 $t \cdot ha^{-1}$ of agricultural land (Kokoszka and Tabor, 2006). Horticulture plays a significant role in the national agriculture and constitutes one of the most important branches of agricultural production. Although, horticultural production is carried out only on 3.4% area, its value is two times higher for grains, although they are cultivated as much as on 63.5% area taken by plant production (Hołownicki, 2006). Specialist horticultural farms, in particular vegetable farms, in Poland are located mainly near big city agglomerations, which constitute an outlet for the produced vegetables and fruit. Vicinity of outlets considerably influences the use of the transport means and as a result the costs of production in farms (Kowalczyk, 2001). However, a serious problem which negatively affects functioning of the horticultural farms, inter alia, through the increase of the transport costs is improper organization of the wholesale market of vegetables and fruit (Kowalczyk, 2011). Other impediment for the fruit and vegetable market is high fragmentation of the horticultural farms and as a result a small scale of production, which to a high degree limits a possibility for single producers e.g. big hypermarkets chains. Due to the above problems, the transport means are one of the most important technical means in a horticultural farm.

Their number and quality selection is reflected in the efficiency of the performed transport works but also in the inputs incurred for transport (Kokoszka, 2011). Also, acc. to Marczuk (2011), selection of proper organization of the transport means work at relatively low inputs may bring considerable advantages for a farm.

Objective, scope, methodology of work

The objective of the paper was to analyse the level and effectiveness of using delivery trucks and trucks in the selected horticultural farms. The scope of the paper covers: delivery trucks and trucks which constitute the equipment of 60 farms which deal with production of vegetables and fruit located on the territory of Świętokrzyskie and Małopolskie Voivodeships. The research was carried out in the form of a guided survey entailing filling out the questionnaire. The collected information, except for general data which characterize farms, such as the structure of the land use, the size and structure of production concerned mainly organization of the transport works, that is work timing of the transport means, their age, capacity, etc. The coefficient of using the capacity was calculated as percentage quotient of the amount of load transported one time and the capacity of the transport mean. Coefficient of using operation time K_{07} determines participation of the effective work time – T_1 to operation time T_{07} (which includes also time losses due to the organizational reasons) where: T_1 – driving time with a load, T_{07} – includes: driving time with a load, driving time without the load, time for loading activities, time for crossings to and from the work place and technical stopovers, time of technical service, time of removing technical and technological faults, rest time, operation time of accompanying machines carried out in the presence of a transport mean, time of stopovers independent from the mean (e.g. organizational and others). Efficiency of the transport means work was calculated based on the operation time.

TheaAnalysis of the obtained results was carried out in two farm groups, that is: vegetable and horticultural, separately for delivery trucks and trucks.

Research results

The size and structure of production constitute the basis for a rational selection of the transport means. As table 1 shows, the average area of agricultural land of farms included in the research exceeded the average for the entire Małopolska region and was respectively for vegetable and horticultural farms: 9.47 and 7.51 ha.

Table 1
The structure of land use in agricultural farms

Specification	Area of agricultural land (ha)	Area of arable land (%)	Area of grasslands (%)	Area of orchards (%)
Vegetable farms				
– average	9.47	91.90	7.83	0.27
– standard deviation	8.38	6.46	6.24	2.16
Horticultural farms – average	7.51	4.97	2.70	92.26
– standard deviation	5.29	5.44	2.95	8.05

Table 2 presents the size of the produce crop in groups of farms. In case of vegetables and fruit a decisive majority of crop is transported by cars into the outlet that is the most frequently to the agri-food fair in Cracow. Obviously, in a total mass of crops horticultural products prevail, but total crops of produce are higher in vegetable farms and are at the average 241 tonnes per a farm, while in horticultural – 152 tonnes.

Table 2
Crops of produce (t·farm^{-1})

Specification	Vegetables	Fruit	Others	Total
Vegetable farms				
– average	167	2	72	241
standard deviation	138	2	104	217
Horticultural farms				
– average	1	142	9	152
– standard deviation	1	118	12	159

Table 3 includes information concerning the transport means covered by the research thus delivery trucks and trucks. The stock of cars both delivery trucks and trucks per a farm, is higher in case of the vegetable farms, and is respectively: 0.85 and 0.73 item.·farm^{-1}, while in the horticultural farms this stock is 0.79 and 0.11 items·farm^{-1}. The equipment in the form of delivery trucks with reference to the area of agricultural land for both groups is at a similar level of 10.4 and 10.7 item·100 ha^{-1}AL. For comparison in other horticultural farms of the Małopolska region, the stock of delivery trucks is 9.0 items.·100 ha^{-1}AL whereas of trucks – 5.3 items·100 ha^{-1}AL (Kowalski et al., 2002).

Table 3
Characteristics of the selected transport means

Specification	Stock (item·farm^{-1})	Stock (item·100 ha^{-1}AL)	Age (years)	Capacity (t)	Annual use (h·year^{-1})
Vegetable farms					
– delivery truck	0.85	10.4	13	1.6	1050
– truck	0.73	8.9	16	3.8	1285
Horticultural farms					
– delivery truck	0.79	10.9	15	1.4	955
– truck	0.11	1.7	18	3.9	1014

Taking into consideration the age of cars, the vegetable farms, which have cars at the average two years younger are more favourable in comparison to the horticultural farms. When analysing the data included in table 3, one may see very high use of both type of cars not related to the type of the business activity, which is within the range 955-1285 h·year^{-1} Such high loading with work results mainly from often and sometimes very long stays at the agri-food fairs. Unfortunately, organization of the transport processes also influences negatively prolongation of this time, i.e. both loading of vegetables and fruit as well as

unloading of goods, which were not sold, was performed manually in majority of farms. It is influenced by the lack of specialist devices such as fork lifts as well as specificity of goods. Some vegetables, such as e.g. cauliflowers, broccoli – are sold without group packages so they are arranged in a loose state in a car, which impedes mechanization of loading and unloading. Kuboń's research (2007) proves that the use of delivery trucks in horticultural farms shaped at the level of 582 $h \cdot year^{-1}$, and trucks – 101 $h \cdot year^{-1}$.

Table 4 presents, inter alia, majority of the transported load and as it can be seen in both groups of farms, delivery trucks transport a bigger mass of the collected produce, which due to their higher capacity is understandable. According to Kokoszka's research (2007) special attention should be paid to the size of single transported batches of load at execution of transport tasks, because increase of the use of capacity causes savings of time and decrease of the transport costs, even by 70% in case of the set composed of a tractor and a trailer. Table 4 presents also a coefficient of the capacity use, which constitutes a percentage quotient of the amount of a load which is transported singularly and the capacity of the transport mean. As one can see, loads which are transported one time are almost comparable to the capacity of cars, and in case of delivery trucks used for transport of vegetables - the mass of the transported load was sometimes higher than the capacity of a car, which is proved by the coefficient of using capacity which is 104%. The cars, which are possessed by farms are characterized with especially low operational capacity of W_{07} which is from 0.12 to 0.18 $t \cdot h^{-1}$ in the vegetable farms and from 0.13 to 0.20 $t \cdot h^{-1}$ in case of the horticultural farms, which in calculation per $tkm \cdot h^{-1}$ is respectively: 5.6-11.7 (vegetable farms) and 7.6-14.1 (horticultural farms). From among the presented values - delivery trucks show lower efficiency. It is also worth to pay attention to the particularly low values of operational time use coefficient K_{07} of cars, which is included within 7.3-7.6% - in case of transport of vegetables and 9.8-10.4% – referred to the fruit transport. So low operational efficiencies and a low degree of using the operational time results mainly from very time-consuming stopovers on the agri-food fairs. According to Kuboń's research (2004) in case of delivery trucks the use of capacity is 80% and W_{07} – 0.61 $t \cdot h^{-1}$ (Kuboń 2004). Whereas, Kokoszka's and Tabor's research (2006) show that in the vegetable farms, values of coefficients K_{07} for delivery trucks and trucks were respectively: 90% and 22% but it relates to domestic transport.

Table 4
Characteristic of transports

Specification	Size of the transported load (t)	Coefficient of capacity use (%)	Efficiency W_{07} ($t \cdot h^{-1}$)	K_{07} (%)	Performance W_{07} ($tkm \cdot h^{-1}$)
Vegetable farms					
– delivery truck	127	104	0.12	7.3	5.6
– truck	233	96	0.18	7.6	11.7
Horticultural farms					
– delivery truck	118	99	0.13	9.8	7.6
– truck	180	95	0.20	10.4	14.1

Figure 1 presents the structure of using operation time of cars divided into internal and external transport. When analysing the above figure, a decisive prevail of cars in the external transport, which consists mainly in delivery of vegetables and fruit to outlets, can be reported. In case of vegetable farms, external transport constitutes as much as 93% to 97% of car use, while in horticultural farms, external transport involves from 88% to 93% of work time of cars.

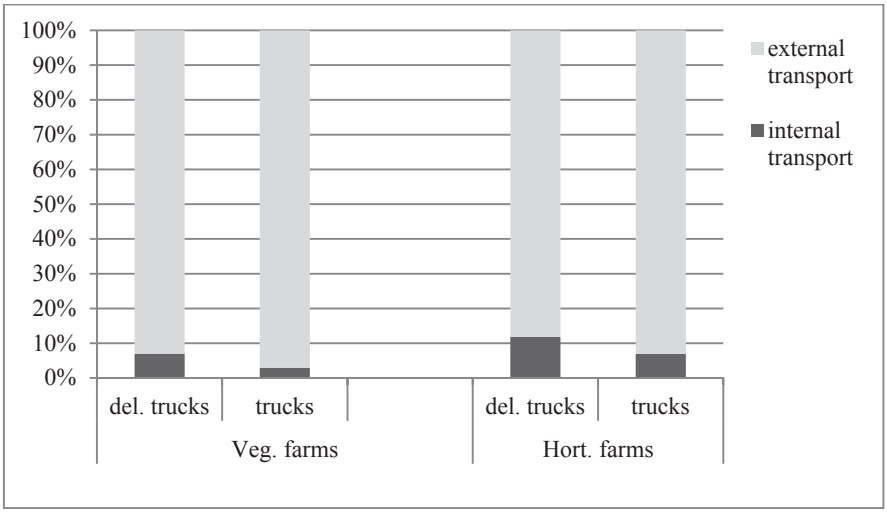

Figure 1. Structure of use of operation time of cars

Conclusions

Based on the analysis of the research, it was determined that:

1. The vegetable farms have a higher stock of delivery trucks and trucks in comparison to the horticultural farms, but this difference is particularly visible in case of delivery trucks, the number of which in vegetable farms is over six times higher.
2. Despite a high number of delivery trucks and trucks in farms (average stock is within 0.11 to 0.85 item·farm^{-1}), their age, which is within 13-18 years is important. In the vegetable farms, in comparison to horticultural, at the average two years younger cars occur.
3. Cars, which are the subject of the research, were used decisively for internal transport, thus their operational efficiency is very low, at the average 0.12 to 0.20 t·h^{-1} . The reasons for this state of matters should be looked for in improper organization of the sale of vegetables and fruit, which consequently prolongs the time of cars stay on the agri-food fairs.
4. A relatively high use of cars capacity, which is within 95 and 104% is a positive fact; however, undoubtedly necessity of double transport of the same goods to fairs is a negative phenomenon, which takes place in case of difficulties with finding a client.

References

Hołownicki, R. (2006). Miejsce agroinżynierii w rozwoju produkcji ogrodniczej w Polsce. *Inżynieria Rolnicza, 11*(86), 135-146.
Kokoszka, S.; Tabor, S. (2006). Postęp technologiczny a struktura czasu pracy, koszty i efektywność nakładów w transporcie warzyw. *Inżynieria Rolnicza, 11*(86), 185-191.
Kokoszka, S. (2007). Ocena wielkości jednorazowo przewożonych ładunków w zależności od rodzaju transportu i wielkości gospodarstwa rolniczego. *Inżynieria Rolnicza, 6*(94), 65-71.
Kokoszka, S. (2011). Analiza wyposażenia w środki transportowe w kontekście wielkości gospodarstwa rolniczego. *Inżynieria Rolnicza, 4*(129), 127-133.
Kowalczyk, Z. (2001). Poziom intensywności produkcji a efektywność postępu naukowo-technicznego w różnych typach gospodarstw. *Praca doktorska*. Kraków. Maszynopis.
Kowalczyk, Z. (2011). Poziom i struktura zużycia technicznych środków trwałych w różnych typach gospodarstw rolniczych, *Inżynieria Rolnicza, 2*(127), 5-120.
Kowalski, J. i in. (2002). *Postęp naukowo-techniczny a racjonalna gospodarka energią w produkcji rolniczej*. PTIR i KMR AR Kraków. ISBN 83-905219-9-7.
Kuboń, M. (2004). Ocena techniki przewozu w transporcie rolniczym. *Inżynieria Rolnicza, 3*(58), Kraków, 277-285.
Kuboń, M. (2007). Wyposażenie i wykorzystanie środków transportowych w gospodarstwach o różnym typie produkcji rolniczej. *Inżynieria Rolnicza, 8*(96), Kraków, 141-148.
Marczuk, A.; Misztal, W. (2011). Optymalizacja transportu produktów rolniczych w warunkach nierównowagi rynkowej. *Inżynieria Rolnicza, 4*(129), 221-226.

POZIOM I EFEKTYWNOŚĆ WYKORZYSTANIA SAMOCHODÓW DOSTAWCZYCH I CIĘŻAROWYCH W WYBRANYCH GOSPODARSTWACH OGRODNICZYCH

Streszczenie. Celem pracy jest analiza poziomu i efektywności wykorzystania samochodów dostawczych i ciężarowych w gospodarstwach ogrodniczych.. Zakresem pracy objęto: samochody dostawcze i ciężarowe stanowiące wyposażenie 60 gospodarstw zajmujących się produkcją warzyw i owoców położonych na terenie województw: świętokrzyskiego i małopolskiego. Określono m. in.: wykorzystanie roczne, wydajność, strukturę prac transportowych, wykorzystanie ładowności. Stwierdzono m. in., że w gospodarstwach warzywniczych występuje większa liczba zarówno samochodów dostawczych jak i ciężarowych w przeliczeniu na jedno gospodarstwo. Wydajność przewozowa samochodów w gospodarstwach warzywniczych jest niższa w porównaniu z samochodami w gospodarstwach sadowniczych.

Słowa kluczowe: samochód dostawczy, samochód ciężarowy, transport, wykorzystanie, wiek

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ANALYSIS OF THE SELECTED FACTORS IMPACT ON THE AMOUNT OF THE STORED HEAT AND THE MASS CHANGE IN THE ROCK-BED STORAGE PLACED IN THE LABORATORY TUNNEL[1]

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ABSTRACT

The paper presents results of analysis of the air flow through the rock - bed storage. Air was collected from the inside of the plastic tunnel and pressed to the segments of the storage with area was 18.7m^2 and volume was almost 13.1 m^3. The research was carried out from March to October 2013. The cycle of the storage work (charging or discharging) was controlled based on the algorithm, in which a controlling signal was based on the difference in the temperature between the average temperature of the bed and the temperature inside a tunnel. 318 measurement cycles were selected for a detailed analysis. In those cycles, based on the measured parameters of air pressed into and flowing out of the storage, the amount of the stored heat in the storage and the change in the concentration of steam included in air was determined. For the obtained results multiple regression equations, describing a unitary heat stream and mass exchanged during the air flow through the storage, were found. Moreover, the quantity relations between a unitary heat and the mass stream exchanged during the air flow through the storage including two sets of independent variables, were determined. The first one includes: velocity of the pressed air (measured in the air pressing conduit for particular segments), initial temperature of the storage and the pressed heat stream. The second set of independent variables includes: temperature of the pressed air, deficiency of steam pressure inside the facility and the stream of the pressed air. Non-linear estimation with the use of quasi-Newton method was applied for determination of these relations.

The list of symbols:

q_{pow} – pressed air stream (m^3·s^{-1}),
ρ_{pow} – air density (kg·m^{-3}),
τ_1, τ – respectively initial time (τ_1) duration of a cycle (τ) (s),

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i_{WY}, i_{WE} – enthalpy of air which is flowing out (i_{WY}) and pressed into (i_{WE}) the storage, ($J \cdot kg^{-1}$)
f_{WE}, f_{WY} – absolute moisture of the air which is flowing out (f_{WY}) and pressed into (f_{WE}) the storage, ($g \cdot m^{-3}$)

Introduction

Searching for technical solutions used in the production processes should be integrally related to the improvement of the product quality and reduction of its costs. Undoubtedly, reduction of production costs in roofed facilities may be performed inter alia by using the excess of heat from the inside of the facility for heating the object. This issue, for crops under covers, concerns both the type of the object structure and its equipment. Research, concerning the impact of the object structure, efficiency of heat storage in the storage bed including aspects of the heat demand, was carried out in many scientific centres. From the point of view of the facility structure, Abreu et al, (2001) analysed the impact of its structure (single tunnel, blocked) on the effect of cultivated tomatoes. In the conclusion it was determined that in the blocked objects, it is easier to maintain the required parameters of the internal microclimate, which was seen with the improvement of the quality of tomatoes as well as limitation of use of plant protection substances. Volkaerts et al. (2012) analysed the answer of temperature and air humidity changes during natural ventilation in the facility, where precise control of the ventilator location was applied. Authors developed a mathematical model of the heat and mass exchange process and its validation was carried out in the blocked greenhouse. Kittas and Bartzanas (2007) in the analysis of the issue of the greenhouse ventilation (with various geometry of a ventilator) used the CFD programme and upon recognition of a satisfactory compliance, they carried out simulation experiments. Impact of the wind direction and velocity on the distribution of air velocity inside the facility in the aspect of temperature changes and concentration of steam was analysed. Boulard et al. (2004) carried out a series of research on the impact of ventilation intensity (through change of location ventilation openings) on the process of mass exchange during transpiration of tomatoes cultivated in the plastic tunnel. Impact of location of ventilators both on parameters describing intensity of transpiration (physiological resistance of mass conduct inside a leaf and on the leaf- surrounding air border) which in consequence affects microclimate in the facility, was reported. Researchers recognized a great usefulness of the obtained results for biological plant protection and controlling their growth. On the other hand, from the scope of use of waste heat from a greenhouse, Condori et al. (2001) presented results of their research related to the use of heat from the inside of the prototype greenhouse for drying vegetables (sweet pepper, garlic). Authors determined changes of water content in products dried with air obtained from the inside of the object and determined relation between temperature of dried air and intensity of solar radiation, recognizing usefulness of such system in a conclusion. Moreover, a similar issues concerning the use of waste heat from the inside of the facility were analysed by Fuller and Charters (1997) determining possibilities of using this heat from a production plastic tunnel for drying grapes. In the construed system, air sucked from the inside was moved to a heater. Authors developed an algorithm for controlling the operation of this system and its usefulness for practice was confirmed during test research. From the scope of storing heat surplus from the inside

of the facility (Ozgener and Ozgener 2010) carried out a series of experiments in the storage, where the system of steel conduits was installed (placed in the loop shape) placed in soil. Conduits were supplied with hot air obtained from the inside of a greenhouse. Authors determined a coefficient of heat transfer between conduits and soil and determined efficiency of the heat storing process recognizing its usefulness in the region with high sun exposure (Mediterranean Sea region). Kurklu (1998) in his review paper presented constructional solutions of heat storages which use phase changes of material (salt hydrate, paraffin and polyethylene glycol) along with determination of potential heat effects at their use in a greenhouse. Boniecki (1999) presented assumptions for construction of the simulation model of the charging process of a rock-bed storage of thermal energy at including a random distribution of temperature of air pressed inside it. Thus in the paper (Muller and Maćkowiak 2010) presented and verified an alternative to the existing, a probable mathematical model of heat transfer, which more fully in comparison to previous models includes a stochastic nature of the bed structure and additionally reflects an uneven air flow through the storage during a charging phase. The presented review of research works shows clearly that the use of heat surplus from the inside of the facility, which was formed from solar radiation, in the process of heating a horticultural facility is one of the solutions which are used for the microclimate change. This issue is an object for the research carried out in the plastic tunnels located in the University of Agriculture facilities and the Institute of Horticulture in Skierniewice (Kurpaska et al., 2012; Hołownicki et al., 2012). In the process of heat storing, both thermal processes as well as mass exchange processes occur (condensation, evaporation) through changes of steam concentration in air. Therefore, determination of these effects which were formed during pressing air to the rock-bed storage is an essential problem. It will be a main objective of the paper.

Material and method

Experimental research was carried out in the facility composed of a 4-segment rock-bed storage (with the area of 18.7 m^2 and the volume close to 13.1 m^3 each), which is placed in the experimental tunnel (without plant cultivation) in the facilities of the Department of Production Engineering and Power Industry of the University of Agriculture in Cracow. A schematic representation of the test bench with marked measurement points were presented in figure 1.

During the experiments, the following parameters were measured:

a) air pressed and flowing out of the rock-bed storage: speed, temperature, relative humidity,
b) temperature and humidity of air which flows through the rock-bed storage,
c) of the external air: temperature, humidity, intensity of solar radiation and the wind velocity.

All measured sizes along with determination of the location of electric gate valves were controlled with the use of the original measurement system with the time of sampling equal to 120 s.

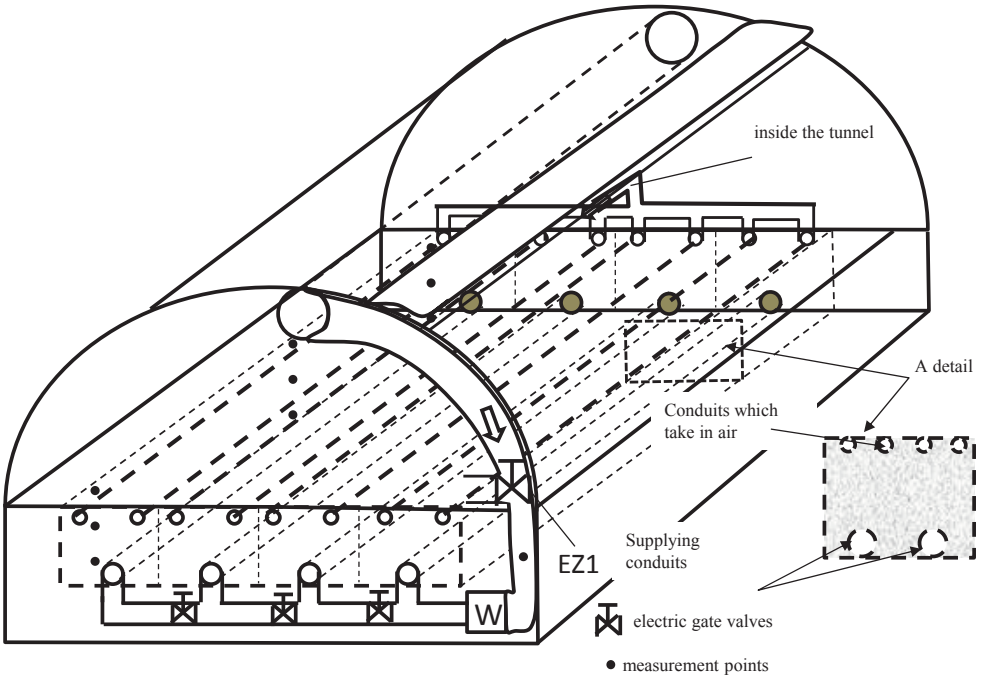

Figure 1. Schematic representation of the measurement stand

Change of a location of electric gate valves was performed with the use of the alogorithm presented in fig.2.

The presented schematic representation of signals flow shows clearly that the process of both charging the storage (left part of the algorithm) as well as its discharging (right part of the algorithm) takes place in case of excceding the temperature difference (Δt_1, Δt_2) between the bed temperature (t_I, t_{II}, t_{III} i t_{IV}) a temperature above shadowing (t_{NC}) or inside the facility (t_{wew}). Value of this difference was determined in the research in order to maintain stability of this system operation. As a result of complex temperature difference, change of the control of location of the guide valve in EZ1 device took place.

In the analysis of the storage charging process, two mutually related sizes (parameters of the pressed air and air in the storage) may be distinguished i.e. the amount of the stored air in each measurement cycle and the change of the mass content (counted as a difference in the steam concentration in air between air pressed to the storage and air flowing inside the tunnel).

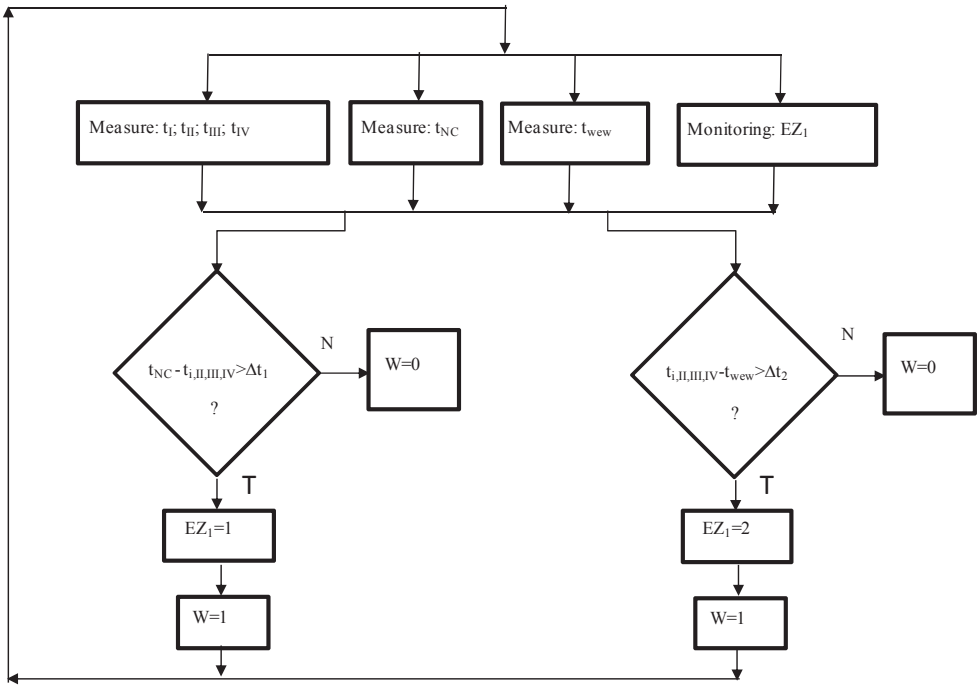

Figure 2. Schematic representation of the control of the charging/discharging process of the rock-bed storage

Thus, the amount of the stored heat in the storage (dQ_{ak}) in the differential time $d\tau$ was calculated from the relation:

$$dQ_{ak} = q_{pow} \cdot \rho_{pow} \cdot \int_{\tau_1}^{\tau_1+\tau} (i_{WE} - i_{WY}) d\tau \tag{1}$$

while the change of the mass amount with the steam concentration change in the air pressed by the storage from the formula:

$$dm_{H2O} = q_{pow} \cdot \int_{\tau_1}^{\tau_1+\tau} (f_{WE} - f_{WY}) d\tau \tag{2}$$

For generalization of the obtained results average values of parameters were calculated (W_{avg}) which determine changes in the scope of the stored heat amount and the change in the amount of the absorbed/ moistened water in the storage. These values were calculated using their actual values from the relation:

$$W_{avg} = \frac{1}{\tau} \cdot \int_{\tau_1}^{\tau_1+\tau} w(\tau) d\tau \tag{3}$$

All parameters indispensable for determination of these relations were determined for each cycle using the standard psychometric relations.

Results and a discussion

Research was carried out between March and October 2013. The scope of the temperature difference used in the control of the air flow process was determined in the initial research in 2012. Figure 3 presents temperature changes in the storage bed and the facility with no working ventilator.

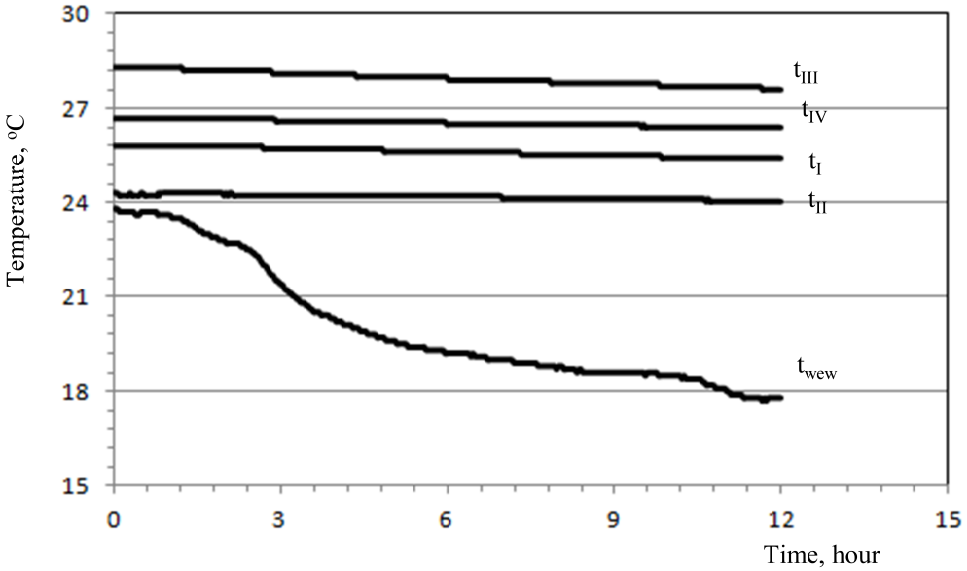

Figure 3. Temperature changes in the bed segments and inside the tunnel

One may notice that for conditions of surrounding, difference between the initial and final temperature of the bed is within 0.3 to 0.8 K. Higher value were reported for the bed segment, which was characterized with a higher value of initial temperature. It proves a good insulation of segments, whereas as a result of narrow scope of temperature changes temperature difference between a final and initial temperature (from 1.1 to 2.9%) towards the initial values, it was assumed in the nomogram that the difference between temperature values used in the control algorithm will be 2K.

During the research, as a result of selection 318 measurement cycles were selected from all possible states of accumulator operation.

Table 1 presents measured and calculated average values of the measured parameters during the measurement cycles along with the detailed duration of experiments.

Table 1

Values of parameters in the analysed cycles during the experiments which were carried out R – intensification of the solar radiation, t – air temperature, RH – relative humidity, V_{wiatr}- wind velocity

Specification	Time, (s)	Surrounding climate				Input		Output		Bed temperature	Air stream
		R ($W \cdot m^{-2}$)	t (^oC)	RH (-)	V_{wiatr} ($m \cdot s^{-1}$)	t (^oC)	RH (-)	t (^oC)	RH (-)	$t_{I,II,III,IV}$ (^oC)	q_{pow}, ($m^3 \cdot cykl^{-1}$)
Minimum value	689	23.3	-6.2	0.261	0.01	10.8	0.155	6.4	0.296	6.7	65.1
Maximum value	53673	891.1	37.1	0.975	3.47	48.7	0.706	33.1	0.944	39.7	6370.2

The course of changes in the amount of the stored heat and changes in the water mass content in air flowing out from the storage was presented graphically in fig. 5 and 6.

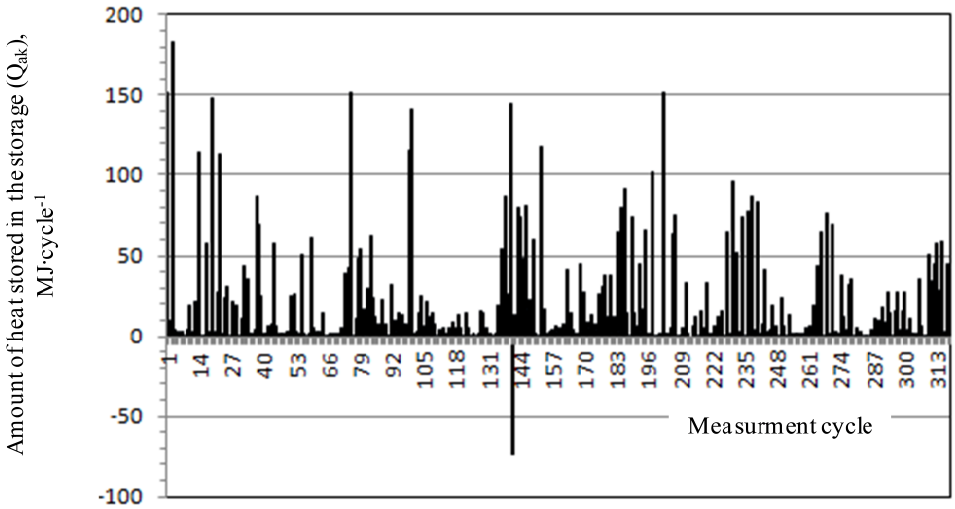

Figure 5. The course of the amount of heat stored in the rock storage

Positive values mean that the heat was stored in the storage whereas, the negative value (cycle 141) shows that in the condition of the performed cycle the amount of the heat obtained from the storage is lower than the amount of the supplied heat. When analysing these data one may assume that the amount of the stored heat in the storage is within -74 to over 182 MJ.

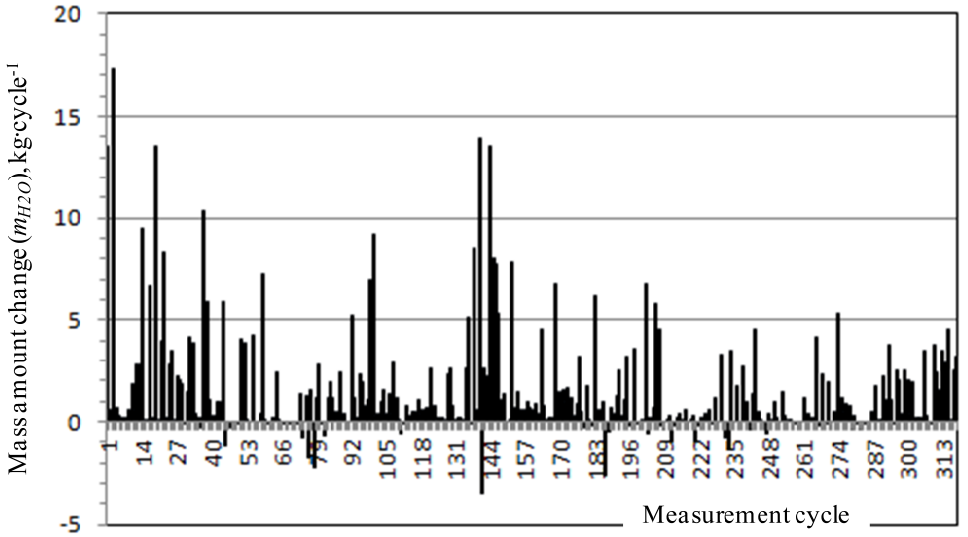

Figure 6. The course of water mass changes in the air flowing out from the storage bed in particular measurement cycles

When analysing the data presented in fig. 6 (positive values mean that the air was dried, the negative, on the other hand mean that it was moistened); similarly to the previous situation, one may report that during experiments, such cycles occurred, as a result of which, evaporation of water from the bed took place and as a result the increase of absolute moisture in air, which was supplied to the inside of the tunnel. In the measurement cycles, which were carried out, the scope of changes was within -3.5 to 17.5 kg·cykl^{-1}.

In order to generalize the obtained results and their application to similar systems which use the rock bed as a heat storage, two approaches were applied. In the first on, the heat stream and the change of the mass stream were determined as dependent variables from velocity (V_{pow}) of the pressed in air (measured in the conduit with diameter 300 mm which presses air to particular segments), initial temperature of the storage (t_{0ak}) and the pressed heat stream (q_{WE}). For the obtained results, the found equation which includes this relation (the form of the power model based on the highest value of coefficient of determination; this relation has been determined with non-linear estimation with quasi-Newton method at maintaining the convergence factor 0.001) takes the following form:

a) for the heat stream (q_{ak})

$$q_{ak} = -295{,}2 \cdot V_{pow}^{0{,}508} + 51{,}18 \cdot q_{WE}^{0{,}43} - 6{,}21 \cdot t_{0ak}^{1{,}16} + 10{,}5 \quad (\mathrm{W \cdot m^{-2}})$$

b) for the heat mass (m_{H2O})

$$m_{H_2O} = -12{,}71 \cdot V_{pow}^{0{,}19} + 5{,}79 \cdot q_{WE}^{0{,}17} - 0{,}0182 \cdot t_{0ak}^{1{,}49} \quad (\mathrm{g \cdot m^{-2} \cdot min^{-1}})$$

Within the scope of use:

$$1.34 \le V_{pow} \le 3.25 \text{ m·s}^{-1};\ 185.5 \le q_{we} \le 1064.8 \text{ W·m}^{-2};\ 2 \le t_{0ak} \le 37.7 \text{ (°C)}$$

These formulas have been developed including duration of experiments (table 1).

Figure 7 and 8 present graphical comparison between the values calculated from the suggested models and measured values.

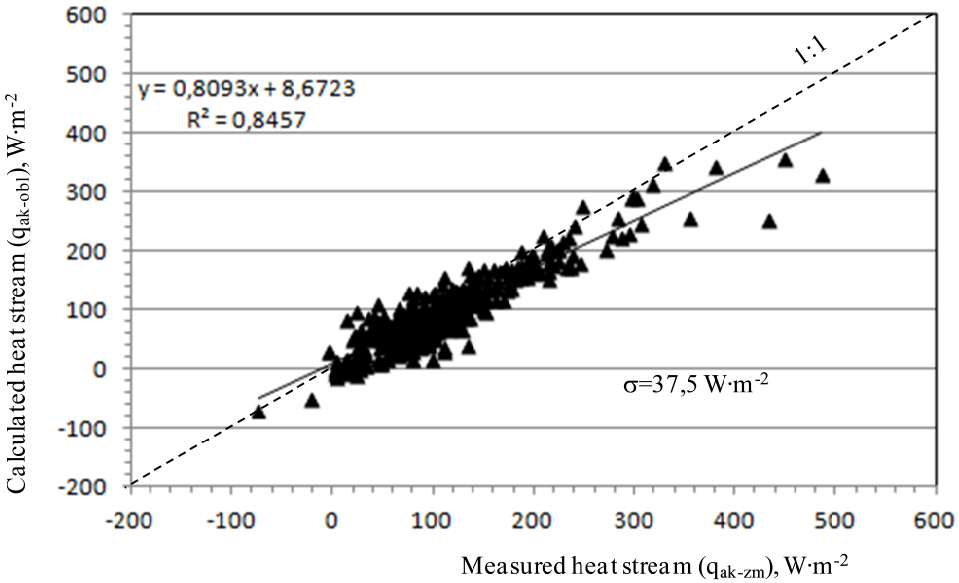

Figure 7. Comparison between the calculated and measured heat streams stored in the rock bed (independent variables: V_{pow}, q_{we}, t_{0ak})

While, in the second case, the values of the dependent variables (heat and mass streams) were made dependent from: supply temperature (t_{WE}), deficiency of steam pressure in the air inside the tunnel (VPD) and the stream of the pressed air (q_{pow}). Using, similarly as in the previous case, a procedure, the relation ,which describes the analysed values takes the following form:

– for the heat stream (q_{ak})

$$q_{ak} = 124{,}8 \cdot t_{WE}^{0{,}59} - 65{,}45 \cdot VPD^{0{,}3} - 12{,}92 \cdot q_{pow}^{-1{,}07} \quad (\text{W·m}^{-2})$$

– for the heat mass (m_{H2O})

$$m_{H_2O} = -612{,}5 \cdot t_{WE}^{0{,}011} + 616{,}22 \cdot VPD^{0{,}0055} - 1{,}1 \cdot q_{pow}^{1{,}49} \quad (\text{g·m}^{-2}\text{·min}^{-1})$$

Within the scope of use:

$$49.4 \le t_{WE} \le 11.1 \text{ m·s}^{-1};\ 364.4 \le VPD \le 8422.4 \text{ Pa};\ 0.09 \le q_{pow} \le 0.22 \text{ (m·s}^{-3})$$

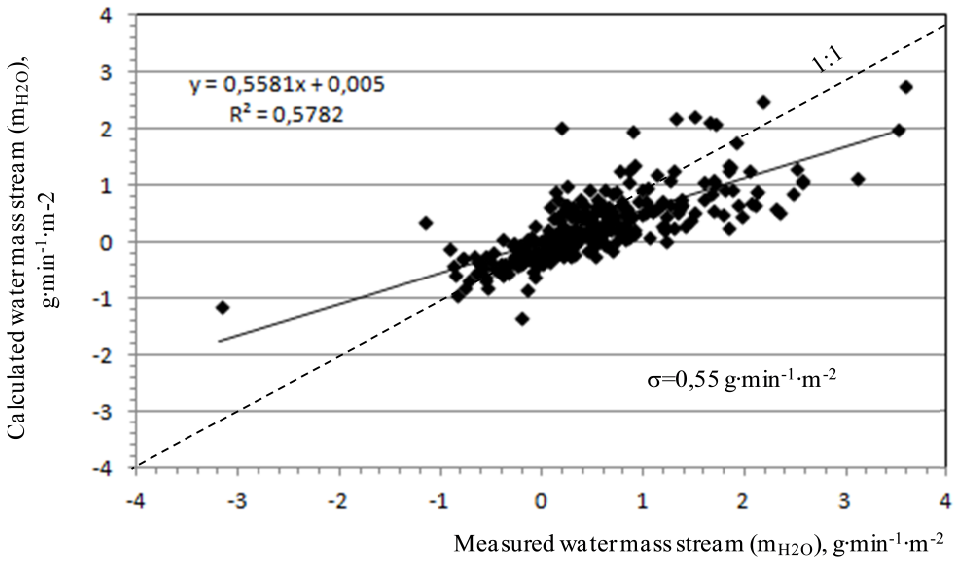

Figure 8. Comparison between the calculated and measured water mass streams in air flowing out from the rock storage (independent variables: V_{pow}, q_{we}, t_{0ak})

Both in the first case (equations a and b) and the other case, statistical analysis proved significance of the determined values of coefficient and exponents, which describe the impact of independent variables on the analysed dependent variables.

Fig. 9 and 10 presents the comparison between values calculated from the relation (c and d) and the measured ones.

Summing up the obtained relations one may conclude that they have (except for cognitive values) also application features. These formulas (within the provided scopes of use of initial variables and the duration of the process) allow determination of the heat and mass stream density. Thus, having a storage of the analysed area (18.7 m^2) and knowing the time of pressing air into it, it is simple to calculate the effects in the form of the amount of the stored heat and exchanged mass.

When analysing changes in the amount of heat stored in the storage and changes of steam content in air which flows out from the bed, one may also observe, that for some values of independent variables there are such cases, in which the storing process does not occur and air is moistened. A detailed analysis of such case will be a subject of further analyses.

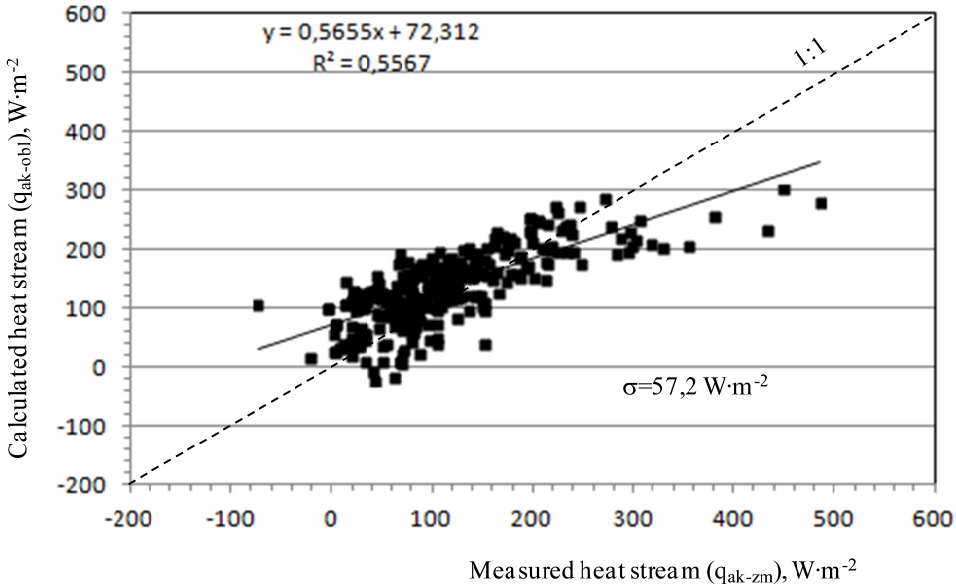

Figure 9. Comparison between the calculated and measured heat streams stored in the rock bed (independent variables: t_{WE}, VPD, q_{pow})

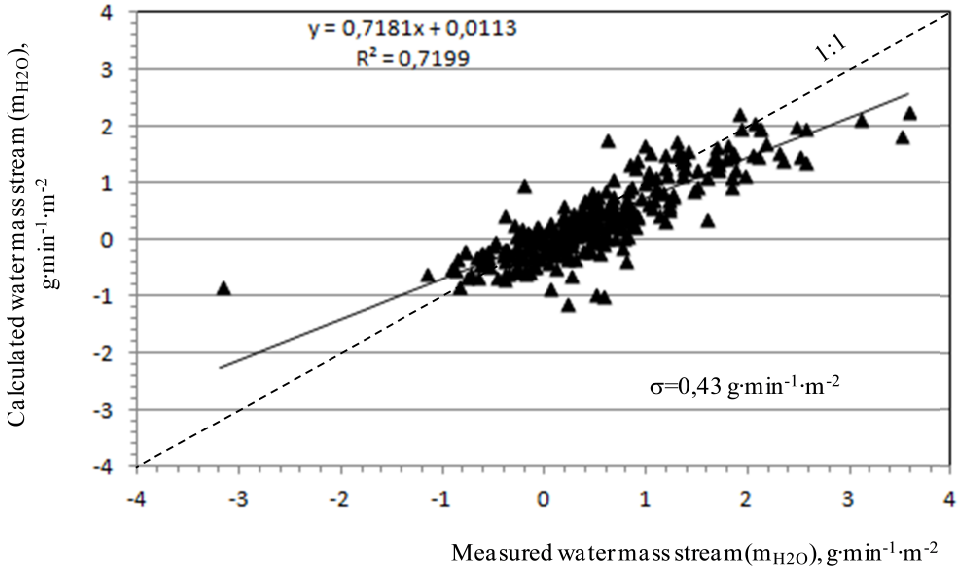

Figure 10. Comparison between the calculated and measured water mass streams in air flowing out from the rock storage (independent variables: t_{WE}, VPD, q_{pow})

Conclusions

1. The total scope of changes in the amount of stored heat in the considered rock storage in the investigated cycles is within -74 and 182 MJ.
2. In the investigated cycles of pressing air inside the rock storage, the scope of changes in the amount of water (calculated as a difference between the water content in the pressed air and flowing out the bed) is within -3.5 to 17.5 kg.
3. Based on the experimental results, equations were determined, which allow, at known input parameters, determination of the heat and mass stream density mentioned in the process of air flow through the rock - bed storage in the cycle of charging.

References

Abreu, M.J.; Ferreira, V.C.; Sottomayor, A.; Vargues, A.C.; Meneses, J.F. (2001). Evaluation of greenhouse structures for tomato spring crops in the entre douro e Minho region of Portugal. *Acta Horticulturae, 559*, 169-176.

Boniecki, P. (1999). Uwzględnienie stochastycznych parametrów źródła ciepła w procesie ładowania akumulatora energii cieplnej. *Prace Przemysłowego Instytutu Maszyn Rolniczych, Vol. 44(2)*, 66- 68.

Boulard, T.; Fatnassi, H.; Roy, J.C.; Lagier, J.; Fargues, J.; Smits, N.; Rougier, M.; Jeannequin, B. (2004). Effect of greenhouse ventilation on humidity of inside air and in leaf boundary-layer. *Agricultural and Forest Meteorology, 125(3-4)*, 225-239.

Condori, M.; Echazu, R.; Saravia, L. (2001). Solar drying of sweet pepper and garlic using the tunnel greenhouse drier. *Renewable Energy, Vol. 22*(4), 447-460.

Fuller, R.J.; Charters, W.W.S. (1997). Performance of a solar tunnel dryer with microcomputer control. *Solar Energy, Vol. 59(4-6),* 151- 154.

Hołownicki, R.; Konopacki, P.; Kurpaska, S.; Latała, H.; Treder, W.; Nowak, J. (2012). Magazynowanie nadwyżek ciepła w tunelach foliowych – koncepcja kamiennego akumulatora ciepła. *Inżynieria Rolnicza, 2(136),* 79-87.

Kittas, C.; Bartzanas, T. (2007). Greenhouse microclimate and dehumidification effectiveness under different ventilator configurations. *Building and Environment, Vol 42(10)*, 3774- 3784.

Kurklu, A. (1998). Energy storage applications in greenhouses by means of phase change materials (PCMs): a review. *Renewable Energy, Vol. 13(1)*, 89-103.

Kurpaska, S.; Latała, H.; Rutkowski, K.; Hołownicki, R.; Konopacki, P.; Nowak, J.; Treder, W. (2012). Magazynowanie nadwyżki ciepła z tunelu foliowego w akumulatorze ze złożem kamiennym. *Inżynieria Rolnicza, Nr 2(136),* 157-167.

Mueller, W.; Maćkowiak, S. (2010). Symulacja przepływu ciepła w kamiennym akumulatorze o losowej strukturze złoża. *Inżynieria Rolnicza, 7(125)*, 153-160.

Ozgenger, L.; Ozgener, O. (2010). Energetic performance test of an underground air tunnel system for greenhouse heating. *Energy, Vol. 35(10)*, 4079-4085.

Volkaerts, D.; Youssef, A.; Ozcan, S.E.; Exadaktylos, V.; Berckmans, D. (2012). Modelling greenhouse temperature and humidity dynamics in order to develop an energy saving model-based control strategy. *Acta Horticulturae, 952,* 87-92.

ANALIZA WPŁYWU WYBRANYCH CZYNNIKÓW NA ILOŚĆ ZMAGAZYNOWANEGO CIEPŁA ORAZ ZMIANY MASY W AKUMULATORZE O ZŁOŻU KAMIENNYM ZLOKALIZOWANYM W TUNELU DOŚWIADCZALNYM

Streszczenie. W pracy przedstawiono wyniki analizy związanej z przepływem powietrza przez złoże akumulatora kamiennego. Powietrze pozyskiwano z wnętrza tunelu foliowego i tłoczono do segmentów akumulatora o powierzchni 18,7m^2 i objętości blisko 13,1m^3. Badania przeprowadzono w okresie od marca do października 2013r. Cyklem pracy akumulatora (ładowanie lub rozładowanie) sterowano w oparciu o algorytm, w którym sygnał sterujący opierał się o różnicę temperatury między średnią temperaturą złoża a temperaturą wewnątrz tunelu. Do szczegółowej analizy wyodrębniono 318 cykli pomiarowych, w których na bazie zmierzonych parametrów zatłaczanego i wypływającego z akumulatora powietrza określono ilość zmagazynowanego ciepła w akumulatorze oraz zmianę w koncentracji pary wodnej zawartej w powietrzu. Dla uzyskanych wyników znaleziono równania regresji wielokrotnej opisującej jednostkowy strumień ciepła i masy wymienianej podczas przepływu powietrza przez akumulator. Wyznaczono także ilościowe zależności między jednostkowym strumieniem ciepła i masy wymienianym podczas przepływu powietrza przez akumulator uwzględniających dwie grupy zmiennych niezależnych. W pierwszej grupie wykorzystano: prędkość zatłaczanego powietrza (zmierzoną w przewodzie tłoczącym powietrze do poszczególnych segmentów), temperaturę początkową akumulatora oraz strumienia ciepła zatłaczanego. Druga grupa zmiennych niezależnych obejmuje: temperaturę tłoczonego powietrza, deficyt ciśnienia pary wodnej wewnątrz obiektu oraz strumienia zatłaczanego powietrza. Do określenie tych zależności zastosowano estymację nieliniową z wykorzystaniem metody quasi-Newtona.

Słowa kluczowe: magazynowanie ciepła, akumulator kamienny, tunel foliowy

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ENERGY EFFICIENCY OF HYBRID RYE CULTIVATION IN RELATION TO THE MANNER OF SOIL CULTIVATION

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ABSTRACT

In a one-factor field experiment, carried out in 2011-2012 in Demo Farma in Drzęczewo near Gostyń in Wielkpolskie Voivodeship, the size and structure of energy inputs incurred for cultivation of hybrid rye and index of energy efficiency were compared. The size of energy accumulated was not varied by the compared systems of field cultivation, because it depended mainly on inputs of energy accumulated brought in the form of materials (approx. 85%). The use of no-tillage cultivation reduced energy inputs brought in the form of fuel by 2.4% and in the form of aggregates (by 34.5% in comparison to tillage cultivation). The compared systems of field cultivation diversified the size of hybrid rye seed crop by 4.7%, value of the energy efficiency index by 3.9% and the size of the accumulated energy inputs by 0.9%.

Introduction

New solutions in the technology of plant cultivation are based inter alia on the reduction of intensity of field cultivation in a crop rotation, introduction of the no-tillage cultivation systems and even on the total abandonment of the mechanical impact on soil and the use of the so-called direct sowing, particularly in large-scale agricultural farms. A plough system of field cultivation, characterizes with great energy-consumption and favours water and wind erosion and causes excessive soil over drying. Introduction of the systems for the simplified cultivation systems is a response (Kordas, 2011).

Advantages from introduction of the no-tillage systems are very explicit, since they not only decrease the energy and human labour expenditures by approx. 35% (Dzienia et al., 2006) but also positively influence the soil environment and may considerably influence maintenance of balance in the natural environment (Holland, 2004; Dzienia et al., 2006; Derpsch, 2007). The aspect of the environmental protection is not without significance, because the systems of no-tillage soil cultivation are said to reduce CO_2 emission to atmosphere as a result of a slower rate of organic substance decomposition and lower fuel consumption (Derpsch, 2007).

Hybrid rye is a plant with a systematically rising economic significance. Hybrid varieties characterize with lower height of plants, better production propagation which enables obtaining a higher stock of spikes. These varieties are less susceptible to lodging, which favours greater mineral fertilization and obtaining a higher crop (Dopierała et al., 2003).

The objective of the research

The objective of the research was to analyse the size and structure of energy inputs incurred on hybrid rye cultivation in the production conditions and determination and comparison of the value of energy efficiency index of the applied cultivation systems.

Methodology and conditions of the research

A one-factor field experiment was carried out in 2011 and 2012 in Demo Farma founded in an individual farm in Drzęczewo next to Gostyń in Wielkopolskie Voivodeship. On the determined fields with 10 ha area each plough and non-plough hybrid rye cultivation of Visello variety. The soil conditions were equal on the surface of the whole experiment - soil of a granulometric composition of hard loamy sand, included to the IVa soil quality class. Winter rye was sown in the second decade of September in the amount of 60 kg·ha^{-1}, which responded to the stock of 180 items·m^{-2} of germinating seeds. Each year, winter wheat was a forecrop and mineral fertilization was in total 142 kg·ha^{-1} N, 96 kg·ha^{-1} K_2O and 36 kg·ha^{-1} P_2O_5. According to the IOR (the Institute of Plant Protection) chemical protection and retardants were applied.

After-harvest cultivation, fertilization, sowing and plant protection were not diversified on the investigated fields. Only basic cultivation was subject to diversification. In the tillage systems, a four-furrow plough Kverneland EM80 was used and in the no-tillage system Cultus 300 unit. These machines were aggregated with a tractor of 140 KM power. Skimming was carried out with a skimming unit KOS, sowing with Rapid 300 sower, mineral fertilization with Amazone ZAF 803 spreader and application of the crop protection chemicals and leaf fertilization was carried out with Pilmet 615.

The size of the energy inputs (E_{tech}) incurred on the winter rye production was determined with the use of the accumulated energy consumption methodology (Anuszewski et al., 1979; Wójcicki, 2002).

$$E_{tech} = \sum E_{mat} + \sum E_{agr} + \sum E_{pal} + \sum E_r \quad (\text{MJ·ha}^{-1}) \tag{1}$$

Because determination of the amount of energy brought in the form of human labour (ΣE_r) in field conditions was not possible for determination, this component of the accumulated energy was omitted and the formula assumed the form suggested by Piskier (Piskier, 2011):

$$E_{tech} = \sum E_{mat} + \sum E_{agr} + \sum E_{pal} \quad (\text{MJ·ha}^{-1}) \tag{2}$$

ΣE_{agr} – the sum of energy consumption of the used aggregates (MJ·ha^{-1}),
ΣE_{mat} – the sum of energy consumption of used materials (MJ·ha^{-1}),
ΣE_{mat} – the sum of energy consumption of the consumed fuel (MJ·ha^{-1}).

Efficiency of machines was determined with the use of simplified timing and fuel consumption during carrying out particular treatments was determined through a direct measurement. Energy brought in the form of materials was calculated through multiplication of the mass of the used material during production by the value of energy included in it assuming: for the sowing material 9 $MJ \cdot kg^{-1}$, of nitrogen fertilizers 77 $MJ \cdot kg^{-1}$ N, potassium fertilizers 10 $MJ \cdot kg^{-1}$ K_2O, phosphorus fertilizers15 $MJ \cdot kg^{-1}$ P_2O_5, for diesel oil 48 $MJ \cdot kg^{-1}$, for pesticides 300 $MJ \cdot kg^{-1}$ active substance (Wójcicki, 2002).

The value of the index of energy efficiency was calculated by dividing the energy value of the rye seed crop by the amount of the accumulated energy input incurred on its production. The amount of the seed crop was accepted according to the data obtained from a combine harvester. The energy inputs related to the plant collection were not included in calculations.

Research results and discussion

Tillage cultivation of hybrid rye (not related to the years of research) required the input of the accumulated energy on the level of 16.99 $GJ \cdot ha^{-1}$. The use of non-tillage cultivation required a slightly lower input of the accumulated energy (by 1%) and this input was 16.84 $GJ \cdot ha^{-1}$ (tab. 1).

Energy brought in materials decided on the amount of inputs of energy accumulated in both cultivation systems. At the average in the investigated years it was 14.46 $GJ \cdot ha^{-1}$ and constituted respectively 85.1% of the incurred inputs of energy accumulated in the tillage and no-tillage cultivation 85.9%. Respectively the size of energy brought in the form of aggregates in the tillage cultivation was 0.39 $GJ \cdot ha^{-1}$ which constituted 2.3% of the total amount of the energy brought in the cultivation system, whereas the accumulated energy brought in the form of fuel was 2.14 $GJ \cdot ha^{-1}$ which constituted 12.6%. In the no-tillage cultivation, the energy brought in the form of aggregates was 0.29 $GJ \cdot ha^{-1}$ (1.7% of the entire input), whereas the energy brought in the form of fuel was 2.09 $GJ \cdot ha^{-1}$ – which constituted 12.3% of the energy accumulated consumed for hybrid rye cultivation.

Table 1

The size of the accumulated energy inputs incurred for hybrid rye cultivation in different cultivation systems (at the average in 2011-2012)

Cultivation system	Energy brought in ($GJ \cdot ha^{-1}$)			Accumulated energy input ($GJ \cdot ha^{-1}$)
	Materials	Aggregates	Fuel	
Tillage	14.46	0.39	2.14	16.99
No-tillage	14.46	0.29	2.09	16.84

When comparing the size of the accumulated energy input brought in aggregates one may assume that it is almost identical in both cultivation systems. In the non--tillage cultivation, its amount is lower by approx. 34.4% – in comparison to the tillage cultivation. Similar differences occurred in the amount of the energy brought in fuel. The use of no-tillage cultivation (in comparison to the tillage one) required by 2.4% of lower inputs incurred in this form (table 1).

Table 2
Energy efficiency of hybrid rye cultivation

Cultivation system Years	Seed crop (dt·ha^{-1})	Energy value of a crop (GJ·ha^{-1})	Accumulated energy input (GJ·ha^{-1})	Index of energy efficiency
		2011		
Tillage	76.70	69.03	16.69	4.13
No-tillage	66.80	60.21	16.56	3.63
		2012		
Tillage	72.70	65.45	17.32	3.78
No-tillage	75.80	68.27	17.14	3.98
		Average in 2011-2012		
Tillage	74.70	67.24	16.99	3.96
No-tillage	71.30	64.24	16.84	3.81

Two factors decide on the energy efficiency of production - energy value of a crop and the size of the accumulated energy input (table 2). Energy value of the crop differed in particular years of the research. In 2011 it was from 60.21 GJ·ha^{-1} in facilities with a no-tillage cultivation to 69.03 GJ·ha^{-1} after plough cultivation. In 2012 energy value of a crop was higher by 4.3% in the facilities cultivated in a no-tillage system was 68.27 GJ·ha^{-1}. At the average for the years of the research, the energy value of crop obtained in the tillage system of rye production was 67.24 GJ·ha^{-1}, whereas in the no-tillage system it was 64.24 GJ·ha^{-1}. The obtained differences of energy value of the crop resulting from the applied systems of field cultivation were 4.7%.

The value of the energy efficiency index (table 2) did not differ in particular years of research and was at the level of 3.88. According to Wielicki (1989) per one unit of the energy inputs incurred in production there should be four energy units of the produced product. Data presented in table 2 show that the index of the energy efficiency of rye production was varied by the applied systems of field cultivation and difference concerning its value was 3.9%. Also Czarnocki (2013) points out differences of the energy efficiency index between the applied systems of field cultivation, stating that often savings of the energy input obtained due to simplifications are reduced by values of crop losses and may exceed even 50%. On the other hand, Kordas' research (1999) shows that considerably higher effectiveness was obtained after the use of direct sowing.

In the author's own research which was carried out, differences in the amount of inputs of the energy accumulated between the analysed cultivation systems were respectively 0.8% in 2011 and 1.05% in 2012 and at the average 0.9%. Czarnocki (2013) using a no-tillage cultivation obtained 6% reduction of the size of the accumualted energy inputs in winter barley cultivation. Similar savings at the level of 6.1% on energy inputs incurred on no-tillage cultivation and 5.6% in direct sowing was proved by Orzech et al. (2004). The no-tillage cultivation causes decrease of the amount of fuel consumption, this relation was confirmed in the author's own research (Piskier, 2011; Piskier and Majchrzak, 2013). Also Jaskulski et al. (2013) replacing a classic tillage non-plough cultivation reported limitation of fuel consumption in winter rape and winter wheat by 3.9 to 4.6 l·ha^{-1}. The highest participation in the accumulated energy inputs is reported in materials including nitrogen fertilizers (Starczewski et al., 2008; Klikocka et al., 2012; Czarnocki, 2013). According to

Nasalski (2004) fertilization constitutes a basic factor which decides on economic efficiency of agricultural production. It is a considerable crop-shaping factor and at the same time it has a significant participation in the structure of inputs and the production costs. The systems of field cultivation, applied in the author's own research, differentiated the size of the winter rye seed crop. Moreover, Weber and Podolska (2008), Jug et al. (2011) as well as Halinairz et al. (2013) inform on the reduction of the winter wheat seed crop in the field experiments influenced by simplifications in the field cultivation. On the other hand Piskier and Sławiński did not report significant differences in yielding hybrid rye between the plough and no-tillage system. Whereas in the research carried out by Entrup and Schneider (2003) and Fiszet et al. (2006) a positive impact of non-plough soil cultivation on the size of the winter wheat crop, which was significantly higher than the one obtained in the plough system of field cultivation, was reported.

Conclusions

1. Inputs brought in the form of materials decide on the size of the incurred energy inputs, independent from the field cultivation system. They constitute 85.1% of the size of energy inputs incurred in the tillage cultivation and 85.9% in the no-tillage cultivation.
2. The use of the no-tillage cultivation system allows reduction of the inputs of the energy brought in the form of fuel by approx. 2.4% and in the form of aggregates by 34.5%.
3. The application of the no-tillage cultivation system in 2011 caused decrease of the hybrid rye seed crop by 12.9%, value of the energy efficiency index by 11.1% and the size of the accumulated energy inputs by 0.8%. These different values were reported in 2012. Non-plough field cultivation caused the increase of the seed crop by 4.3%, the value of the energy effectiveness index by 5.3% and the decrease of the amounts of the acummulated energy inputs by 1%.

References

Anuszewski, R.; Pawlak, J.; Wójcicki, Z. (1979). Energochłonność produkcji rolniczej. Metodyka badań energochłonności produkcji surowców żywnościowych. IBMER Warszawa.

Czarnocki, S. (2013). Ocena energetyczna alternatywnych technologii przygotowania roli do siewu jęczmienia ozimego. *Inżynieria Rolnicza*, *3*(146), T.2, 69-75.

Derpsch, R. (2007). The no-tillage revolution in South America. *Proc. Farm Tech., Edmonton,* Alberta 24-26 January 2007, 54-68.

Dopierała, P.; Bujak, H.; Kaczmarek, J.; Dopierała, A. (2003). Ocena wartości hodowlanej linii mieszańców żyta ozimego. *Biuletyn IHAR,* 230, 235-242.

Dzienia, S.; Zimny, L.; Weber, R. (2006). Najnowsze kierunki w uprawie roli i technice siewu. *Fragm. Agron*., *23*(2), 227-241.

Entrup, N.L.; Schneider, M. (2003). Nachhaltigkeit und Umweltverträglichkeit Landwirtschaftlicher Systeme der Bodennutzung durch Fruchtfolgegestaltung und konservierende Bodenbearbeitung/Direksaat. Braunschweig, 27-28 Oktober, 7-35.

Fiszer, A.; Dworecki, Z.; Kaźmierczak, P.; Morkowski, A. (2006). Analiza porównawcza tradycyjnej i bezorkowej uprawy pszenicy ozimej. *Journal of Research and Applications in Agricultural Engineering*, *Vol. 51*(3), 23-25.

Haliniarz, M.; Gawęda, D.; Bujak, K.; Frant, M.; Kwiatkowski, C. (2013). Yield of winter wheat depending on the tillage system and level of mineral fertilization. *Acta Scientiarum Polonorum, Agricultura, 12*(4), 59-72.

Holland, J.M. (2004). The environmental consequences of adopting conservation tillage in Europe: reviewing the evidence. *Agriculture Ecosysem & Environment, 103*, 1-25.

Jug, I.; Jug, D.; Sabo, M.; Stipešević, D.; Stosić, M. (2011). Winter wheat yield and yield components as affected by soil tillage systems. *Turkisch Journal Agriculture Forestry, 35*, 1-7.

Jaskulski, D.; Jaskulska, I.; Kotwica, K.; Gałęzewski, L.; Wasilewski, P. (2013). Zużycie paliwa na uprawę roli w zależności od stopnia jej uproszczenia i przedplonu w zmianowaniu roślin. *Inżynieria Rolnicza*, 3(145) T.1, 109-116.

Klikocka, H; Głowacka, A.; Juszczak, G.; Cybulska, M.; Michałkiewicz, G.; Pawliszak, R. (2012). Energochłonność produkcji jęczmienia jarego w warunkach zróżnicowanej uprawy roli i nawożenia mineralnego. *Fragm. Agron., 29*(3), 71-80.

Kordas, L. (1999). Energochłonność i efektywność różnych systemów uprawy roli w zmianowaniu. *Materiały konferencyjne Agronomia w Zrównoważonym Rozwoju Współczesnego Rolnictwa. IV konferencja PTA, SGGW Warszawa* 05-07.09.2011, 41-42.

Kordas, L. (2011). Agrotechniczne i ekonomiczne aspekty uproszczeń uprawy roli. *Fol. Univ. Agric. Stetin. Agricultura, 74*, 47-52.

Nasalski, Z.; Sadowski, T.; Stępień, A. (2004). Produkcyjna, ekonomiczna i energetyczna efektywność produkcji jęczmienia ozimego przy różnych poziomach nawożenia azotem. *Acta Scientiarum Polonorum, Agricultura, 3*(1), 83-90.

Orzech, K.; Marks, M.; Nowicki, J. (2004). Energetyczna ocena trzech sposobów uprawy roli na glebie średniej. *Ann. UMCS,* sec. E 59(3), 1275-1281.

Piskier, T. (2010). Analiza energetyczna bezorkowej uprawy jęczmienia ozimego. *Technika Rolnicza Ogrodnicza Leśna*, *3*, 8-9.

Piskier, T. (2011). Efektywność energetyczna produkcji biomasy w teorii i praktyce. *Technika Rolnicza Ogrodnicza Leśna, 3*, 5-7.

Piskier, T.; Majchrzak, L. (2013). Wielkość i struktura nakładów energetycznych bezorkowej i orkowej uprawy żyta hybrydowego. *Inżynieria Rolnicza*, *3*(146), T.2, 295-300.

Piskier, T.; Sławiński, K. (2012). Reakcja żyta hybrydowego na uprawę bezorkową. *Journal of Research and Applications in Agricultural Engineering*, *Vol. 57*(4), 65-67.

Starczewski, J.; Dopka, D.; Korsak-Adamowicz, M. (2008). Ocena energetycznej efektywności wybranych technologii uprawy żyta jarego. *Acta Agrophysica, 11*(3), 733-739.

Weber, R.; Podolska, G. (2008). Wpływ sposobu uprawy roli, terminu i gęstości siewu na plonowanie odmian pszenicy ozimej. *Inżynieria Rolnicza*, *1*(99), 395-400.

Wójcicki, Z. (2002). *Wyposażenie i nakłady materiałowo energetyczne w rozwojowych gospodarstwach rolniczych.* IBMER Warszawa. ISBN 83-86264-62-4.

EFEKTYWNOŚĆ ENERGETYCZNA UPRAWY ŻYTA HYBRYDOWEGO W ZALEŻNOŚCI OD SPOSOBU UPRAWY GLEBY

Streszczenie. W jednoczynnikowym doświadczeniu łanowym, prowadzonym w latach 2011-2012 w Demo Farmie w Drzęczewie koło Gostynia w województwie wielkopolskim porównywano wielkość i strukturę nakładów energetycznych poniesionych na uprawę żyta hybrydowego oraz wartość wskaźnika efektywności energetycznej. Wielkość nakładu energii skumulowanej nie była zróżnicowana przez porównywane systemy uprawy roli, zależała ona bowiem w głównej mierze od nakładów energii skumulowanej wniesionej w formie materiałów (około 85%). Zastosowanie uprawy bezorkowej zmniejszyło nakład energii wniesionej w formie paliwa o 2,4%, a w formie agregatów o 34,5% (w porównaniu do uprawy orkowej). Porównywane systemy uprawy roli różnicowały wielkość plonu ziarna żyta hybrydowego o 4,7%, wartość wskaźnika efektywności energetycznej o 3,9%, a wielkość skumulowanych nakładów energetycznych o 0,9%.

Słowa kluczowe: system uprawy, plon ziarna, wskaźnik efektywności energetycznej, żyto hybrydowe

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METHOD OF MATHEMATICAL MODELLING OF THE SURFACE OF THE EGG SHELL SHAPE, EGG YOLK AND AIR CHAMBER OF CHICKEN EGGS

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ABSTRACT

The paper presents a method of mathematical modelling of the shape of the surface of the egg shell, egg yolks and air chamber. For modelling of the shape, eggs with dimensions: length 60; 57.2; 56.4 mm, width 47.1; 42.3; 41 mm and thickness of 46; 41.1 and 39.2 mm were selected. Two Bézier patches were used to map the shape of the surface of the egg shell, yolk and the air chamber. Calculation and visualization was carried out in Mathcad computer program. The developed mathematical model of the 3D shape of chicken eggs and its basic elements can be used for modelling the processes occurring in their production and processing.

Introduction and objective of the paper

Production of chicken eggs in Poland within 2006-2013 was at the level of 10,393 million pieces (MRSP, 2013). Siepka et al. (2010) emphasize that the scope of use is wide. They are widely used in the food, pharmaceutical, cosmetics, chemical and feed industry. The research carried out by Śmiechowska and Pogórniak (2013) shows that eggs from a laying hen of greenleg partridge hen breed have length from 50 to 61 mm (average 54.7 ±2.52 mm), width from 38 to 44 mm (average 41 ±1.52 mm) and the shape index 1.24-1.40 (average 1.31 ±0.036). According to Shultz (1953) heredity of the shape index of chicken eggs is between 0.11 and 0.19. Mass of a chicken egg is between 40 to 80 g. Eggs with mass within 58 to 60 g are the most popular. Average thickness of a shell is 0.3 mm. A percentage share of egg white is 55.5%, of yolk 31.9% and a shell 12.3%. Height of the air chamber in fresh egss is within 4 to 6 mm. The egg shape is a feature that identifies its origin (Preston, 1968). According to Bardyn and Krysiak (2013), a cross-section of a chicken egg is elliptically shaped and narrowed at one end. A yolk is rounded and is centrally located. Calik (2013) determined that storing conditions of eggs affect both decrease of the egg mass, yolk dimensions and air chamber as well as the egg white content.

Research on the quality of eggs on account of freshness, improper shape, mechanical damages, blood stains inside an egg are carried out automatically with technologies related

to computer graphics with the use of neuron networks. The obtained research results are used for creation of databases of eggs with correct and incorrect structure (Arivazhagen et al., 2013). In production and food processing of eggs, collection, washing, sorting and packing are basic technological operations, for which the egg shape is of basic importance. The mentioned technological operations are manually carried out in small farms and in innovative large scale production they are automatised and roboted (Garcia-Alegre et al., 1997; 1998; 2000; Patel et al., 1998). In the processes of sorting, detection of egg defects and their irregular shapes non-destructive technologies with the use of vision systems and databases of shapes and eggs image are applied (Garcia-Alegre et al., 1998). In the robots used for packing eggs, vacuum pneumatic suckers, the shape of which is selected to the egg shape, are used. Structure of sorting machines, elevator belts, dosing wheels, lantern pinions which transfer eggs to rod cross and diagonal conveyors, counting systems, which assess the quality, incubators, baskets, containers etc., depends greatly on the egg shape. Modern, computer aided methods of designing machines and devices for a poultry force constructors to know geometric properties of processed eggs. Determination of the egg shape in a contractual manner does not suffice, e.g. elyptic, oval. Designers are provided with useful tools for description of the body shape by computer graphics (Kiciak, 2000; Foley et al., 2001). Mieszkalski (2011) used a parametric spatial curve and a four-rod network spread on the external surface of the modelled body for description of plant raw materials.

Keshavarzpour (2011), Rashidi and Gholami (2011), Rashidi and Keshavarzpour (2011) suggested models of linear regression, by means of which they expressed a relation between the egg mass and its geometrical parameters. Many works concern the description of the cross section outline in the two-dimensional system on the plane. Mónus and Barta (2005) and Barta and Székely (1997) suggest function $y=f(x)$, which is a thrid degree polynomial for description of the egg outline. Based on digital pictures of ostrich eggs Nedomová and Buchar (2013) with the use analysis of the image, using a technology for detecting edges, obtained points coordinates for egg profiles, which were approximated with Fourier's row. Nishiyama (2012) says that longitudinal cross sections of eggs are neither rounded not elyptic but oval, therefore for description of the shape of longitudinal cross section outline, he used Cassini's oval.

The issue which must be solved is development of a method, with which 3*D* description of the eggs shape and their components would be possible.

The objective of the paper is developing a method of modelling the chicken egg shape and its basic elements (shell, yolk, air chamber) with the use of Bezier patches.

Research material

Chicken eggs were the material for the research, which come form OLDAR from Sokołow from a cage breeding from 2014. Three different egg shapes were selected, marking them as I, II, III. Eggs were photographed with a digital camera Lumix Panasonic DMC – TZ3 in the JPEG format. Basic shell dimensions (long axis, short axis I, short axis II, shell thickness), yolks (diameter), air chamber (length, width, height) were measured with a caliper with precision up to 0.1 mm. The size of an egg and air chamber were determined after boiling. Results of measurements of the selected chicken eggs were presented in table 1.

Table1
Basic dimensions of the selected chicken eggs

Name of a component of an egg	Name of a dimension	Results of basic dimensions of components of eggs (mm)		
		I	II	III
Shell	Long axis	60	57.2	56.4
	Short axis I	47.1	42.3	41
	Short axis II	46	41.1	39.2
	Shell thickness	0.5	0.5	0.4
Yolk	Diameter	32.2	29.8	29.1
Air chamber	Length	8.2	7.4	7.1
	Width	8.1	7.2	7
	Height	3.4	3.1	2.6

Description of the method

Modelling the shape of the egg shell body was carried out with the use of Bezier patches. Parametric equations of coordinates of the Bézier patches in the matrix record take the following form (Kiciak, 2000; Foley et al., 2001):

$$x(s,t) = T^T \cdot M^T \cdot G_x \cdot M \cdot S \tag{1}$$

$$y(s,t) = T^T \cdot M^T \cdot G_y \cdot M \cdot S \tag{2}$$

$$z(s,t) = T^T \cdot M^T \cdot G_z \cdot M \cdot S \tag{3}$$

The parametric representation of the area $x=x(s, t)$, $y=y(s, t)$, $z=z(s, t)$ depends on parameters s and t (vectors 4, 5). In equations (1, 2, 3) a base matrix of the Bézier patch occurs M (6).

$$T = \begin{bmatrix} t^3 \\ t^2 \\ t \\ 1 \end{bmatrix} \tag{4}$$

$$S = \begin{bmatrix} s^3 \\ s^2 \\ s \\ 1 \end{bmatrix} \tag{5}$$

$$M = \begin{bmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix} \tag{6}$$

Elements of three matrices of Bézier patch geometry G_x, G_y, G_z as matrices of geometric limitations are coordinates of 16 control points which are control points: The change of the coordinates of the control points decides on the patch shape and thus on the egg shape.

Matrices of geometry of Bézier patch *A* have the form:

$$GA_x = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \\ 2 & 2 & 2 & 2 \\ 2 & 2 & 2 & 2 \end{bmatrix} \tag{7}$$

$$GA_y = \begin{bmatrix} 1{,}5 & 1{,}5 & 1{,}5 & 1{,}5 \\ 0 & 0 & 3 & 3 \\ 0 & 0 & 3 & 3 \\ 1.5 & 1.5 & 1.5 & 1.5 \end{bmatrix} \tag{8}$$

$$GA_z = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 4 & 4 & 0 \\ 0 & 4 & 4 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \tag{9}$$

Whereas for the patch *B*: $GB_x = GA_x$, $GBy = GA_y$,

$$GB_z = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & -2 & -2 & 0 \\ 0 & -2 & -2 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix} \tag{10}$$

The model of the external surface of the chicken egg shell consists of two connected Bézier patches *A, B*. Bézier patch *A* was used for modelling the shape of more rounded (smaller radius of rounding) part of an egg located in the end of its long axis, and patch *B* for modelling the shape of less rounded (bigger radius of rounding) of the egg part, located on the opposite side of patch *A*. Continuity and smoothness of the surface is obtained by connecting rod points of patches *A* and *B* at their edges (values of their coordinates are the same) and corresponding control points must be located on common straight lines. Determination of values of matrix elements of Bezier patch geometry G_x, G_y, G_z consists in adjusting the patch shape to the shape of egg piece.

Parametric equations, which determine coordinates of the network points of Bézier patch *A* have the following form:

$$xA_{i,j} = 6 \cdot t_j^2 - 4 \cdot t_j^3 \tag{11}$$

$$yA_{i,j} = -4{,}5 \cdot t_j + s_i^2 \left[27 \cdot t_j - 27 \cdot t_j^2\right] + 4{,}5 \cdot t_j^2 + s_i^3 \left[18 \cdot t_j^2 - 18 \cdot t_j\right] + 1{,}5 \tag{12}$$

$$zA_{i,j} = \left[36 \cdot t_j - 36 \cdot t_j^2\right] \cdot s_i + \left[36 \cdot t_j^2 - 36 \cdot t_j\right] \cdot s_i^2 \tag{13}$$

where:

$$s_i = i \cdot \frac{1}{N} \tag{14}$$

$$t_j = j \cdot \frac{1}{N} \tag{15}$$

$$i = 0 \ldots N \tag{16}$$

$$j = 0 \ldots N \tag{17}$$

$$t, s \in (0,\ 1) \tag{18}$$

N – matrix dimension (number of lines and columns).

Similarly to Bezier patch B the open forms of the parametric equations, which determine coordinates of the network points of the patch B are as follows:

$$xB_{i,j} = 6 \cdot t_j^2 - 4 \cdot t_j^3 \tag{19}$$

$$yB_{i,j} = -4{,}5 \cdot t_j + s_i^2 \left[27 \cdot t_j - 27 \cdot t_j^2\right] + 4{,}5 \cdot t_j^2 + s_i^3 \left[18 \cdot t_j^2 - 18 \cdot t_j\right] + 1{,}5 \tag{20}$$

$$zB_{i,j} = \left[-22{,}5 \cdot t_j^2 + 22{,}5 \cdot t_j\right] \cdot s_i^2 + \left[22{,}5 \cdot t_j^2 - 22{,}5 \cdot t_j\right] \cdot s_i \tag{21}$$

In order to obtain the body surface shaped similarly to an egg, a new matrix *XAB* should be formed by horizontal connection to a matrix *xA* of the matrix *xB* at the same number of lines in the added matrices. Similarly the matrices *yA* and *yB* are added, forming *YAB* and matrices *zA* and *zB*, obtaining matrix *ZAB*. Coordinates of points of surfaces obtained with the use of the matrix *XAB*, *YAB*, *ZAB* should be scaled in order to obtain surfaces similar with their dimensions to external and internal real surfaces of the egg shell. Scaling is carried out towards *X, Y, Z* axes of the coordinates system. The matrices, after scaling, which represent real shapes of the external surface of the chicken egg shell (*Xsz*, *Ysz*, *Zsz*), take the following form:

$$Xsz = \frac{XAB \cdot b}{\max(XAB) - \min(XAB)} \tag{22}$$

$$Ysz = \frac{YAB \cdot c}{\max(YAB) - \min(YAB)} \tag{23}$$

$$Zsz = \frac{ZAB \cdot a}{\max(ZAB) - \min(ZAB)} \tag{24}$$

The matrices, after scaling, representing real shapes of the internal surface of the chicken egg shell (*Xsw, Ysw, Zsw*), have the following form:

$$Xsw = \frac{XAB \cdot bw}{\max(XAB) - \min(XAB)} \tag{25}$$

$$Ysw = \frac{YAB \cdot cw}{\max(YAB) - \min(YAB)} \tag{26}$$

$$Zsw = \frac{ZAB \cdot aw}{\max(ZAB) - \min(ZAB)} - \tag{27}$$

The external dimensions (in mm) of a shell (*a* – length, *b* – width, *c* – thickness) and internal dimension of a shell (*aw* – length, *bw* – width, *cw* – thickness) of chicken eggs were placed in matrix 28.

$$\begin{bmatrix} a & aw \\ b & bw \\ c & cw \end{bmatrix} = \begin{bmatrix} 60 & 59 \\ 47{,}1 & 46{,}1 \\ 46 & 45 \end{bmatrix} \tag{28}$$

Model 3D of the chicken egg shell was presented in figure 1.

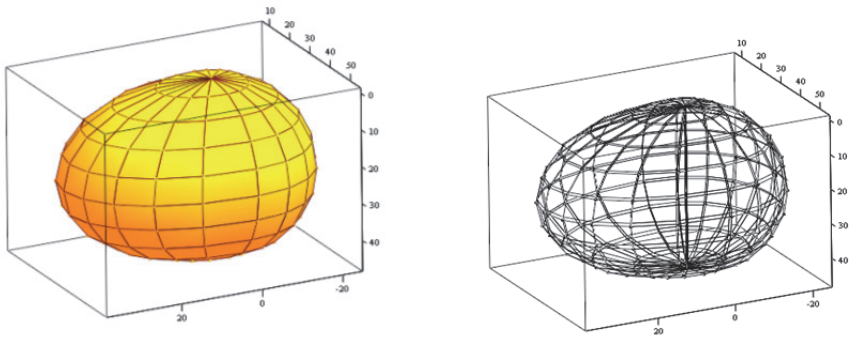

Figure 1. Surface and network model 3D of the chicken egg shell

In order to obtain the body surface shaped similarly to an egg yolk, a new matrix *XXż* should be formed by horizontal connection to the matrix *xB* of the matrix *xB* at the same number of lines in the added matrices. Similarly the matrices *yB* and *yB* are added, forming

YYż and the matrices *zB* and *-zB*, obtaining the matrix *ZZż*. The coordinates of points of surfaces obtained with the use of the matrix *XXż*, *YYż*, *ZZż* should be scaled in order to obtain surfaces similar with their dimensions to the external and internal real surfaces of the egg yolk. Matrices, after scaling, which represent real shapes of the external surface of the yolk (*Xż*, *Yż*, *Zż*) take the following form:

$$Xż = XXż \cdot \frac{aż}{\max(XXż) - \min(XXż)} + \frac{b - aż}{2} \tag{29}$$

$$Yż = YYż \cdot \frac{aż}{\max(YYż) - \min(YYż)} + \frac{b - aż}{2} + (\max(YYż) - \min(YYż)) \tag{30}$$

$$Zż = ZZż \cdot \frac{aż}{\max(ZZż) - \min(ZZż)} \tag{31}$$

In order to obtain the surface of the body shaped similarly to the egg air chamber, a new matrix *XXp* should be formed by horizontal connection to the matrix *xA* of the matrix *xA* at the same number of lines in the added matrices. Similarly the matrices *yA* and *yA* are added, forming *YYp* and the matrices *zA* and *-Za*, obtaining the matrix *ZZp*. The coordinates of points of surfaces obtained with the use of the matrix *XXp*, *YYp*, *ZZp* should be scaled in order to obtain a surface similar with its dimensions to the external and internal real surfaces of the egg air chamber. The matrices, after scaling, which represent real shapes of the external surface of the air chamber (*Xp*, *Yp*, *Zp*) take the following form:

$$Xp = XXp \cdot \frac{ap}{\max(XXp) - \min(XXp)} + 0{,}5 \cdot (\max(X) - \min(X)) - \frac{ap}{2} \tag{32}$$

$$Yp = YYp \cdot \frac{bp}{\max(YYp) - \min(YYp)} + (\min(Y) + 0{,}5 \cdot (\max(Y) - \min(Y)) - \frac{bp}{2}) + \\ - (\max(YYp) - \min(YYp)) \tag{33}$$

$$Zp = ZZp \cdot \frac{cp}{\max(ZZp) - \min(ZZp)} + \max(Z1) - \frac{cp}{2} \tag{34}$$

Dimensions (in mm) of the yolk diameter (*aż*) and the air chamber(*ap* – length, *bp* – width, *cp* – height) of the chicken egg placed in vector 35.

$$\begin{bmatrix} aż \\ ap \\ bp \\ cp \end{bmatrix} = \begin{bmatrix} 32{,}2 \\ 8{,}2 \\ 8{,}1 \\ 3{,}4 \end{bmatrix} \tag{35}$$

Model 3*D* of the chicken egg body and air chamber was presented in figure 2.

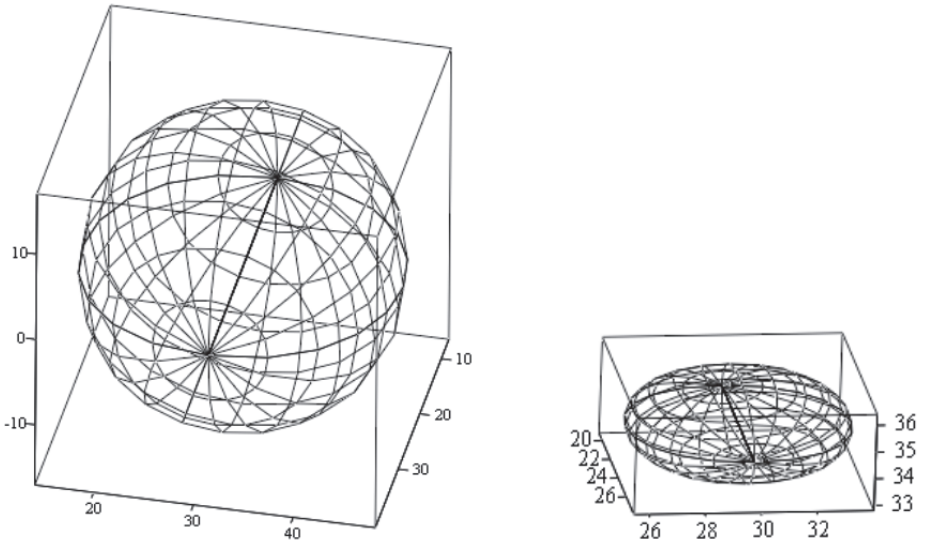

Figure 2. Models3D of the yolk body and air chamber of a chicken egg

*Model 3*D of a shell, yolk and air chamber of a chicken egg was presented in figure 3.

In order to verify a mathematical model, which describes the shape of chicken eggs I, II, III (dimensions in table 1) photographs of eggs and their models were taken folded on each other projected on the plane *YZ* and they were presented in the background of horizontal lines of a diagram (fig. 4). Horizontal lines cross the image of the model projection of the real body of an egg. Specific horizontal lines, crossing the outlines of projections, indicate the length of the indicated cross sections. The determined lengths of these cross sections for an egg and a model were compared and differences were described between them and a relative error was calculated (table 2).

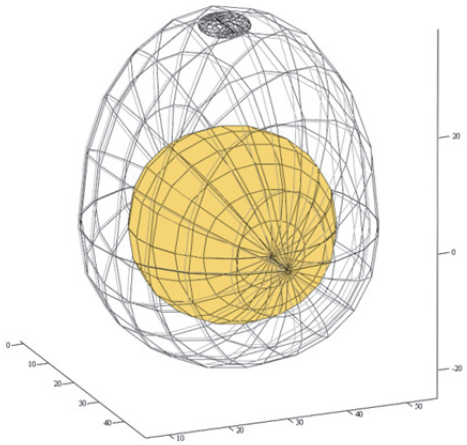

Figure 3. Model 3D of the body of a shell, yolk and air chamber of a chicken egg

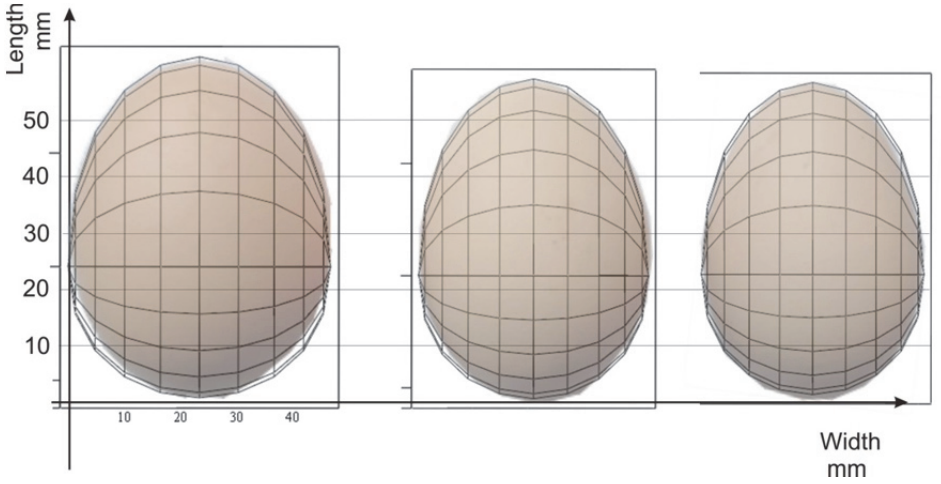

Figure 4. Projections on a plane YZ of models and real bodies of chicken eggs I, II, III

Comparison of the projections of eggs I, II, III and their models overlapping the plane YZ proves that themodels of chicken eggs reflect the eggs shapes chosen for modelling.

Table 2
Differences in the length measurement of models cross sections and lengths of marked cross sections of eggs and relative error

Distance between indicated cross sections of eggs (mm)	Differences between lengths of indicated cross sections of the model and length of the indicated cross sections of eggs (mm)			Relative error (%)		
	I	II	III	I	II	III
1	2	3	4	5	6	7
10	3.8	1.9	0.7	10.9	5.9	2.2
20	0.5	0	0	1.1	0	0
30	-0.4	-2.3	0	-0.9	-5.6	0
40	-1.3	-1.7	0.3	-3.1	-4.7	0.9
50	-0.9	-0.1	0.7	-2.7	-0.4	3.1

Table 3
Differences between long axis, short axis I, short axis IIof chicken eggs I, II, III and dimensions of their models

Dimension	Labelling of an egg	Differences between basic dimensions of eggs and dimensions of their models (mm)
Long axis	I	60 – [max(*ZszI*) – min(*ZszI*)]=0
	II	57.2 – [max(*ZszII*) – min(*ZszII*)]=0
	III	56.4 – [max(*ZszIII*) – min(*ZszIII*)]=0
Short axis I	I	47.1 – [max(*XszI*) – min(*XszI*)]=0
	II	42.3 – [max(*XszII*) – min(*XszII*)]=0
	III	41 – [max(*XszIII*) – min(*XszIII*)]=0
Short axis II	I	46 – [max(*YszI*) – min(*YszI*)]=0
	II	41.1 – [max(*YszII*) – min(*YszII*)]=0
	III	39.2 – [max(*YszIII*) – min(*YszIII*)]=0

Table 4
Differences between length, width, height of airing chamber and a diameter of egg yolk and the same dimensions of their models

Dimension	Differences between basic dimensions of air chamber, eggs yolk and dimensions of their models (mm)		
	I	II	III
	Air chamber		
Length	8.2 – [max(*XpI*) + – min(*XpI*)]= 0	7.4 – [max(*XpI*) + – min(*XpI*)]= 0	7.1 – [max(*XpI*) + – min(*XpI*)]= 0
Width	8.1 – [max(*YpI*) + – min(*YpI*)]= 0	7.2 – [max(*YpI*) + – min(*YpI*)]= 0	7 – [max(*YpI*) + – min(*YpI*)]= 0
Height	3.4 – [max(*ZpI*) + – min(*ZpI*)] = 0	3.1 – [max(*ZpI*) + – min(*ZpI*)] = 0	2.6 – [max(*ZpI*) + – min(*ZpI*)] = 0
	Yolk		
Diameter	32.2 – [max(*XżI*) + – min(*XżI*)]= 0	29.8 – [max(*XżII*) + – min(*XżII*)]= 0	29.1 – [max(*XżIII*) + – min(*XżIII*)]= 0
	32.2 – [max(*YżI*) + – min(*YżI*)]= 0	29.8 – [max(*YżII*) + – min(*YżII*)]= 0	29.1 – [max(*YżIII*) + – min(*YżIII*)]= 0
	32.2 – [max(*ZżI*) + – min(*ZżI*)]= 0	29.8 – [max(*ZżII*) + – min(*ZżII*)]= 0	29.1 – [max(*ZżIII*) + – min(*ZżIII*)]= 0

The analysis of the results included in table 1 shows that preciseness of chicken egss II and III is sufficient for practical purposes because a relative error in the indicated cross sections of the egg II is within -5.4 to 5.9% and for the model of III egg within 0 to 3.1.%. In case of the I model of egg a relative error of mapping, which is 10.9% occurred at the length being at the distance of 10 mm. Tables 3 and 4 show that the suggested method precisely maps the basic dimensions of the composing parts of chicken eggs (shell, yolk, air chamber).

Conclusions

1. Bézier patches may be used for modelling shapes of a shell, yolk and air chamber of a chicken egg.
2. The developed model *3D* of the chicken egg body which mapps the shell shape may serve for representing real eggs everywhere a great precision of mapping the shape is not required.
3. Mapped Bézier patches of the body of the composing parts of chicken eggs have identical basic dimensions of a shell (long axis, short axis I, short axis II, yolk surface (diameter) and air chamber (length, width, height) as corresponding chicken eggs.
4. The suggested method of modelling particular components may facilitate mapping the real shape of chicken eggs, e.g. in various states of their freshness may be used by designers for construing conveyors and separators.

References

Arivazhagan, S., Newlin Shebiah, R., Hariharan, S.; Rajesh K.; Ramesh, R. (2013). External and Internal Defect Detection of Egg using Machine Vision. *Journal of Emerging Trends in Computing and Information Sciences*, *Vol. 4, No. 3*, 257-262.

Barta, Z, Székely, T. (1997). The optima shape of avian eggs. *Functional Ecology*, *11*, 656-662.

Budryn G., Krysiak, W. (2013). Towaroznawstwo artykułów spożywczych. Ocena towaroznawcza jaj. *Kolegium Towaroznawstwa. Instytut Chemicznej Technologii Żywności. Zakład Technologii Skrobi i Cukiernictwa*. Łódź.

Calik, J. (2013). Zmiany cech jakościowych jaj, pochodzących od kur nieśnych żółtonóżka kuropatwiana (Ż-33), w zależności od warunków ich przechowywania. *ŻYWNOŚĆ. Nauka. Technologia. Jakość*, *2*(87), 73-79.

Fanatico, A. (2006). Alternative Poultry Production Systems and Outdoor Access. *National Sustainable Agriculture Information Service, National Center for Appropriate Technology*. *Page 15*. Available online at http://attra.ncat.org/attra-pub/poultryoverview.html.

Foley, J. D.; van Dam A.; Feiner, S.K.; Hughes, J.F.; Phillips R. L. (2001). *Wprowadzenie do grafiki komputerowej*. WNT, Warszawa, ISBN 83-204-2662-6.

Garcia-Alegre, M. C.; Enciso, J.; Ribeiro, A.; Guinea, D. (1997). Towards an automatic visual inspection of eggshell defects, in Proc. *Int. Workshop on Robotics and Automated Machinery for Bio-Productions*, Gandia, Spain, 51-66.

Garcia-Alegre, M. C.; Ribeiro, A.; Guinea, D.; Cristobal, G. (1998). Eggshell Defects Detection Based on Color Processing. *International Workshop on Robotics and Automated Machinery for Bio-Productions*, Spain, 51-66.

Garcia-Alegre, M. C.; Ribeiro, A., Guinea, D.; Cristobal, G. (2000). Color index analysis for automatic detection of eggshell defects, in Proc. *SPIE* 3966, 380-387.

Keshavarzpour, F. (2011). Prediction of egg mass on some geometrical characteristics. *World Engineering & Applied Sciences Journal*, *2*(1), 1-6.

Kiciak, P. (2000). *Podstawy modelowania krzywych i powierzchni. Zastosowania w grafice komputerowej*. WNT, Warszawa, ISBN 83-204-2464-X.

Mieszalski, L. (2011). Metoda matematycznego modelowania kształtu bryły ziarna pszenicy za pomocą parametrycznej krzywej przestrzennej i czterowęzłowej siatki. *Postępy Techniki Przetwórstwa Spożywczego*, *1*, 41-45.

Mały Rocznik Statystyczny Polski. (2013). Główny Urząd Statystyczny. Warszawa, Rok LVI.

Mónus, F.; Barta Z. (2005). Repeatability analysis of egg shape in a wild tree sparrow (passer montanus) population: a sensitive method for egg shape description. *Acta Zoologica Academiae Scientiarum Hungaricae, 51*(2), 151-162.

Nedomová, Š.; Buchar, J. (2013). Ostrich eggs geometry. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, *Volume LXI, 81*, 3, 735-742.

Nishiyama, Y. (2012). The mathematics of egg shape. *International Journal of Pure and Applied Mathematics, 78*(5), 679-689.

Patel, V. C.; Mc Clendon, R. W.; Goodrum, J. W. (1998). Color Computer Vision and Artificial Neural Networks for the Detection of Defects in Poultry Eggs. *Artificial Intelligence Review*, *12*, 163-176.

Preston, F.W. (1968). The shapes of bird's eggs: mathematical aspects. *The Auk*, *85*, 454-463.

Rashidi, M., Gholami, M. (2011). Prediction of egg mass based on geometrical attributes. *Agric. Biol. J. N. Am., 2*(4), 638-644.

Rashidi, M.; Keshavarzpour, F. (2011). Classification of egg size and shape based on mass and outer dimensions analysis. *Libyan Agriculture Research Center Journal International*, *2*(5), 221-223.

Shultz, F.T. (1953). Analysis of egg shape of chickens. *Biometrics*, *9*, 336-353.

Siepka, E.; Bobak, Ł.; Trziszka, T. (2010). Frakcjonowanie żółtka w celu pozyskiwania preparatów wzbogaconych w substancje biologicznie aktywne. *Żywność. Nauka. Technologia. Jakość*, *6*(73), 158-167.

Śmiechowska, M.; Podgórniak, P. (2013). Study and assessment of selected quality parameters of organic hen eggs available on the tri-city market. *Journal of Research and Applications in Agricultural Engineering*, *58*(4), 186-189.

METODA MATEMATYCZNEGO MODELOWANIA KSZTAŁTU POWIERZCHNI SKORUPY, ŻÓŁTKA I KOMORY POWIETRZNEJ JAJA KURZEGO

Streszczenie. Przedstawiono metodę matematycznego modelowania kształtu powierzchni skorupy, żółtka i komory powietrznej jaja. Do modelowania kształtu wybrano jaja kurze o wymiarach: długość 60; 57,2; 56,4 mm, szerokość 47,1; 42,3; 41 mm i grubość 46; 41,1; 39,2 mm. Do odwzorowania kształtu powierzchni skorupy, żółtka i komory powietrznej jaja wykorzystano dwa płaty Béziera. Obliczenia i wizualizację zrealizowano w programie komputerowym Mathcad. Opracowany matematyczny model 3*D* kształtu jaja kurzego i jego podstawowych elementów można wykorzystać do modelowania i sterowania operacjami technologicznymi procesów produkcji i przetwarzania jaj.

Słowa kluczowe: jajo kurze, skorupa, żółtko, komora powietrzna, kształt, powierzchnia, płaty Béziera, model matematyczny.

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DEVELOPMENT OF RENEWABLE ENERGY SOURCES IN THE NORTHERN BLACK SEA COAST

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ABSTRACT

The objective of the study was to analyse the policy and economy of renewable energy sources development in the Northern Black Sea Coast of Ukraine. Presently the share of the renewable energy resources in the power balance of Ukraine is rather small, namely 0.3% of the general development of the electric power. Nevertheless, Ukraine has huge potential with this regard. The accepted power strategy of Ukraine till 2020 has to play an important role. The potential of renewable energy sources in Ukraine makes 113 million tons of equivalent fuel whereas taking into consideration the modern level of production, traditional energy sources can provide Ukraine with 68 million tons of equivalent fuel with fuel and energy resources. The required theoretical level of the research included the use of analysis, comparison and synthesis. The analysis of the alternative energy development, which aims at experience and forecast of possible ways of development has given the opportunity to obtain the result of the research within vertical (historical) and horizontal (functional) scopes. In the southern regions of the country the investment projects aiming at the creation of power plants, working with sun and wind energy are actively carried out. The Northern Black Sea Coast of Ukraine is the most suitable region for development of this branch of alternative power engineering.

Introduction

The excessive growth of energy consumption in the country was presented in «The Energy Strategy of Ukraine through 2030», so now the significant budget funds are invested in building the energy capacity. According to the strategy, the level of energy efficiency in 2030 Ukraine will reach Poland nowadays. The alternative energy sources are the priority in many countries, both developed and still developing. It is based on the need for energy safety in the European Union and it was decided that the renewable energy will have made up 20% by 2020. The development of the renewable energy sources is one of the priority directions promoting the achievement of the energy safety by Ukraine. Ukraine has its own

technology, their manufacturers and integrators of the modern energy systems, but we have to develop the alternative sources that faced the administrative barriers and monopoly providers of the traditional energy sources (Shevtsov, 2004; Sinchuk et al., 2013).

The objective and the scope of the study. Policy and economy of the development of renewable energy sources in the Northern Black Sea Coast are discussed in this article.

The research methods include the analysis of the alternative energy development, comparison of the potential of renewable energy sources and the synthesis of the results of research into vertical (historical) and horizontal (functional) scopes.

Main part. According to the Institute of Renewable Energy National Academy of Sciences, the total potential of renewable energy amounts to 113 million tons of equivalent fuel and it can provide Ukraine with fuel and energy resources completely (Esypov, 2011; Khmara, 2010). Figure 1 shows the potential of the renewable energy sources (tons of equivalent fuel). Modern mining energy of equivalent fuel is 68 million tons. Thus the potential of renewable sources of energy can ensure Ukraine's fuel and energy resources completely (Kordon, 2010; Perga, 2009).

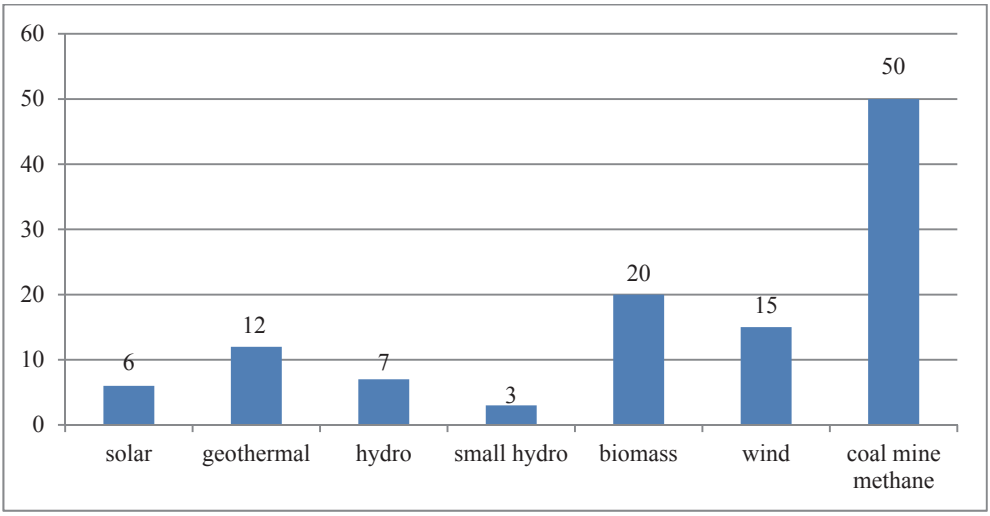

Figure 1. The potential of the renewable energy sources (tons of equivalent fuel)

Now this branch is most intensively developed in the Crimea. Today three available on the peninsula of solar power stations have got 187.5 MW of the electric power. Also six Crimean wind power plants make generally 70 MW of electricity. In energy balance of the Crimea the share of alternative energy makes about 20%. According to the Ministry of Ecology and Natural resources, functioning of alternative power plants in the Crimea reduces emissions of carbon dioxide in the atmosphere by 250 thousand tons per year (Taranenko, 2011; Gnatush, 2013).

It has taken away the land plots with a total area of 3.196 thousand hectares for placement of objects of alternative power engineering in the Kherson region. The development and coordination of project's documents with regard to allocation of the alternative power

engineering objects proceeds by area of 100 more hectares of lands. For the «solar» potential the Kherson region occupies one of the first positions. The quantity of sunny days in a year reaches 240, or 65%. Average solar insolation in this area is 1.25 $MWh \cdot m^{-2}$ a year. The flat relief of this territory promotes the development of the solar power (Gnatush, 2013).

Mykolaiv district has excellent starting conditions for the development of the alternative energy. The number of sunny days in the Ochakov area is about 300 cloudless days per year. Around 10% of the total wind potential of Ukraine is focused on the territory. The development of the alternative renewable energy sources is the priority of the Program of Economic and Social Development of Mykolaiv region in the future years. The construction of renewable energy will not only gain extra energy generating capacity for the region's needs, but also attract the significant investment in the local economy, create hundreds of new jobs, develop the infrastructure and favor implementation of the important social projects.

In 2013 in the Mykolaiv district the renewable energy sources has brought 400 MW of energy, and this year the level is in one GW, i.e. one million kilowatts that is equal to the power of one block of a nuclear power plant. According to the State plans it is expected that 10% of all obtained energy will be undertaken from renewable sources by 2015. In 2020 this figure will be 20%, in 2030 – 30%, and in 2050 – more than 50%.

In the Mykolaiv district the wind park «Ochakov» (Figure 2) with 500 megawatts works and the Tiligulsky hydroelectric power station is planned to be built. This project is investment attractive. In the present conditions the payback of the solar stations makes up 5 years, and the wind ones – 7. In 2013 in the Mykolaiv district the first solar plant of 29.3 MW power was opened. The power plant consists of 121,176 polycrystalline solar modules installed in 4 rows, and 27 inverter stations. It is planned to establish the similar 6 environmentally friendly power plants in 6 regions of the territory.

Figure 2. The wind park «Ochakov» in the Mykolaiv district of Ukraine

The most promising areas in Mykolaiv region for the development of wind power is the Ochakov and Berezan wild fields with the total area of 4,000 hectares. With the aim of harnessing the wind energy potential of the Mykolaiv region «Ochakov Windy Park Power» implements the investment project for the construction of the wind station, which answers to the trend of «New energy» Ukraine national projects.

During 2013 the wind installations Ltd. «Ochakov Windy Park Power» 117.8 million kWh energy was produced. In addition, «Ochakov Windy Park Power» has been designing the construction of three wind farms. The planned design capacity of the Ochakov's wind power plant is 300 MW (120 wind installations). The total amount of investment for the construction of the Ochakov's wind power plant is expected to be 6 billion USD. Putting into operation the Ochakov's wind power plant at full capacity will be able to save the equivalent of 30% power of 1 nuclear reactor of the nuclear power plant.

The share of the installed capacity of wind turbines wind of Mykolaiv district from 01.01.2014 is 10% of the total operating power of the wind of Ukraine. Implementation of these projects of construction of wind power plants in Mykolaiv district will increase the installed capacity of the wind power to 1,000 MW and attract investments in this territory of 20 billion USD. The main problem of the wind energy development in Mykolaiv district is the lack of the electrical networks for attaching the wind plants to the united energy system of Ukraine. The cost of the construction of the electric networks voltage 35 kW and 150 for joining the wind plants is estimated at 600 million USD.

The investment projects of building solar power plants are supported in Mykolaiv oblast. At this time, the projects for the construction of solar power plants are planned to be carried out in the seventh regions. The implementation of the projects for construction of solar power plants will take place with the help of investors. The project «Voskhod Solar» is carried out outside the settlements within the territory of Berezan district of Mykolaiv district. From 01.01.2014 Ltd. «Voskhod Solar» construction of the solar power capacity of 52.9 MW was completed. Currently the works with connecting power to the joint power system are being carried out. The cost of the attracted investment is valued at 1.3 billion USD. The project «Pluton Solar» will be performed within the Kazankivsky district of Mykolaiv region. The installed capacity of the specified plant is 10 MW, the estimated cost of the attracted investments is about 28 million euro. The project «Neptune Solar» was built within the Voznesensky district of Mykolaiv oblast (Figure 3). The installed capacity of the specified plant is 29.8 MW, the cost of the attracted investments is 775 million USD. Within the period of May-December 2013 24.9 million kWh of electricity was produced by the solar power plant.

It is a definite environmental policy of the district to replace fossil fuels with alternative types of energy based on the biological materials. Therefore, the area of winter rape up to 65,000 hectares was increased. There are about 50 businesses which are able to provide the biological raw materials for processing it into energy. On the basis of JSC «Zeleny Gay», which is located in the Voznesensky district, the line of processing branches after trimming was established. Moreover, biomass for the production of biogas that is burned in the cogenerating setup type Cento T120S (capacity 125 kW, thermal – 160 kW) is provided. Biogas installation can metabolize 10 tons of green material per day, capacity of 2,000 m^3 of biogas per day. The heat from the cooling of the generator can be uses for heating greenhouses covering 15 acres. The expected savings in transitioning into natural gas is about 500, 000 m^3 per year.

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Figure 3. Project «Neptune Solar» in the Voznesensky region of Mykolaiv district

Odessa district is the leader among regions of Ukraine in construction of the solar power stations. Four solar energy stations with the power capacity of 184 MW are already put into the operation. While in Odessa district there are no successful projects of the wind use for the electricity development. But in some of the southern areas the measuring towers are installed which measure the wind speed. Furthermore, there are perspectives for installation of the wind-driven generations in the next five years.

Conclusion

The Northern Black Sea coast of Ukraine is the most favorable in Ukraine for the development of the renewable energy, especially wind and solar power plants. Therefore, there are all the investment projects for the development of the alternative energy.

The environmental public policy and economy in the district aims at the investments in the wind energy industry to reduce the dependence from hydropower, as well as investing in the solar panels for the population and buildings in the city also to reduce the dependence from the grid. For the realization of the energy strategy the Ukrainian authorities should resolve two tasks. Firstly, they should improve the administrative conditions for creation of new energy companies and allow individual users to provide energy to a common network. Secondly, to support the production of energy from alternative sources which have great potential.

References

Гнатуш, В. (2013). *Солнце и ветер – зелёная энергетика уже в Украине*. Мировые прогнозы и Украина. Pozyskano z: http://inpress.ua/ru/politics/20832-solntse-i-veter-zelenaya-energetika-uzhe-v-ukraine.

Гнатуш, В. (2013). *Южные регионы Украины активно используют энергию солнца*. Pozyskano z: http://inpress.ua/ru/economics/21408-yuzhnye-regiony-ukrainy-aktivno-ispolzuyut-energiyu-solntsa.

Єсипов, В. (2011). *Зелёный переворот*. *GEO*, 8, 36-43.

Кордон, М. (2010). Проблеми енергетичної та екологічної безпеки України. *Історія. Філософія. Релігієзнавство*, *3*(4), 19-24.

On the status of implementation of the national plan of action to implement the provisions of the Kyoto Protocol to the UN Framework Convention on climate change. (2013). Pozyskano z: http://economy-mk.gov.ua/social-economics-development/strategiya.

Перга, Т. (2009). Альтернативна енергетика як фактор конкурентоспроможності України на світовій арені, *Зовнішні справи*, *12*, 38-41.

Сінчук, І. та ін. (2013). *Нетрадиційні та відновлювальні джерела енергії.* Кременчук, ISBN 978-617-639-043-5.

Тараненко, А. План дій – альтернативна енергетика, *Зовнішні справи*, *2*, 26-29.

Хмара, Д. (2010). Як підвищити енергетичну безпеку України. *Нова тема, 1*(24), 41-43.

Шевцов, А. (2004). *Енергетика України на шляху до Європейської інтеграції.* Дніпропетровськ, ISBN 966-554-069-6.

ROZWÓJ ODNAWIALNYCH ŹRÓDEŁ ENERGII NA PÓŁNOCNYM WYBRZEŻU MORZA CZARNEGO

Streszczenie. Celem pracy jest przedstawienie polityki i gospodarki na rzecz rozwoju odnawialnych źródeł energii na północnym wybrzeżu Morza Czarnego na Ukrainie. Obecnie udział odnawialnych źródeł energii w bilansie energii Ukrainy jest niewielki i stanowi tylko 0,3% ogólnego potencjału energetyki konwencjonalnej. Niemniej jednak Ukraina posiada ogromny potencjał w odnawialnych źródłach energii. Przyjęta strategia udziału OZE w bilansie energetycznym Ukrainy do 2020 roku ma do odegrania ważną rolę. Potencjał odnawialnych źródeł energii na Ukrainie oceniany jest na poziomie 113 mln ton paliwa umownego, natomiast biorąc pod uwagę nowoczesny poziom produkcji, źródła tradycyjne są w stanie dostarczyć Ukrainie 68 mln ton paliwa umownego w postaci zasobów paliw i energii. W celu spełnienia wymagań związanych z poziom teoretycznym badań zastosowano metodę analizy, porównania i syntezy. Analiza rozwoju alternatywnych źródeł energii, której celem było doświadczenie i prognoza możliwych sposobów rozwoju umożliwiła uzyskania wyniku badania w zakresie pionowym (historycznym) i poziomym (funkcjonalnym). W południowych regionach kraju projekty inwestycyjne ukierunkowane na budowę elektrowni, pracę z energią słoneczną i wiatrową są aktywnie realizowane. Północne wybrzeże Morza Czarnego na Ukrainie jest najbardziej odpowiednim obszarem dla rozwoju tej gałęzi energetyki alternatywnej.

Słowa kluczowe: polityka z odnawialnych źródeł energii, bezpieczeństwo energetyczne

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CONTROL OF HEAT COLLECTION AND AIRING PROCESS DURING COMPOSTING WITH COMPACTRIO CONTROLLER[1]

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ABSTRACT

Composting of biological waste constitutes an exothermic process. Some heat generated during composting is required to maintain the process and possible batch disinfection. The compost heap temperature increases often during the process up to 80ºC. According to the literature, the most advantageous composting temperature of the thermophilic phase is the temperature of 55ºC. However, excessive heat collection may be used at another location. Yet temperature inside the composting material shall not decrease below 50ºC as it may cause slowing down or even inhibition of the composting process. During composting, air supply (oxygen) is crucial to ensure optimum conditions for microorganism growth. Therefore the proper control of heat collection and airing process is required. The paper presents the fuzzy logic and LabView language based application that ensures control of the composting process. Conducted tests of the workstation and application confirmed heat collection of 101 MJ and pumping 0.68 m^3 of water.

Introduction

Composting relates to the natural process that enables processing of biologic waste and conversion into a natural fertilizer. Such a natural process follows spontaneously. However, in case of a large quantity of waste the process may be improved with some intentional actions. Composting process depends on the main three following factors.

C/N ratio of charge. Impact of this parameter on the composting process has been described in many papers – (Peigne, 2002; Rosik-Dulewska, 2010). The optimum carbon to nitrogen ratio during composting shall be between 25 and 35. If this parameter is out of this range the composting process will follow very slowly or release will follow of ammonia large quantity (Guo et al., 2012).

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Compost internal temperature. The temperature increase during composting relates to a natural process. Depending on the mass of the composted material, temperature of the composting bed may be over 80ºC. Proper temperature during composting process shall be approx. 55ºC, and at the same time, the higher the temperature the higher release of ammonia and carbon dioxide follows (Pagans et al., 2006), and on the second hand the decrease of the temperature results in slowing down the composting process and inhabitation in extreme cases as well.

Composting bed airing. In case of natural composting, airing follows during heap overturning provided on regular basis – and the composting process follows properly often also without overturning. Yet it results in the long total time of composting (often over 6 months). Intense airing shortens composting up to approx. 30-60 days depending on the composition and volume, and simultaneously reduces ammonia release (e.g. Yang et al., 2013). According to Wang et al. (2013) a single composting session takes a few weeks, around 60 days depending on the additives applied to improve compost properties. Whereas according to Guo et al. (2012) the composting process takes around 40 days. Excessively intensive airing causes the temperature decrease inside the bed and simultaneously reduces heap moisture – which results in a longer period of the composting process or inhibition of the process in extreme cases (Puyuelo et al., 2010; Kulcu and Yaldiz, 2004).

To sum up – for the proper composting process, the proper control should be provided regarding substrates/composition purposed for composting to ensure appropriate C/N ratio– it may also be improved with the use of special additives – (Dach et al. 2009) – although sometimes it may not be possible. Also proper temperature shall be maintained inside the bed – according to the literature the most advantageous temperature for the second (thermofilic) phase of composting is 55°C. The higher temperature ensures disinfection of the obtained humus (Lashermes et al., 2012; Raj and Antil, 2011) – but not all materials purposed for composting require disinfection, e.g. the agricultural industry wastes, mowed grass, fallen leafs etc. In case of composting this type of material, it is possible to collect the excessive heat to ensure internal bed temperature of 55°C, whereas the collected heat may be used at other location – e.g. for heating the ground of a greenhouse. Intensity of provided airing shall also depend on the phase of the composting process.

According to the above information, the following assumptions have been made regarding control – the input values included:

Internal bed temperature, intensity of heat collection and airing, and potential dependent output values included: intensity of airing and intensity of heat collection.

The designed control system was based on the fuzzy logic. The world literature included some examples of the fuzzy logic used for this purpose (Castelli and Ferrari, 2007). Whereas the fuzzy logic based control system for the composting process only has been referred to in other papers (Giusti and Marsili, 2010; Qin et al., 2007; Xi et al., 2008). The general input regarding the fuzzy logic based control systems has been described in many works, e.g. (Gerla, 2005; Mamdani, 1977; Muhamad and Ali, 2008) and many others.

The objective and the scope of the research

The objective of the paper was to provide the control system for the process related to heat collection, airing and the internal bed temperature based on the fuzzy logic, integrated with the process parameters archiving and performance verification.

Description of the control system structure

The control system has been based on fuzzy logic with the use of:

- CompactRIO NI 9024 controller, provided with an incorporated drive that cooperates with LabView based applications purposed for control, registration and analysis of the measurement data, as well as for uploading the control program, reading of the measurement data, fitted with USB port and RS232 serial port;
- Extension NI 9113, with FPGA system, fitted with 4 slots for any cRIO module and possibility of automatic control, as well as signal conversion with LabView.
- 2 multi-function modules NI 9217 to be connected to Pt 100 sensors
- NI 9381 module, with 8 channels 12-bite analogue inputs, from 0V to 5V where an inverter and a flow meter are to be connected;

The application was developed with LabView 2012 software. The first step is related to programming of all above mentioned elements of a driver. After selecting PPM option, drop down menu of Project Untitled is displayed, where you can add CompactRIO NI 9024 controller and then add Reconfigurable Embedded Chassis NI 9113. Next insert twice NI9217 module.

NI 9381 module shall not be inserted to the software in the same way as NI 9217 modules.1

To use NI 9381 multifunction module, firstly FPGA Target should be defined. Upon system configuration regarding hardware proceed to create a new Virtual Instrument (VI).

NI 9381 module subprogram

As NI 9381 module is fitted with analogue inputs and outputs, as well as digital inputs and outputs, an additional control subprogram need to be developed.

Flat Sequence structure is within While Loop – Fig. 1 – analog.vi. Sequence follows with four steps:

1. Time loop – 500 ms
2. Functions FPGA I/O NODE, to which specific inputs were assigned. Elements that control inputs are the outputs of analogically controlled devices. The value of device analogue output will be inserted at Numeric Control (in airing, in heat collection).
3. Time loop – 500 ms, ensures conversion from analogue into digital of the input data and conversion from digital into analogue of the output data. Interrupt – makes for the key element of a subprogram. Actually it is a simple alternative of FIFO for data transfer to a proper software. When a signal is present in the second sequence, next activation follows of Interrupt which enables the data transfer to the proper program. Next the proper program upon logic functions completion provides for data conversion and sends data back to Interrupt, which gives approval and sends data to the analogue device outputs (fourth sequence).

4. Functions FPGA I/O NODE, to which specified outputs are assigned. Control of outputs is provided with inputs of the analogue controlled devices. Value of analogue device input is shows on Numeric Control (out airing, out heat collection).

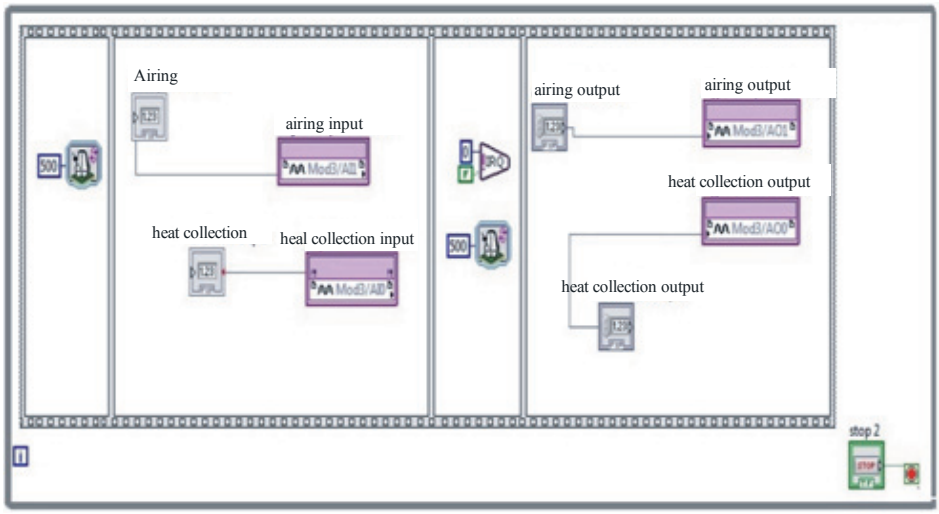
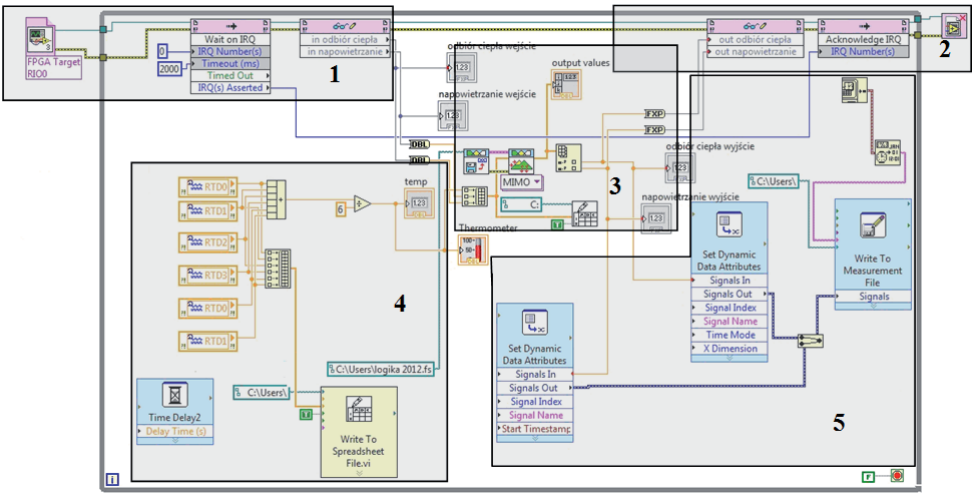


Figure 1. NI 9381 module control subprogram

Core control application

Figure 2 describes the core control application.



Source: Own graphics prepared with LabView software

Figure 2. Core application

For the purpose of transparency, the application was divided into 5 areas which were described one by one. Figure 2 related to 1 area and FPGA Target sequence (Open FPGA VI Reference), which enables data transfer activation from the subprogram (Figure No. 1). When connected to Invoke Method it plays a function of waiting for Interrupt (waiting until data appears for conversion). Read/Write Control ensures reading of input data.

The software part covered with area no. 2 Read/Write Control provides recording of outputs in charge of airing and heat collection, whereas Invoke Method ensures approval for transfer of the proper data sent to the Subprogram on inputs of the analogue devices. Close FPGA VI Reference closes the communication between the Subprogram „analog.vi". Open and Close FPGA VI Reference are outside structure of While Loop and are used only during new activation of software and deactivation.

Heat collection, input/output and airing input/output make for the Numeric Indicator blocks located within area no. 3 that display values of input and output on analogue channels of controller. Data from heat collection and airing input is transferred to Build Array table along with an average of six temperature sensors inside bioreactor. Values from table are saved in Write To Spreadsheet File block on spreadsheet. Next dataset is forwarded to FL Fuzzy Controller that plays a function of a regulator and converts data on the basis of the inserted principles. The recorded principles are taken up from external file with the use of FL Load Fuzzy System. Upon leaving the regulator data is sent to Index Array block, which breaks up the structure of spreadsheet for particular data. Output values ensure displaying of output data, for the purpose of verification at this phase.

Elements within area no. 4 – Time Delay2 is in charge of the application operation interval. Outputs of pt100 resistance sensor temperature from two analogue NI9217 modules, send values of temperature to the Compound Arithmetic block, where summing follows, and then are forwarded to Divide function where are divided according to the number of temperature sensors. Before summing of temperature values, they are inserted on Array Table and recorded in a spreadsheet. Moreover graphic displaying was provided of average temperature with the use of the analogue thermometer and digital with the use of a numerical block. Area 5 – Set Dynamic Date Attributes assign a subheading for data. Current timer and date is assigned by Get Date block, and next Format Date changes data type into String. Output data is recorded with Write To Measurement File block.

Layout of input and output variable data sets, as well as the fuzzy logic principles set were used as referred to in the paper of Neugebauer et al. (2014).

Research results and analysis

Upon assembly of the workplace the test was carried out. The drum of a bioreactor was filled with water and heated with electric heater at ambient temperature of 20ºC. For the test water was used at quantity of 180 dm^3 at output temperature of 8.94ºC, heater 900 W. Water heating to temperature 55ºC took 15 hours. Heat collection followed for 40 hours. Upon 55 hours the heater was turned off and measurements followed during cooling – up to 70.5 h. The results were as follows:

– 101 MJ of heat collected on a cooling system;
– 0.687 m^3 – qty of water pumped by heat exchanger.

Figure 4, 5 and 6 presents diagrams of average temperature, airing and heat collection values during the test.

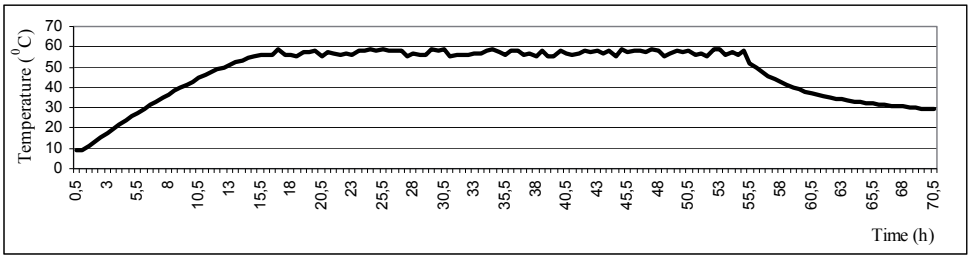


Figure 4. Temperature values in fermentation tank during tests with water

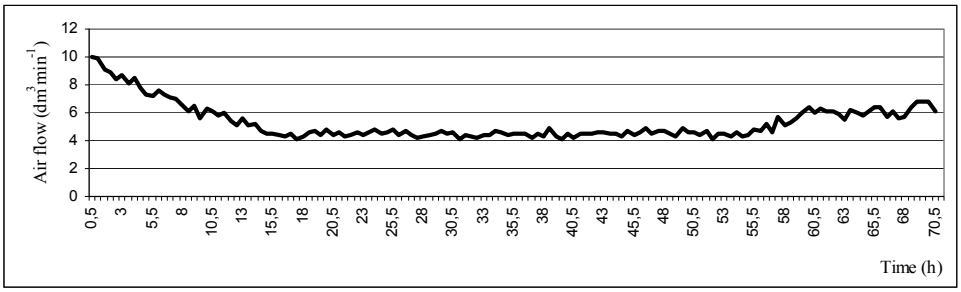


Figure 5. Intensity of airing in fermentation tank during tests with water

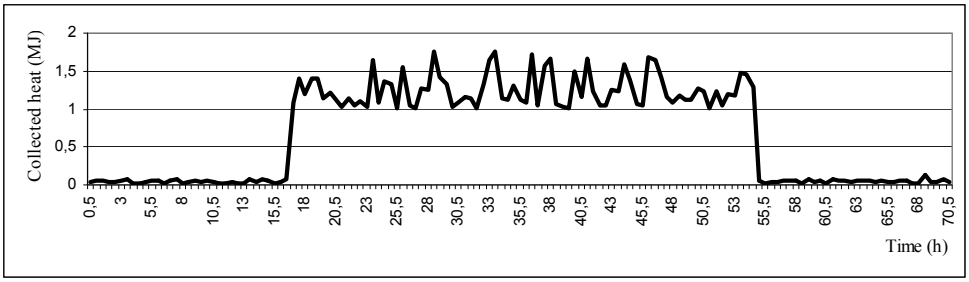


Figure 6. Heat collection in fermentation tank during tests with water

Conclusions

1. The conducted initial research indicated usefulness of the developed control system and application for control of biological wastes composting process.
2. For the purpose of full control over biological wastes composting process, sensors may be connected to the control system for the measurement of moisture and oxygen content in the air discharged from bioreactor.
3. Thanks to the use of CompactRIO controller and LabView software, possibility was ensured for smooth and quick modification of the control system parameters.

References

Castelli, L.; Ferrari, R. (2007). *Fuzzy Logic Control Applied to In-Vessel Composting*. US Composting Council 2007. Conference, Orlando, Florida. Pozyskano z: http://nebula.wsimg.com/6091ca06b369e24d1d6a82361f42fd6f?AccessKeyId=1A23BDC9F081DE6ACE22&disposition=0.

Dach, J.; Wolna-Maruwka, A.; Zbytek, Z. (2009). Wpływ dodatku efektywnych mikroorganizmów (EM) na przebieg kompostowania i wielkość emisji gazowych. *Journal of Research and Applications in Agricultural Engineering, vol., 54*(3), 49-54.

Gerla, G. (2005). Fuzzy Logic Programming and Fuzzy Control. *Studia Logica, 79*, 231-254.

Giusti, E.; Marsili-Libelli, S. (2010). Fuzzy modelling of the composting process. *Environmental Modelling & Software, 25,* 641-647.

Guo, R.; Li, G.; Jiang, T.; Schuchardt, F.; Chen, T.; Zhao, Y.; Shen, Y. (2012). Effect of aeration rate, C/N ratio and moisture content on the stability and maturity of compost. *Bioresource Technology 112,* 171-178.

Kulcu, R.; Yaldiz, O. (2004). Determination of aeration rate and kinetics of composting some agricultural wastes. *Bioresource Technology, 93,* 49-57.

Lashermes, G.; Barriuso, E. ; Le Villio-Poitrenaud, M. ; Houot, S. (2012). Composting in small laboratory pilots: Performance and reproducibility. *Waste Managemen,t 32,* 271-277.

Mamdani, E. (1977). Application of fuzzy logic to approximate reasoning using linguistic systems. *Fuzzy Sets and Systems, 26,* 1182-1191.

Muhamad, N.A.; Ali, S.A.M. (2008). *LabVIEW with Fuzzy Logic Controller Simulation Panel for Condition Monitoring of Oil and Dry Type Transformer*. World Academy of Science, Engineering and Technology Vol: 2 2008-08-29. Pozyskano z: http://waset.org/publications/5002/labview-with-fuzzy-logic-controller-simulation-panel-for-condition-monitoring-of-oil-and-dry-type-transformer

Neugebauer, M.; Sołowiej, P.; Piechocki, J. (2014). Fuzzy control for the process of heat removal during the composting of agricultural waste. *Journal of Material Cycles and Waste Managemen, Vol. 16 Issue 2*, 291-297.

Pagans, E.; Barrena, R.; Font, X.; Sánchez, A. (2006). Ammonia emissions from the composting of different organic wastes. Dependency on process temperature. *Chemosphere 62,* 1534-1542.

Peigne, J. (2002). *Environmental impast of farm-scale composting*. Materiały konferencyjne 10 Międzynarodowej konferencji RAMIRAN Network 2002. Pozyskano z: http://www.ramiran.net /DOC/ F2.pdf

Puyuelo, B.; Gea, T.; Sánchez, A. (2010). A new control strategy for the composting process based on the oxygen uptake rate*. Chemical Engineering Journal 165,* 161-169.

Qin, X.; Huang, G.; Zeng, G.; Chakma, A.; Xi, B. (2007). A fuzzy composting process model. *J Air Waste Manag Assoc, 57(5),* 535-550.

Raj, D.; Antil, R.S. (2011). Evaluation of maturity and stability parameters of composts prepared from agroindustrial wastes. *Bioresource Technology, 102*, 2868-2873.

Rosik-Dulewska, C. (2010). *Podstawy gospodarki odpadami*. Warszawa, PWN, ISBN 978-83-01-16353-2.

Wang, X.; Selvam, A.; Chan, M.; Wong, J. (2013). Nitrogen conservation and acidity control during food wastes composting through struvite formation. *Bioresource Technology, 147,* 17-22.

Xi, B.D.; Qin, X.S.; Su, X.K.; Jiang, Y.H.; Wei, Z.M. (2008). Characterizing effects of uncertainties in MSW composting process through a coupled fuzzy-vertex and factorial-analysis approach. *Waste Management, 28(9)*, 1609-1623.

Yang, F.; Li, G.X.; Yang, Q.Y.; Luo, W.H. (2013). Effect of bulking agents on maturity and gaseous emissions during kitchen waste composting. *Chemosphere, 93,* 1393-1399.

STEROWANIE PROCESEM ODBIORU CIEPŁA I NAPOWIETRZANIA W PROCESIE KOMPOSTOWANIA PRZY POMOCY STEROWNIKA COMPACTRIO

Streszczenie. Proces kompostowania odpadów biologicznych jest procesem egzotermicznym. Część powstającego w procesie kompostowania ciepła jest potrzebna dla podtrzymania samego procesu i ewentualnej higienizacji wsadu. W pryzmie kompostu w czasie procesu temperatura wzrasta często do 80ºC. Według literatury najkorzystniejszą temperaturą kompostowania w fazie termofilnej jest temperatura 55ºC. Nadmiar ciepła może być jednak odebrany z kompostu i wykorzystany w innym miejscu. Nie należy jednak dopuścić do tego, aby temperatura wewnątrz kompostowanego materiału spadła poniżej 50ºC ponieważ może to spowodować zwolnienie lub nawet wstrzymanie przebiegu procesu kompostowania. W trakcie kompostowania trzeba dostarczać powietrze (tlen), aby zapewnić mikroorganizmom optymalne warunki rozwoju. Wynika z tego potrzeba sterowania procesem odbioru ciepła i napowietrzania. W pracy przedstawiono aplikację sterującą procesem kompostowania napisaną w języku LabView i wykorzystującą logikę rozmytą. W trakcie prób stanowiska i aplikacji, w układzie odbioru ciepła odebrano 101MJ ciepła i przetoczono 0,68 m^3 wody.

Słowa kluczowe: kompostowanie, sterowanie procesem kompostowania, logika rozmyta; odbiór ciepła

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QUALITY CHARACTERISTICS OF ELECTRIC ENERGY GENERATED IN A WIND POWER PLANT

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ABSTRACT

The objective of the analysis was the quality of electric energy in the place of attachment of a single wind power plant to the electricity grid. This objective was performed based on the author's own research carried out in a LV switching station located in the place of attachment of a wind turbine with the power 150 kW to the MV distribution network. The object of the research was located in the northern part of Małopolskie Voivodeship. The assessment of the quality of electric energy was carried out based on the requirements set forth in the Ordinance of the Minister of Economy on detailed conditions of functioning of the power system and the Manual of Movement and Operation of Distributive Network. Based on the analysis, which was carried out, one may assume that the requirements referring to frequency changes, efficient value of the supply voltage, voltage unbalance and its deformation from the sinusoidal waveform have been met. In the period which was covered by the research, during the wind turbine work, insignificant surpasses of the admissible level of the root mean square of voltage were reported, but their number constituted less than 0.07% of observations. During the research, also 20 voltage dips of values exceeding 10% of the rated voltage, average depth of which was 172V were reported. In majority these were disruptions caused by other receivers connected to the network.

Introduction

Wind is one of the renewable sources of energy, energy potential of which is estimated at the level of power equal to 40 TW (Korban, 2010). First mentions on the use of wind energy by man reach 3000 B.C. When sails for boat drive began to be used in Egypt. Few hundreds years later around 640 B.C. first information on the use of wind, inter alia, for mills drive and drying off rice fields in China appeared. Windmill structures construed then had a vertical axis of rotation. In Europe, windmills started to be built in the 12th century and in majority these were windmills with the horizontal axis of rotation. Whereas, the first wind power station was built in Denmark by Poul La Cour in the end of the 19th century. Since that time, many structures of wind power stations had been developed, which differ

both on account of the mechanical solutions as well as the structure of the generators of electric energy applied there (Kaldellis and Zafirakis, 2012; Niedźwiecka-Filipiak and Borcz, 1998; Polak and Baranski, 2006).

The total power of wind power stations located on all continents in 2011 was 240 GW and increased in relation to the previous year by approx. 40 GW. The highest increase by 18 GW of the installed power was reported in China. Next positions were taken by the USA (6.8 MW) and India (3MW). In all countries of the European Union a total increase of power by 9.6 GW was reported, out of which the highest number in Germany (2.1 GW), Great Britain (1.3 GW) and Spain (1GW). Assuming an average annual time of operation of the wind turbine as 2200 hours, the obtained electric energy from the wind sources is at the level of 528 TWh. Such amount of the produced energy can satisfy approximately 2.7% of the global demand for electric energy (Global Wind Report, 2011; BTM Consult, 2011).

According to the state as of 31st December 2013 in Poland in the wind power industry there were 3389.5 MW installed (Polskie Stowarzyszenie Energetyki Wiatrowej)**.** On this basis, indexes of the power installed in the wind energy industry per one citizen of the value 0.088 kW and also per a km^2 of the land area at the level of 10.84 kW are the lowest in Europe. Total volume of electric energy generated in Poland by wind turbines along with other renewable energy sources in 2013 was 5822 GWh which constitutes over 2.5% of the total consumption of electric energy (*Polskie Stowarzyszenie Energetyki Wiatrowej*).

The need to meet obligations resulting from, inter alia, the signed protocol in Kioto on reduction of the carbon dioxide emission is a strong impulse for the growth of the wind energy dynamics in Poland, which we have observed in the recent years. However, a systematic increase of the wind power stations participation in the structure of production units brings some negative effects. The most frequent problems are those related to a correct management of generating unit operation, possessed centrally in order to ensure stability of the system and maintain the required quality of electric energy. Main sources which cause deterioration of the electric energy is a change of the rotational moment related to a periodical shadowing of propeller blades by a tower, change of the rotational moment resulting from non-uniform wind speed at various heights and impact of the converter systems installed in some types of wind power stations. The scale of disadvantageous impact on the operation of the electro-energy system to a great extent depends also on the degree of concentration of units which generate wind in this area, distance from conventional wind power stations and the condition of electricity grid (Iwaniak and Chojnowski, 2009; Kowalski, 2007; Nirmal-Kumar, Nair, Jing, 2013; Stavrakakis G.S., 2012; Tascikaraoglu, Uzunoglu, Vural, Erdinc, 2011). Problems of low-investing of distribution networks and transmission grids, and thus unsatisfactory quality of electric energy is especially visible on rural areas (Reiter and Kukiełka, 2011; Trojanowska and Nęcka, 2010), which on account of availability of the area theoretically give the highest possibilities of formation of new wind farms.

Objective of the paper, methodology and object of the research

The objective of the paper was to analyse the electric energy quality in the place of attachment of a single wind power station to the electricity grid and in particular frequency and the root mean square of voltage generated by this power station.

The quality of electric energy is characterized as the quality of supply voltage and reliability of its supplies. The quality of voltage is characterized with inter alia frequency of voltage, its root mean square value and the degree of deformation from the sinusoidal course. Whereas, reliability of the electric energy supply is described mainly with indexes concerning frequency, duration and territorial scope of short and long power cuts in the electric enegry supply.

The objective of the paper was performed based on the author's own research carried out in a LV switching station located in the place of attachment of a wind turbine of Nordtank XLR type with the power 150 kW to the MV distribution network. The object of the research was located on the territory of Słomianki commune in the northern part of Małopolskie Voivodeship. The investigated wind power station was produced in 1997 whereas, in Poland it has been working since 2007. The research which was carried out, consisted in the constant measurement of the amount which characterizes the electric energy quality, which then was averaged and registered in 10-minutes time intervals. For measurements, which were carried out from July to December 2013 a portable analyser of network parameters AS-3 Plus was applied. The result of the investigated research was development of an extensive data base including information on the impact of the wind power station on the quality of electric energy in the distribution network.

The assessment of the quality of electric energy was carried out based on the requirements set forth in the Ordinance of the Minister of Economy as of 4th May 2007 on detailed conditions of functioning of an electro-energy system and the Manual of Movement and Operation of Distributive Network [Polish: IRiESD]. Based on the obtained results it was verified whether particular parameters which characterize the energy quality in the place of attachment of the wind power station to the network of the Distribution System Operator are met. If in the period of research, surpasses of border values of particular parameters were identified, according to IRiESD requirements, it was also checked whether the total time of their duration within one week, when surpasses were reported, is longer than the admissible one.

In the effective acts of law, the frequency of the supply voltage is mentioned as a first parameter which characterizes the quality of voltage. Rated value of frequency for the whole heavy current system in Poland is 50 Hz not related to the root mean square value of voltage. Average value of frequency measured for 10 seconds may deviate from the rated value by ±1% for 99.5% of the one week period. Whereas, for the entire week, it may not change by more than +4% and -6% of the rated value.

For generating units, attached to the distribution network, it is required that for each week at least 95% from the set of 10 - minute average root mean square values of the supply voltage it was within ±5% of the rated value.

Additionally, the operation of the wind power station may not cause sudden changes of root mean square values of the supply voltage which exceed 3% even during the start-up and withdrawal of the wind power station. However, if a regular operation of the wind power station is the source of voltage changes and they have a cyclic nature of frequency from 10 disturbances per one hour, then the change of voltage may not exceed 2.5%. At the increase of disturbances frequency above 100, fluctuations of voltage must be lower than 1.5%. Fast changes of voltage caused by the change of power of the wind power station of frequency 1 Hz should be of amplitude not exceeding 0.7%.

For the supply voltage unbalance it is required that within each week 95% from the set of 10-minute average root mean square values of the constituent symmetrical, the opposite order of the supply voltage was within 0% to 2% of the constituent value of a compatible order.

In the literature, few methods of determination of the unbalance coefficient from the root mean square values of interfacial tensions (EN 61000-4-30; EN 61000-2-2, EN 61000-2-4, EN 61000-4-12, ГОСТ 13109-97, Engineering Recommendation P29) are known. However, from the research results presented by Kosobudzki (2011) one may assume that all methods of determination of the unbalance coefficient give comparable results and existing differences between the obtained results do not exceed few percent.

On account of the paper objective, which consisted in the analysis of the quality of electric energy, results obtained according to the requirements of the standard PN-EN 61000-4-30:2011, pursuant to which the value of the tension unbalance coefficient is determined according to the relation 1, were presented:

$$K_{U2} = 100\% \cdot \sqrt{\frac{1-\sqrt{3-6\cdot\beta}}{1+\sqrt{3-6\beta}}} \tag{1}$$

where:

$$\beta = \frac{U_{AB}^4 + U_{BC}^4 + U_{CA}^4}{\left(U_{AB}^2 + U_{BC}^2 + U_{CA}^2\right)^2}, \tag{2}$$

U_{AB}, U_{BC}, U_{CA} – root mean square values of interfacial tensions.

In the place of attachment of the wind power station to the MV distribution network, the value of particular higher harmonics referred to the basic harmonic may not exceed 0.7%. Whereas, coefficient of tension deformation THD_U which includes all harmonics to the 40th row, in total must be lower than 4%.

Research results

During the research of frequency of the supply voltage, it was between 49.87 Hz and 50.10 Hz independently from the operation of the wind power station. The analyses (fig. 1) which were carried out, show that in over 80% of observations, frequency of supply voltage oscillated in a very narrow scope of variability from 49.96 Hz to 50.04 Hz.

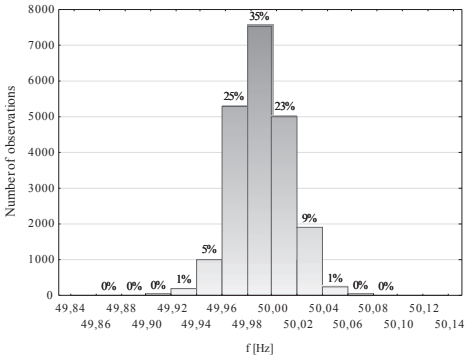

Figure 1. Histogram of the supply voltage frequency

The root mean square value of this voltage was the next parameter of the supply voltage, which was researched.

The average 10-minute root mean square values of supply voltage in the period of all three phases have changed from 224 V to 242 V. In the time when the wind power station worked or worked but with a very low load (fig. 2) a root mean square value of supply voltage oscillated between 226 V and 238 V. During the period of operation of the wind power station with the load exceeding 2.3 kW border values of the tension were 224 and 242 V. Registered average 10-minute maximum values of supply voltage slightly exceeding the admissible value, which was 241.5 V were registered only at a higher production of electric energy. The amount of reported surpasses was however only 15 which constituted almost 0.07% of all observations. One may thus acknowledge that requirements referring to the root mean square value of the supply voltage were met.

On account of the limitations of the used analyser (low volume of memory), during the research, only fast changes of the supply voltage values with values exceeding 10% of the rated voltage were registered. In the period covered by analysis, which was 150 days 20 voltage dips of average depth of 172 V was reported. Its maximum value was 5V. Duration of disruption oscillated between 40 and 1500 ms and its average value was 0.375 s. Due to the fact that in 75% voltage fluctuations took place only in the first stage additional research was carried out which aimed at determination whether disruptions came from the wind power station or from the network. Analysis of time of their appearance showed that in majority of cases, these disruptions took place in the time, when the wind power station did not work. Voltage dips during the work were reported only in the period of electric energy production in extreme conditions when hurricane Ksawery was over Poland. During the research short stoppages in supply were reported 8 times. Their average time of duration was 1.2 s and they occurred in all phases at the same time. These events were registered independently from the electric energy production by the wind power station. However, on account of the equipment limitations based on the research which was carried out, it is

impossible to clearly assess whether normative requirements concerning sudden supply voltage changes are met.

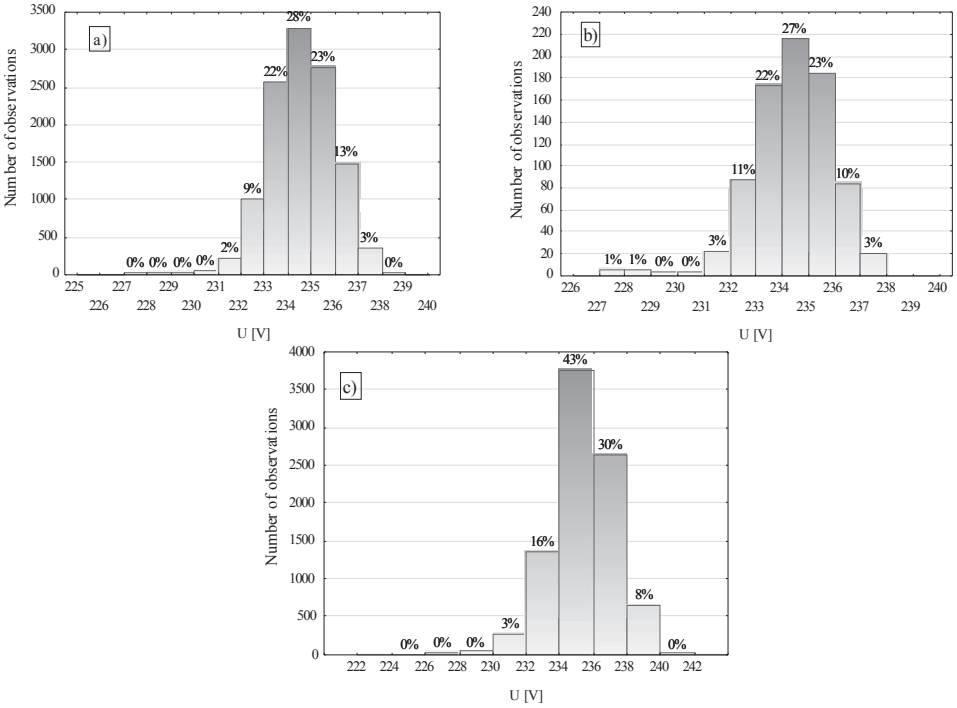

Figure 2. Histogram of the root mean square value of voltage, when: a) a wind power station does not work, b) works with a minimum load of (to 2.3 kW), c) works with a load above 2.3 kW

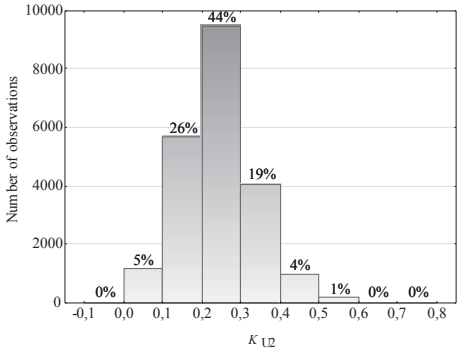

Figure 3. Histogram of changes of the coefficient of voltage unbalance

The analyses which were carried out (fig. 3) show that in the whole period of research, the value of coefficient of voltage unbalance K_{2U} oscillated between 0a 0.6% not exceeding the border level which was 2%.

Figure 4 presents the course of the distribution function of the relative frequency of the determined levels of the voltage deformation coefficient THD_U. During the research, the value of the average coefficient of voltage deformation THD_U was 1.85 and its maximum values reached the level of 3.8%. The participation of observations, the level of which exceeded 3%, was very low and was only 1%. In comparison to the previous research on the quality of electric energy in rural distribution networks [Trojanowska, Nęcka, 2010] one may see that in the researched line of the value of the analysed coefficient it is at the lower level. The analyses which were carried out show that the requirements of the admissible deformation of the voltage curve from the sinusoidal waveform are maintained.

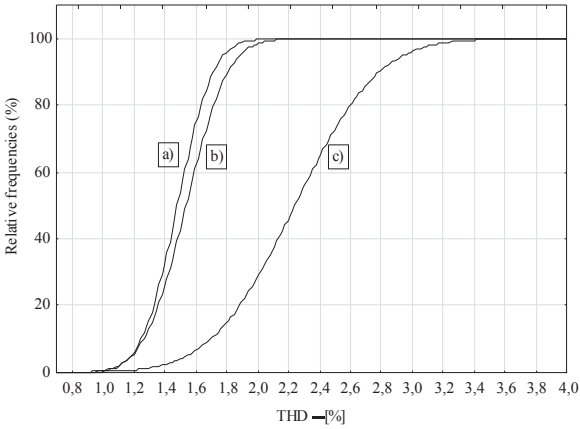

Figure 4. Empirical distribution functions of the voltage deformation coefficient THD_U when: a) a wind power station does not work, b) works with a minimum load of (to 2.3 kW), c) works with a load above 2.3 kW

Conclusion

Based on the analyses which were carried out, one may recognize that requirements concerning the changes of frequency and the root mean square value of the supply voltage have been met. In the period which was covered by the research, during the wind power station work, insignificant exceeding of the upper border value of 241.5 V were recorded, but their number constituted less than 0.07% of observations. Moreover, values of coefficients concerning tension unbalance and its deformation from the sinusoidal course were within the limits considered as admissible.

On account of the limitation of the applied analyser, it is impossible to explicitly assess the impact of the investigated wind power station on the sudden changes of the supply voltage and the index of flickering. Since, during the research only 20 voltage dips were registered but of values exceeding 10% of the rated voltage, average depth of which is 172 V. In majority, however, these were disruptions, the source of which, are other receivers

attached to the network. In the further part of the research, the use of the advanced analyser and the detailed analysis in the above-mentioned indexes is planned.

The research, which was carried out, show that cooperation of single wind powers stations of relatively low power with electric energy network with a suitable technical condition, which compose its elements and devices, does not result in deterioration of the electric energy quality. Unquestionable advantage of diffused generation is limitation of transmission losses due to limitaton of the distance between the source of its generation and final recipients.

References

Global Wind Report – Annual market update (2011). *Global Wind Energy Council*. Pozyskano z: http://www.gwec.net.

BTM Consult, World Market Update 2011.

Polskie Stowarzyszenie Energetyki Wiatrowej. *Energia wiatrowa w Polsce*. Pozyskano z: http://www.pwea.pl/pl/energetyka-wiatrowa/ewi-w-polsce

ENION – Spółka Akcyjna. *Instrukcja Ruchu i Eksploatacji Sieci Dystrybucyjnej*. 31 marca 2009 roku.

Iwaniak, A.; Chojnowski, P. (2009). Jakość energii elektrycznej z siłowni wiatrowej. *Wiadomości Elektrotechniczne*, *11*, 14-17.

Kaldellis, J.K.; Zafirakis, D.P. (2012). 2.21 - Trends, Prospects, and R&D Directions in Wind Turbine Technology. *Reference Module in Earth Systems and Environmental Sciences, from Comprehensive Renewable Energy*, *Vol.2*, Current as of 15 January 2014, 671-724.

Korban, Z. (2010). Wybrane aspekty wykorzystania energetyki wiatrowej w Polsce. *Górnictwo i geologia*, *Tom 5, Zeszyt 2*, Politechnika Śląska, Gliwice, 79-90.

Kosobucki, G. (2011). Pomiar niesymetrii napięcia w sieciach trójfazowych. *Prace Naukowe Instytutu Maszyn, Napędów i Pomiarów Elektrycznych Politechniki Wrocławskiej*, *65*, 401-410.

Kowalski, Z. (2007). *Jakość energii elektrycznej*, Wydawnictwo Politechniki Łódzkiej, Łódź 2007.

Niedźwiecka-Filipiak, I.; Borcz, Z. (1998). Zastosowanie niekonwencjonalnych źródeł energii w infrastrukturze wsi. *Inżynieria Rolnicza*, *1*(2), 55-62.

Nirmal-Kumar, C.; Nair, Lei J. (2013). Power quality analysis for building integrated PV and micro wind turbine in New Zealand. *Energy and Buildings*, *Vol. 58*, 302-309.

PN-EN 50160:2010, *Parametry napięcia zasilającego w publicznych sieciach elektroenergetycznych*

PN-EN 61000-2-12:2004, Kompatybilność elektromagnetyczna (EMC), *Poziomy kompatybilności dla zaburzeń przewodzonych niskiej częstotliwości i sygnałów sygnalizacji w publicznych sieciach zasilających średniego napięcia.*

PN-EN 61000-2-2:2003. Kompatybilność elektromagnetyczna (EMC), *Poziomy kompatybilności zaburzeń przewodzonych małej częstotliwości i sygnałów przesyłanych w publicznych sieciach zasilających niskiego napięcia.*

PN-EN 61000-4-30:2011, Kompatybilność elektromagnetyczna (EMC), *Metody badań i pomiarów - Metody pomiaru jakości energii.*

Polak, A.; Baranski, M. (2006). Porównanie turbin wiatrowych. *Zeszyty Problemowe – Maszyny Elektryczne*, *74*, 147-151.

Reiter, E.; Kukiełka, L. (2011). Problematyka wykorzystania energii wiatru w gospodarstwie rolnym. *Inżynieria Rolnicza*, *5*(130), 243-249.

Rozporządzenie Ministra Gospodarki z dnia 4 maja 2007 w sprawie szczegółowych warunków funkcjonowania systemu elektroenergetycznego. Dz. U. 2007 r. Nr 93, poz. 957; 2008 r. Nr 30, poz. 178; 2008 r. Nr 162, poz. 1005.

Stavrakakis, G.S. (2012). Electrical Parts of Wind Turbines *Reference Module in Earth Systems and Environmental Sciences*, *from Comprehensive Renewable Energy*, *Vol. 2,* 269-328.

Tascikaraoglu, A.; Uzunoglu, M.; Vural, B.; Erdinc, O. (2011). Power quality assessment of wind turbines and comparison with conventional legal regulations: A case study in Turkey, *Applied Energy*, *Vol. 88, Issue 5*, 1864-1872.

Trojanowska, M.; Nęcka, K. (2010) Badanie wskaźników charakteryzujących jakość napięcia w wiejskich sieciach elektroenergetycznych. *Inżynieria Rolnicza*, *4*(120), 269-274.

CHARAKTERYSTYKA JAKOŚCI ENERGII ELEKTRYCZNEJ GENEROWANEJ W SIŁOWNI WIATROWEJ

Streszczenie. Celem pracy była analiza jakości energii elektrycznej w miejscu przyłączenia pojedynczej siłowni wiatrowej do sieci elektroenergetycznej. Cel ten zrealizowano na podstawie badań własnych wykonanych w rozdzielni nN, zlokalizowanej w miejscu przyłączenia siłowni wiatrowej o mocy 150 kW do sieci rozdzielczej SN. Obiekt badań był zlokalizowany w północnej części województwa małopolskiego. Oceny jakości energii elektrycznej dokonano w oparciu o wymagania zawarte w Rozporządzeniu Ministra Gospodarki w sprawie szczegółowych warunków funkcjonowania systemu elektroenergetycznego oraz Instrukcji Ruchu i Eksploatacji Sieci Dystrybucyjnej. Na podstawie wykonanych analiz można uznać, że wymagania odnośnie zmian częstotliwości, wartości skutecznej napięcia zasilającego, asymetrii napięcia oraz jego odkształcenia od przebiegu sinusoidalnie zmiennego zostało spełnione. W okresie objętym badaniem podczas pracy siłowni wiatrowej rejestrowano nieznaczne przekroczenia dopuszczalnego poziomu wartości skutecznej napięcia, ale ich liczba stanowiła niespełna 0,07% obserwacji. W czasie badań zarejestrowano również 20 zapadów napięcia o wartościach przekraczających 10% napięcia znamionowego, których średnia głębokość wynosiła 172V. W większości były to zakłócenia, których źródłem są inne odbiorniki przyłączone do sieci.

Słowa kluczowe: generacja wiatrowa, energia elektryczna, jakość energii, sieć elektroenergetyczna

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ANALYSIS OF AWARENESS CONCERNING THE OCCUPATIONAL HEALTH AND SAFETY OF FOOD SECTOR EMPLOYEES

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ABSTRACT

Raising the awareness of workers with regard to the occupational health and safety should be a key role in every workplace. Promoting safety is aimed at involvement of employees in this issue and the change of attitude. The article presents an analysis of the awareness of employees in the food sector. The analysis was developed on the basis of the questionnaire. The questions focused on some important issues concerning the employees' awareness. The survey which was conducted in the agri-food industry in the Lublin region, indicated that employees understand the issues of safety and health at work, they can use the knowledge obtained in the training in their workplace and know the hazard in the workplace.

Introduction

The need for adjustment to new, more restrictive provisions of the market economy requires the use of more effective technologies and production lines, new machines and devices in each branch of economy also in the agri-food industry. An improved machinery park influences a change of the work conditions and many times occupational threats, which have not been known yet, leading to accidents at work. Each year in Poland as a result of improper work conditions few dozens of thousands accidents at work take place. According to the present Main Statistical Office data, the number of injured in 2013 in the food sector was 5821 people (Main Statistical Office, 2014). In many work establishments, increased activities related to ensuring work safety through optimal shaping of technical, organizational aspects and introduction of the work safety and hygiene management system are undertaken. However, long-lasting effects of activities aiming at safety may be reached only when in a work establishment, next to the introduction of technological and organizational changes, shaping awareness of all employees – from a director to a regular employee, is cared for. Employees comply with principles, regulations and safety rules, only when they understand them and are properly motivated to perform safe work. All actions undertaken in order to raise the safety level should be aimed at reaching the aim, which is non-accident work of all employees of the business. Safety should be ensured for guests who visit and companies which carry out the commissioned works on the territory of a given enterprise.

Ignoring safety provisions and rules by employees and also failure to use the safety means causes threat to the work safety. The reason for such conduct may be lack of knowledge and not understanding threats in the work place. Often, also for their own convenience or lack of conviction for their use, employees purposefully omit the use of different types of protection. Thus, informing employees on the implemented safety means is necessary, explanation of reasons for accidents and the occupational risk is necessary. Such actions should cause that employees will implement the safety process on their own initiative. The earlier employees are aware of the need to carry out their work safely, the faster the safety may authentically become an integral part of everyday activities of each employee.

Carrying out visualisation of many types of threats, improper, dangerous conducts and manners of correct conduct is a priority of many companies. More and more frequently, such manner is used also in vocational guidance and analyses of accidents. Detailed elaboration on accidents with the use of pictures allows drawing employees' attention to threats and eliminate the reasons for an accident, before it happens.

Safe work is based on concentration, planning and thinking. Employees' awareness concerning safety is included in the resources, which are the most frequently used and appreciated, and the engagement of which in the safety management system should bring notable effects.

In order to raise the level of knowledge on occurring threats and manner of their elimination effective tools, such as subject seminars, discussions, practices are used. Safety rules trainings should be adjusted to the specifics of work and employees' needs (Milczarek, 2000). Employee's knowledge plays a significant role, also at creating culture of work safety (Pawlak et al., 2006). Employee, according to the requirements of the Labour Code, is obliged to train a new employee on the safety rules and to inform him/her on the safety rules, which are applicable in a company. Moreover, specialist trainings are carried out, which aim at employees who face specific threats which occur at particular work positions in the labour institution. Trainings and meetings of particular company departments allow getting information on current issues and enable informing a greater number of the company employees on issues concerning the work safety (Chmielewski, 2009). The employer's obligation includes also rising professional qualifications by employees. Pursuant to the provision of Labour Code, an employee may make an attempt in order to rise own professional qualifications and an employer should enable execution of this task (Labour Code).

One of the elements of shaping the culture of work safety is engagement of the management in activities which aim at improvement of the safety conditions and work hygiene (Chmielewski, 2009; Lardner et al., 2002). Meaning of the management engagement in safety rules issues were emphasised both in the document ILO-OSH 2001 prepared by the International Labour Office in Geneva concerning guidelines for the work and hygiene safety management systems as well as in the Polish norm PN-N-18004:2004. In many labour institutions the so-called minutes for safety were introduced (Kostka, 2010). These are short conversations, carried out by a direct supervisor with a small group of employees. Subjects of meetings mainly concern specific activities carried out by employees.

Actions based on indirect communication with the use of both traditional media (e.g. printed training materialism, brochures, leaflets, posters on work safety) and electronic media (Internet, intranet) are a helpful tool in construing awareness of employees and promoting work safety (Szczygielska, 2009). Organizing competitions with prizes, awarding

directly at work places of employees, who present a suitable work culture and give a good example to other employees, safety rules knowledge competitions are another effective activity which bring positive results in the process of rising employees' awareness. Employees may report places which are potentially accident prone and ideas for improvement safety rules as a part of programmes and actions, carried out in establishment which aim at raising the level of safety (Mauer, 2013).

Work safety culture is shaped and recorded according to the system of accepted rules among employees of a given enterprise. The pattern will be recorded by employees only when they understand it and it constitutes an indisputable manner of behaviour. Identification with accepted patterns of conduct and awareness of activity is of great significance. As early as at the stage of school education, shaping of conduct of a future employee should take place and it should last during the professional activity.

The issue of safety culture is a difficult issue on account of an individual nature of the approach to safety. Only a systematic approach that includes all aspects which influence the safety facilitates evaluation of the safety culture and predicting shortcomings resulting from habits and behaviour of staff. "Organizational culture may constitute an element of actions strengthened by leadership and structure, which decides on its relations with the quality management" (Szczepańska, 2011).

A factor that the best motivates people to work and raises its efficiency is their full engagement in matters of their own enterprise, inter alia, through cooperation of employees based on the group work. "Employees should be included in the works of a team, which evaluates the professional risk, in consultations and also in searching for technical and organizational solutions, which reduce the risk or maintain it at the acceptable level" (Szczygielska, 2009).

Solution of problems related to the safety is successful only when employees consciously treat risks, which they face at their work places. When there is a need, they will react at dangerous situations and inform their supervisors or the safety rules department on it. Thus, they do not only care for their own safety but also for the safety of their co-workers.

The objective and the methodology of work

The objective of the paper was analysis of the work safety and hygiene awareness among employees of the food sector. The assumed objective was achieved by carrying out the author's questionnaire in nine establishments of various agri-food industry branches. Research was carried out in agri-food establishments in the region of Lublin. Management of particular establishments did not give their consent to provide the names of enterprises.

At the selection of establishments, the number of employed people and the work organization system were taken into account. Research was carried out in two diaries which had automated technological lines and the Diaries which produced a wide assortment of diary products operated in a three-shift system employing 30 employees per a shift. In the assessed diaries in the research 60% of the employees took part. Manufacturer of pasta, was another establishment with a 3-shift work. Whereas, a meat factory, where the questionnaire was carried out, is an average-sized work establishment. It specializes in production of various sausages, smoked products, terrines and raw meat. A fruit and vegetable establishment is a small manufacture, where production takes place in a one-shift work system

every day, but in a peak season, the establishment operates in a 3-shift system and additionally employs, employees, which not always are properly prepared. Research was carried out after the peak season thus the questionnaire was filled in only by 10 employees (at a fixed number of 15 employees). A herb plant, where the research was carried out, is fully automated and employees showed high interest in the questionnaire. An automated bakery offering a wide assortment of bakery products (inter alia various types of bread, white and sweet bakery products), working in a 3-shift system and employing 85 employees was a next establishment. Breweries belong to big, fully automated production establishments, where work takes place in a constant system. The last establishment, where the research was carried out, was the sugar industry establishment which employs over 50 people in a 3-shift work system.

Issues, which were prepared in the form of 15 category questions concerned the awareness in relation to the work safety in the production establishment with possible answers YES, NO were dealt with in the questionnaire. The questionnaire was available as a network service and was active for employees for the time of research. A single access to the form, for each employee was possible after previous obtaining a random code indispensable for identification of employees from particular establishments. Questions from the questionnaire were grouped in 4 categories related to: safety, trainings, threats and care for safety and order in the work place. Whereas, three from among all questions, were not included in the division into categories. Questionnaires with employees were a supplement to the questionnaire.

Research results

174 employees of various branches of agri-food industry participated in the questionnaire. Table 1 presents information on the age and education of employees.

Table 1
Division of employees in relation to their age and education

Education	Age group							
	18-30		31-50		50+		Total	
	men	women	men	women	men	women	men	Women
Elementary	0	0	2	0	1	3	3	3
Vocational secondary	3	0	14	10	9	5	26	15
Secondary education	13	4	23	18	9	14	45	36
University	9	5	16	13	0	3	25	21
Total	25	9	55	41	19	25	99	75

As a place of residence, respondents provided: 46% rural areas, 23.5% city up to 20 thousand citizens, 6.9% city up to 21-100 thousand citizens, 2.3% city 100-300 thousand citizens and 21.3% city above 300 thousand citizens.

All respondents answered positively to questions, which were not included in categories, i.e. "In your opinion are you well prepared and trained to work at your position?" and "Have you been informed on the rules of conduct in case of accident at work?". Whereas,

only in one establishment out of nine, which were investigated, employees said that supervisors do not verify whether safety rules are complied with. It was confirmed by the answers to the question "Did supervisors verify whether safety rules were complied with". In the remaining eight enterprises, direct supervisors paid attention to the manner, in which employees carry out their duties.

Positive answers on three questions from the first group concerning safety were presented in figure 1. In five establishments out of nine, where research was carried out for all employees, safety is equally significant as work efficiency and quality. Positive answers from employees from the remaining enterprises, were at a high level - over half of the questioned answered that safety is as much significant as work quality and efficiency (range 60-95%) of positive answers). Such attitude of employees towards safety is translated into the level of culture and conscious safe work performance. Only in one work establishment 58% of all employees think that sometimes due to production purposes, one should step back from the safety rules. Whereas in the remaining 8 establishments, 11-37% were for. Similarly, there is no unanimity in relation to usefulness of safety instructions.

Figure1. Results of positive answers concerning issues related to safety

Positive answers to three questions from the first group concerning safety were presented in figure 2. Usually, employees think that they are well prepared and trained to work at their positions. Employees are well and systematically informed on threats, risks, protection means and any undesired situations which occur in the work place. However, despite the

fact that there are meetings held, at which rules, safety rules and safety rules issues are discussed in detail, not all employees can transfer the knowledge obtained at the training to their work place. Confirmation for this situation is the fact that in one establishment, only 8% from among all employees can use the obtained knowledge in practice. Employees of al establishments agreed that the issues discussed at the meetings rise awareness on the work safety. Employees of al establishments agreed that the issues discusses at the meetings rises awareness on the work safety.

Figure 2. Results of positive answers concerning issues related to trainings

Positive answers to three questions from the third group concerning safety were presented in figure 3. The fact that over 70% of employees of all establishments see the need to inform supervisors on noticed irregularities, proves awareness of employees concerning safety. Employees (70-100%) know the threats which occur at the work place and react on bad conduct of their co-workers. Only in the establishment no. 4 as much as 80% of employees remain neutral to bad conduct of co-workers.

The last group of answers related to care for order in the work place was presented in figure 4. The obtained answers show that in all establishments, employees declare that their care for order at their work places.

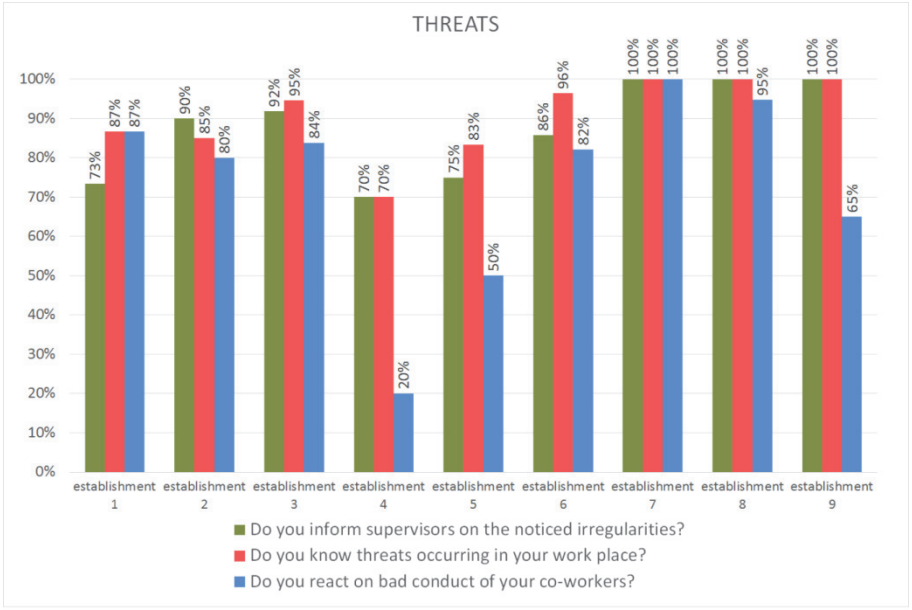

Figure 3. Results of positive answers concerning issues related to threats

Figure 4. Results of positive answers concerning issues related to care for safety and order at the work place

Depending on the specificity of an establishment, employers provide their employees with personal protective equipment equipping them with protective shoes, aprons, caps and masks. Personal protective equipment, which follows from legal provisions, not only is available but also used by staff. Employees know the safety principles and instructions. This information favour shaping appropriate conduct related to safe conduct during performance of works and at the same time rise the users' trust to the system of compliance of products with basic safety requirements and efficiency of the market supervision.

Conclusion

Based on the analysis of the results obtained from questionnaires it was determined that

1. Employees from the investigated food sector establishments know the concept of the work safety and hygiene.
2. Food sector employees from the region of Lublin regularly participate in the trainings and can transfer the obtained knowledge during the training to their work place.
3. Respondents proved the knowledge on threats, which occur in the work place and after they notice irregularities they inform their direct supervisors.
4. Awareness concerning the work safety and hygiene is also a care for order at the work place, which was emphasised by the questioned employees in the questionnaire.

Due to the engagement of all employees, developing conduct principles and organizational and technical solutions at the work place is possible. In order to improve awareness within the work safety, habits of save conduct should be worked out in employees. Information obtained from the research which was carried out, will be used at developing a programme of safety rules in food sector labour institutions in the Lublin region.

References

Chmielewski, J. (2009). *Kultura bezpieczeństwa i higieny pracy*. Praca i zdrowie 10, 40.

Główny Urząd Statystyczny. Monitoring Rynku Pracy. Departament Badań Demograficznych i Rynku Pracy. (2014). *Wypadki przy pracy w 2013 r.* Pozyskano z: http://www.stat.gov.pl/cps/rde/xbcr/gus/ PW_wypadki_przy_pracy_1-4kw_2013.pdf.

Kostka, J. (2010). *Minuty dla bezpieczeństwa*. Pozyskano ze strony: http://www.kirschstein.org/download/art-sawo-minutes-pl.pdf

Lardner, R.; Fleming, M.; Joyner, P. (2002). *Towards a Mature Safety Culture.* Institution of Chemical Engineers Conference, Symposium Series No. 148, Menchester.

Mauer, E. (2013). Kreowanie bezpieczeństwa pracy. *Bezpieczeństwo Pracy, 12*, 2-5.

Międzynarodowe Biuro Pracy. (2001). *Wytyczne do systemów zarządzania bezpieczeństwem i higieną pracy ILO-OSH 2001*. Genewa, tłumaczenie polskie: CIOP, Warszawa.

Milczarek, M. (2000). Kultura bezpieczeństwa w przedsiębiorstwie – nowe spojrzenie na zagadnienia bezpieczeństwa pracy. *Bezpieczeństwo Pracy, 10*, 17-20.

Pawlak, H.; Jasiński, K.; Maksym, P. (2006). Tworzenie kultury bezpieczeństwa pracy w zakładzie przemysłu spożywczego. *Inżynieria Rolnicza, 6*(81), 117-123.

PN-N-18004:2004. *Systemy zarządzania bezpieczeństwem i higieną pracy. Wytyczne*.

Szczepańska, K. (2011). *Zarządzanie jakością. W dążeniu do doskonałości*. Warszawa, wyd. C.H. Beck, ISBN 978-83-255-1600-0.

Szczygielska, A. (2009). Promowanie bezpieczeństwa pracy w przedsiębiorstwach – na przykładzie Forum Liderów Bezpiecznej Pracy. *Bezpieczeństwo Pracy, 4*, 26-29.

Ustawa z dnia 26 czerwca 1974 r. Kodeks pracy (Dz. U. 1998 r. nr 21, poz. 94 z późn. zm.).

ANALIZA ŚWIADOMOŚCI BEZPIECZEŃSTWA I HIGIENY PRACY PRACOWNIKÓW SEKTORA SPOŻYWCZEGO

Streszczenie. Podnoszenie świadomości pracowników w zakresie bezpieczeństwa i higieny pracy powinno stanowić kluczową rolę w każdym zakładzie pracy. Promowanie bezpieczeństwa ma na celu zaangażowanie pracowników w tę problematykę i zmianę postawy. Celem pracy była analiza świadomości bezpieczeństwa i higieny pracy pracowników sektora spożywczego. Analizy dokonano na postawie opracowanej ankiety, której pytania zwracają uwagę na kilka istotnych kwestii dotyczących poziomu świadomości pracowników. Ankieta, która została przeprowadzona w zakładach przemysłu rolno-spożywczego na terenie Lubelszczyzny, wykazała że pracownicy znają problematykę z zakresu bezpieczeństwa i higieny pracy, potrafią wykorzystać zdobytą na szkoleniach wiedzę na swoim stanowisku pracy oraz znają zagrożenia występujące w miejscu pracy.

Słowa kluczowe: przemysł spożywczy, bezpieczeństwo i higiena pracy, świadomość pracownika, warunki pracy

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IMPACT OF ORGANIC ADDITIVES ON BIOGAS EFFICIENCY OF SEWAGE SLUDGE[1]

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ABSTRACT

Methane fermentation, which constitutes at the same time a precious biogas source, is the most frequently applied stabilization method of sewage sludge. Municipal or industrial sewage does not, however, provide for the effective biogas production, mainly on account of their chemical composition. The objective of the paper was to verify susceptibility to the methanation process of the selected organic substrates (refined glycerine, beet molasses, whey) with sewage sludge. The scope of the research covered initial analysis of the raw material (pH, dry mass, dry organic mass), methane fermentation of the suitably prepared samples of fermentation mixtures and the assessment of biogas and methane efficiency. The highest concentration of methane was obtained from the mixture of sewage sludge with refined glycerine (63.10%), whereas the lowest – from the mixture with whey (49.8%).

Introduction

Sewage sludge is a product of sewage treatment and its processing and disabling constitute an essential element of technological processes of sewage treatment.

Sewage which is formed in the municipal sewage treatment plants tends to decaying, which is related to secretion of unpleasant odours. It is also characterized with high hydration, which impedes the process of their management. Whereas sludge from industrial sewage treatment plants is characterized with the increased content of heavy metals and toxic components (Magrel, 2002; Pierścieniak and Bartkiewicz, 2011).

During the last few years, sludge production in the European Union has been constantly increasing, presently even to several tonnes of dry mass of sewage annually. Sludge handling, and in particular the use of sewage sludge, which is formed in the sewage treatment plants, must comply to the environmental requirements. The provisions included in the

1 This work was carried out under a grant NCN no. N N313 432539: "Assessment of the fertilizer value and impact on the soil of afterdigest pulpy originating from the process of biogas production, with application of different organic substrates"

Council Directive 91/271/EEC (CEC, 1991) impose construction of new sewage treatment plants and optimization of work – of those existing. Construction of a higher number of sewage treatment plants and also the use of more and more effective processes of urban sewage treatment plants causes the increase of production of the amount of sewage sludge. Additionally taking into consideration the number of sludge that has been already stored and very limited perspectives of its storage, these facts constitute a serious problem.

Sewage that is formed during sewage sludge treatment is subjected to the dehydration and stabilization processes. The most frequently, biological processes are applied: aerobic, anaerobic, chemical and thermal processes of stabilization of sewage sludge (Miodoński and Iskra, 2011). Methane fermentation is a popular technology, which improves the quality of the sewage sludge in the aspect of usage in agriculture, being at the same time a precious biogas source. However, both municipal sewage as well as industrial ensures effective biogas production, due to their chemical composition, which is mainly characterized with carbon deficiency. Issues related to the improvement of biogas efficiency of sewage sludge, constitute a present research problem of the known scientific centres around the world. In the selected works, various, interesting solutions have been suggested, which aim at the increase of biogas production, at optimally conducted methane fermentation of the sewage sludge. Anaerobic decomposition of this substrate with organic waste is one of the proposals. Due to the fact that the most favourable relation C:N is 20:30 (Parkin and Owen, 1986; Fugol and Prask, 2011) and the sewage sludge has 6:16, co-fermentation (fermentation in the multi-component system) with organic waste of any type which has high C:N, may effectively improve balance of nutritious components and cause the increase of the carbon amount, and consequently raise biogas production (Sosnowski et al. 2007). Among other advantages of carrying out the process of co-fermentation, the fact of balancing mineral components should be mentioned: Na, K, Mg, Mn, dilution of toxic substances, optimal use of the volume of fermentation chamber, reduction of retention time (HRT), increase of the degree of re-digestion of substrates and general decrease of costs.

In the literature, the use of sewage sludge in the process of methane digestion with organic additives is reported in the form of: pigs and poultry manure (in the first case the increase of biogas yield was by 40% Borowski et al., 2014) of beet pulp (Montañés et al., 2013) and grease waste, in case of their use, a considerable improvement of biogas productivity was obtained , even to 60% (Noutsopoulos et al., 2013; Silvestre et al., 2011; 2013). These solutions mainly give a high biogas potential including methane. During execution of the process, however, it is hard to avoid potential operational problems, the most frequently related to: inhibition of methanogenesis, caused by release of ammonia (for example at the use of poultry droppings, Borowski et al., 2014), accumulation of LCFA (long chain fatty acids), unfavourable decrease of pH of the system (Shin et al., 2003; Silvestre et al., 2014) as well as low-effective reduction impact of digestion - towards pathogens (the most frequently E.coli), included in added animal droppings (Borowski et al., 2014; Scaglia et al., 2014). Moreover, high load of a digestion chamber may cause difficulties (Montañés et al., 2013), formation of digestion foam (Kabouris et al., 2008) or issues related to the transport of substrates (Pereira et al., 2004). In numerous research, attempts to solve the mentioned problems are made on account of decisive prevail of advantages: pro-environmental, economic, social, which result from handling of sewage sludge in co-fermentation with organic waste.

In the presented paper, refined glycerine, beet molasses and whey were used as organic additives to sludge. The most favourable results were reported for a sample of sewage sludge with glycerine.

The objective and the scope of research

The objective of the research was verification of susceptibility of the mixture of sewage sludge with specific organic additives on the methanation process and determination of biogas efficiency of substrate. The scope of the research covered initial analysis of the raw material (pH, dry mass, dry organic mass), methane digestion of suitably prepared samples of digestion mixtures and assessment of biogas and methane efficiency according to proper analytic procedures.

Research methodology

pH Measurement

pH measurement of particular substrates was carried out according to the specific procedure. Firstly, to two beakers with the volume of 250 ml for 20 g of material was collected, which was then diluted with demineralized water. A pH-meter electrode (Elmetron CP215) was kept in the mixture for stabilization of pH value. Measurement was repeated three times, and results were averaged.

Determination of dry mass

Fresh material,which was collected from a bioreactor to two aluminium forms was weighed (RADWAG precision to 0.01 g) and then dried for approximately 12 h in temperature 105ºC to the moment of obtaining solid mass.

Percentage content of dry mass is calculated with the following equation:

$$s.m. = \frac{(m_2 - m_3)}{m_1} \cdot 100 \tag{1}$$

where:

s.m. – dry mass (%),
m_1 – mass of a sample before drying (g),
m_2 – mass of a sample after drying (g),
m_3 – average mass of an aluminium form≈ 6.02 g

Moisture, which is calculated according to the following formula, is a reverse of the dry mass content of output material (fresh mass):

$$ś.s. = 100 - s.m. \tag{2}$$

where:

ś.s. – moisture (fresh mass) (%),
s.m. – dry mass (%),

Determination of organic substance content

Method of determination of organic substance content consists in weight determination of losses at combustion of samples in the temperature of 520ºC to the moment of obtaining solid mass. As a result of roasting we obtain ash (mineral matter) whereas organic compounds included in the mixture, in the set temperature of roasting (520ºC) – transfer into volatile state.

Organic substances content in the investigated sample should be calculated in percentages in relation to dry mass samples according to the equation:

$$S_{org} = \frac{m_1 - m_2}{m_1} \cdot 100 \tag{3}$$

where:

S_{org} – organic substance content (%),
m_1 – mass of a sample before roasting (g),
m_2 – mass of a sample after roasting (g).

Preparation of samples

Preparation of digestion mixtures was carried out based on the pH value of substrates so that it was approximately 7. It is a reaction characteristic for a batch in fermentors of really working biogas plants as well as optimal for anaerobic bacteria.

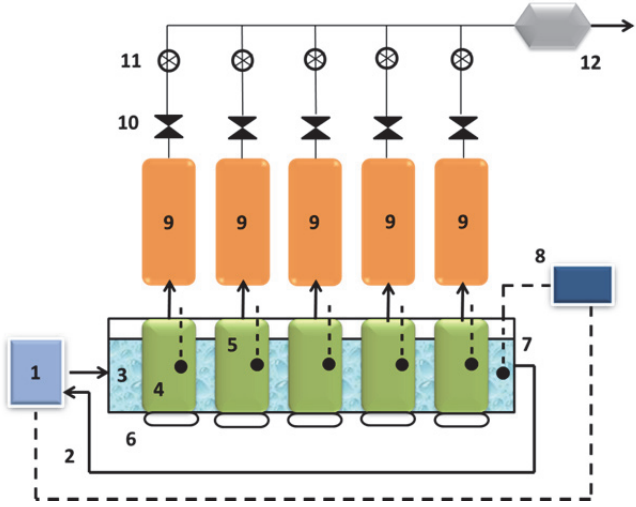
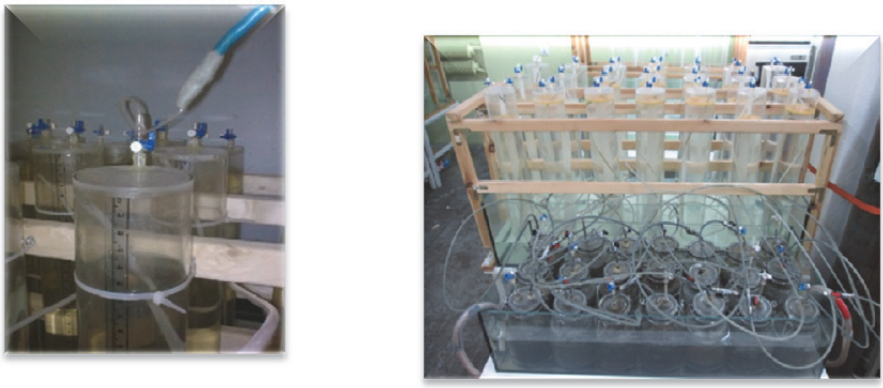


Figure 1. Schematic representation of a fermentor for research of biogas production: 1 – water heater with temperature controller; 2 – isolated conduits of heating liquid; 3 – water jacket; 4 – biofermentor with a batch of volume of 1.4 dm^3; 5 – pH sensors; 6 – magnetic stirrers of a batch; 7 – temperature sensors; 8 – record control room; 9 – biogas containers; 10 – cut-off valves; 11 – gas flowmeter; 12 – gas analyser (CH_4, CO_2, NH_3, H_2S, O_2)

Sewage sludge was used in the research, which came from Municipal Sewage Treatment Plant in Wolsztyn. On account of conditions required for correct course of methane fermentation, it was non-hygienized (pH=6-8). For preparation of fermentation mixtures the following were used: whey from dairy Kościan, molasses from sugar factory Opalenica and refined glycerine (Bio-Chem Sp. z o.o. Grodków). As a factor that initiates the process, pig manure from an agricutlural farm, which produces pigs, was used. Selection of the so-called graft resulted from inter alia effects of previous research, which unanimously proved that pigs manure along with glycerine gives higher biogas yield than combined with cattle manure (Pilarski et al., 2010). Proper samples were prepared using specific proportions of substrates, which were presented in table 1. Half less amount of glycerine was used on account of its high susceptibility to decomposition, which as a result was going to prevent too fast process of hydrolysis and to protect a sample against acidification in further stages of methane fermentation (Dach et al., 2009).

Realization of the methane fermentation process

The prepared raw material was subjected to fermentation in biofermentors, which were designed and performed in the Institute of Biosystems Engineering of the Poznan University of Life Sciences (fig. 1,2 a, b). 9 fermentors were used in the research. Experiment was carried out for 40 days, in temperature 38ºC (mesophile conditions), which was maintained at a constant level, due to the use of water jacket. Measurement of the amount of obtained biogas was carried out according to the standard DIN 38 414: Bestimmung das Faulverhaltens *Schlamm Und Sediment* (Beuth Verlag GmbH, Berlin, 1985), which is the most frequently used method in Europe (mainly in Germany, Austria and Holland). Batch in reactors was mixed every 24 hours for approximately 1 minute. The amount of the produced biogas was measured each day of the research with the use of a scale placed on the biogas containers (fig. 2a). Analysis of the quantity composition was carried out for the volume of the produced biogas which was 1.1 dm^3. For the research system MSMR-4/BIO by ALTER S.A. was applied (stationary analyser of gases in biogas).



a B

Figure 2. a – biogas container filled with water and marked with a scale, b – multi-chamber biofermentor

Analytic procedures related to the research on biogas and methane efficiency of substrates were developed as a part of the research projects, ordered by the Ministry of Science and Higher Education.

Discussion on the research results

In the first stage of research, analysis of basic physical and chemical parameters of the applied substrates, such as: pH, dry mass and organic dry mass, was carried out. Parameters and proportions of substrates in the prepared samples were presented in table 1.

Table 1
Physical and chemical properties of substrates and composition of fermentation mixtures

	Sludge Wolsztyn (without hygienization) (A)	Whey Kościan (B)	Molasses Opalenica (C)	Refined glycerine (D)	Graft (pigs manure) (E)
Dry mass* of substrates subjected to fermentation process (%)	15.88	4.88	75.68	99.60	3.80
Solid residue* of substrates subjected to fermentation process (%)	61.28	86.33	83.19	99.90	79.81
pH of the mixture at the beginning of fermentation	6.90	6.85	7.28	7.45	7.51
Amount of substrate added to fermentation (g)	200.10 (A)/ 1300.10 (E)	100.00 (B)/ 100.10 (A)/ 1300.20 (E)	100.00 (D)/ 100.10 (A)/ 1300.10 (E)	50.20 (C)/ 150.20 (A)/ 1300.15 (E)	–

*dry mass – dry mass; DOM – dry organic mass

Reaction of all used substrates is approximately neutral, which is a basic condition for correct and efficient realization of the methane fermentation process. Refined glycerine has the biggest dry organic mass and the sewage sludge has the lowest.

Sample (B) with an addition of whey (fig. 3b) fermented in the shortest time and in the least effective manner. Its initial pH which is 6.85 (table 1) was relatively low with reference to pH of the remaining substrates and requirements for correct course of the process. Slightly acid reaction of whey caused inhibition of the process in the entire methanation process and considerably lowered biogas profitability of this sample (15.80 dm^3 of biogas, table 2). Worse results in the discussed case where thus assigned to low pH of the substrate, which influenced fermentation disorders and as a result to acidification of the process environment (pH = 4.59; table 2).

Table 2
Data concerning biogas yield in the anaerobic fermentation process

Specification	Sludge Wolsztyn without hygienization (A)	Whey Kościan (B)	Molasses Opalenica (C)	Refined glycerine (D)
Amount of the obtained biogas (dm^3)	17.80	15.80	27.6	33.4
Average content of methane in biogas (%)	51.3	49.80	58.40	63.10
Amount of the obtained methane (dm^3)	9.13	7.87	16.11	21.20
pH of substrates subjected to methane fermentation	6.9	4.59	7.11	7.71
Biogas efficiency of the investigated substrates ($dm^3 \cdot kg$ ś.m.$^{-1}$)	26	6	118	338

Next sample, which was subjected to anaerobic fermentation, was a mixture with beet molasses (C). This sample was characterized with a regular methanation process (fig. 3 c). In the first 7 days a constant increase of biogas production was reported. From the 8th day of process, performance a daily decrease of biogas yield took place, which lasted regularly to the 32nd day. Total amount of the obtained biogas was 118 $dm^3 \cdot kg^{-1}$ ś.m., which is a worse result in comparison to the data included in the literature (KTBL, 2011) and indicates insufficient content of micro and macro-elements in the investigated sample. No proper quantity of elements which support the methane fermentation process causes low-effective transformation (the so-called bio-gasing) of biomass in a fermentor.

In practice, sterile substrates or disorders of conditions of the process realization put potential biogas works owners to a danger of considerable economic losses. Thus, maintaining constant monitoring of biogas works operation on account of the quantity and quality scope is important, of both produced biogas as well as input substrates and post-fermentation pulp.

According to data included in table 2, the highest biogas yield took place in case of using glycerine (sample (D); 33.4 dm^3). At the same time, from fermentation mixture with glycerine, as an organic additive, biogas, which is the richest in methane (63.10%) was obtained, which is mainly justified with chemical structure of a particle of this compound, which is characterized with relatively high amount of carbon atoms ($C_3H_8O_3$).

A plot presented in figure 3d, indicates that intensity of the methanation process of the mixture (D) in the second week of the research decreased due to the raise of pH inside a fermentor, caused by too fast rate of hydrolysis and acidogenesis. In the fourth week, according to the diagram analysis, biogas production increased followed by its extinguishing - in the 34th day. The amount of the obtained biogas is close to literature data (Dach et al., 2009).

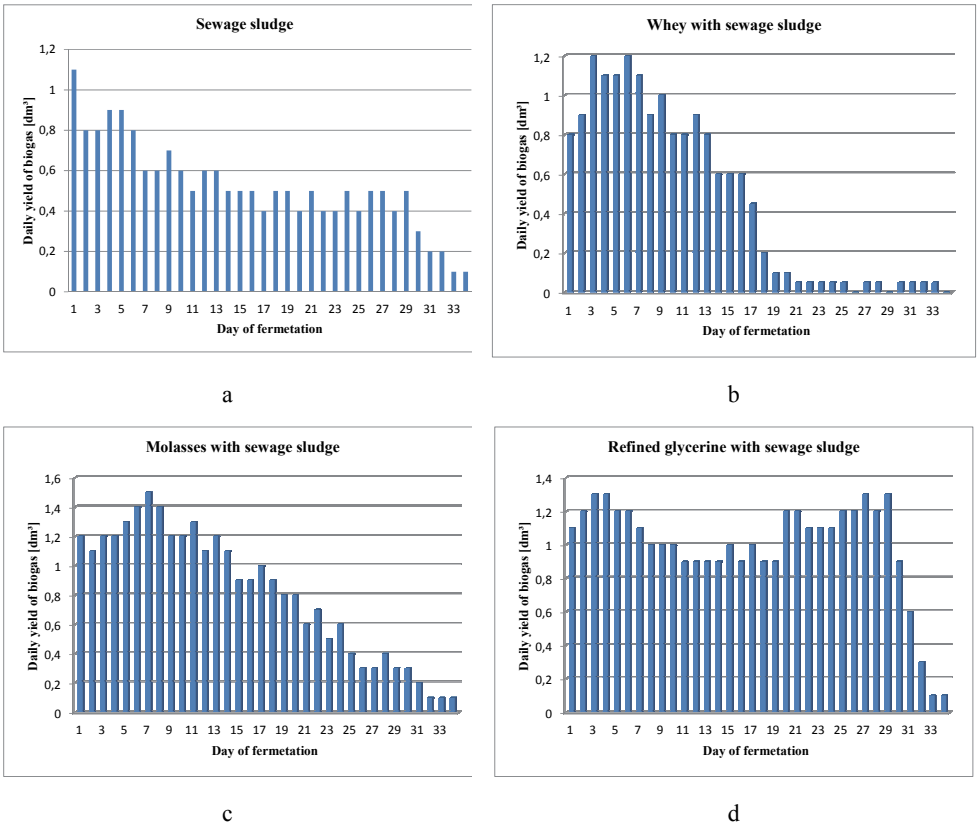


Figure 3. Daily biogas yields for:a – sewage sludge and b – whey, c – molasses, d – refined glycerine with sewage sludge

Conclusions

1. Whey as a co-substrate with sewage sludge is a low efficient additive (only 15. 8 dm^3 of the obtained biogas) and requires strict control during execution of methane fermentation.
2. Beet molasses subjected to methane fermentation with sewage sludge gave lower biogas yields (27.6 dm^3) in the research which was carried out, compared to the literature values (30-35 dm^3), which resulted the most probably from the low quality of the substrate (limited content of micro and macro-elements).
3. Biogas yield from the mixture of refined glycerine and sewage sludge was the most advantageous (33.4 dm^3). Refined glycerine as a co-substrate raises considerably the efficiency of the biogas installation.
4. Correct selection of the co-substrate for biogas works constructed at the sewage treatment plants may considerably improve their profitability.

References

Borowski, S.; Domański, J.; Weatherley L. (2014). Anaerobic co-digestion of swine and poultry manure with municipal sewage sludge. *Waste Management, 34*, 513-521.

CEC (1991). Council Directive of 21 of May 1991 on urbane waste water treatment. Council of the European Communities *(Directive 91/271/EEC).*

Dach, J.; Zbytek, Z.; Pilarski, K.; Adamski, M. (2009). Badania efektywności wykorzystania odpadów z produkcji biopaliw jako substratu w biogazowni. *Technika Rolnicza Ogrodnicza Leśna, 6*, 7-9.

Fugol, M.; Prask, H. (2011). Porównanie uzysku biogazu z trzech rodzajów kiszonek z kukurydzy, luceryny i trawy. In*żynieria Rolnicza,* 9, 31-39.

Kabouris, J.C.; Tezel, U.; Parlostathis, S.G.; Engelmann, M.; Todd, A.C.; Gilette, R.A. (2008). The anaerobic biodegradability of municipal sludge ad fat, oli, and grease at mesophilic conditions. *Water Environment Research, 80*, 212-221.

Kuratorium für Technik und Bauwesen in der Landwirtschaft (2011). Biogaz – produkcja i wykorzystywanie (Poradnik BIOGAZ), *Institut für Energetik und Umwelt gGmbH, Leipzig.*

Magrel, L. (2002). Metodyka efektywności procesu fermentacji wybranych osadów ściekowych. *Rozprawy naukowe, 93.* Wydawnictwo Politechniki Białostockiej. ISSN 0867-096X.

Miodoński, S.; Iskra, K. (2011). Ocena efektywności procesu skojarzonej fermentacji osadów ściekowych oraz odpadów tłuszczowych na przykładzie oczyszczalni ścieków w Brzegu. *Ochrona środowiska i zasobów naturalnych, 47*, 62-69.

Montañés, R.; Pérez M.; Solera, R. (2013). Biomass adaptation over anaerobic co-digestion of sewage sludge and trapped grease waste. *Bioresource Technology, 142*, 655-662.

Noutsopoulos, C.; Mamais, D.; Antoniou, K.; Avramides, C.; Oikonomopoulos, P.; Fountoulakis, I. (2013). Anaerobic co-digestion of grease sludge and sewage sludge: The effect of organic loading and grease sludge content. *Bioresource Technology, 131*, 452-459.

Parkin, G.F.; Owen, W.F. (1986). Fundamentals of anaerobic digestion of wastewater sludge. *ASEE Journal Environment Engineering, 112*, 867-920.

Pereira, M.A.; Sousa, D.Z; Mota, M.; Alves, M.M. (2004). Mineralization of LCFA associated with anaerobic sludge: kinetics, enhancement of methanogenic activity, and effect of VFA. *Biotechnology and Bioenergy, 88*, 502-511.

Pierścieniak, M.; Bartkiewicz, B. (2011). Zagospodarowanie biogazu powstającego w procesie fermentacji metanowej w oczyszczalniach ścieków. *Ochrona środowiska i zasobów naturalnych, 47*, 47-61.

Pilarski, K.; Dach, J.; Mioduszewska, N. (2010). Comparison of efficiency of methane production from liquid muck and dung with refined glicerin addition. *Journal of Research and Applications in Agricultural Engineering, 55*, 78-81.

Scaglia, B.; D'Imporzano, G.; Garuti, G.; Negri, M.; Adani, F. (2014). Sanitation ability of anaerobic digestion performed at different temperature on sewage sludge. *Science of the Total Environment*, *466-467*, 888-897.

Shin, H.; Kim, S.H.; Lee, C.Y. (2003). Inhibitory effects of long - chain fatty acids on VFA degradation and beta - oxidation. *Water Science Technology, 47*, 139-146.

Silvestre, G.; Illa, J.; Fernández, B.; A. Bonmatí, A. (2014). Thermophilic anaerobic co-digestion of sewage sludge with grease waste: Effect of long chain fatty acids in the methane yield and its dewatering properties. *Applied Energy, 117*, 87-94.

Silvestre, G.; Rodríguez-Abalde, A.; Fernández, B.; Flotats X.; Bonmatí A. (2011). Biomass adaptation over anaerobic co-digestion of sewage sludge and trapped grease waste *Bioresource Technology, 102*, 6830-6836.

Sosnowski, P.; Klepacz-Smolka, A.; Kaczorek, K.; Ledakowicz, S. (2007). Kinetic investigations of methane co-fermentation of sewage sludge and organic fraction of municipal solid wastes. *Bioresource Technology, 99*, 5731-5737.

WPŁYW DODATKÓW ORGANICZNYCH NA WYDAJNOŚĆ BIOGAZOWĄ OSADÓW ŚCIEKOWYCH

Streszczenie. Najczęściej stosowaną metodą stabilizacji osadów ściekowych jest fermentacja metanowa, stanowiąca jedocześnie cenne źródło biogazu. Ścieki komunalne czy przemysłowe nie zapewniają jednak efektywnej produkcji biogazu, przede wszystkim ze względu na ich skład chemiczny. Celem badań było sprawdzenie podatności na proces metanizacji wybranych substratów organicznych (gliceryna rafinowana, melasa buraczana, serwatka) z osadem ściekowym. Zakres badań obejmował wstępną analizę surowca (pH, suchą masę, suchą masę organiczną), fermentację metanową odpowiednio przygotowanych próbek mieszanin fermentacyjnych oraz oszacowanie wydajności biogazowej i metanowej. Największe stężenie metanu uzyskano z mieszaniny osadu ściekowego z gliceryną rafinowaną (63,10%), natomiast najmniejsze – z mieszaniny z serwatką (49,8%).

Słowa kluczowe: stabilizacja osadu ściekowego, fermentacja metanowa, substrat, wydajność biogazowa

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BIOCHAR FROM A DIGESTATE AS AN ENERGY PRODUCT AND SOIL IMPROVER

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ABSTRACT

Digestate, as bio-degradable agricultural biogas waste may be subject to the direct management as a fertilizer or, after separation of the solid and liquid phase – solid phase may be subjected to thermo-chemical transformation to biochar. Biochar is a carbonization product with high carbon concentration and relatively low decomposition susceptibility, obtained from various types of organic waste (International Biochar Initiative). Biomas carbonization takes place in the torrefaction process in the temperature from 200ºC to 320ºC. The chemical composition and utility properties of biochar depend on the substrate type and the process parameters. Biochar obtained from biodegradable waste may be an element of carbon biosequestration and used as biofuel, whereas in agriculture – as soil improver, which decomposes for a long time and which positively influences soil fertility, number of biogenic components and physical and water properties. The paper presents characteristic of the torrefaction process, process products and utility values of biochar from the point of view of energy and the agricultural value.

Introduction

Along with the development of the biogas sector, amount of the generated digestate increases. It is estimated that to 2020 approx. 2.5 thousand agricultural biogas plants will be founded, which relates to production of approx. 25 million post-fermentation residues annually (Czekała et al., 2012). Moreover, Poland prohibits storing biodegradable waste of the content above 5% of the total organic carbon, including digestate (Czekała et al., 2012).

The main trend in managing digestate is using it as a fertilizer directly to the soil, or after separation – application in the form of a solid and liquid fertilizer or also other use of the solid fraction, e.g. as energy pellet or litter (Mumme et al., 2011; Troy et al., 2013). Currently, particularly the second form of using digestate gets significance due to the potential of generating positive economic effects through the limitation of storing costs and costs of transport to the field as well as the environmental effects through limiting the loss of nutrients (leaching, oxidization, biogens drop (Lehman and Joseph, 2009; Nelissen et al., 2014; Zheng et al., 2013).

From among the perspective concepts related to the improvement or development of new technologies of processing the post-fermentation mass, conversion of the solid fraction of a digestate to biochar in a themo-chemical torrefaction process draws attention (Gołaszewski et al. 2013, Mohan et al., 2014; Sun et al., 2014).

The objective and the scope of the study

The objective of this paper is to review the literature on account of usefulness and potential of using a digestate obtained from the agricultural biogas plant for production of biofertilizer (soil improver) and energy material (biofuel). The paper presents characteristic of the torrefaction process, process products and the utility values of biochar from the point of view of energy and agricultural value.

Thermo-chemical biomass conversion - torrefaction

Biochar – according to a definition by *International Biochar Initiative* it is a carbonization product in high carbon concentration and relatively low susceptibility to decomposition, therefore it may be used as a soil improver and an element of carbon sequestration in soil (Lehman et al., 2011; Mohan et al., 2014; Sun et al., 2014; Sunil and Ajay, 2012; Zheng et al., 2013).

Production of biochar takes place in the thermo-chemical process of conversion – pyrolysis. Pyrolysis is defined as a thermal process of decomposition of the organic matter in the anaerobic conditions within the scope of temperatures 200-600ºC (Mohan et al., 2014). In relation to the parameters of the process, such as: temperature, stop time, pressure and the type of substrate, one may obtain a product, which is varied on account of the quality and quantity (Table 1) (Mohan et al., 2014; Sunil and Ajay; van der Stelt et al., 2011). The highest amounts of biochar are obtained in the slow heating processes, where biocarbonization product may constitute approx. 35%. Therefore torrefaction is considered to be the main process of biochar production (Mohan et al., 2014; van der Stelt et al., 2011).

Table 1
Types of thermo-chemical biomass conversion (modified)

Parameter	Thermo-chemical process				
	Slow pyrolysis	Torrefaction	Torrefaction	Gasification	Hydro-thermal carbonization
Temperature scope (ºC)	350-800	200-300	400-600	700-1500	175-250
Heating rate	slow (< 10ºC/min)	slow (< 10ºC/min)	very fast (~ 1000ºC/s)	fast	slow
Pressure	atmospheric	atmospheric	vacuum - atmospheric	raised atmospheric	–
Retention time	seconds - hours -	minutes-hours	seconds	seconds-minutes	hours
Product	Biochar	Biochar	Biooil	Syngas	Hydrochar

Source: Mohan et al., 2014

Torrefaction as a type of thermo-chemical biomass conversion (roasting, carbonization) is carried out the most frequently within the scope of the temperatures from 200ºC to 300ºC, in the pressure conditions similar to the atmospheric ones and in the inert environment. In the subject literature there are also other definitions of the torrefaction process, such as: roasting, slow and mild pyrolysis, high-temperature drying (Bergman et al., 2005; Kopczyński and Zuwała, 2013; van der Stelt et al., 2011).

The torrefaction products, depending on the physical state may be divided into three groups: solid, liquid and gas. The solid phase which constitutes the main product of the reaction contains the torrefaction product, ash and additionally sugar structures. The sas phase is composed of permanent gases (H_2, CO_2, CO, CH_4) as well as aromatic components, such as benzene and toluene. The liquid components (non-condensing) may be divided into three subgroups: water, organic (generated mainly during degassing) and lipid (remains after raw biomass) (Bergman et al., 2005).

During the torrefaction process, many chemical reactions take place in biomass, as a result of which the increase of the condensation and aromatization degree takes place, which translates into the change in mol relations O/C and H/C (Jinig et al., 2014; Sunil and Ajav, 2012). Relation of H/C may serve as an index of aromatization degree, whereas O/C relation constitutes index of carbonization degree (Jinig et al., 2014). It is commonly recognized that biochar has an element relation O/C below 0.4 and H/C below 0.6. Moreover, the content of the condensed aromatic groups, which increases during the process, known as black carbon, directly influences the increase of the biochar stability in the environment (Jinig et al., 2014; Sunil and Ajay, 2012).

Biochar and its utility values in agriculture

Biochar may be used in many fields. In agriculture it may be used as an organic fertilizer that decomposes for a long time, which positively influences the soil fertility, the amount of biogenic components, physical and water properties as well as biological properties (Galvez et al., 2012; Gołaszewski et al., 2013; Lehman et al., 2011; Mohan et al., 2014; Zheng et al., 2013).

The main function of biochar is regulation of dynamics of changes and circulation of C and N in soil (Galvez i in., 2012; Zheng i in., 2013), due to which it may impact the increase of the organic matter content. High content of stable fraction of organic carbon causes that biochar may take part in the biosequestration of carbon in soil (Mohan et al., 2014). As reservoir of carbon, which is mineralized slowly, it causes decrease of the greenhouse effect caused by excessive emission of the greenhouse gases, including CO_2 (Mohan et al., 2014). Taking into account that the average time of biochar decomposition in soil (MRT, Mean Residence Time) is estimated as approx. 1300-4000 years (Sunil and Ajay, 2012), it was assumed that through biochar, used on cultivation fields one may permanently depose 428 Gt C (Sunil and Ajay, 2012). Whereas a considerably small content of labile fraction, biochar which may be subject to fast decomposition, additionally influences the increase the amount of organic matter in soil (SOM, Soil Organic Matter) and the number of mineralized nutrients available for plants (Sunil and Ajay, 2012).

Biochar participates also in a biogeochemical cycle of nitrogen. The research proves that biochar addition influences the decrease of the nitrification level (decrease of NH_3 oxidization); moreover, it influences the increase of the number of the ammonification

bacteria, whereas through stimulation of nitrogen immobilization influences the reduction of N_2O emission to atmosphere (Zheng et al., 2013). According to the research carried out by Ding et al. (2010) application 0.5% of biochar to the external layer of soil influenced the decrease of NH_4^+ leaching by 15.2%, through absorption of ammonium ions on the surface of biochar (Zheng et al. 2013). Reduced washing out of NO_3 – from soil after the application of biochar fertilization was also proved by Knowles et al. (2011). Similarly a positive impact on nitrogen management was proved in the research carried out by Nelissen et al. (2014), where limitation of N_2O emission by 52-84% and NO by 47-67% was reported.

A positive influence of the biocarbonization product is also reflected in the biological properties of soil, through the influence on the quality and quantity properties of the soil microflora (Galvez et al., 2012; Nelissen et al., 2014; Tang et al., 2013; Zheng et al., 2013). Due to the biocarbonization product properties, such as a big specific surface (approx. 400-800 $m^2 \cdot g^{-1}$) and a porous structure, good living conditions and development conditions for the soil microflora are created (Galvez et al., 2012; Sunil and Ajay, 2012). In the research carried out by Steiner et al. (2004) a considerable increase of the microbiological activity after the use of biochar fertilization was proved. It could be seen in both the increase of the amount of biomass of microorganisms, as well as the increase of the biodiversity of the soil microflora (which additionally may influence stability of the ecosystem and had a nature of protection against pathogenic microorganisms). The increased microbiological activity influences the raise of the rate of mineralization, and thus the increase of bioavailability of nutrients for plants (Sunil and Ajay, 2012).

Physical and chemical properties, such as a developed specific area and porosity positively influence not only the biological properties (microbiological) but also improvement of the chemical properties and water relations of soil. Through the increased water retention (improvement of water-air relations), indirectly influences the decrease of the level of leaching biogenic components along with soil solution. Biochar acts as a modification filter for the retention time and the flow of soil solution (Sunil and Ajay, 2012; Zheng et al., 2013). Moreover, a positive influence of biochar addition on the pH increase and total cation capacity (CEC) was proved and thus availability of nutrients for plants (Galvez et al., 2012; Nelissen et al., 2014; Tang et al., 2013; Zheng et al., 2013).

The biocarbonization product may be used not only on cultivated soils as a biofertilizer, but also may be used in the remediation process of polluted and reduced soils, inter alia through inactivation of polyaromatic hydrocarbon and heavy metals bioavailability (Jinig et al., 2014; Mohan et al., 2014; Tang et al., 2013;). As Mohan et al. (2014) state biochar may play a role of a sorbent of the toxic organic compounds, such as pesticides, polycyclic aromatic hydrocarbons and synthetic chloro- and phospohorus – organic compounds. The use of carbon as a toxic sorbent is also presented in Sun et al. (2011), who shows ability to remove the phenatren (Phen), bisphenol A (BPA) and estradiol (EE2) compounds from water. Moreover, the potential use of the biocarbonization product. Moreover, possible use of biocarbonization product for removal of non-organic pollution, due to high sorptive properties in relation to heavy metals such as Pb^{2+}, Cu^{2+}, Ni^{2+}, and Cd^{2+}, was proved by Inyang et al. (2012) and Han et al. (2013).

Biochar as biofuel

In the power industry, drying digestate limits humidity, which constitutes ballast during storing and transport and also during the combustion processes or co-combustion of the dehydrated digestate in a heating plant, heat and power station, power stations and other industrial facilities (Kopczyński and Zuwała, 2013; Liu et al., 2013). High biomass humidity influences not only the increase of the transport costs but also the decrease of energy concentration (lower energy density). A high level of the water content during storing favours the biodegradation processes of the organic matter and thus from the point of view of power industry – lowering energy value. Moreover, hydrated biomass creates favourable conditions for pathogenic microflora development, which is dangerous for human and animal health. Fresh or dried digestate is a problematic fuel also from the point of view of installation, influencing its faster exploitation, therefore also in the co-firing processes, participation of this type of biomass is admissible and it should constitute up to 10% (Kopczyński and Zuwała, 2013). It means that energy potential of the remains from biogas plant may be increased through biomass torrefaction, which next to the processes such as drying of briquetting or pelleting may determine the wider energy use (Kopczyński and Zuwała, 2013; Liu et al., 2013; Troy et al., 2013).

During the torrefaction process, the loss of mass takes place in biomass (decrease of humidity) and chemical energy of raw material. The obtained product of carbonification – torrefaction product characterizes with an increased uniformity of material, grinding susceptibility and energy density (concentration), obtains also a hydrophobic nature. As a result of loss of mainly oxygen and hydrogen, it resembles carbons with its physical and chemical properties (Kopczyński and Zuwała, 2013; van der Stelt et al., 2011). Parameters of the selected biochars as biofuels were presented in Table 2.

Table 2

Characteristics of biochars as biofuel. Designations of substrates used for biochar production and temperature of the process: 1. Solid fraction of the digestate from pig manure (600°), 2. Coconut fibre (220ºC), 3. Coconut fibre (250ºC), 4. Coconut fibre (300°C), 5. Digestate from corn silage (190ºC) 6. Digestate from corn silage (230ºC) 7. Digestate from corn silage (270ºC)

Parameter	Substrate						
	1	2	3	4	5	6	7
Volatile substances (% d.m.)	69.7	69.8	67.9	53.6	-	-	-
Ash (% d.m.)	22	6.2	5	4.3	11.45	10.68	13.1
Combined carbon (%)	8	24	27.1	42.1	-	-	-
Total carbon (% d.m.)	45.2	-	-	-	30.72	19.71	12.34
Higher calorific value ($kJ \cdot mol^{-1}$)	19.1	24.7	26.7	29.4	25.4	30.3	33.8
Energy density	-	1.34	1.45	1.6	-	-	-
Energy capacity (% d.m.)	-	76.67	65.7	65	-	-	-
The molar ratio H/C	1.37	-	-	-	1.37	1.17	1.13
The molar ratio O/C	-	-	-	-	0.39	0.21	0.12
Biochar yield	-	-	-	-	71.8	46.2	41.3

Source: Liu et al., 2013; Mumme et al., 2011; Troy et al., 2013

In the research carried out by Liu et al. (2013), Mumme et al. (2011) and van der Stelt et al. (2011) decrease of the product- torrefaction product efficiency of yield was proved. On the other hand, research prove that along with the increase of the process temperature, increase of the calorific value takes place and grindability of the torrificated biomass (Liu et al., 2013; Mumme et al., 2011; Troy et al., 2013). Moreover, with the decrease of the the molar ratio of hydrogen and carbon and oxygen and carbon (indexes of aromatization and carbonization degree) calorific value of torrefaction product increases ($MJ \cdot kg^{-1}$). Efficiency of biochar production is within 46-76%, whereas energy efficiency 77-90% (Kopczyński and Zuwała, 2013; Liu et al., 2013; Mumme et al., 2011; Troy et al., 2013).

Conclusion

Based on the literature review which was carried out, one may state that digestate mass may constitute a valuable substrate for biochar production.

Biochar due to its properties, may be used as soil improver, decomposing for a long time, which positively influences soil fertility, abundance in biogenic components and physical and water properties. Additionally, it may constitute an element of carbon biosequestration, thus contributing to the reduction of a greenhouse effect.

Use of biochar as biofuel through reduction of the waste amount and the increased participation of energy generated from the renewable sources, contribute to the decrease of the greenhouse gases emission. Additionally, the torrefaction process may constitute a stage of preconditioning (initial processing) before such processes as gasification and production of the 2nd generation biofuels.

To sum up, one should state that the process of torrefaction of the digestate and the application dimension of biochar are relatively weakly researched, which opens new areas for the research and development works on the possible use and meaning of biochar in the process of carbon biosequestration.

References

Bergman, P.C.A.; Boersm,a A.R.; Zwart, R.W.R.; Kiel, J.H.A. (2005). *Torrefaction for biomass co-firing in existing coal-fired power stations "biocoal"*. Report ECN-C-05-013 ECN, Petten, Holandia.

Czekała, W.; Pilarski, K.; Dach, J.; Janczak, D.; Szymańska, M. (2012). Analiza możliwości zagospodarowania pofermentu z biogazowni. *Technika rolnicza ogrodnicza leśna*, 4, 6-8.

Ding, Y.; Liu, Y.; Wu, W.; Shi; D.; Yang, M.; Zhong, Z. (2010). Evaluation of biochar effects on nitrogen retention and leaching in multi-layered soil columns. *Water, Air, and Soil Pollution, 213* (1), 47-55.

Sunil, K.; Ajay, B. (red.) (2012). *Management of composting engineering*. Synergism between compost and biochar for suitanable soil amelioration. Chorwacja, InTech, 167-199.

Galvez, A.; Sinicco, T.; Cayuela, M.L.; Mingorance, M.D.; Fornasier, F.; Mondini, C. (2012). Short term effects of bioenergy by-products on soil C and N dynamics, nutrient availability and biochemical properties. *Agriculture, Ecosystems & Environment*, *160*, 3-14.

Gołaszewski, J.; Wiśniewski, D.; Stolarski, M.; Zieliński, M.; Krzyżaniak, M.; Dębowski, M.; Białowiec, A.; Olba-Zięty, E.; Radawiec, W. (2013-2014). *ERANET Bioenergy: SE.Biomethane.* Raporty wewnętrzne. CBEO-UWM Olsztyn.

Han Y., Boateng A.A., Qi P.X., Lima I.M., Chang J. (2013). Heavy metal and phenol adsorptive properties of biochars from pyrolyzed switchgrass and woody biomass in correlation with surface properties. *Journal of Environmental Management*, 118, 196-204.

Inyang M., Bin Gao B.,Ying Yao Y., Yingwen Xue Y., Zimmerman A.R, Pullammanappallil P., Cao X. (2012). Removal of heavy metals from aqueous solution by biochars derived from anaerobically digested biomass. *Bioresource Technology*, 110, 50-56.

Jining, Z.; Lü, F.; Luo, C.; Shao, L.; He, P. (2014). Humification characterization of biochar and its potential as a composting amendment. *Journal of Environmental Sciences*, *26*(20, 390-397.

Knowles, O.A.; Robinson, B.H.; Contangelo, A.; Clucas, L. (2011). Biochar for the mitigation of nitrate leaching from soil amended with biosolids. *Science of the Total Environment*, *40917*, 3206- 3210.

Kopczyński, M.; Zuwała, J. (2013). Toryfikacja biomasy drogą do eliminacji barrier technologicznyhc wielkosklaowego jej współspalania. *Polityka Energetyczna*, *16*(4), 271-284.

Lehman, J.; Joseph, S. (red). (2009). *Biochar for Environmental Managment: Science Technology*. Earthscan. Londyn, 184-249.

Lehmann, J.; Rillig, M.C.; Thies, J.; Masiello, C.A.; Hockaday, W.C; Crowley, D. (2011). Biochar effects on soil biota. *Soil Biology and Biochemistry*, *43*(9), 102.

Liu, Z.; Quek, A.; Hoekman, S.K.; Balasubramanian, R. (2013). Production of solid biochar fuel from waste biomass by hydrothermal carbonization. *Fuel*, *103*, 943-949.

Masto, E.; Kumar, S., Rout, T.K.; Sarkar, P.; George, J.; Ram, L.C. (2013). Biochar from water hyacinth (Eichornia crassipes) and its impact on soil biological activity. *Catena, 111*, 64-71.

Mohan, D.; Sarswat, A.; Ok, Y.S.; Pittman, Jr. C.U. (2014). Organic and inorganic contaminants removal from water with biochar, a renewable, low cost and sustainable adsorbent. *Bioresource Technology*, *160*, 191-202.

Mumme, J.; Srocke, F.; Heeg, K.; Werner, M. (2011). Use of biochars in anaerobic digestion. *Bioresource Technology*, *164*, 189-197.

Nelissen, V.; Saha, B.K.; Ruysschaert, G.; Boeckx, P. (2014). Effect of different biochar and fertilizer types on N_2O and NO emissions. *Soil Biology and Biochemistry*, *70*, 244-255.

Sun, Y.; Gao, B.; Yao, Y.; Fang, J.; Zhang, M.; Zhou, Y.; Chen, H.; Yang, L. (2014). Effects of feedstock type, production method, and pyrolysis temperature on biochar and hydrochar properties. *Chemical Engineering Journal*, *240*, 574-578.

Tang, J.; Zhu, W.; Kookana, R.; Katayama, A. (2013). Characteristics of biochar and its application in remediation of contaminated soil. *Journal of Bioscience and Bioengineering*, *116*(6), 653-659.

Troy, S.H.; Nolan, T.; Leahy, J.J.; Lawlor, P.G.; Healy, M.G.; Kwapinski, W. (2013). Effect of sawdust addition and composting of feedstock on renewable energy and biochar production from pyrolysis of anaerobically digested pig manure. *Biomass and Bioenergy*, *49*,1-9 ,

Van der Stelt, M.J.C.; Gerhauser, H.; Kiel, J.H.A.; Ptasinski, K.J. (2011). Biomass upgrading by torrefaction for the production of biofuels. *Biomass and Bioenergy*, *35*(9), 3748-3762.

Zheng, H.; Wanga, Z.; Denga, X.; Herbert, S.; Xing B. (2013). Impacts of adding biochar on nitrogen retention and bioavailabilty in agricultar soil. *Geoderma*, *206*, 32-39.

BIOWĘGIEL Z MASY POFERMENTACYJNEJ BIOGAZOWNI ROLNICZEJ JAKO PRODUKT ENERGETYCZNY I POLEPSZACZ GLEB

Streszczenie. Masa pofermentacyjna, jako biodegradowalny odpad biogazowni rolniczej może podlegać zagospodarowaniu bezpośredniemu jako nawóz lub też, po separacji fazy stałej i ciekłej – faza stała może być poddana termochemicznej transformacji do biowęgla. Biowęgiel jest karbonizatem o wysokiej koncentracji węgla i względnie małej podatności na rozkład, pozyskany z różnego rodzaju odpadów organicznych (International Biochar Initiative). Uwęglenie biomasy następuje w procesie toryfikacji w temperaturze od 200ºC do 320ºC. Skład chemiczny oraz właściwości użytkowe biowęgla uzależnione są od rodzaju substratu oraz parametrów procesu. Pozyskiwany z odpadów biodegradowalnych może być elementem biosekwestracji węgla i wykorzystany jako biopaliwo, zaś w rolnictwie – jako długo rozkładający się polepszacz gleby pozytywnie wpływający na żyzność gleby, zasobność w składniki biogenne oraz właściwości fizyczne i wodne. W pracy przedstawiono charakterystykę procesu toryfikacji, produkty procesu oraz walory użytkowe biowęgla z punktu widzenia wartości energetycznej i rolniczej.

Słowa kluczowe: biowęgiel, toryfikacja, bionawóz, biosekwestracja, biopaliwo

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PROBLEMS WITH DERIVING THE FRUIT TREE PRUNED BIOMASS FOR ENERGY USE

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ABSTRACT

Biomass, wood in particular, is one of the main renewable energy sources. The authors' point of interest is the use of the orchard biomass, produced annually as a result of pruning the trees and shrubs, for the heating purposes, as such biomass is used for this purpose only to a little extent both in our country and in Europe. Such biomass, consisting mainly of branches and shoots, is usually shredded and left in the orchard interrows to serve as a natural fertilizer. This paper focuses on the reasons why it should be collected and removed from the orchard. It presents the technologies of pruning and collecting such biomass, and analyses the newest machine constructions that allow for fast collection and compaction of dendromass to the form which facilitates its storage and natural drying.

Introduction

As the civilization progresses, the world needs more and more energy. It is evident that the conventional energy sources are rapidly diminishing. Therefore, the use of the renewable sources is the necessity of our times. Nowadays, it is the biomass that is the main renewable energy source. It is the cheapest form of renewable energy and, importantly, it is easy to obtain (Romański, 2013). Forest dendromass constitutes the largest part of wood that is used for heating purposes in our country. The biomass derived from the municipal management sector, cultivation of trees growing on the roadside, parks, local green squares and short rotation plantations, is definitely used less frequently as a renewable energy source (Piszczalka et al., 2007). The orchard biomass, produced every year as a result of pruning of trees and shrubs, was used for heating purposes, both in our country and in Europe, only to a small extent.

According to the data of National Agricultural Census carried out in 2010, the orchard area in Poland amounted to 374,200 ha, and, compared to 2002, it was bigger by 103,200 ha, i.e. by 38.1% (GUS, 2013). On the other hand, the number of farms with orchards decreased by 10.2% (by 32,200 ha) compared to the previous census of 2002, and amounted to 284,600. The average area of orchards in agricultural farms was increased from 0.86 ha in 2002 to 1.31 ha in 2010, which reflects the fact that the orchards are localized in bigger

farms. Nowadays 60% of orchard farms in Poland grow their trees on the areas bigger than 5 ha. The largest parts of such areas are covered with apple orchards (fig. 1). We are the third largest producer and first largest exporter of apples in the world.

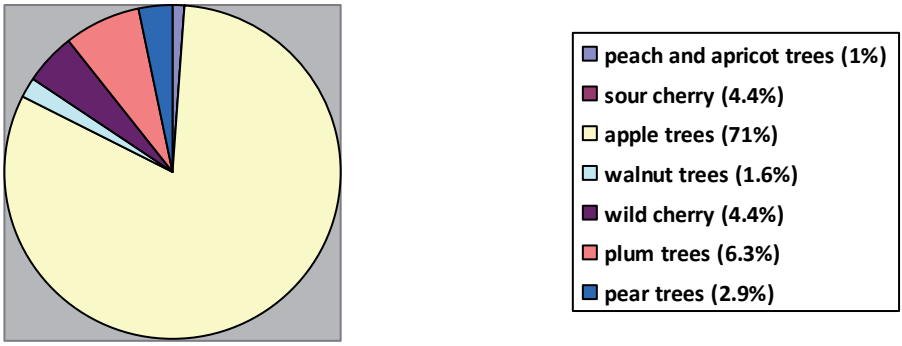

Figure 1. Pie chart illustrating the cultivation of fruit trees in Poland in 2012 (GUS, 2013)

A lot of biomass, mainly composed of branches and shoots, is obtained as a result of annual cultivation works carried out in high productivity farms. Pruning is the main and most important cultivation method. It is used to control the growth of trees and shrubs, as well as to improve the quality of fruit and the size of yield. It is difficult to determine the amount of dendromass produced in Poland as, up until now, the orchardists' interests and research focused mainly on the works aiming at the increase of amount and efficiency, as well as the deduction of costs of obtaining the fruit from a hectare.

There are major differences in the scarce specifications of the amount of biomass residue, depending whether it is the opinion of the practitioners or literature – both domestic and foreign. The substantial differences (100-300%) in the amount of pruned wood biomass most probably result from the method of calculating such amount. Table 1 presents the amount of wood that is possible to be derived from apple orchards (Maciak and Lipińska, 2006).

Assuming that the orchard is used for 25 years, the total of (40-70%) of wood pulp is derived from the yearly cultivation works (thinning) compared against the total biomass produced by the orchard during the time period of its use. The remaining amount (30-60%) includes the matter of trunks and branches recovered during the clearing of an orchard. As you can see, in the case of the total amount of the recovered wood, there will even be a two-time difference in the results.

The wood biomass, which is the fruit trees pruning residue, is rarely used in the energy sector. The cut-off branches and shoots are, in most cases, left by the trees. When the manual pruning is applied, the most popular method, both the branches and shoots are thrown onto the interrows. Thanks to that, they can be easily mechanically shredded and left as a natural fertilizer. Some of the orchardists remove the pruned biomass to the far end of the orchard and burn it, assuming that it is cheaper for them to manage the residue in such a way. The least popular method of handling such biomass involves collecting it and treating it as a heating fuel.

Table 1
Average amount of wood that is possible to be derived from apple orchards

Planting density (pcs·ha^{-1})	Amount of wood (m^3·ha^{-1})		
	from trunks	from branches	from thinning
up to 1,200	12.75	13.04	0.83
1,200-2,400	11.98	6.84	1.71
above 2,400	2.90	2.18	–

Leaving the dendromass between the trees to serve as a natural fertilizer or burning it should be analysed, first of all, by taking into account the environmental protection. The LCA (Life Cycle Assessment) of the final product will enable the analysis of these two opposite technologies (fertilizing or combusting for heating purposes). The aim of the assessment is the comprehensive analysis of how the product affects the environment and natural resources.

The LCA analysis of the aforementioned two technologies used in apple orchards was carried out by Boschiero's team from the University in Bolano (Boschiero et al., 2013). The analysis proved that the technology in which the dendromass residue is collected and combusted for heating purposes is safer for the environment.

Furthermore, this technology leads to a decreased consumption of energy from conventional sources. The useful heat is the tangible and direct outcome of using this technology by an orchardist.

Orchard dendromass – pruning methods

The branches and shoots may be cut off manually or mechanically. The following tools are used for manual cutting, the method which is still used for most of the tree species: lever pruning shears, two-handed pruning shears, telescopic pruning shears, and all kinds of saws (Rabcewicz, 2007). Either the pneumatically (fig. 2) or electrically (fig. 3) driven tools may be used in order to facilitate the works carried out in the orchards with larger surface areas (especially apple and pear orchards), where winter pruning is commonly associated with aching muscles and sprained wrists.

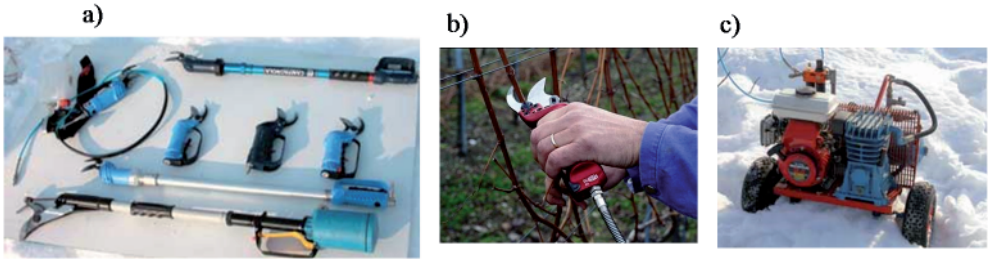

Figure 2. Set of pneumatically driven orchard tools: a), b) pruning shears, c) air compressor powered by a combustion engine

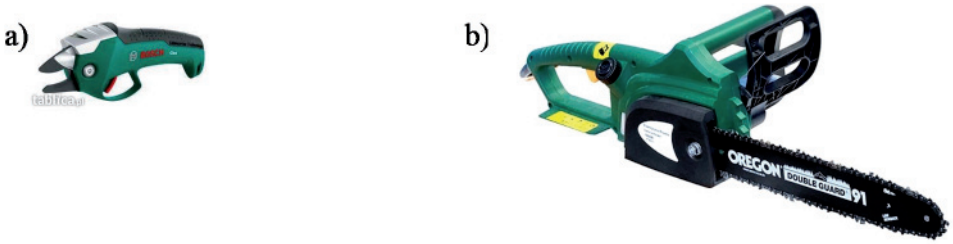

Figure 3. Set of electrically driven orchard tools: a) lever pruning shears with the battery under the housing, b) chain saw

The pneumatic pruning shears used in orchards are powered by 1-1.2 MPa compressed air generated in a portable compressor. Depending on the size of such compressor, it may supply power to 2 to 6 pruning shears at one time. If there are more than 3 pruning shears, the compressor unit is most commonly supplied with power from PTO (power take-off) of a tractor. The thickness of the cut amounts to approx. 30 mm. The use of the discussed pruning shears reduces the effort of the employees engaged for pruning work, and increases the work efficiency by 20-30% when compared to the use of manual pruning shears.

Electrical pruning shears allow for a greater freedom of movement and not being bound by the compressor unit.

Mechanical pruning in orchards is getting more and more popular in Western countries (Scholten, 2010). The main advantage of mechanical pruning of branches is the fact that the energy intensity of this activity is much lower. For example, the pruning time in an apple orchard is reduced from several dozen hours to approx. 3 $h \cdot ha^{-1}$ (Wilczyńska, 2013). The result of mechanical pruning is the so-called "fruit wall" in an orchard, i.e. a line which is not usually higher than 3.5 m and the crown thickness of which amounts to 0.6-0.8 m at the bottom and 0.4-0.6 at the top (fig. 4), depending on the species. The spacing between the rows should amount to 3-3.5 m so that the tractor with a cutting machine could move along. With this geometry of an apple orchard, it is possible to have 25 fruit from 1 m^2 of the wall, which means the crops in the amount of 70 $t \cdot ha^{-1}$.

The disadvantages of mechanical pruning include: 2-5-day delay in harvesting fruit compared to the manual pruning, risk of the tendency of producing fruit of small size and less intensive colours in the case of small variety of fruit.

The machines used for pruning the annual plant growth in orchards may be divided into blade and disc pruning machines (fig 5). The blade pruning machines are suitable for cutting off small branches, the diameter of which does not exceed 30 mm. Due to their simple structure, they are cheaper than disc pruning machines. The idea for the design was adopted from the cutter bar mowers used for cutting grass. Such machines are usually mounted at the front of the tractor and they are supplied with power from PTO. They consist of two operating sections: a vertical section – used for pruning the side of the line of trees, and a horizontal section, located above the vertical one – used for pruning the tops of the trees to a set height. The most popular machine on the European market is called Edward and it

is produced by a German company called Fruit Tec. Another popular machine, CMA 250 type, is produced by Italian company called FA MA.

Figure 4. Apple orchard after being pruned mechanically using the method: "fruit wall"

Figure 5. Pruning machine being operated in an apple orchard: a) blade pruning machine, b) disc pruning machine

The latter machine can cut the branches the diameter of which reaches up to 40mm. Moreover, one of the machine setups allows for cutting the branches between the trunks, making the so-called windows. This configuration is possible as the machine is equipped with two rows of cutting sections: the outer one which is used for shaping the tree crowns into the form of a wall, and the inner one, made of four blades, which cuts the shoots between the trunks (Czerwiński, 2013).

The disc machines for pruning trees in orchards (Wilczyńska, 2013) are characterized by their versatility, as they may be used for pruning the new plantings and for reconstruction cuts in old orchards. The 45 kW tractors should usually be sufficient to power such machine. Its main components include two operating bars: a horizontal and a vertical one, on which the cutting discs are installed – same as in the saws for cutting wood. The possi-

ble inclination of the vertical bar towards the cut line of trees is max. 30°. Depending on the type of machine and its producer, it is equipped with 6-9 cutting discs which may cut the 3.5-4 m long branches. The horizontal bar of the machine, equipped with 2-3 discs, is used for pruning the tops of the trees. Such bar is 0.6-1 m wide. Additionally, there is a disc installed at the bottom, which is used for cutting the branches that drop too low. The discs may be replaced with blades during summer pruning. The machine is operated from the tractor cabin, with the use of a joystick.

Regardless of the machine used for pruning braches, the principle of the technology of pruning the orchard into the so-called wall, is that the old orchards are converted in the wintertime. Following the wintertime conversion, the regrowth is pruned every ear at the turn of May and June, so 6-7 weeks after the blossoming of the trees. In the case of small-fruit apple trees (e.g. Golden Delicius, Szampion), they are pruned either when the buds are pink or directly after the harvesting of fruit.

Furthermore, the small-fruit trees should be pruned manually, as it allows for more precise cutting. Even in this case the difference in man-hours between the manual pruning and mechanical pruning with supplementary manual pruning will amount to approx. 50 $h \cdot ha^{-1}$.

Management of the pruned branches and shoots

The branches and shoots that have been pruned and left in the orchard interrows may be disposed of in two ways, i.e. by shredding or removing from the orchard. Hammer shredders (fig. 6) are used for shredding and leaving the dendromass in the interrows. They are also referred to as hammer mowers or mulchers. These machines are mounted on the back of the tractor on a three point linkage and they are supplied with power from PTO. The so-called oscillating hammer blades are mounted on the horizontal bar. Depending on the shape and thickness of such blades, the machine is suitable for cutting and shredding the grass, overgrowth or branches in orchards.

Figure 6. Hammer shredder being operated in an orchard

The removal of branches and shoots beyond the area of an orchard or plantation, despite being more costly, offers measureable benefits. First of all, the orchardist disposes of dendromass affected by diseases and pests, which positively affects the health of the trees, and second of all, the orchardist obtains the biofuel which may be used for heating purposes. The pruned dendromass may be collected in one or two-stage processes.

In the case of the common, yet more expensive, two-stage technology (Magagnotti et al. 2012), you need to first prepare the branches and shoots for removal by gathering them in the middle of the interrows. The machine called a sweeper (fig. 7), modelled on hay rakes and tedders, produced by the Polish company Agromod, may be used for this purpose. The presented machine simultaneously removes the branches from both sides of the interrows. It is possible thanks to the adjustable distance between the sweeping rotors, which are made of flexible, but highly resistant plastic bars. Adjustable distance allows the machine to be operated in orchards with the interrow spacing within the scope of 2.7-4.3 m. The rotational speed of rotors may be smoothly adjusted with the use of hydraulic drives, depending on the needs and conditions. The machine performance amounts to 1.5 $ha \cdot h^{-1}$ and when the shredder is mounted on it - to 1.5-1.7 m (at the back of the tractor the performance is a little lower and amounts to 1 $ha \cdot h^{-1}$).

Figure 7. Sweepers gathering the pruned pulp into the middle of the interrow: a) with raking out elements, b) with belts

In the second stage, the branches and shoots arranged in the middle of the interrows are collected and shredded by mowers (shredders) with collectors (fig. 8). The shredded wood biomass may then be used for the production of pellets or be combusted in a heater. The biofuels obtained in this manner may also be sold to the companies involved in energy generation. After both the shredder and the sweeper are mounted on the tractor, the collection of wood biomass may be carried out in one stage.

Besides the technology of collecting and shredding the dendromass, the dendromass baling technology is progressing as well. Nowadays, the balers (fig. 9) are mainly used at the grapevine plantations (Spineli and Pichci, 2010; Cavalagio and Contana, 2007; Contana

et al., 2009). They may also be used for pressing the pruned biomass in the orchards and berry plantations. The pruning residue is collected from the interrows with the use of a pickup. It is then fed into the machine where, in the bale chamber, the rubber belts, rolls, or a combination of rolls and chains, roll up the pruned residue into cylindrical-shaped bales.

Figure 8. Flail mower collectors of wood biomass

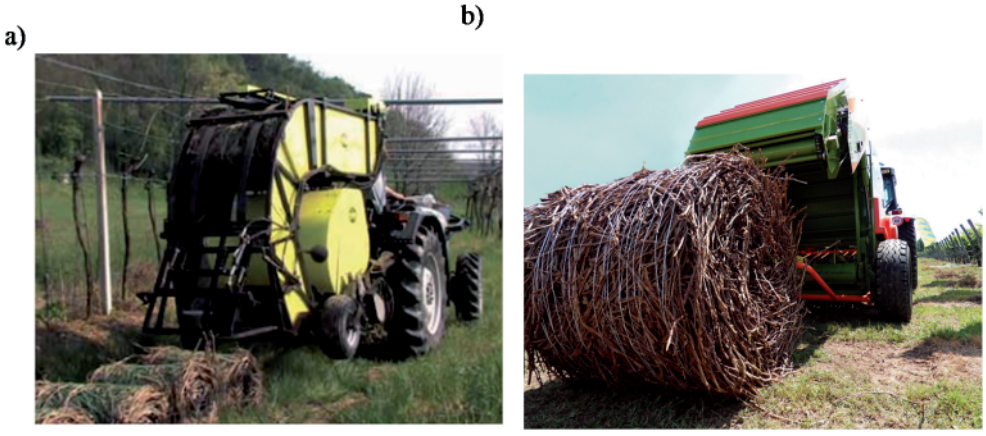

Figure 9. Baler: a) diameter of bales: 0.4-0.45 m, b) diameter of bales: 1.2 m

When the bale reaches the appropriate size and level of compaction, it is wrapped with a plastic net, rope or a thin wire. After securing such bale against unwinding, the rear wall of the baler is opened and the bale is released outside of the machine. The most common balers are the ones produced by the company CAEB International and Wolagri from Italy.

These are the machines that are mounted on the tractor and supplied with power from PTO. The main difference between these machines is their size, and so the mass of the rolled bales. The smaller machines (e.g. Quickpower series machines) for rolling single bales may be powered with 15 kW tractors. The diameter of the produced bales amounts to 0.4-0.45 m, and their length to 0.6 m. The weight of one bale does not usually exceed 35 kg, after it is dried: 10-15 kg. The machines may be optionally equipped with a "bales storeroom" for storing 8 bales (fig. 9a). Storing the bales facilitates and shortens the time for transporting them beyond the area of an orchard.

The company Wolagri manufactures much bigger and efficient machines (fig. 9b). These machines operate in a similar way to the ones discussed above. The diameter of the bales rolled by these machines reaches 1.2 m, with the length of approx. 1 m. Additionally, there are vertical cylindrical pick-up reels installed before the inlet to the bale chamber which facilitate the intake of the biomass. In order to supply the power to the baler, the tractor's power needs to be over 30 kW (Wolagri, 2013). On the one hand, large-sized bales shorten the time of collecting the pruned dendormass, but on the other hand, they might be difficult to use as they often do not fit into the boiler and furnace throats, or into the stationary shredders. Simultaneous shredding of several bales in the feed mixing wagon, used for the preparation of roughage for cattle, is an interesting solution (Cavalagio and Contana, 2007).

Except for the round balers, it is also possible to use rectangular balers that press the bales to the cuboid form (fig. 10). Such balers are not very popular in Europe.

Figure 10. Rectangular baler for compacting the dendromass.

The humidity of the collected pruned material often exceeds 40% and makes it unsuitable for burning. Therefore, such material should be dried first. The bales should be arranged in stockpiles in order to dry as quickly as possible. The drying is easier if the bales are not densely compacted (400-550 $kg \cdot m^{-3}$). As a result, the material is ready to be combusted in the form the entire bales or chips (after being shredded), already after several months. Such drying method guarantees the elimination of fermentation and mould growth risk.

Conclusion

The branches and shoots pruned in Polish orchards as a result of the cultivation and sanitary purposes are either shredded and left in the interrows, or removed from the orchard area and incinerated. In the first case, the dendromass is treated as a natural fertilizer. In the second one, besides the removal of branches from the orchard, we also eliminate the potential sources of infection for the healthy trees. Therefore, this method could be recommended if the economic balance was not taken into account. Each kilogram of wood pulp that is burned is the unused heating source (2-4 $kWh \cdot kg^{-1}$). The international research team has been established within the project called Europruning in order to prevent these unbeneficial tendencies. The objective of this team, the members of which also include the authors of this paper, is to comprehensively solve the problem of the dendromass produced every year in orchards. The aim of the Polish part of the team is to specify the amount of the dendromass in Polish orchards and its energy potential, as well as to design, execute and test the prototypes of machines used for collecting and compacting the biomass residue in orchards. This paper, presenting the review of the applied technologies and machines used for pruning and management of orchard dendromass, is one of the many works implemented by the persons engaged in the execution of the project, as a result of which the problem of obtaining and preparing the dendromass for the energy purposes will be resolved comprehensively.

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References

Bisaglia, C. (2010). *Collecting and baling prunings to produce energy*. Pozyskano z: http://www.caebinternational.it/w/lang1/biomasses.html.

Boschiero, M.; Neri, P.; Zerze, S. (2013). Apple orchard pruning residues as a potential bioenergy source in South Tyrol: a LCA case study. *Bioresources Technology, 128*, 697-703.

Cavalagio, G.; Contana, S. (2007). *Recovery of vineyards pruning residues in an agro-energetic chain*. 15th European Biomass Conference & Exibition. Florence.

Contana, F.; Cavalagio, G.; Rinaldi, S. (2009*). Energy and environmental performance of a polygeneration plant from vineyard pruning residues*. 17th European Biomass Conference & Exhibition . Amburgo. Pozyskano z: http://www.crbnet.it.

Czerwiński, H. (2013). Cięcie mechaniczne w praktyce. *Owoce warzywa kwiaty, 1*, 52-55.

GUS. (2013). *Produkcja ogrodnicza. Badanie sadów.* Wyd. GUS Warszawa, ISNN 1898-4347.

Maciak, A.; Lipińska, G. (2006). Możliwości i koszty pozyskiwania drewna z sadów. *Nowy sad,* 3, 59-61.

Magagnotti, N.; Pari, L.; Pichci, G.; Spinelli, R. (2012). Technology alternatives for tapping the pruning residue resource. *Bioresour Techol., 128*, 697-702.

Piszczalka, J.; Kaernko, M.; Rutkowski, K. (2007). Ocena energetyko-ekonomiczna ogrzewania dendromasom. *Inżynieria Rolnicza, 6*(94), 189-196.
Rabcewicz, J. (2007). Maszyny i narzędzia do cięcia krzewów jagodowych. *Hasło ogrodnicze, 1*, 12-16.
Romański, L. (2013). Energia odnawialna. *Ekonatura, 11*,14-19.
Spineli, R.; Pichci, G. (2010). Industrial harvesting of olive tree pruning residua for energy biomass. *Bioresource Technology, Vol.101*, Issue 2 ,730-735.
Scholten, H. (2010) .Szpaler koroną przyszłości?. *Sad Nowoczesn*, *4*, 12-14.
Silvestri, S.; Cristoforetti, A.; Mescalchin, E. (2011). *Recovery of pruning waste for energy use: agronomic, economic and ecological aspets*. Central European Biomass Conference. Graz. Austria.
Wilczyńska, A. (2013). Mechaniczne cięcie jabłoni. *MPS Sad, 2*, 12-13.
Wolagri. (2013). *Katalig-Columbia R98 Energy*. Pozyskano z: http://www.wolagri.com.

PROBLEMY POZYSKIWANIA BIOMASY Z PRZYCINKI DRZEW OWOCOWYCH DLA CELÓW ENERGETYCZNYCH

Streszczenie. Jednym z głównych źródeł energii odnawialnej jest biomasa, a szczególnie drewno. W obszarze zainteresowania Autorów jest masa drzewna z upraw sadowniczych, corocznie powstająca w wyniku przycinania drzew i krzewów dla celów grzewczych, gdyż w naszym kraju, ale także w Europie, jest ona wykorzystywana w małym stopniu. Masa ta, głównie w formie gałęzi i pędów jest najczęściej rozdrabniana i pozostawiana w sadach w międzyrzędziach drzew jako naturalny nawóz. W pracy zwrócono uwagę na powody, dla których powinna ona być zbierana i wywożona z sadu. Przedstawiono technologie wycinania i zbioru tej masy oraz omówiono najnowsze konstrukcje maszyn umożliwiające szybki zbiór i zagęszczenie dendromasy do postaci, w której ułatwione będzie jej przechowywanie i naturalne podsuszanie.

Słowa kluczowe: dendromasa, metody wycinki, zbiór masy drzewnej

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COMPARISON OF GREENHOUSE GAS EMISSIONS DURING SUMMER FROM DEEP LITTER AND FULLY-SLATTED PIGGERY

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pigs

ABSTRACT

The aim of the study was to determine greenhouse gases emission factors from fattening pigs kept on deep litter and on fully slatted floor in order to compare them. The emissions were measured from July to September 2013. The buildings were located in the farms in the neighbourhood, in the Wielkopolskie Voivodeship. Gas concentrations were measured by photo – acoustic spectrometer Multi Gas Monitor INNOVA 1312. The average value of CO_2 emission factor was 105 g·day^{-1}·kg^{-1} (V_{CO2}=29%) for the deep litter and 62 g·day^{-1}·kg^{-1} (V_{CO2}=31%) for a system with a fully slatted floor. For N_2O value was respectively 0.047 g·day^{-1}·kg^{-1} (V_{N2O}=31%) and 0,027 g·day^{-1}·kg^{-1} (V_{N2O}=34%). The CH_4 emission factor value was respectively 0.809 g·day^{-1}·kg^{-1} (V_{CH4}=63%) and 0.715 g·day^{-1}·kg^{-1} (V_{CH4}=30%). The emission factors of researched gases were higher in deep litter fattening house, for CO_2 by 69%, for N_2O by 74% and for CH_4 by 13% than in the building with a fully slatted floor. According to the warming potentials of greenhouse gases, rearing pigs on deep litter would emit 59% more of CO_2 –equivalents.

Introduction

Agriculture, and in particular animal production, is one of the main reasons for environmental problems worldwide (Monteny et al., 2006; Steinfeld and Wassenaar, 2007). It is the main source of gas pollution (Kolasa-Więcek, 2012). Greenhouse gases such as: carbon dioxide, methane and nitrous oxide influence global warming and cause climatic changes. Additionaly, methane and nitrous oxide affect decrease of ozone layer in the stratosphere (IPCC, 2007; Jugowar, 2001; 2013).

In the FAO report (2006) „*Livestock Long Shadow: Environmental Issues and Options*" it was stated that agriculture causes 18% of global emission of anthropogenic greenhouse gases, including: 9% CO_2 emission, 37% CH_4 emission and 65% N_2O emission. These values differ in relation to the world part. According to KOBIZE (State Centre for Emission

Balancing and Management) participation of agriculture in the national emission of greenhouse gases in 2011 was 9.4% (not including CO_2). It is estimated that this sector causes up to 34.1% of total methane emission in Poland and 83.7% of the national nitrous oxide emission (KOBIZE, 2013). Emission of gas pollutions is calculated based on theoretical emission factors, values of which differ from factors obtained during research carried out in livestock buildings (Mielcarek, 2012).

Review of national and international papers shows that there are considerable differences in values of greenhouse gases emission factors. They depend on many factors, inter alia: measurement period, various micro and macro-climate parameters and also measurement devices (Jungbluth et al., 2001; Rigolot et al., 2010). Research concern mainly non-litter housing systems, whereas not many of them is carried out in buildings with the litter housing system. It is caused by a relatively low popularity of these systems in the industrial pigs rearing in the Western Europe. There are not many papers, where research of gas emissions from two different pigs housing systems were carried out at the same time.

The aim of the study was determination of greenhouse gases in the summer season, from deep litter and fully-slatted piggery for fattening pigs and their comparison. It allowed determination of emission factors of the researched pollutions and indication of the housing systems of the less negative impact on the environment.

Methodology

Research facilities

The research was carried out from July to September 2013 in two piggety for fattening pigs with various housing systems. They were located in the farms in the neighbourhood, in the Wielkopolskie Voivodeship. It allowed prevention of the impact of meteorological conditions on the obtained results. In the piggeries pigs were fattened in the open system. In the A building pigs were kept on the deep litter and fed dry fodder ad libitum. It has 10 chambers in which is kept 100 pigs in two pens (nominal livestock of a piggery was 1000 items).

Whereas, in the B building pigs were housed without litter, on the fullty-slatted floor and fed 4 times a day liquid fodder. Ten pens for fattening pigs are located on each of two storeys of the piggery (nominal animal number was 600 pigs). For comparative research one chamber from the A building and the ground floor of B piggery were selected, where, during the measurement period fattening pigs of a comparative mass were kept (initial 30 kg, final 80 kg). The area per one pigs in both buildings was 0.77 $m^2 \cdot pig^{-1}$.

Both piggeries were equipped with temperature controlled mechanical ventilation. In the investigated A piggery, there were installed 2 fans of a nominal efficiency 6,250 $m^3 \cdot h^{-1}$ each (nominal efficiency per pigs 125 $m^3 \cdot h^{-1} \cdot pig^{-1}$). Whereas, on the ground floor of the B facility there were installed 3 fans of a nominal efficiency 7.850 $m^3 \cdot h^{-1}$ each (nominal efficiency per pig 125 $m^3 \cdot h^{-1} \cdot pig^{-1}$). In both buildings, the regulated inlets of fresh air were placed in side walls of buildings.

Figure 1. Piggery A

Figure 2. Chamber in the A piggery

Figure 3. Piggery B

Figure 4. Lower storey of B piggery

Measurement of air exchange and concentration of gas pollution

The real efficiency of fans in the investigated piggery was determined according to the standard PN-EN 12599:2013 "Ventilation of buildings – Procedures of research and measurement methods used during the reception of ventilation installation and air conditioning" for two flap positions in air inlets (fully-opened and half-opened). Based on the prepared temperature characteristics of the ventilation systems and data from daily temperature monitoring inside the buildings a daily air exchange rate were calculated.

In order to determine greenhouse gases emission, 4 daily measurements of concentration of gas pollution were carried out for each. Photo-acoustic spectrometer Multi Gas Monitor 1312 was used thereto. Air samples were collected at the inlet to the ventilation channel and the concentration value of gas pollutions were registered every hour.

Temperature and relative humidity of air inside buildings were measured in one hour intervals used TESTO recorder 175-H2.

Gas pollutions emission

Daily emission of the investigated gases (E_g) was calculated as a product of the concentration value in the investigated piggery and a daily air exchange rate in buildings (1). Daily greenhouse gases emission factor (WE_g) was determined as a quotient of daily gas emission and total mass of animals from the equation (2):

$$E_g = c_g \cdot V_d \cdot 10^{-6} \tag{1}$$

where:
E_g – emission of gasses (kg·day^{-1}),
c_g – average daily concentration of gases in air removed from a building (mg·m^{-3}),
V_d – daily air exchange (m^3·day^{-1}),

$$WE_g = E_g \cdot m^{-1} \cdot 10^3 \tag{2}$$

where:
WE_g – daily gases emission factor (g·day^{-1}·kg^{-1}),
m – total mass of animals in the building (kg).

Calculated values of factors were described with basic descriptive statistics: arithmetic mean, standard deviation and coefficient of variance.

Total emission factor of the investigated greenhouse gases in the equivalent of CO_2 (WE_{qCO2}) calculated from the relation (3):

$$WE_{qCO_2} = WE_{CO_2} + 23\,WE_{CH_4} + 296\,WE_{N_2O} \tag{3}$$

where:
WE_{CO2} – daily carbon dioxide emission factor (g·day^{-1}·kg^{-1}),
WE_{CH4} – daily methane emission factor (g·day^{-1}·kg^{-1}),
WE_{N2O} – daily nitrous oxide emission factor (g·day^{-1}·kg^{-1}).

Thermal potential GWP (*Global Warming Potential*) for methane and nitrous oxide was accepted after IPCC (2001).

Results and a discussion

Results of daily measurements of concentrations of the investigated gases were presented in table 1. It also presents average daily values of temperature and relative humidity of air inside researched buildings and total mass of animals kept in the piggeries during the research.

Average daily values of carbon dioxide and nitrous oxide concentrations in both buildings were comparable, they characterized with low diversity and had values from 2,004 to 2,865 mg·m^{-3} for CO_2 and from 0.88 to 1.17 mg·m^{-3} for N_2O. Considerable changes occurred in concentration of methane between the investigated buildings as well as between particular measurement data. Is was lower in the deep litter piggery and was from 6.3 to 60.7 mg·m^{-3}, whereas in a non-litter piggery, it was on the level from 17.7 to 44.4 mg·m^{-3}. The last day of measurement was an exception. Difference favorable for the building B resulted from bedding down in a piggery on deep litter which was not on time.

Table 1
Average daily concentration of greenhouse gases in a piggery

Measurement date		Average daily		Total mass of pigs (kg)	Average daily concentration ($mg \cdot m^{-3}$)		
		temperature (°C)	relative humidity (%)		CO_2	N_2O	CH_4
Building A	08.07.2013	25.4	65.8	3570	2223	1.00	6.3
	22.07.2013	25.6	60.5	4798	2102	0.97	7.5
	12.08.2013	24.8	63.7	5693	2269	1.02	22.5
	05.09.2013	23.8	61.1	7920	2865	1.17	60.7
Building B	09.07.2013	25.5	61.7	8730	2004	0.88	17.7
	23.07.2013	25.3	51.6	13095	2212	0.95	22.3
	13.08.2013	23.7	62.4	17460	2660	0.96	44.4
	04.09.2013	23.9	61.4	23280	2049	0.90	26.7

Table 2 presents values of daily emission of gas pollutions from a piggery, calculated based on the equation (1).

Table 2
Daily emission of gas pollutions

Measurement date		Average air exchange ($m^3 \cdot h^{-1}$)	Average daily emission ($kg \cdot day^{-1}$)		
			CO_2	N_2O	CH_4
Building A	08.07.2013	10082	530	0.239	1.51
	22.07.2013	9983	494	0.227	1.73
	12.08.2013	9972	537	0.240	5.26
	05.09.2013	8714	584	0.241	12.12
Building B	09.07.2013	16264	747	0.334	6.74
	23.07.2013	15467	778	0.346	7.93
	13.08.2013	11321	719	0.259	11.96
	04.09.2013	11137	539	0.238	6.95

Average emissions of nitrous oxide in the investigated facilities were on a comparable level despite almost three times higher stock in the building with a slatted floor. Relation between the stock and the level of emission was noticeable in case of carbon dioxide and methane. In deep litter piggery average daily emission of CO_2 was lower and in case of CH_4 it was even few times lower than in building B.

From the relation (2) daily emission factors of the above mentioned air pollutions were calculated in each investigated day and presented in table 3.

Table 3
Daily factors of gas pollution emission related to 1 kg of body mass

Measurement date		Daily emission factor ($g \cdot day^{-1} \cdot kg^{-1}$)		
		CO_2	N_2O	CH_4
Building A	08.07.2013	148	0.07	0.42
	22.07.2013	103	0.05	0.36
	12.08.2013	94	0.04	0.92
	05.09.2013	74	0.03	1.53
Building B	09.07.2013	86	0.04	0.77
	23.07.2013	59	0.03	0.61
	13.08.2013	41	0.01	0.69
	04.09.2013	23	0.01	0.30

Calculated values of gas emission factors were described with arithmetic means, standard deviation and coefficient of variance and were presented in table 4. It allowed comparison of the investigated piggery between themselves and with results presented in other papers

Table 4
Average gas pollutions emission factors in the investigated period

	CO_2		N_2O		CH_4	
	Building A	Building B	Building A	Building B	Building A	Building B
$\bar{y}$ ($g \cdot day^{-1} \cdot kg^{-1}$)	105	62	0.047	0.027	0.809	0.715
SD ($g \cdot day^{-1} \cdot kg^{-1}$)	30	19	0.014	0.009	0.511	0.218
V_y (%)	29	31	31	34	63	30

$\bar{y}$ – average, SD – standard deviation, V_y – coefficient of variance

Comparing the researched buildings, it has been found that differences between the emission factors of CO_2 and N_2O are statistically very significant ($p<0.001$). Their values in deep litter piggery were higher than in a fully-slatted piggery, for carbon dioxide by 69% and nitrous oxide by 74%. In case of methane, differences in values of emission factor were also statistically significant ($p<0.05$). Its value was by 13% higher in deep litter building.

Factor of carbon dioxide emission from deep litter piggery (105 $g \cdot day^{-1} \cdot kg^{-1}$) was almost two times higher than for non-litter system (62 $g \cdot day^{-1} \cdot kg^{-1}$). Philippe et al. (2007) compared emission of greenhouse gases for those two systems of housing pigs for CO_2 obtained

values 29 g·day^{-1}·kg^{-1} in the deep litter system and 26 g·day^{-1}·kg^{-1} for the fully-slatted floor. Comparing calculated in the paper values of factors with the research results, concerning non-litter systems carried out by Gallmann et al. (2003), Dong et al. (2007) and Costa and Guarino (2009), which are within 26 to 40 g·day^{-1}·kg^{-1}, they are higher, which is caused by a summer period of measurements and parameters of ventilation system operation.

Higher emission of N_2O was reported from the deep litter piggery. Similar relation was reported by Philippe et al. (2007) emission of this gas was also higher in a litter system piggery (0.02 g·day^{-1}·kg^{-1}) than in a non-litter system (0.001 g·day^{-1}·kg^{-1}). Available in literature values of factors of emission of N_2O for systems with a slatted floor are considerably lower than the obtained in this paper and they are within 0.001 to 0.007 g·day^{-1}·kg^{-1} (Sneath et al., 1997; Guarrino et al., 2003; Amon et al., 2007; Dong et al., 2007; Blanes-Vidal et al., 2008; Costa and Guarrino, 2009). Rzeźnik (2013) determined an average daily factors of nitrous oxide emission when he carried out research in deep litter piggery. Its value was higher than the results of this paper and it was 0.074 g·day^{-1}·kg^{-1}. Philippe et al. (2007) state that a literature data show higher diversity in values of N_2O emission factors for deep litter systems and slatted floor systems, respectively from 0.03 to 8 g·day^{-1}·pig^{-1} and 0.17 to 2.26 g·day^{-1}·pig^{-1}. The obtained results in the paper were within these scopes (2.36 g·day^{-1}·pig^{-1} – deep litter system and 1.01 g·day^{-1}·item^{-1} – a fully-slatted floor system).

Methane emission factor was also higher in the deep litter building and was 0.81 g·day^{-1}·kg^{-1}, and in fully-slatted piggery was equal to 0.72 g·day^{-1}·kg^{-1}. Philippe et al. (2007) obtained results over three times lower than the results of this paper. Values of CH_4 emission factors for the researched housing systems by them were comparable and were 0.24 g·day^{-1}·kg^{-1}. The literature presents high diversity in the values of methane emission factors for the fully slatted housing system from 0.06 to 0.38 g·day^{-1}·kg^{-1} (Sneath et al., 1997; Gallmann et al., 2003; Guarino et al., 2003; Amon et al., 2007; Dong et al., 2007; Blanes-Vidal et al., 2008; Costa and Guarino, 2009). Only few papers concerned the deep litter housing system. Rzeźnik (2013) determined average methane emission factor equal to 1.71 g·day^{-1}·kg^{-1}. Whereas Philippe et al. (2007) after Stout et al. (2003) and after Nicks et al. (2004) state that average emission of CH_4 is equal to respectively 2.77 g·day^{-1}·pig^{-1} and 7.39 g·day^{-1}·pig^{-1}. These values are few times lower than those obtained in this paper (51.88 g·day^{-1}·pig^{-1}).

Calculated according to the equation (3) values of total greenhouse gases emission in the CO_2 equivalent prove 59% higher potential of creating a greenhouse effect of deep litter piggery (WE_{qCO2}=137 g·day^{-1}·kg^{-1}) than a building with fully-slatted floor (WE_{qCO2}=86 g·day^{-1}·kg^{-1}).

Conclusions

Based on the research which was carried out, the following conclusions have been made:

- Average values of the investigated gases emission factors from deep litter piggery were: CO_2 –105 g·day^{-1}·kg^{-1}, N_2O – 0.047 g·day^{-1}·kg^{-1}, CH_4 – 0.809 g·day^{-1}·kg^{-1}.
- Factors of the investigated gases emission from a fully-slatted took the following values: CO_2 – 62 g ·day^{-1}·kg^{-1}, N_2O – 0.027 g·day^{-1}·kg^{-1}, CH_4 – 0.715 g·day^{-1}·kg^{-1}.

– Values of the investigated gases emission factors were higher in deep litter piggery CO_2 by 69%, N_2O by 74% and for CH_4 by 13% than in building with fully-slatted floor.
– Average factor of greenhouse gases emission of expressed in the CO_2equivalent was 137 $g_{ekwCO2} \cdot day^{-1} \cdot kg^{-1}$ for deep litter housing system and (WE_{qCO2}=86 $g \cdot day^{-1} \cdot kg^{-1}$) for building with fully-slatted floor. It proves 59% higher potential of creating a greenhouse effect of the facility on deep litter.

Summarizing, it should be noted that deep litter piggeries guarantee a higher level of pigs welfare. However, they emit more gas pollutions to the environment than fully-slatted piggeries. Due to a small number of papers on greenhouse gases emission from production of pigs kept in the litter systems and high diversity of values of greenhouse gases emission factors,one should continue research on this subject. This allow for precise determination the range of their values and comparison of various housing systems of pigs with regard to the greenhouse gases emission and explicit indication of technology which is more environmentally friendly.

References

Amon, B.; Kryvoruchko, V.; Fröhlich, M.; Amon, T.; Pöllinger, A.; Mösenbacher I.; Hausleitner, A. (2007). Ammonia and greenhouse gas emissions from a straw flow system for fattening pigs: Housing and manure storage. *Livestock Science, 112*, 199-207.

Blanes-Vidal, V.; Hansen, M.N.; Pedersen, S.; Rom, H.B. (2007). Emissions of ammonia, methane and nitrous oxide from pig houses and slurry: Effects of rooting material, animal activity and ventilation flow. *Agriculture, Ecosystems and Environment*, *124*, 237-244.

Costa, A.; Guarino, M. (2009). Definition of yearly emission factor of dust and greenhouse gases through continuous measurements in swine husbandry. *Atmospheric Environment*, 43, 1548-1556.

Dong, H.; Zhu, Z.; Shang, B.; Kang, G.; Zhu, H.; Xin H. (2007). Greenhouse gas emissions from swine barns of various production stages in suburban Beijing, China. *Atmospheric Environment*, *41*, 2391-2399.

FAO (2006*). Livestock's Long Shadow – Environmental Issues and Options*. Food and Agriculture Organization of the United Nations, Rome.

Gallmann, E.; Hartung, E.; Jungbluth, T. (2003*). Long-term study regarding the emission rates of ammonia and greenhouse gases from different housing systems for fattening pigs-final results*. W: Proceedings of the International Symposium on Gas and Odor Emissions from Animal Production, Horsens, Denmark. CIGR, 122-130.

Guarrino, M.; Fabbri, C.; Navarotto, P. (2003). *Ammonia, methane and nitrous oxide emissions and particulate matter concentration in two different buildings for fattening pigs*. W: Proceedings of the International Symposium on Gas and Odor Emissions from Animal Production, Horsens, Denmark. CIGR, 140-149.

IPCC (2001). *IPCC Third Assessment Report – Climate Change 2001*. The Scientific Basis. Cambridge University Press, Cambridge.

IPCC (2007). *Climate Change 2007: The Physical Science Basis*. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom/New York, NY, USA.

Jugowar, J.L. (2001). Metody analizy emisji i rozprzestrzeniania się gazów szkodliwych z budynków inwentarskich na przykładzie amoniaku. *Inżynieria Rolnicza*, *3*(23),77.

Jugowar, J.L. (2013). *Aktualne kierunki badań nad redukcją gazów i odorów z budynków inwentarskich*. W: Hołownicki R., Kuboń M. (Red.). Współczesna inżynieria rolnicza – osiągnięcia i nowe wyzwania. Monografia tom II. Wydawnictwo PTIR, Kraków, 35-54.

Jungbluth, T.; Hartung, E.; Brose, G. (2001). Greenhouse gas emissions from animal houses and manure stores. *Nutrient Cycling in Agroecosystems, 60*, 133-145.

KOBIZE, (2013). *Krajowy Raport Inwentaryzacyjny 2013*. Inwentaryzacja gazów cieplarnianych w Polsce dla lat 1988-2011. Warszawa.

Kolasa-Więcek, A. (2012). Analiza składowych głównych w ocenie zależności sposobu użytkowania gruntów z emisją gazów cieplarnianych z rolnictwa. *Inżynieria Rolnicza*, *2*(137), 105-112.

Mielcarek, P. (2012). Weryfikacja wartości współczynników emisji amoniaku i gazów cieplarnianych z produkcji zwierzęcej. *Inżynieria Rolnicza*, *4*(139), 267-276.

Monteny, G.J.; Bannink, A.; Chadwick, D. (2006). Greenhouse gas abatement strategies for animal husbandry. *Agriculture*, *Ecosystems and Environment*, *112*, 163-170.

Nicks, B.; Laitat, M.; Farnir, F.; Vandenheede, M.; Désiron, A.; Verhaeghe, C.; Canart, B. (2004). Gaseous emissions from deep-litter pens with straw or sawdust for fattening pigs. *Animal Science*, *78*, 99-107.

Philippe, F.X.; Laitat, M.; Canart, B.; Vandenheede, M.; Nicks, B. (2007). Comparison of ammonia and greenhouse gas emissions during the fattening of pigs, kept either on fully slatted floor or on deep litter. *Livestock Science*, *111*, 144-152.

Rigolot, C.; Espagnol, S.; Robin, P.; Hassouna, M.; Beline, F.; Paillat, J.M.; Dourmad, J.Y. (2010). Modelling of manure production by pigs and NH_3 N_2O and CH_4 emissions. Part II: effect of animal housing, manure storage and treatment practices. *Animal*, *4*, 1413-1424.

Rzeźnik, W. 2013. Ograniczanie emisji zanieczyszczeń gazowych z tuczarni poprzez zastosowanie instalacji do odzysku ciepła. *Inżynieria Rolnicza*, *3*(146), 331-339.

Steinfeld, H.; Wassenaar, T. (2007). The role of livestock production in carbon and nitrogen cycles. *Annual Review of Environment* and *Resource*, *32*, 15.1–15.24.

Sneath, R.; Phillips, V.R.; Demmers, T.G.M. (1997). *Long-term measurement of greenhouse gas emission from UK livestock building.* In: Proceedings of the 5th International Symposium on Livestock Environment, St. Joseph, ASAE, MI, 146-153.

Stout, V.; Richard, T.L.; Singh, A.; Hoff, S.J.; Dixon, P.; Harmon, J.; Bundy, D.S. (2003). *Variability in greenhouse gas emission measurements using the tracer gas technique.* W: Commission Internationale du Génie Rural (Red.), Proceedings of the International Symposium on gaseous and odour emissions from animal production facilities. Horsens, Denmark, 1-4 June 2003, 96-104.

PORÓWNANIE EMISJI GAZÓW CIEPLARNIANYCH Z RÓŻNYCH SYSTEMÓW UTRZYMANIA TUCZNIKÓW W SEZONIE LETNIM

Streszczenie. Celem pracy było określenie i porównanie emisji gazów cieplarnianych z tuczarni na głębokiej ściółce i z budynku dla tuczników z podłogą szczelinową (system bezściołowy). Badania przeprowadzono, w sezonie letnim, od lipca do września 2013 roku. Budynki były zlokalizowane w województwie wielkopolskim, na terenie gospodarstw, będących w bezpośrednim sąsiedztwie. Stężenie gazów mierzono foto-akustycznym spektrometrem Multi Gas Monitor 1312. Średnie wartości wskaźników emisji z budynku z podłogą szczelinową wynosiły: CO_2 – 62 g·doba^{-1}·kg^{-1}, N_2O – 0,027 g·doba^{-1}·kg^{-1} i CH_4 – 0,715 g·doba^{-1}·kg^{-1}. W tuczarni z systemem utrzymania na głębokiej ściółce przyjmowały wartości: CO_2 – 105 g·doba^{-1}·kg^{-1}, N_2O – 0,047 g·doba^{-1}·kg^{-1} i CH_4 – 0,809 g·doba^{-1}·kg^{-1} i były one większe odpowiednio o 69%, 74% oraz 13%. Po przeliczeniu wartości wskaźników na ekwiwalent CO_2 system utrzymania na głębokiej ściółce charakteryzuje się o 59% większym potencjałem tworzenia efektu cieplarnianego.

Słowa kluczowe: emisja gazów cieplarnianych, głęboka ściółka, system utrzymania, trzoda chlewna

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THE IMPACT OF THE THERMAL TREATMENT OF GRASS PEA ON THE CONTENT OF THE SELECTED CHEMICAL COMPONENTS

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ABSTRACT

The objective of the paper was to estimate the impact of infrared rays heating of grass pea seeds on the protein solubility in KOH, content of fibre fraction: NDF (neutral detergent fibre), ADF (acid detergent fibre) and ADL (acid detergent lignin) and the content of carotenoids. Grass pea seeds (*Lathyrus sativus* L.), of Derek variety constituted the research material. The investigated seeds were heated by infrared rays in the temperature of 180ºC in the time: 30, 60, 90, 120 or 180 s. It was found out that the used thermal treatment did not have a significant impact on the protein solubility in KOH. After 180 s of heating this parameter was above 95%. Heating with infrared rays caused changes in the content of the fibre fraction in grass pea seeds. As a result of the process, the content of the NDF fraction was reduced and the growth of ADF and ADL was reported. Heating grass pea seeds with infrared rays did not cause the decrease of the carotenoids content.

Introduction

Recently the growth of interest in alternative plants, which may be used in food production, may be reported. From among leguminous plants, grass pea is interesting (*Lathyrus sativus*). Grass pea seeds include a high amount of protein of a beneficial amino acid composition and characterize with a high content of protein. They also have a lower energy value in comparison to soybeans (Grela et al., 2011). On account of the above, they may constitute an attractive component of the vegetarian diets. The use of grass pea seeds limits the presence of anti-nutritious compounds e.g. neurotoxins and toxin and trypsin inhibitors. Thus, grass pea seeds are subjected to thermal processing, which causes deactivation of the anti-nutrients components (Grela et al., 2001; Szmigielski and Szczepanik, 2008). Thermal processes may also cause changes of content and property of other active native components of the heated material, such as e.g. changes in the fibre fractions, changes of the protein quality, reduction of the content of the thermolabile nutritious components (Krasucki et al., 2002; Căpriță et al., 2010; Grela et al.,1999).

Infrared radiation may be the source of heat in technological processes (Andrejko, 2007). In the recent years the research have been carried out on the use of radiation in the food industry, inter alia, for drying fruit, conditioning grain seed before milling and treatment of leguminous plants seeds. Convectional drying with the use of infrared rays in comparison to traditional convectional drying, shortens the time of apple drying and the initial pea seed treatment with infrared rays shortens the time of preparation (Rząca and Witrowa-Rajchert, 2009; Rydzak et al., 2012; Andrejko et al., 2008).

The objective of the paper

The objective of the paper was to estimate the impact of infrared rays heating of grass pea seeds on the protein solubility in KOH and the content of fibre fraction and carotenoids.

Material and methods

Research material consisted in grass pea seeds (*Lathyrus sativus* L.) of Derek variety which were obtained in the company "Spójnia" Cultivation and Seeding in Nochów. Grass pea seeds were heated with infrared rays (wave length $\lambda = 2.5\text{-}3.0$ μm) in the temperature of 180ºC in the time: 30, 60, 90, 120 or 180 s. Seeds were heated in the specially designed and made laboratory device (fig.1). Main elements of the stand are: bearing frame, belt conveyor and heating system with easy temperature control. Raw material is poured to the basket equipped with a slide valve and then it is fed to the conveyor belt (one layer).

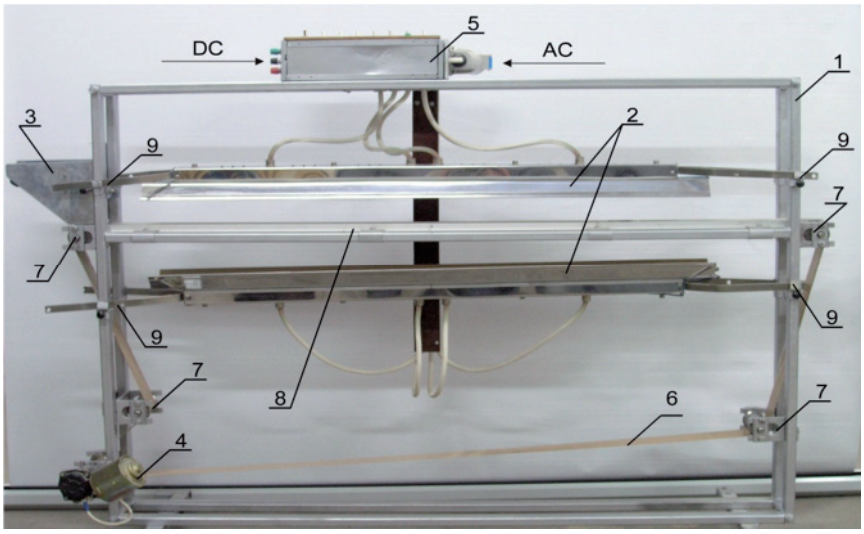

Figure 1. Laboratory device for infrared rays treatment of granular plant raw materials: 1 – frame bearer, 2 – head with 4 separately supplied radiators, 3 – charging hopper, 4 – direct current engine, 5 – control module, 6 – conveyor belt, 7 – rolls, 7 – heating zone, 9 – control of heads position (Andrejko et al., 2011)

Material placed on the conveyor belt moves to the heating zone, where it is subjected to infrared radiation. The device is equipped with two heating heads (4 radiators in each); the upper one placed over the conveyor belt and the bottom one located under the belt. Average temperature of a filament is approx. 500ºC.

In raw and heated seeds of grass pea protein solubility in 0.2% KOH (Araba i Dale, 1990) was determined, content of fibre fraction NDF (neutral detergent fibre), ADF (acid detergent fibre) and ADL (acid detergent lignin) were determined with Robertson and Van Soest method (1981) and the content of carotenoids according to Manza and Bühler-Steinbrunna (1988). All designations were carried out in three repeats. Results of designation were subjected to one-factor analysis of variance. Significance of differences between averages was verified with Tukey's test at $p \leq 0.05$. Calculations were carried out with Statistica 8.0.

Results and discussion

Protein solubility in KOH is one of indexes useful for assessment of the quality of protein of the heated material. In case of soya products it allows identification of excessively heated batch of material (Căpriță et al., 2010).

Protein solubility in KOH in raw grass pea seeds was 99.3% (fig. 2). No impact of heating with infrared rays of grass pea seeds on the content of protein soluble in KOH was reported ($p > 0.05$). It was reported that after 180 s of treatment, the researched value did not differ significantly from the value in raw seeds and was 95.1%. Căpriță et al. (2010) state that short (5 min) heating of soybean meal in temperature 120ºC did not also have a bigger impact on the protein solubility in KOH. However, prolongation of duration of the process led to reduction of this index below 70%.

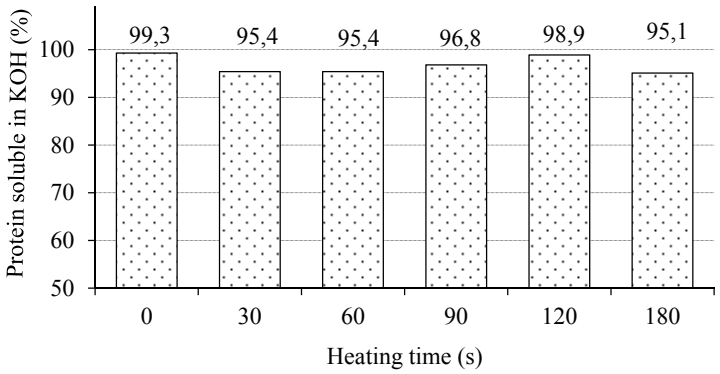

Figure 2. Protein soluble in KOH in seeds Lathyrus sativus L. (values do not differ significantly at $p \leq 0.05$)

Impact of the infrared rays heating on the content of fibre fraction content was presented in figures 3-5. Content of neutral detergent fibre (NDF) in raw grass pea seeds was 26.7% of dry mass. (fig.3) and was lower than in another Polish variety Krab (33.2%s.m.). Where-

as content of acid detergent fibre (ADF) which was 8.48% d.m.. (fig. 4) was similar to the amount in grass pea seeds of Krab variety (Smulikowska et al., 2008).

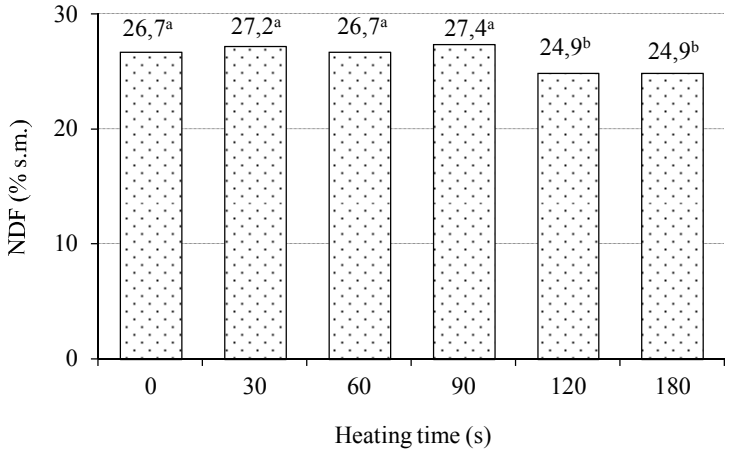

Figure 3. The content of neutral detergent fibre (NDF) in seeds Lathyrus sativus L. (values marked with various letters differ significantly at p ≤ 0.05)

Heating with infrared rays caused changes in the content of specific fibre fractions in grass pea seeds. After treatment lasting 120 s, the content of neutral detergent fibre decreased by 7%, in comparison to the output sample. In case of ADF the increase of content after 60 and 90 s of heating was reported. Whereas, the ADL content in the final sample (heating by 180 s) was over three times higher than in raw seeds.

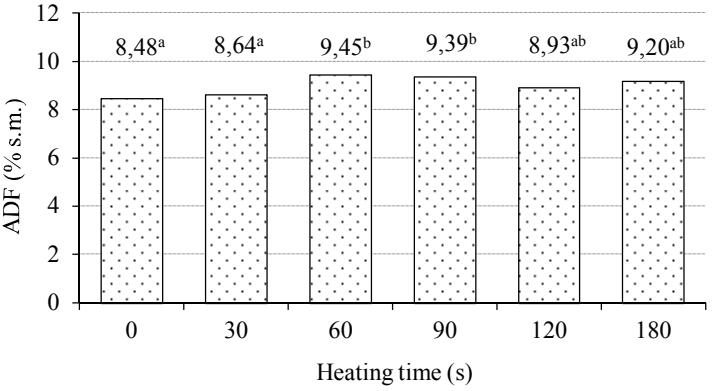

Figure 4. The content of acid detergent fibre (ADF) in seeds Lathyrus sativus L. (values marked with various letters differ significantly at p ≤ 0.05)

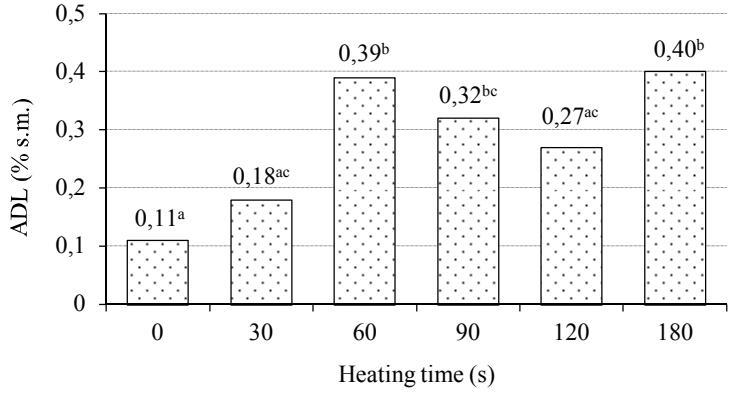

Figure 5. The content of acid detergent lignin (ADL) in seeds Lathyrus sativus L. (values marked with various letters differ significantly at $p \leq 0.05$)

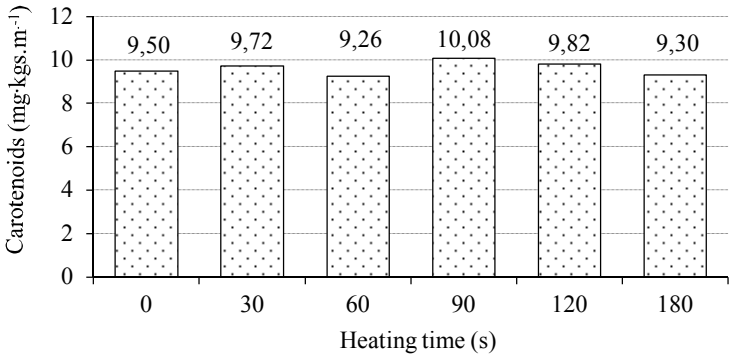

Figure 6. Content of carotenoids in seeds Lathyrus sativus L. (values do not differ significantly at $p \leq 0.05$)

Other authors also observed the impact of heating on changes in fibre fractions. The effect of drying rapeseed in temperature 120ºC (Krasucki et al., 2002) was decrease of the content of NDF and ADF fraction and increase of the process temperature to 180ºC led to the increase of NDF, ADF and ADL content in comparison to the control sample. Extrusion of mixture of grass pea and corn materials caused decrease of the NDF and ADF content and increase in ADL (Kasprzak and Rzedzicki, 2008).

Carotenoids as polyene compounds are included to natural antioxidants. Moreover, those which include in its fraction a fragment of retinol structure, prove activity of A vitamin (Sikorski, 2007). They may partially lose biological activity under the effect of light or heating. Grela et al. (1999) proved that extrusion of grass pea seeds caused decrease of the content of beta-carotene and luteine.

The content of carotenoids in raw and heated grass pea seeds (fig. 6) was at a similar level (from 9.30 to 10.08 mg·kgs.m^{-1}). It was lower than the value of averages presented by Korus et al. (2002) for Krab and Derek varieties, whereas it was similar to the sum of beta-karoten and luteine content which is presented by Grela et al. (1999) in grass pea seeds. The obtained results prove that infrared rays heating of grass pea seeds did not influence the carotenoids content ($p > 0.05$).

Conclusions

1. Heating grass pea seeds with infrared rays did not result in a significant decrease of protein solubility of protein in KOH.
2. The applied thermal treatment had a significant impact on the fibre fraction content in grass pea seeds. It caused decrease of the NDF fraction and ADF and ADL.
3. Infrared rays heating of grass pea seeds did not affect the content of carotenoids.
4. Analysis of the obtained results proved that the applied method of heating with infrared rays of grass pea seeds does not cause deterioration of the researched indexes of the quality and on this account it may be recommended as a method of deactivation of anti-nutrient compounds in grass pea seeds.

References

Andrejko D.; Goździewska M.; Oszczak Z. (2007). Laboratoryjne urządzenie do obróbki ziarnistych surowców roślinnych promieniami podczerwonymi. *Acta Scientiarum Polonorum, Technica Agraria*, *6*(2), 9-14.

Andrejko, D.; Grochowicz, J.; Goździewska, M.; Kobus, Z. (2011). Influence of infrared treatment on mechanical strength and structure of wheat grains. *Food Bioprocess Technology*, *4*(8),1367-1375.

Andrejko, D.; Rydzak, L.; Ślaska-Grzywna, B.; Goździewska, M.; Kobus, Z. (2008). Influence of preliminary thermal processing applying infra-red radiation on pea seed cooking process. *International Agrophysics*, *22*, 17-20.

Araba, M.; Dale, N.M. (1990). Evaluation of protein solubility as an indicator of overprocessing of soybean meal . *Poultry Science, 69*, 76-83.

Căpriță, R.; Căpriță, A.; Crețescu, I. (2010). Protein solubility as quality index for processed soybean. *Animal Science and Biotechnologies*, *43*(1), 375-378.

Grela, E.R.; Jensen, S.; Jakobsen, K. (1999). Fatty acid composition and content of tocopherols and carotenoids in raw and extruded grass pea (Lathyrus sativus L). *Journal of the Science of Food and Agriculture*, *79*, 2075-2078.

Grela, E.R.; Studziński, T.; Matras, J. (2001). Antinuritional factors in seed of *Lathyrus sativus* cultivated in Poland. *Lathyrus Lathyrism Newsletter*, *2*,101-104.

Grela, E.R.; Rybiński, W.; Sobolewska, S. (2011). Wartość odżywcza i dietetyczna nasion lędźwianu siewnego (*Lathyrus sativus* L.) i czerwonego (*Lathyrus cicera* L.). *Problemy Higieny i Epidemiologii*, *92*(4), 866-868.

Kasprzak, M.; Rzedzicki, Z. (2008). Application of everlasting pea wholemeal in extrusion-cooking technology. *Inernational. Agrophysics*, *22*, 339-347.

Korus, A.; Lisiewska Z.; Kmiecik W. (2002). Effect of freezing and canning on the content of selected vitamins and pigments in seeds of two grass pea (Lathyrus sativus L.) cultivars at the not fully mature stage. *Nahrung/Food*, *46*(4), 233-237.

Krasucki, W.; Tys, J.; Szafran, K.; Rybacki, R.; Orlicki, Ł. (2002). Wpływ różnych temperatur suszenia nasion rzepaku na ich skład chemiczny. *Rośliny Oleiste*, *XXIII*, 427-438.

Manz, U.; Bühler-Steinbrunn, I.I. (1988). Determination of Natural Carotene in Complete Feeds and Raw Materials by Open-Column Chromatography on Aluminium Oxide. W: Keller, H.E. (red). *Analytical Methods for Vitamins and Carotenoids in Feed.* Department of Vitamin Research and Development ROCHE Basle, 75-76.

Robertson, J.B.; Van Soest, P.J. (1981). The detergent system of analysis and its application to human foods. W: James, W.P.T.; Theander, O. (red.). *The analysis of dietary fibre in food*. Marcel Dekker, New York, 123-158.

Rydzak, L.; Andrejko, D.; Sagan, A.; Nakonieczny, P. (2012). Wpływ impregnacji próżniowej i obróbki promieniowaniem podczerwonym na energochłonność przemiału żyta. *Inżynieria Rolnicza*, *3*(138), 217-226.

Rząca, M.; Witrowa-Rajchert, D. (2009). Zmiany aktywności przeciwrodnikowej i zawartości polifenoli w suszu jabłkowym uzyskanym przy wykorzystaniu promieniowania podczerwonego. *Żywność. Nauka. Technologia. Jakość*, *1*(62), 99-108.

Sikorski, Z.E. (red.) (2007). *Chemia żywności.* Warszawa, WNT, 142-170.

Smulikowska, S.; Rybiński, W.; Czerwiński, J.; Taciak, M.; Mieczkowska, A. (2008). Evaluation of selected mutants of grasspea (*Lathyrus sativus* L.) var. Krab as an ingredient in broiler chicken diet. *Journal of Animal and Feed Sciences*, *17*, 75–87.

Szmigielski, M.; Szczepanik, M. (2008). Gotowanie nasion lędźwianu siewnego i koncepcja zastosowania nowego sposobu do oceny skutków obróbki cieplnej. *Acta Scientarum Polonorum, Technica Agraria*, *7*(1-2), 27-34.

WPŁYW PRZETWARZANIA CIEPLNEGO NASION LĘDŹWIANU SIEWNEGO NA ZAWARTOŚĆ WYBRANYCH SKŁADNIKÓW CHEMICZNYCH

Streszczenie. Celem pracy była ocena wpływu ogrzewania promieniami podczerwonymi nasion lędźwianu siewnego na rozpuszczalność białka w KOH, zawartość frakcji włókna: NDF (włókno detergentowe neutralne), ADF (włókno detergentowe kwaśne) i ADL (lignina detergentowo-kwaśna) oraz zawartość karotenoidów. Materiał badawczy stanowiły nasiona lędźwianu siewnego (*Lathyrus sativus* L.), odmiany Derek. Badane nasiona poddawano ogrzewaniu promieniami podczerwonymi w temperaturze 180ºC, w czasie: 30, 60, 90, 120 lub 180 s. Stwierdzono, że zastosowana obróbka cieplna nie miała istotnego wpływu na rozpuszczalność białka w KOH. Po 180 s ogrzewania parametr ten wynosił powyżej 95%. Ogrzewanie promieniami podczerwonymi spowodowało zmiany w zawartości frakcji włókna w nasionach lędźwianu. Na skutek procesu zmniejszeniu uległa zawartość frakcji NDF, a nastąpił wzrost zawartości ADF i ADL. Ogrzewanie nasion lędźwianu siewnego promieniowaniem podczerwonym nie spowodowało obniżenia zawartości karotenoidów.

Słowa kluczowe: promieniowanie podczerwone, lędźwian siewny, rozpuszczalność białka, frakcje włókna, karotenoidy

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FLAX SEED SEPARATION WITH VIBRATING SCREENS

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ABSTRACT

The objective of the research consisted in comparing the operation efficiency of a separator provided with fixed screens mounted to the shoe and the one fitted with spring-mounted screens, determination of the impact of the basic kinematics parameters on the separation efficiency. Analysis was also carried out regarding the use of cylindrical spring-mounted screens and flat spring-mounted screens. The process of mass movement on the screen surface was examined also including the movement upward, downward and throwing up. The values characteristic for the separation process were output (capacity) of screens and the impurity separation degree. The analyzed kinematic parameters included: screen shoe vibration amplitude, screen vibration amplitude, screen inclination angle, screen vibration operation angle, own vibration frequency, kinematics limits coefficient. As a result, the mathematical models of separation were determined regarding the unit efficiency and the impurity separation degree. Next calculation based on these equations determined the value of the following parameters: A_p=1, 2, A=8 mm, K=2, 3, for which q_F=0.72 kg·s^{-1}·m^{-2}, E=0.87. The parameters of springs ensuring proper modulus may be determined with the monogram or formula (20). According to the conducted experiments q_F screen capacity depended on the straight-line basis on A_p spring stiffness, A screen shoe vibration amplitude and it increased as q_F and A_p values increased. The increase was less evident in case of ω and ε value increase. Whereas the non straight-line basis and significant increase followed as the values of α and K parameter increased. Impurity separation degree E increased initially and next decreased as increase followed of spring stiffness A_p, and along with screen hopper vibration amplitude increase. This increase was less evident in case of ω frequency and ε angle increase. Separation of impurities significantly decreased in case of α and K parameter increase.

Introduction

Cultivating and processing of flax in Poland follows mainly for two purposes related to production of fibre and seed. The whole processing has been mechanized, yet mechanization of these processes has not been satisfactory (Andrzejewska, 2006; Kruglenja, 2006; Kruglenja et al., 2011; Pawlak, 2010). Cultivating and processing of flax by sustainable and ecological farms has established the requirements with regard to limitation of negative impact on environment (Grabowska and Heller 2009; Heller, 2012; Janowska-Biernat, 2012). Threshing and separation of mass flax is one of such important processes. Many scientific and research works have been carried out in this regard aimed at production of good quality fibre and seed of high germination capacity. Therefore much emphasis has been placed on threshing and separation of the flax threshed mass (Kazarovec et al., 2004; Maksimov, 2004; Šaršunov et al., 2012; Kamiński et al., 2014a).

The objective of the research

The objective of the research was to compare the operation efficiency of a separator provided with fixed screens mounted to the shoe and the one with spring-mounted screens, determination of the impact of basic kinematics on theseparation efficiency. The analysis was also carried out with regard to the use of spring-mounted cylindrical screens and flat screens. The process of mass displacement on the screen surface including movement upward, downward, throwing up was examined also. The values characteristic for the separation process were output (capacity) of screens and the impurity separation degree.

Material and research methodology

To reduce energy consumption during flax seed separation with traditional equipment the efforts were made to design the seed-ball threshing machine that would provide initial and final seed separation. Consequently the separator was constructed purposed for initial separation of free seeds and in order to prevent damage caused by a threshing unit, as well as separated lightweight and fine impurities to improve output (capacity) of a separator (Šaršunov et al., 2010; Kamiński et al., 2014b). The Figure No. 1 includes the layout of the separator.

The process of flax seed separation is carried out according to the following. The mass of flax seed including impurities upon initial drying is placed inside the feeding shoe (1) and next is fed to the pneumatic duct (3), where air circulation ensures separation of light impurities. Next the mass is carried to the top screen shoe (2) which ensures separation of heavy impurities and single seeds. Whereas fine impurities after passing through the screen are placed on V-shaped chute that discharges them outside the machine. Bulk seeds after coming out from the screen are placed on the chute (7) and fed to the lower screen shoe (8). Poorly threshed seed-bags are fed from the top screen shoe (2) to the threshing unit (5) provided with two elastic rolls, and next are carried with the chute (6), to the respiration duct (4), where separation of light impurities generated during further threshing of seed-bags follows. Next seeds are fed to the lower screen shoe (8) where separation of impurities that are discharged from machine with II and IV duct follows.

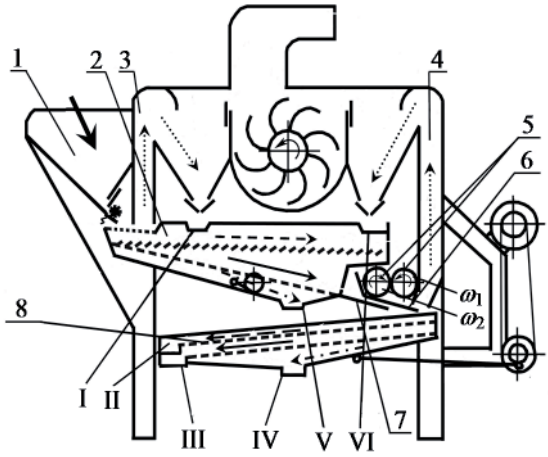


Figure 1. Process diagram of a flax seed separator: (1) feeding hopper, (2,8) screen shoe, (3,4) pneumatic ducts, (5) threshing device, (6,7) chutes, (I,VI) chute of light impurities, (II) chute of heavy impurities, (III) chute of flax seeds, (IV) and (V) chute of fine impurities, movement direction of: ⟶ – mass, ⋯➔ – light impurities, – – ➔ – seed-bags, ⟶ – bulk seeds, – · ➔ – fine impurities.

The main disadvantage of spring-mounted screen shoe was poor efficiency of separation caused mainly by an ineffective movement of mass on the shoe flat surface with vibration direction similar to horizontal one, in particular in case of operation of round hole screens when particles passing through the screen should have be in vertical position.

In case of the above described separator, the shoe has been constructed (fig. 2) fitted with spring-mounted screens vibrating thanks to inertia, which enabled to improve separation efficiency due to additional vibration of a screen that provided for dynamic separation of mixture components and throwing up of seeds that facilitated entering of particles into screen slots (Kocuba and Kruglenja, 2004; Kruglenja et al., 2011). The basic components of flax threshed mass featured with absolute moisture content: seed- bags – 40-50%, single seeds – 15-27%, weeds 45-80%, targan – 25-65%.

The body of screen shoe vibration was driven with the cranked shaft. Inertia forces of shoe and spring stiffness forces resulted in additional vibration within vertical plane, and at the same time a shoe vibration angle increases, which results in dynamic separation of mixture components. Moreover the movement of particles followed because of throwing up at small values of screen shoe kinematics limits, which facilitates dynamic separation with round slotted screens.

Separation efficiency may be increased by mounting removable chutes (5) to the screen shoe, due to optimal use of lower screens that feed seed to the beginning of a screen, as well as improvement of screen shoe technical capacities. Additionally screens with slots of different type (rectangular and round shaped) require different kinematics parameters. In case of screen shoes being in operation at present it is difficult to provide, and usually operation follows for determined kinematics, which results in efficiency reduction. Inertial vibrating screens may be mounted inside the screen shoe independently from each other.

Adjustment of spring stiffness may ensure proper kinematics parameters for operation of each screen.

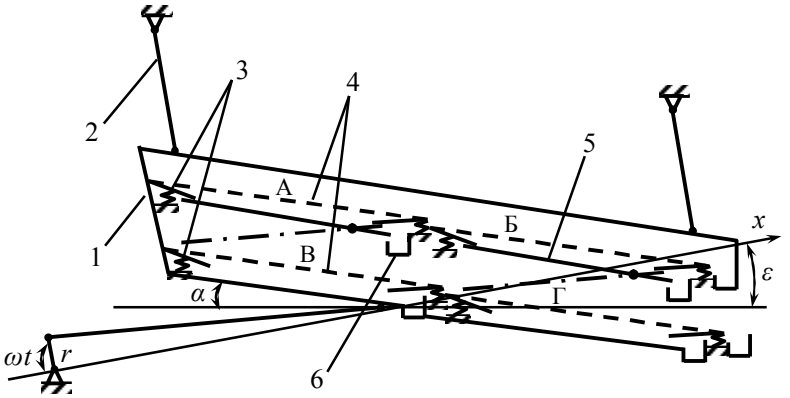


Figure 2. Diagram of a shoe with inertial vibrating screens: (1) screen shoe body, (2) suspending rods, (3) screen suspending springs, (4) screens, (5) screen shoe (return chutes), (6) separated fraction chute

Figure 3 specified schematic vibration of suggested screens (Kocuba and Kruglenja, 2004; Kruglenja et al., 2011). The screens were replaced with "m" mass mounted with spiral springs to the tilted casing. The screens were subjected to F_j inertia and $m \cdot g$ weight forces.

Moreover movement characteristic was specified on the OXY fixed coordinate system and Oxy mobile coordinate system

Equations of screen vibration (fig. 3) may be defined on the Oxy mobile coordinate system as follows:

$$x = -r\cos\omega t(1 + A_q\cos^2(\alpha+\varepsilon) + A_p\sin^2(\alpha+\varepsilon)); \tag{1}$$

$$y = -r\cos\omega t\sin(\alpha+\varepsilon)\cos(\alpha+\varepsilon)(A_p - A_q); \tag{2}$$

or OXY fixed coordinate systems:

$$X = -r\cos(\alpha+\varepsilon)\cos\omega t(1 + A_q); \tag{3}$$

$$Y = -r\sin(\alpha+\varepsilon)\cos\omega t(1 + A_p), \tag{4}$$

where:

r – connecting rod arm, (m)
ω – crank arm angular speed, (rad·s^{-1})
α – screen inclination angle, (^{o})
ε – vibration direction angle, (^{o})

$A_p = \frac{\omega^2}{(2\pi p)^2 - \omega^2}$ and $A_q = \frac{\omega^2}{(2\pi q)^2 - \omega^2}$ – spring stiffness coefficient, taking into account the impact from own vibration of longitudinal springs (p) and diagonal ones (q).

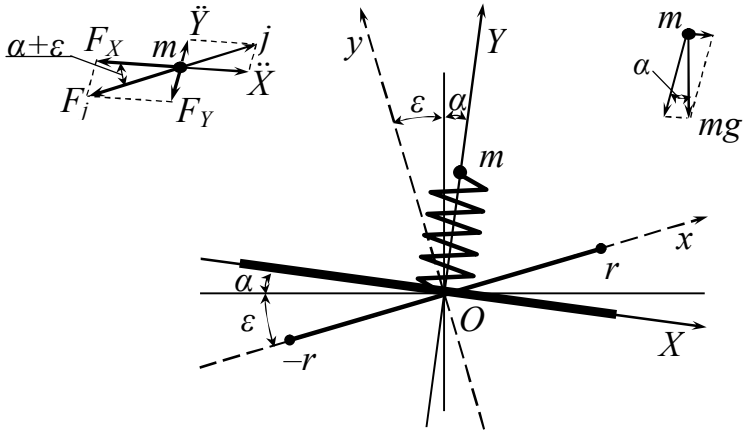


Figure 3. Kinematics diagram of the inertial vibrating screen

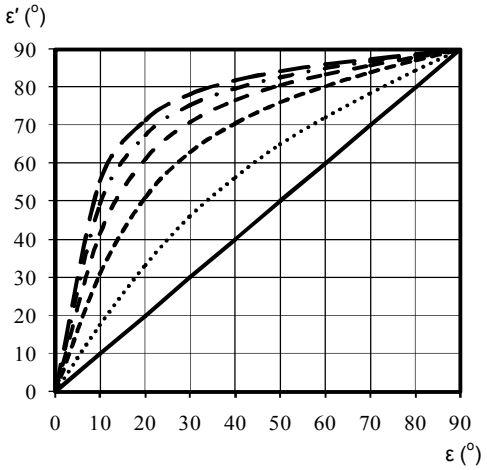


Figure 4. Relation of vibration direction angle (ε') of inertial screens to screen shoe vibration direction angle (ε) and the relationship of longitudinal (A_p) and diagonal (A_q) spring stiffness for the following cases: ——— – $A_p = A_q$; ---------- – $A_p = 2A_q$; – – – – – $A_p = 4A_q$ — — — – $A_p = 6A_q$; — · — · – $A_p = 8A_q$; —— —— – $A_p = 10A_q$

According to equations (1) and (2) screens harmonic vibration follow at frequency corresponding to screen shoe vibration frequency, but different amplitudes that depend on A_p and A_q.

These equations are true also after replacing cylindrical springs with flat ones, yet additional vibration will follow only in the plain perpendicular to screens surface (own vibration of flat springs were determined with stiffness modulus A_p and $A_q = 0$.

In case of spring absence (A_p and $A_q \rightarrow 0$) the equations of inertial screens movement take the form of screen shoe movement equations.

In case of $A_p = A_q$, screen vibration direction angle ε' was equal to ε screen shoe vibration direction. In case of $A_p > A_q$, screen vibration direction angle ε' was bigger than screen shoe vibration direction angle ε (fig. 4), what in practice improved operation quality of round slots.

Screen shoe operation limits for mass moved upwards *(K_1) and downwards (K_2)*, as well as throwing up *(K_o)* may be defined with the following equations:

$$K_1 = \frac{\sin(\alpha+\varphi)}{\cos(\alpha+\varepsilon+\varphi)+\frac{1}{2}\left((A_q+A_p)\cos(\alpha+\varepsilon+\varphi)+(A_q-A_p)\cos(\alpha+\varepsilon-\varphi)\right)}; \quad (5)$$

$$K_2 = \frac{\sin(\varphi-\alpha)}{\cos(\alpha+\varepsilon-\varphi)+\frac{1}{2}\left((A_q+A_p)\cos(\alpha+\varepsilon-\varphi)+(A_q-A_p)\cos(\alpha+\varepsilon+\varphi)\right)}; \quad (6)$$

$$K_O = \frac{\cos\alpha}{(1+A_p)\sin(\alpha+\varepsilon)}, \quad (7)$$

where:

φ – friction angle of separated mass against screen surface, (°).

In case of equal longitudinal and diagonal spring stiffness ($A_p = A_q$) operations limits of screen shoe fitted with inertial vibrating screens K may be defined with the following formula:

$$K = \frac{K_{gr}}{(1+A_p)} \quad (8)$$

where:

K_{gr} –kinematics limits for operation of used screen shoes (without springs).

Figure No. 5 determined the relationship regarding operation limits of inertial vibrating screens and vibration direction angle.

According to the Figure No. 5 for inertial vibrating screens fitted with cylindrical springs, the kinematics parameter of screen shoe was lower comparing to the traditional screen shoe $1+A_p$ times.

As drive power of the screen shoe depends on the kinematics limits, reduction thereof results in the reduction of power required for seed separation by 31.1-68.8%.

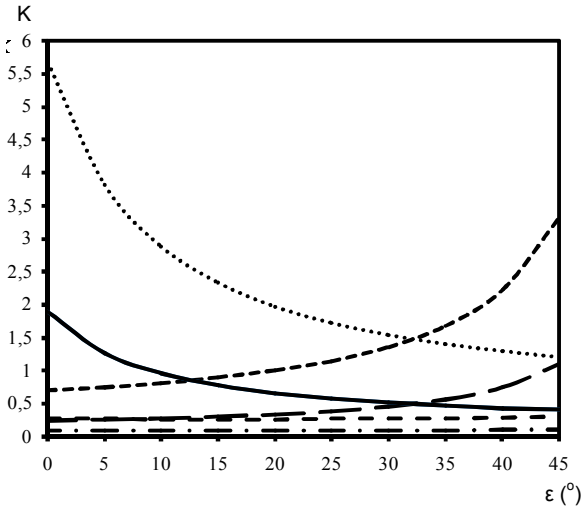


Figure 5. Diagram regarding relationship of inertial vibrating screen operation limits from ε vibration direction angle — — – K_1; – – – – – K_{gr1}; — · — · – K_2; — — — – K_{gr2}; ——— – K_O; ---------- – K_{grO}

Additionally the separated mass movement range increases including throwing up above the screen surface. Therefore at the vibration direction angle $\varepsilon = 0°$ in case of previous screens throwing up followed at the kinematics limits ratio of K=5.67, and in case of inertial vibrating screens at K=1.89, which ensures effective operation of round slotted screens at screen shoe kinematics decreases 3 times.

Analysis regarding conditions for material movement on (5), (6) and (7) screen indicated the following relationships for currently used inertial vibrating screens:

$$\frac{K_1}{K} = \frac{K_{gr1}}{K_{gr}}; \quad \frac{K_2}{K} = \frac{K_{gr2}}{K_{gr}}; \quad \frac{K_0}{K} = \frac{K_{gr0}}{K_{gr}}. \tag{9}$$

To determine the mass movement speed on the shoe a multiplier was applied in Letoszniew's formula (1963) that took into account a change of speed resulted from action of springs in (3) and (4) dependency.

$$v_1 = \omega r(1 + A_q)\cos(\alpha + \varepsilon)\left[(\sin\psi - \sin\psi_1) - (\psi - \psi_1)\frac{K_1}{K}\right]; \tag{10}$$

$$v_2 = \omega r(1 + A_q)\cos(\alpha + \varepsilon)\left[(\sin\theta - \sin\theta_1) + (\theta - \theta_1)\frac{K_2}{K}\right], \tag{11}$$

where:

v_1 and v_2 – speeds of mass upward and downward movement on screen surface, (m·s^{-1});

ψ and ψ_1 – current and initial moment of material upward movement on screen surface, (^{o});

θ and θ_1 – current and initial moment of material downward movement on screen surface, (^{o}).

Equation (9) and (10) may be also formulated as follows:

$$v_{1(2)} = \omega r(1+A_q)\cos(\alpha+\varepsilon)\left[\sin(U_{1(2)} - \arccos Z_{1(2)}) + \sqrt{1-Z_{1(2)}^2} - U_{1(2)}Z_{1(2)}\right] \quad (12)$$

where:

$$Z_1 = \frac{K_1}{K},\ Z_2 = \frac{K_2}{K},\ U_1 = \psi - \psi_1,\ U_2 = \theta - \theta_1$$

Maximum speed of mass movement on the screen will be obtained at *U=arccosZ,* and (12) equation will be as follows:

$$v_{1(2)\max} = 2\omega r(1+A_q)\cos(\alpha+\varepsilon)\left[\sqrt{1-Z_{1(2)}^2} - U_{1(2)}Z_{1(2)}\right] \quad (13)$$

Figure 6 presents diagram regarding relationship between the maximum speed of mass movement and kinematics at $\omega = 10$ rad·s^{-1}, $r = 6$ mm, $\alpha = 10°$, $\varepsilon = 0°$ and $A_q = 2$.

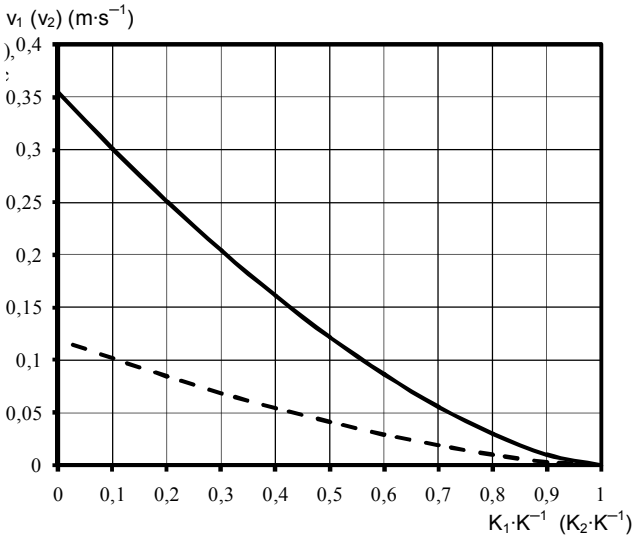


Figure 6. The relationship between the mass movement speed $v_1(v_2)$ and kinematics $K_1 \cdot K^{-1}$ ($K_2 \cdot K^{-1}$) ———— – inertial vibrating screens; — — — – current non vibrating screens

According to Figure no. 6 the use of inertial vibrating screen resulted in $1+A_p$ times speed increase of separated mass movement on screen's surface, which improved efficiency. Additionally it enabled reduction of frequency and amplitude of screen shoe vibration, what also decreased demand for screen shoe drive power and counterweight mass required to maintain balance.

An average speed of mass movement upon screen surface may be calculated from the following formula:

$$v_{śr} = \frac{\xi_d - \xi_g}{2\pi}\omega \tag{14}$$

Where: ξ_d and ξ_g – particle movement upward and downward on screen surface, (m).

Value of movement is calculated using the following equation:

$$\xi_{1(2)} = r(1+A_q)\cos(\alpha+\varepsilon)[Z_{1(2)} - \cos\left(U_{1(2)} - \arccos Z_{1(2)}\right) + \\ + U_{1(2)}\sqrt{1-Z_{1(2)}^2} - \frac{1}{2}U_{1(2)}^2 Z_{1(2)}]. \tag{15}$$

Mass movement speed above the limit value results in reduced fine fraction shifting efficiency, due to passing of particle next to the slot or particle reflected against the edge.

Limit values of mass upward and downward movement on screen surface may be defined with the following equations:

$$v_{gr1} = (B\cos\alpha - r_M)\sqrt{\frac{g}{2(r_M + B\sin\alpha)}} \tag{16}$$

$$v_{gr2} = (B\cos\alpha - r_M)\sqrt{\frac{g}{2(r_M - B\sin\alpha)}} \tag{17}$$

where:

B – screen slot width, (m)

r_M – particle radius (seed), (m).

On the basis of particle speed movement (12), (13), (16) and (17), as well as its path (15) it was possible to determine separation degree of mass passing through screen slots.

The mathematical models for flax mass separation with inertial vibrating screens have been determined with the traditional methodology, including separating single-coefficient experiments, 2^3 total coefficient experiment and three-level program of second row Boks-Bienkin's for three coefficients.

Results

As a result of physical and chemical properties examination of flax mass, the technological diagram was prepared for flax seed separation with separating plant fitted with inertial vibrating screens, actuating separation with blown air stream at speed of 3.5-4.0 $m \cdot s^{-1}$, separation of coarse impurities from mass with screen of rectangular slot 1.2-1.5 mm wide and

separation of fraction passing through screens with round slots of 2.2mm diameter, with rectangular slots 1.1 mm wide and round slots of 1.8 mm diameter.

Figure No. 7 presents the results from laboratory tests of proposed vibrating screens. The objective function was unit efficiency of screen q_F (kg·s^{-1}·m^{-2}) and impurity separation degree (from passing fraction) *E*. The variability intervals of coefficients and their limits were defined on basis of conducted theoretical discussion and a′priori information.

As a result of experiments, the rational intervals regarding coefficient changes were determined for flax threshed mass separation:

Spring stiffness modulus A_p – 0.8-1.6; connecting rod angular speed ω – 30-60 rad.·s^{-1}; vibration amplitude A – 8-15 mm; vibration direction angle ε – 30-45º; screen inclination angle α – 9-12º; kinematics limits coefficient for screen shoe *K* – 2.0-3.0.

The conducted experiments related to shifting determined that the factors that had most significant impact on optimization of flax threshed mass separation process were: spring stiffness modulus, vibration amplitude and kinematics limits ratio of screen shoe (Kruglenja et al., 2011; Zagajewski and Dreszer, 2008).

Further research defined mathematical models for flax threshed mass separation with inertial vibrating screens taking into account the basic coefficients:

– regarding unit output (capacity)

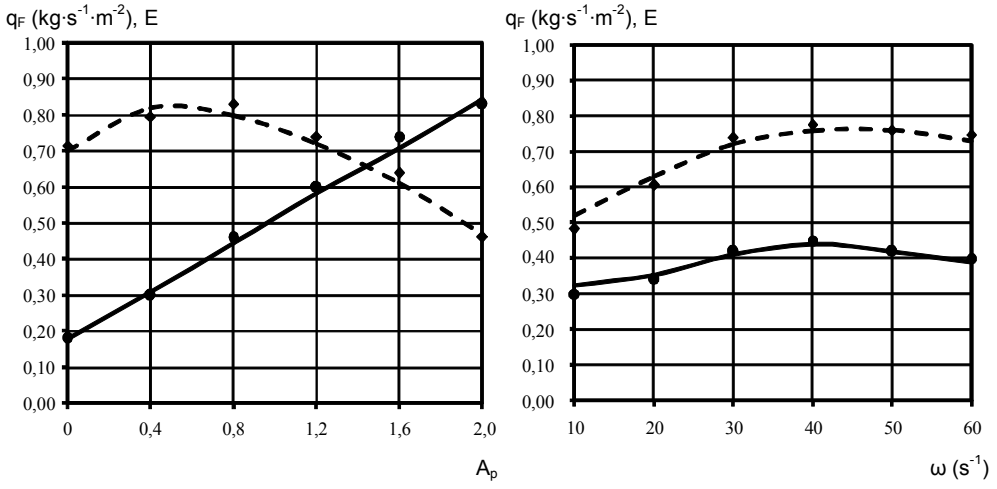
$$q_F = 0,51 + 0,06 \cdot A_p + 0,03 \cdot A + 0,08 \cdot K + 0,01 \cdot A_p \cdot A + \\ +0,01 \cdot A_p \cdot K + 0,01 \cdot A \cdot K + 0,01 \cdot A_p^2 - 0,02 \cdot A^2 + 0,01 \cdot K^2; \tag{18}$$

– regarding impurity separation degree

$$E = 0,67 - 0,05 \cdot A_p - 0,04 \cdot A - 0,06 \cdot K + 0,01 \cdot A^2 - 0,01 \cdot K^2. \tag{19}$$

To solve the problem, electronic calculation technology and Microsoft Excel software were used that provided the rational values of the following parameters:

A_p = 1.2, A = 8 mm, K = 2.3. At q_F = 0.72 kg·s^{-1}·m^{-2}, E = 0.87



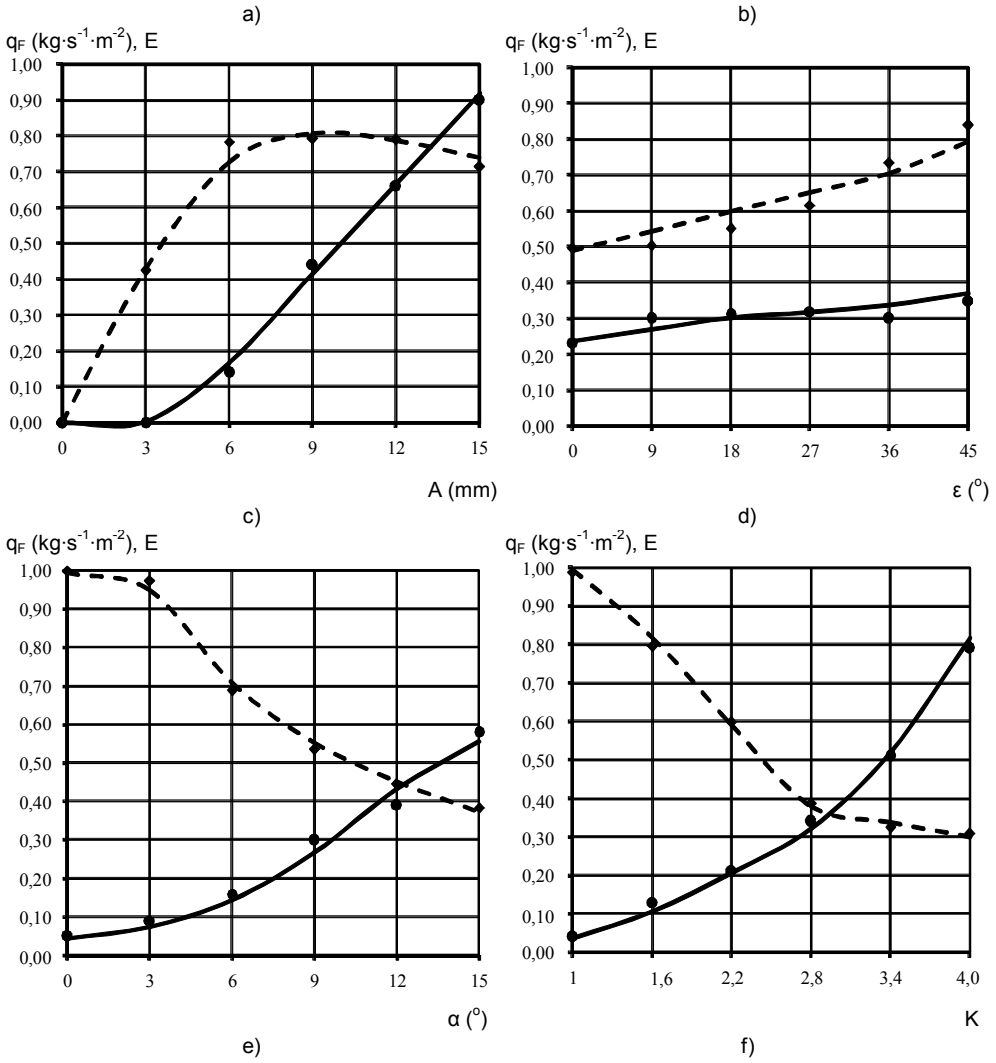


Figure 7. Diagrams regarding the relationship of q_F single screen output (capacity) and E impurity separation degree with A_p (a) spring stiffness modulus, ω (b) frequency, A (c) amplitude, ε (d) direction angle of screen shoe vibration, α (e) screen inclination angle and kinematics coefficient of screen shoe operation limits K (f), ——— – q_F (kg·s^{-1}·m^{-2}); — — — E;

The performance tests of a designed threshing plant – a separator fitted with inertial screens were conducted in 2003-2005 at Seed Centre in Gorecko.

To determine rational structure parameters of inertial screens it was suggested to use the monogram included in Figure No. 8, determined on the basis of theoretical research and experiments.

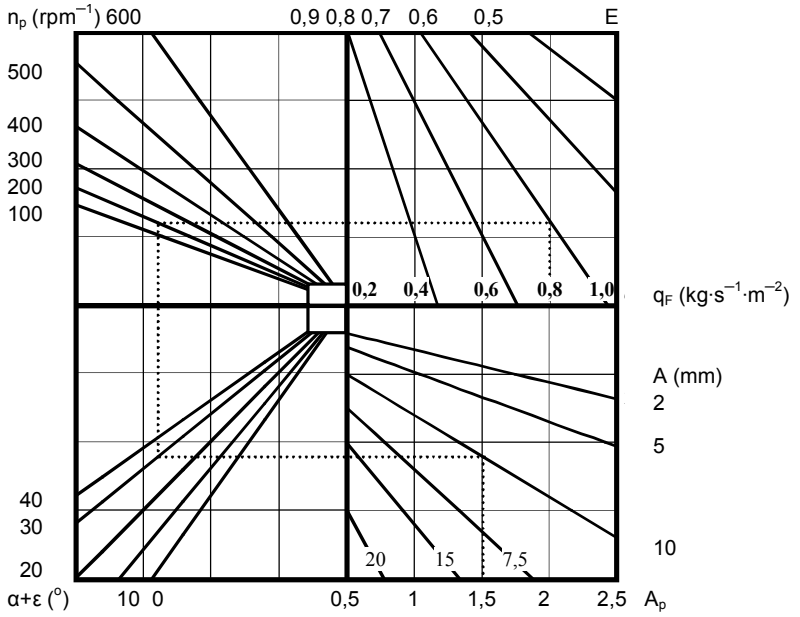


Figure 8. Monogram for determination of flax separation spring-mounted screens parameters: q_F – single screen output, (kg·s^{-1}·m^{-2}); E – impurity separation degree, n_p – screen shoe vibration frequency, (min^{-1}); α – screen inclination angle, (°); ε – screen vibration direction angle, (°); A – screen shoe vibration amplitude, mm; A_p – spring stiffness modulus

Spring stiffness modulus may be determined on the basis of single screen output and impurity separation degree, and upon choice of connecting rod rotation frequency, screen inclination angle, direction angle and screen shoe vibration amplitude. Depending on the output data also other parameters used in the monogram may be specified.

Thus for single screen output q_F = 0.8 kg·s^{-1}·m^{-2}, impurity separation degree E=0.7, screen shoe vibration frequency n_p = 200 rpm^{-1}, the sum of screen inclination angle and vibration direction angle α+ε=30° and screen shoe vibration amplitude A=10 mm, the required spring stiffness modulus was A_p = 1.5.

Spring parameters that provided the required modulus, may be determined according to the monogram or following formula:

$$A_p = \frac{\omega^2}{\frac{\pi^2 G d_B^4}{2 n_B m D_{\Pi}^3} - \omega^2} \tag{20}$$

where:

ω – connecting rod angular speed, (s^{-1})
G – nature deformation modulus, (MPa)
d_B – spiral spring wire section diameter, (m)
n_B – cylindrical spring coil number;
m – screen mass, (kg)
D_{Π} – cylindrical spring diameter, (m).

Comparing to the previous ones, the inertial vibrating screens allowed to increase seed separation degree by 6-8%, reduce cracking and damages of seed surface by 9-12%, as well as increase machine output by 10-25% (Kruglenja et al., 2011).

Conclusions

1. Comparing the results of theoretical discussion and experiments conducted with the use of the separator fitted with fixed screens mounted to the shoe and spring-mounted screens, for proper kinematics parameters the spring-mounted screens featured with improved output (capacity), precise fine and coarse impurity separation, as well as the reduced demand for screen shoe drive power.
2. Basic physical values that had impact on the separation process, namely, single screen output and impurity separation degree were: the screen shoe vibration degree, screen inclination degree and vibration direction, vibration amplitude and spring stiffness modulus. The rational values of these parameters may be specified using the mathematical formulas and the prepared monogram.
3. The screen capacity, namely q_F was on the straight-line basis dependent on A_p screen stiffness, A screen shoe vibration amplitude and increased along with the increase of q_F and A_p values. The increase was less evident in case of ω and ε value increase. Whereas a significant non-linear increase was evident in case of α and K parameters increase.
4. The impurity separation degree, namely E initially increased and then decreased as A_p spring stiffness increased, along with the increase of the screen shoe vibration amplitude. The increase was less evident in case of ω frequency and ε angle increase and decreased as a result of α and K parameter value increase.

References

Andrzejewska, A. (2006). *Poradnik plantatora lnu włóknistego*. Poznań. Instytut Włókien Naturalnych. ISBN 83-90973-960.

Grabowska, L.; Heller, K. (2009). *Uprawa lnu i konopi w ekologicznych gospodarstwach agroturystycznych* (on-line). Materiały szkoleniowe Podlaskiego Ośrodka Doradztwa Rolniczego w Szepietowie. Pozyskano z: http://www.lenikonopie.zielonewrota.pl/ pliki/Materialy_sz_lenkon.pdf

Janowska-Biernat, J. (2012). Tendencje w rozwoju rolnictwa ekologicznego w Polsce – prognozy a stan faktyczny. *Journal of Research and Applications in Agricultural Engineering. Vol. 57*(3), 179-181.

Heller, K. (2012). *Metodyka integrowanej ochrony roślin dla uprawy lnu włóknistego*. Instytut Włókien Naturalnych i Roślin Zielarskich. Poznań, 87.

Kamiński, E.; Šaršunov, V. A.; Kruglenja, V. E. (2014a). Fizyczno-mechaniczne i technologiczne właściwości lnianej masy omłotowej i jej części składowych. (Physico-mechanical and technological characteristics of flax threshed mass and its components). *Problemy Inżynierii Rolniczej, 2*(84), 63-75.

Kamiński, E.; Šaršunov, V. A.; Kruglenja, V. E. (2014b). Wstępna obróbka masy omłotowej lnu włóknistego w celu pozyskiwania nasion. (Pretreatment of flax threshed mass grown for seed). *Problemy Inżynierii Rolniczej, 2*(84), 77-86.

Казакевич, П.П.; Чеботарев, В.П.; Князев, А.А. (2004). Состояние и направления развития средств механизации предварительной очистки зерновороха в Республике Беларусь. В: *Ресурсосберегающие технологии в сельскохозяйственном производстве: сборник статей Международной научно-практической конференции. Т. 1.* Минск. БГАТУ с. 196-199.

Коцуба, В.И.; Кругленя, В.Е. (2004). Обоснование конструкции комбинированной молотилки–сепаратора льновороха МСЛВ-2.5. В: *Ресурсосбережение и экология в сельском хозяйстве: материалы VI международной конференции студентов, магистрантов и аспирантов*. Горки. БГСХА с. 151-153.

Кругленя, В.Е. (ред.) (2006). *Разработка технологических требований проектирования комплекса машин и оборудования для переработки сырого льняного вороха: отчет о НИР*. Рукопис No ГР 20065016. Горки. БГСХА, с. 35.

Кругленя, В.Е.; Коцуба, В.И.; Алексеенко, А.С. (2011). Результаты исследований процесса сепарации льновороха инерционными качающимися решетами. *Вестник Белорусской Государственной Сельскохозяйственной Академии. № 3* с. 147-151.

Letoszniew, M. N. (1963). *Maszyny Rolnicze*. Państwowe Wydawnictwo Rolnicze i Leśne.

Максимов, К.В. (2004). *Повышение эффективности комбайновой уборки льна-долгунца путем разработки устройства для предварительной сепарации льновороха* (on-line). Кандидацка диссертация. Санкт Петербург. с. 207. Научная библиотека диссертаций и авторефератов disserCat. Pozyskano z: http://www.dissercat.com/content/povyshenie-effektivnosti-kombainovoi-uborki-lna-dolguntsaputem-razrabotki-ustroistva-dlya-p#ixzz2x3rl0CEA

Pawlak, J. (2010). Rola mechanizacji w rozwoju rolnictwa. *Roczniki Nauk Rolniczych. Ser. G. T. 97. Z. 2*, 165-175.

Шаршунов, В.А.; Кругленя, В.Е.; Кудрявцев, А.Н.; Алексеенко, А.С.; Коцуба, В.И. (2010). Выбор конструктивно-технологической схемы сепарирующего устройства и параметров его решет. Весци НАН Беларусі. *Серыя аграрных навук. No 4,* 120-125.

Шаршунов, В.А.; Кругленя, В.Е.; Кудрявцев, А.Н.; Алексеенко, А.С.; Коцуба, В.И. (2012). *Механико-технологические основы совершенствования послеуборочной обработки льновороха на семена.* Монография. Горки. Министерство сельского хозяйства и продовольствия Республики Беларусь, Главное управление образования, науки и кадров, Белорусская государственная сельскохозяйственная академия. ISBN: 987-985-467-3776.

Zagajewski, P.; Dreszer, K. A. (2008). The state of theoretical studies on threshing and separation of grain from cereal mass. *Journal of Research and Applications in Agricultural Engineering. Vol. 51*(4), 4-9.

CZYSZCZALNIA DO NASION LNU Z DRGAJĄCYMI SITAMI

Streszczenie. Celem badań było porównanie efektywności pracy czyszczalni z sitami mocowanymi w koszu sitowym na stałe z mocowanymi sprężyście, ustalenie wpływu podstawowych parametrów kinematycznych na wydajność procesu czyszczenia. Analizowano przypadki stosowania mocowania sit na sprężynach cylindrycznych i płaskich. Badano proces przemieszczania się materiału czyszczonego po powierzchni sit z włączaniem etapów ruchu do góry, do dołu, podrzucania. Wielkościami charakteryzującymi proces czyszczenia były wydajność (przepustowość) sit i stopień oddzielania domieszek. Analizowanymi parametrami kinematycznymi były: amplituda drgań kosza sitowego, amplituda drgań własnych sit, kąt pochylenia sit, kąt kierunkowy drgań sit, częstotliwość drgań własnych, wskaźnik reżimu kinematycznego. W rezultacie otrzymano matematyczne modele procesu separacji dla jednostkowej wydajności i stopnia oddzielania domieszek. Z równań tych obliczono najlepsze wartości parametrów: A_p=1,2, A=8 mm, K=2,3, dla których q_F=0,72 kg·s^{-1}·m^{-2}, E=0,87. Parametry sprężyn, zapewniające wymagany współczynnik sprężystości, można określić za pomocą monogramu lub formuły matematycznej (20). Z przeprowadzonych eksperymentów wynika, że przepustowość sit q_F zależy liniowo od sztywności sprężyn A_p, amplitudy drgań kosza sitowego A i rośnie wraz z wartościami q_F i A_p. Mniej wyraźnie wzrasta również ze wzrostem wartości ω i ε. Natomiast nieliniowo i znacznie wzrasta ze wzrostem parametrów α i K. Stopień oddzielania domieszek E początkowo wzrasta a następnie maleje ze wzrostem sztywności sprężyn A_p, oraz ze wzrostem amplitudy drgań kosza sitowego. Mniej wyraźnie wzrasta ze wzrostem częstotliwości ω i kąta ε. Oddzielanie domieszek wyraźnie maleje ze wzrostem wartości parametrów α i K.

Słowa kluczowe: uprawa lnu, omłot**,** nasiona lnu, czyszczalnia, separator

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RELATIONAL DATABASE SUPPORTING EXPERIMENTS CONNECTED WITH PLANT PROTECTION

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ABSTRACT

Carrying out studies connected with application of plants protection products for chemical methods of plants protection against pests and diseases requires to use databases in order to collect the obtained results. Databases, and more precisely information stored in them, may be used not only in the process of conducting further trials, but they may also be helpful for users of the bases, for example with their scientific work. This article presents a database application, "Documents archive", based on the relational database designed and implemented by using SZBD Microsoft Access 2010. The software allows recording results of research and experiments related to efficacy of plant protection products at the Research Institute of Horticulture in Skierniewice, and effective usage of results obtained earlier in the research process of this unit. Uncomplicated, user-friendly and fully automated interface of the presented database application was implemented based on diverse forms, with the usage of macro and VBA language procedures. Possibility of cooperation with diverse software significantly increases the possibilities that are offered by database application "Documents archive" in finding and processing the stored data, which makes it a very useful tool (IT tool) for research connected with plant protection. In this way, based on the research and experiments results stored in the base, the database application allows a quick evaluation of the applied plants protection products, as well as selection of the most effective scenario of their usage for a specific crop or pest.

Introduction

Nowadays, it is very difficult to imagine production of plant produce without application of plant protection products (PPPs) in the farms. In order to enable effective control of plant pests and diseases, products of this type should be used appropriately. Besides, their application is inevitably connected with a possible threat to the natural environment, including human and animals' health. Therefore, carrying out research and experiments that, on one hand deal with effectiveness of application of PPPs, and on the other hand consider

protecting the natural environment against their side effects is thus justified and required by the European Union legislation.

Currently, databases are a mean to store and process huge amount of diverse information. A database may be defined, inter alia, as a model of a certain part of real world (unnecessarily existing in a physical way or such that has never existed physically) that is a subject of interest for future users. A piece of reality that may be modelled by means of databases is farming and, as a particular component, scientific research and experiments conducted in this respect. Examples of database applications supporting farmers in their everyday work are a few (Sarec et al., 2007; Sieczko, 2012; Treder et al., 2013; Bzowska-Bakalarz and Gil, 2008), including some that refer to diverse aspects connected with research of farm production (Urbańska and Gierszal, 2003). The systems of collection of data on sale and consumption of PPPs are the basis to develop national strategies of sustainable plant protection (Stobiecki, 2006). The decision support system presented by Urbańska et al. (2010) is an IT tool for farmers and other professionals (e.g. advisors) aiming at easing identification of pests and diseases, as well as helping to perform an appropriate evaluation of potential threats and the threshold level of infection for a particular crop.

Database application "Documents archives"

To manage the data gathered in experiments and trials carried out at the Research Institute of Horticulture in Skierniewice (RIH), a "Documents archive" database was created. Its main aim was storing the diverse information obtained from efficacy studies of PPPs, and enabling an effective usage of previously obtained results. The need for such kind of software results from the European Union (EU) requirements of electronic archives for efficacy studies (Reg. EU 1107/2009).

The system developed enables thus registering all types of information connected with this activity, storing the data organized in appropriate documents, according to the requirements of the EU and the Main Inspectorate of Plant Protection and Seed Production (GIORiN) as well as internal department procedures. The application carries out the following operations: introduction and management of data (data about contractors, orders, plants protection means, research, experiments, subcontractors), browsing information from diverse charts in the form of documents, all types of inquiries related to the information stored in the database, data exchange (export/import) with other applications, data archiving after certain time, data protection.

The scheme of relational "Documents archive" data base created at SZBD Microsoft Access (2010) for the efficacy studies carried out at RIH is presented in Figure 1.

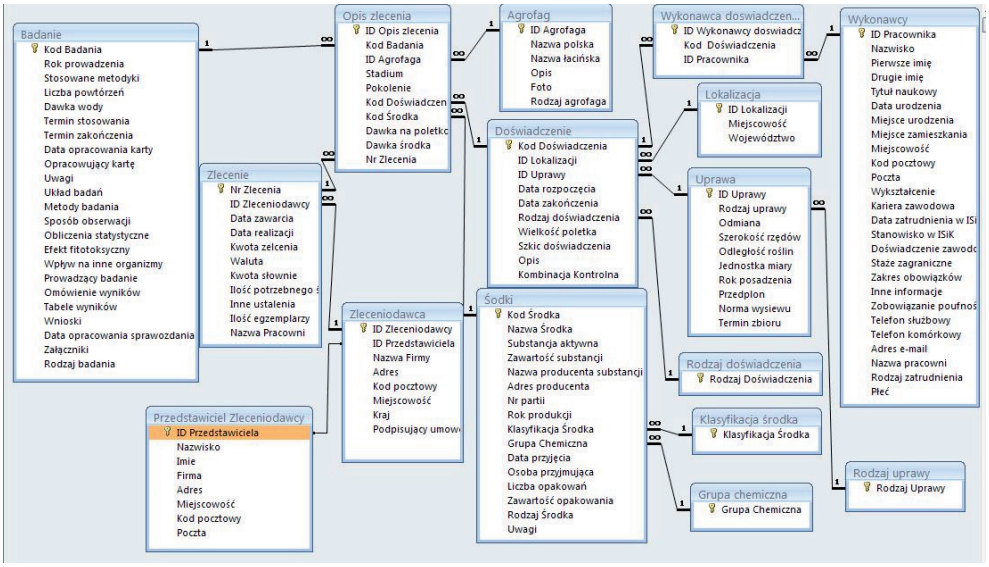

Figure 1. Scheme of the relational database "Documents archive".

In the database all stored data is divided into the following headings: Ordering Party, Orders, Products, Research, Experiments, Pests, Contractors, that were initially planned to be the base charts. However, after the analysis of the scheme it turned out that certain data would be duplicated (i.e. were redundant). Therefore, an initial normalization was carried out of the existing relations. As a result other base relations have been created (e.g. Crop – containing data related to the crop, or Location – storing information about the place of the crop). Some of the database relations store general and basic data, e.g. Products Classification is grouping PPPs on account of their use (insecticide, fungicide, herbicide); the chart Chemical Group classifies the PPPs according to their active substance; the kinds of crops that are subject of the research are considered in the Crop Kind chart.

Interface of database application „Documents archive"

The interface for the database application was developed based on diverse forms offered by Microsoft Access. For it automation, there were various macros diverse macros, as well as with procedures and functions of the Visual Basic for Application language. A simplified scheme of the database application "Documents Archive" is presented in Figure 2.

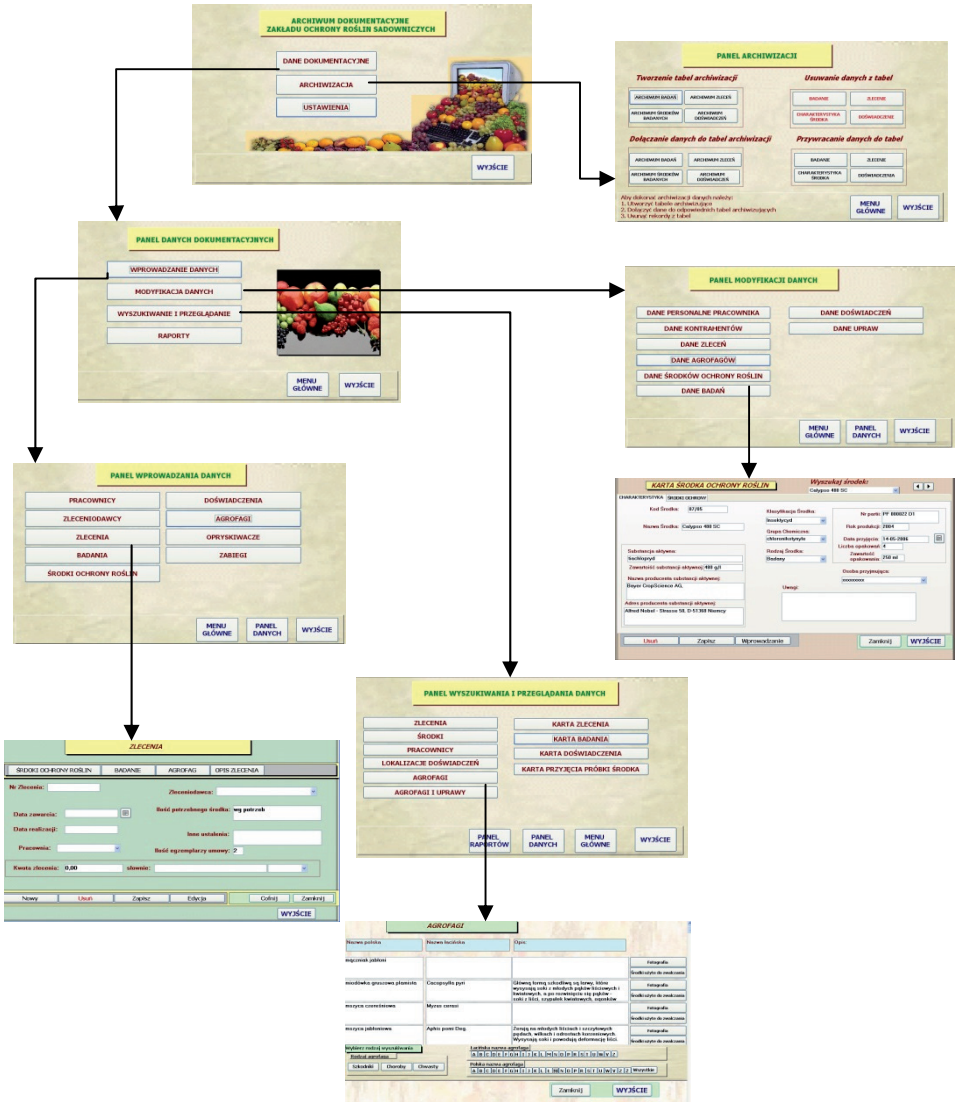

Figure 2. Simplified scheme of the interface of the relational database "Documents archive"

Among the functions which are offered by the presented database application, the possibility of printing data (that come from diverse charts) in the form of reports, which can be basically divided into two groups. To the first group belong all reports that allow to present data in the form of a document, the outlay of which is defined by internal regulations and department procedures (e.g. research report, card of plant protection means, etc.). The second type of reports is formed of diverse statistics that are created based on activities of Department of Fruit Plant Protection of RIH (e.g. lists of conducted tasks, contractors, orders, etc.). The scheme and an example of the report is presented in Figure 3.

The database application allows carrying out diverse analyses and comparisons of the results obtained from independent experiments and tests. It enables simultaneous display of the results of trials carried out in different seasons that refer to e.g. a specific pests or a specific PPP, allowing a comprehensive interpretation of the data. Another useful feature of the database is the possibility of interfacing with other softwares that is particularly helpful at the stage of elaborating the results. When using the software, it is possible to carry out diverse analyses (e.g. statistical ones) that would not be possible if standard tools offered by database software were used. Such diverse lists of data are an additional useful asset that significantly improves and facilitate analysis and drawing conclusions based on the results of trials and tests.

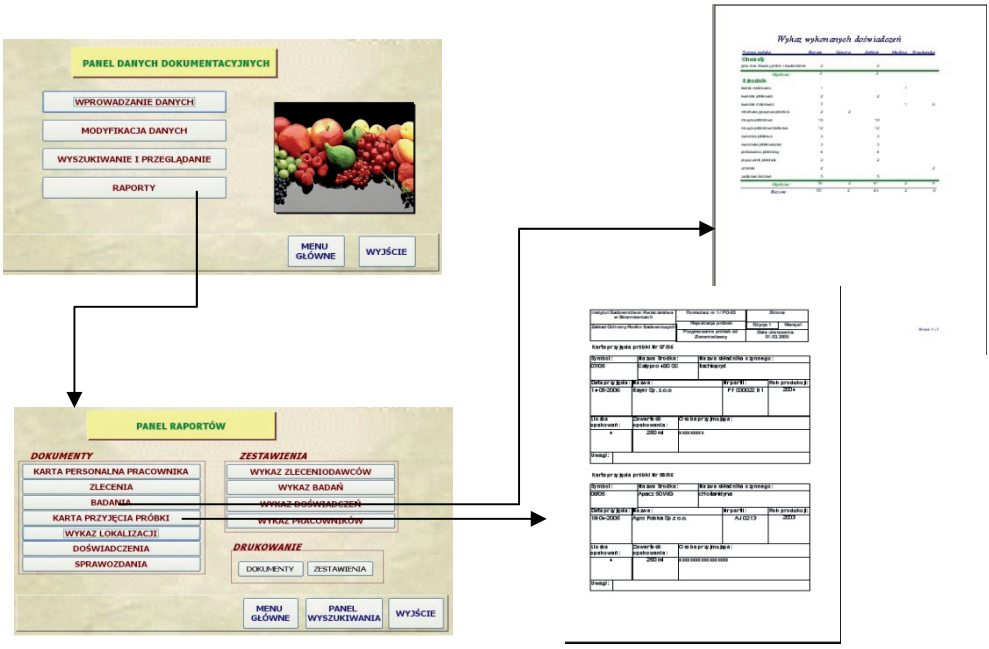

Figure 3. The interface of the relational database "Documents archive" – scheme of using of forms in generating exemplary reports

Possibilities of cooperation with other software

Among the softwares taht can be interfaces with the database „Documents archive" can be listed: calculation sheets, text editors, applications sending mails, fax machines and internet browsers. This is made possible by tools exporting data to other applications, as well as tools that facilitate import of data from such applications. This characteristic improves significantly the possibilities of making available and processing of the stored data. „Documents archive" database application can cooperate with diverse components of MS Microsoft Office package, as well as with other software (e.g. ARM7 application) that support conducting experimental research. Data exchange between the database and other applicationscan be obtained using MS Access tools and by means of them to Exchange data from the whole chart or sheet (in case of data import from MS Excel). It is also possible to exchange only a part of data included in the chart, but appropriate macros must be created and configured also using Visual Basic software. An example of data exchange with MS Excel in „Documents archive" database is presented in Figure 4.

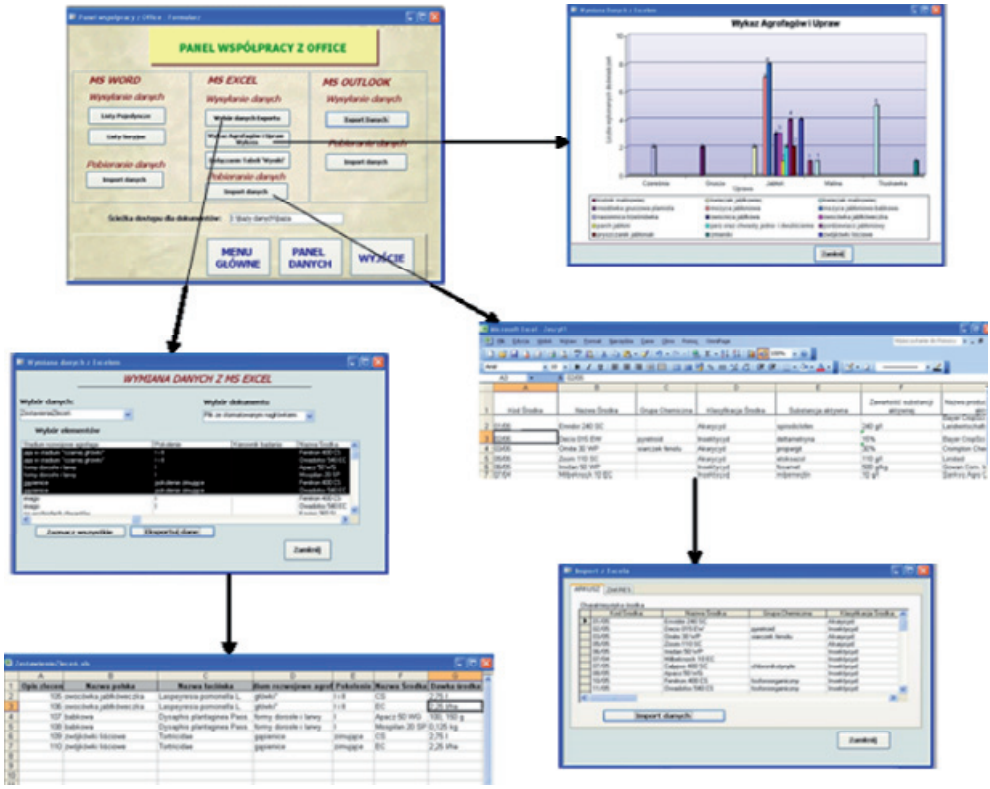

Figure 4. Scheme of data exchange with MS Excel at the relational database "Documents archive"

The database application „Documents archive" uses also sites for data access (DAP – Data Access Pages), which are prepared to be used for websites. They combine features of forms and reports in HTML format documents connected directly with data in the database, which can be placed in the Internet or can be used in MS Access program environment. Access sites use the information that changes dynamically, i.e. a browser can access dynamic data stored in databases in an interactive way. One of the most interesting features of DAP sites is a possibility of accessing grouped data, which is presented in Figure 5. This feature allows using data for the analysis of information stored in charts and makes it possible to browse collected information and access data in a deeper way in order to find out more on specific data connected with collected information.

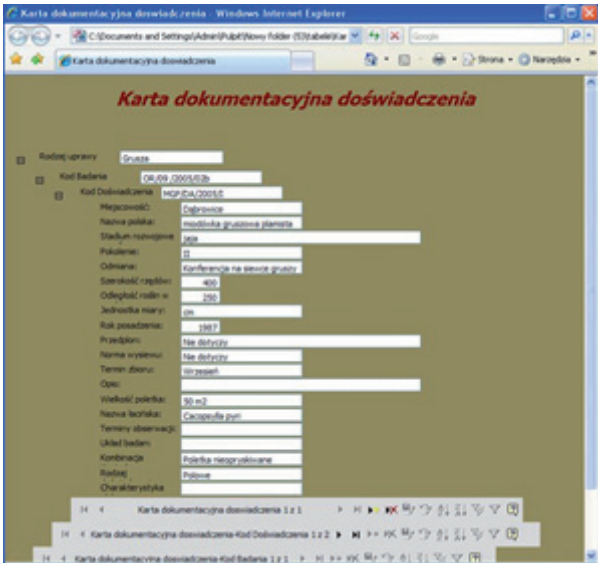

Figure 5. The interface of the relational database "Documents archive" – an access page "Documentation card of the experiment" with shown grouping selectors

In the relation database „Documents archive", it was used Java language, which, is the effective language of Java Server Pages (JSP) technology that is part of JavaPlatform System. JSP uses a bridge in order to make a connection with the database and acquire data: JDBC:ODBC. JDBC allows giving instructions SQL from the level of Java language, and ODBC is an appropriate steering tool for the base. By means of such configured connection it is possible to make all operations at the database using available data (adding, removing, editing and records modification), using the interface created in another programming language. Java language was used in some HTML forms, and in their case all actions are performed by means of the code included in the files *.jsp placed at the local server. It allows using database by users of the local internet web (intranet). Upon performing registration procedure, each time the user's login and password are verified, and if the correctness is confirmed (i.e. they are in the chart 'Users') steering is transferred to another website, e.g. Dane.html (fig. 6), where a user may find all necessary data that refer to a particular PPP, or

may display information on all PPPs available at the data base. When pressing the „Find" button, appropriate data will be selected from the database (Fig. 6).

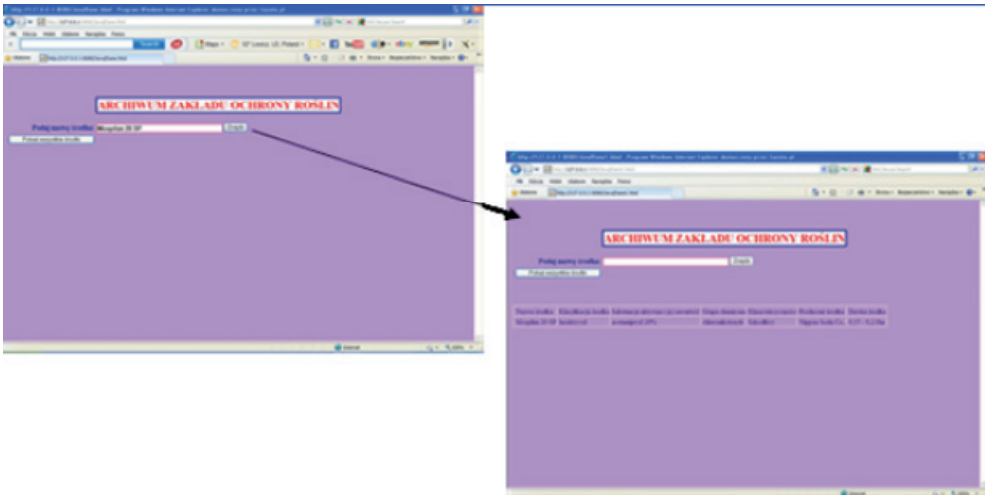

Figure 6. The interface of the relational database "Documents archive" – an example of forms created at JavaPlatform by using Java language

Conclusions

Databases may become an extremely helpful scientific tool used in experiments connected with plant protection. The "Documents archive" database that we have developed is an example of such tool that has been used for storing information obtained from efficiency trials of PPPs conducted at the Horticulture Department of the Research Institute of Horticulture in Skierniewice. It contains all information related to the trials, including the data of employees who performed the study, the used means of plant protection, kind of crop that is the subject of the research, location of experiments and tests, as well as their descriptions. In this way the complete amount of information is made available that may be used for further scientific studies. The scheme of the relational database, on which the presented database application is based, was validated (e.g. charts were appropriately normalized), which prevents redundancy of data. A fully automated interface of the program (because of the usage of macros and VBA language) enables its users, by means of specially selected forms, to quickly acquire the data stored in the database and to display them on the monitor or to print them after selecting one of the several specially designed report forms. A possibility of interfacing with diverse softwares (components of MS Microsoft Office, ARM7 application) as well as using diverse IT tools (Visual Basic for Applications language, SQL language, DAP – Data Access Pages, Java language, Java Server Pages technology, HTML language) allows the presented information system to offer diverse ways of obtaining the stored information and processing it according to the requirements and needs of the users. It is believed that such a database system is a significant support for conducting efficacy stud-

ies of PPPs, which was practically verified by implementing it at the Horticulture Department of the Research Institute of Horticulture in Skierniewice.

References

Bzowska-Bakalarz, M.; Gil, K. (2008). Analiza funkcjonowania bazy danych do monitorowania systemu produkcji buraków cukrowych. *Inżynieria Rolnicza, 2*(100), 15-21.

Petersem, J. (2003). *Wprowadzenie do baz danych.* Wydawnictwo Helion, Gliwice, ISBN 83-7361-716-7.

Prague, C.N.; Irwin, M. R.; Reardon, J. (2004). *Access 2003 PL Biblia*. Wydawnictwo Helion, Gliwice, ISBN 83-7361-381-1.

Rozporządzenie Parlamentu Europejskiego I Rady (We) Nr 1107/2009 z dnia 21 października 2009 r. dotyczące wprowadzania do obrotu środków ochrony roślin i uchylające dyrektywy Rady 79/117/EWG i 91/414/EWG. Dziennik Urzędowy Unii Europejskiej L 309/1. http://www.gis.gov.pl/ckfinder/userfiles/files/EFSA/rozporz%C4%85dzenie%201107_2009.pdf

Šařec, O.; Šařec, P; Dobek, T.K. (2007). Baza danych jako naukowe narzędzie wykorzystywane w technologiach produkcji roślinnej. *Inżynieria Rolnicza, 2*(90), 271-277.

Sieczko, L. (2012). Aplikacja bazodanowa wspomagająca prowadzenie dokumentacji w gospodarstwach ekologicznych starających się o dopłaty rolnośrodowiskowe. *Zeszyty naukowe Uniwersytetu Szczecińskiego, Studia Informatica, 733*(30), 211-219.

Stobiecki, S. (2006). Systemy gromadzenia danych o sprzedaży i zużyciu środków ochrony roślin w Polsce na tle wymogów Unii Europejskiej. Stan obecny i perspektywy. *Postępy w Ochronie Roślin*, *46*(1), 463-469.

Tartanus, M. (2006). Archiwum Dokumentów w zakładzie Ochrony Roślin jako przykład relacyjnej bazy danych programu Microsoft Access. *Praca licencjacka wykonana pod kierunkiem dr T. Antczaka*, Wydział Matematyki Uniwersytetu Łódzkiego.

Tartanus, M. (2009). Programowanie aplikacji bazodanowych programu Microsoft Access współpracujących z innym oprogramowaniem. *Praca magisterska wykonana pod kierunkiem dr T. Antczaka*, Wydział Matematyki i Informatyki Uniwersytetu Łódzkiego.

Treder, W.; Klamkowski, K.; Tryngiel-Gać, A.; Sas, D.; Pych, T. (2013). Serwis nawodnieniowy – internetowa platforma wspomagania decyzji związanych z nawadnianiem roślin sadowniczych. *Infrastruktura i Ekologia Terenów Wiejskich*, *2*(I), 19-30.

Urbańska, M.; Gierszal, H. (2003). System bazodanowy do badań malakofauny. *Inżynieria Rolnicza, 12*(54).

Urbańska, M.; ,Gierszal, H.; Nowacki, M. (2010). System wsparcia decyzji w ochronie roślin uprawnych. *Inżynieria Rolnicza, 7*(125), 223-228.

RELACYJNA BAZA DANYCH WSPOMAGAJĄCA PROWADZENIE DOŚWIADCZEŃ ZWIĄZANYCH Z OCHRONĄ ROŚLIN

Streszczenie. Prowadzenie badań związanych ze stosowaniem środków ochrony w chemicznych metodach ochrony roślin uprawnych przed szkodnikami i chorobami wymaga wykorzystania baz danych w celu gromadzenia uzyskanych wyników. Bazy danych, a ściślej informacje w nich przechowywane, można wykorzystać nie tylko w trakcie prowadzenia dalszych doświadczeń w tym obszarze badawczym, ale także mogą być pomocne dla użytkowników tych baz, choćby w ich pracy naukowej. W niniejszym artykule została zaprezentowana aplikacja bazodanowa "Archiwum dokumentów" oparta na relacyjnej bazie danych zaprojektowanej i zaimplementowanej przy wykorzystaniu SZBD Microsoft Access 2010. Program ten umożliwia zapisywanie wyników badań i doświadczeń prowadzonych nad skutecznością środków ochrony roślin w Oddziale Sadownictwa, Instytutu Ogrodnictwa w Skierniewicach oraz efektywne wykorzystanie wcześniej uzyskanych wyników w toku procesu badawczego w tej jednostce naukowej. Nieskomplikowany, przyjazny użytkownikowi i w pełni zautomatyzowany interfejs prezentowanej aplikacji bazodanowej został zaimplementowany w oparciu o rozmaite formularze, przy wykorzystaniu makr i procedur języka VBA. Natomiast możliwość współpracy z różnorakim oprogramowaniem znacznie zwiększa możliwości, jakie oferuje aplikacja bazodanowa „Archiwum dokumentów" w kwestii wyszukiwania i przetwarzania przechowywanych informacji, czyniąc z niej użyteczne narzędzie (informatyczne) wykorzystywane w prowadzeniu badań i doświadczeń naukowych związanych z ochroną roślin. W ten sposób, w oparciu o przechowywane w bazie danych wyniki badań i doświadczeń, aplikacja bazodanowa umożliwia szybką ocenę stosowanych środków ochrony roślin oraz wybór najbardziej optymalnego wariantu, jeśli chodzi o ich wykorzystanie dla konkretnej uprawy lub agrofaga.

Słowa kluczowe: relacyjna baza danych; aplikacja bazodanowa; interfejs bazy danych; ochrona roślin

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ANALYSIS OF THE ELECTRIC POWER DISTRIBUTION SYSTEMS ON THE RURAL AREAS OF CENTRAL POLAND

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ABSTRACT

Dynamics of the quantity and quality changes of the rural electric power distribution systems compared to the urban systems was analysed. It was found out that in 2006-2011 at the 18% growth of electric energy consumption by rural households approx. 0.5% development of the distribution systems, through which these households are supplied with electric power, was reported. Nonetheless, values of indicators which characterize the quality of supply of recipients have not deteriorated. The degree of use of the line capacity is still low. The issue, from the point of view of the electric power system capacity, are small fragments of overloaded distribution networks, improvement of which is first of all justified by the intensification of existing networks capacity, not by development.

Introduction

In the document by the Ministry of Economics *Energy policy of Poland to 2030* (2009) attention is paid to the necessity of development of the electric power systems in order to improve reliability of their operation, thus certainty of supplying recipients with electric energy. Reliable supplies of electric energy to recipients require a correctly operating electric power system with sufficient capacity and a satisfactory technical condition.

Along with a systematic increase of demand for electric energy and development of dispersed sources, particularly the wind power industry, there is a need to increase the capacity of supplying lines. The necessity of improving the technical condition of the electric power systems follows also from their age, which results not only in the unsatisfactory quality of supply but also excessive network losses. Thus, ensuring an efficient electric power system requires modernization of the existing network systems and construction of new network elements. In order to plan these undertakings, systematic analyses of sizes, which characterize network qualities, particularly their changes in time, are necessary. In the subject literature, there are many works on this scope (Kulczycki et al., 2009; Maciejewski, 2011; Marzecki, 2005; Niewiedział and Niewiedział, 2012; Strożek, 2009; Trojanowska, 2008, 2009). Mainly they concern the whole country or a region. Today, however, the local power industry determines planning trends. Territorial self-governments and distribution enterprises are responsible for supply in electric energy on the local level (Journal of Laws No. 54, 1997).

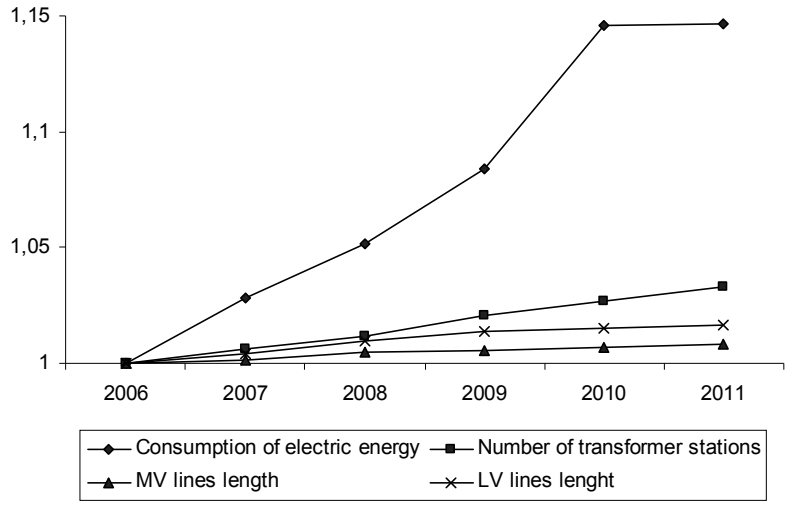
The objective, scope and object of the paper

The objective of the paper was the analysis of development of distribution networks through which rural households are supplied with electric energy, in particular the quantity and quality analysis of these networks. To execute the objective of the paper, dynamics of the electric power infrastructure and indicators, the most frequently used in power industry for assessment of networks' condition, were researched and the description of networks on rural areas was compared to the description of urban networks. The objective of the paper was executed on the example of the rural networks from central Poland located in the region of electric power operation of one distribution enterprise. These networks consist in more than 3,600 km of MV lines, 5,200 km of LV lines and 2,600 of MV/LV power transformer stations.

Research results

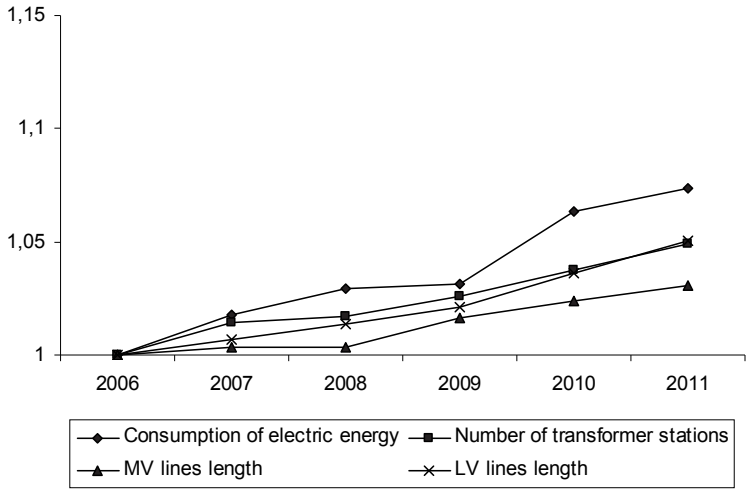
The quantity analysis of the system

Development of electric power networks should be connected with inter alia changes of recipients' demands for electric energy. Figure 1 presents dynamics of changes of electric energy consumption by households on the investigated rural area within 5 years compared to the dynamics of quantity changes of MV and LV lines and the power transformers stations of MV/LV through which these households are supplied with energy. Analogous courses, but referred to the cities were presented in figure 2.



Source: author's own calculations based on data of a distribution company

Figure 1. Dynamics of electric energy consumption by households and development of electric power infrastructure on rural areas



Source: author's own calculations based on data of a distribution company

Figure 2. Dynamics of electric energy consumption by households and development of electric power infrastructure in cities

One may notice that in the analysed period of time dynamics of changes in consumption of electric energy by rural households was considerably higher than in urban households. Annual average increase of this consumption shaped on the level of 3.6% and 1.1% respectively in the country and in the city. Such great increase in the demand for electric energy of rural households results mainly from moving citizens of big agglomerations' to the country. Moreover, rural households consume per one recipient at the average 2.4 MWh of electric energy, i.e. approx. 10% more than the households in cities. Accompanying development of infrastructure was considerably lower in the country than in the city. Therefore, in the investigated period average annual increase of the number of power transformers stations and the MV and LV lines lengths were for rural areas respectively 0.65%, 0.17% and 0.33% whereas for cities – 0.99%, 0.62% and 1.01%.

This tendency does not concern only the recent years. As a result, participation of rural system in the entire system decreases systematically, but in a small degree, which presently for the MV line is 72%, for the LV line – 67% and for the power transformer stations of MV/LV – 73%. At a more dynamic increase of energy consumption than in case of rural electric power infrastructure, profitability of investing in local distribution networks rises. We can only wonder what impact such situation has on their quality.

Analysis of the system quality

Indicators, which directly or indirectly describe the quality of the supplied energy, in particular the supply voltage, are the best for assessment of the quality of networks.

Value of voltages at the ends of power lines depends on their length, cross section and indirectly from the use of admissible load. It is considered that in order to ensure the re-

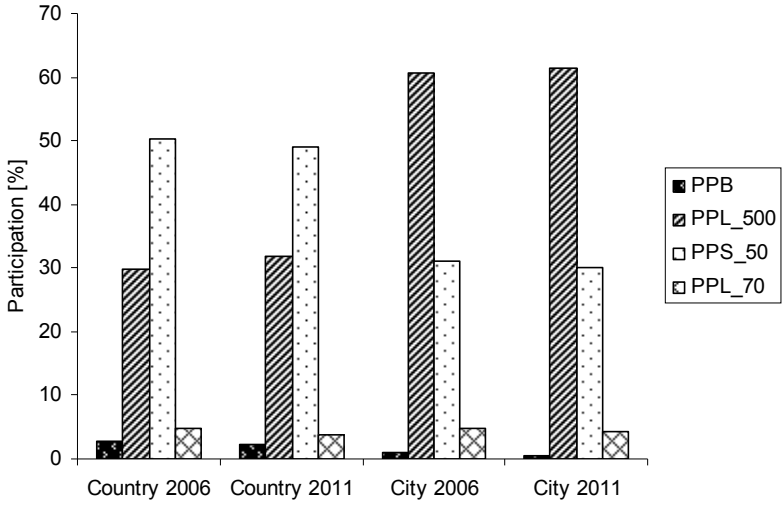
quired level of voltage at the end of the MV power lines, the total length of supply lines from one field of main switching station should not exceed 50 km.

On the investigated rural areas, participation of the MV power lines with the length exceeding 50 km on the rural areas is 10.6% and in the cities 0.4% and it has not changed for years. Many circuits of medium voltage have small cross sections of conduits i.e. bigger than 35 mm^2. In the country they amount to 63% and in the cities to 43% of all MV circuits.

On account of the lines capacity in the country and in the city, situation is similar and participation of circuits with the capacity higher than 50% (but lower than 80%) shapes at the level of 0.07.

For assessment of the quality of low voltage networks, distribution companies use the following indexes:

- percentage participation of the LV circuits with the phase voltage above the rated voltage (Uzn), within the norm, within the scope from Uzn – 10% to Uzn – 20%, below Uzn – 20%,
- percentage participation of circuits with the length below 500 m, from 500 to 1000 m, above 1000 m.
- percentage participation of circuits of the cross section of conduits below 25 mm^2, 35 mm^2, 50 mm^2, 70 mm^2, above 70 mm^2,
- percentage participation of circuits with the use of the line capacity above 90%, from 70 to 89%, from 50 to 69%, to 49%.



Source: author's own calculations based on data of a distribution company

Figure 3. Indexes describing quality of low voltage network in the country and in the city, where: PPB – participation of LV circuits of inadmissible voltage, PPL_500 – participation of LV circuits of the length below 500 m, PPS_50 – participation of LV circuits of the cross-section of conduits below 50 mm^2, PPL_70 – participation of LV circuits of the admissible capacity use degree above 70%

Although, these are recognized values, not all are equally important, and thus useful for assessment of the network quality. According to the research carried out by Trojanowska and Nęcka (2010) to such sizes one should include: participation of LV circuits of inadmissible voltage (PPB) i.e. exceeding ±10% rated voltage Uzn, of the length below 500 m (PPL_500) and the cross-section of conduits below 50 mm^2 (PPS_50) and the circuits of the admissible capacity use degree above 70% (PPL_70). The research was limited only to the analysis of these indexes. Calculations results were presented in figure 3.

As it can be seen in the analysed period, indicators characterizing the quality of the low voltage network have not changed a lot and the quality of rural networks was and is slightly worse than the urban ones. On the rural areas participation of the LV circuits, where voltages inadmissible by provisions occur, reaches 2, 3% locally decreasing below the rated value even by more than 20%. In the cities this phenomenon is marginal. Such state of affairs is influenced by, inter alia, the length of circuits and their cross-sections. In the country approx. 70% of circuits is longer than 500 m and 50% of circuits has cross-sections not bigger than 35 mm^2. The capacity of rural and urban networks is similar. Majority of lines is overloaded to a small extent. However, there are fragments, where overloads occur, which result in limitation of transmitting capacities of networks.

Conclusion

There is a constant need to increase the network capacity on account of development of the dispersed power industry especially the wind power industry. In present realities, however, it seems that instead of expensive and risky development of the electric power systems, first of all, the use of transmission capacities of the existing networks should be intensified. The easiest possibility to increase the overhead line capacity is to increase border working temperature of conduits, which should be accompanied by regulation of the power line sag. Furthermore, the analysis should be carried out to find out whether assumed exploitation times of basic elements of a network, after which they should be replaced, are not too short.

References

Kulczycki, J.; Niewiedział, E.; Niewiedział, R. (2009). Wybrane problemy rozwoju wiejskich sieci elektroenergetycznych. *INPE – Miesięcznik Stowarzyszenia Elektryków Polskich, 122-123*, 75-85.

Maciejewski, Z. (2011). Stan krajowego systemu elektroenergetycznego. *Polityka Energetyczna, 14*(2), 249-259.

Marzecki, J. (2005). Wybrane zagadnienia z problematyki terenowych sieci elektroenergetycznych. *Przegląd Elektrotechniczny, 1*, 62-67.

Niewiedział, E.; Niewiedział, R. (2012). Potrzeby rozwojowe i modernizacyjne sieci elektroenergetycznych na terenach wiejskich. *Wiadomości Elektrotechniczne, 8*(80), 3-10.

Polityka energetyczna Polski do 2030 roku. (2009). *Ministerstwo Gospodarki*: *Załącznik do uchwały nr 202/2009 Rady Ministrów* z dnia 10 listopada 2009 r.

Strożek, K. (2009). *Aktualny stan potrzeb odnowy i modernizacji wiejskich sieci elektroenergetycznych*. Poznań, PTPiREE. Pozyskano z: http://www.sep.com.pl/opracowania/ lokal_el_jadr_k_ atrozek_2010.pdf.

Trojanowska, M. (2008). Analiza stanu technicznego sieci niskiego napięcia na terenach wiejskich Podkarpacia. *MOTROL, 10*, 131-135.

Trojanowska, M. (2009). Statystyczna ocena jakości sieci średniego i niskiego napięcia na terenach wiejskich. *Problemy Inżynierii Rolniczej, 4*, 21-28.
Trojanowska, M.; Nęcka, K. (2010). Badanie wskaźników charakteryzujących jakość napięcia w wiejskich sieciach elektroenergetycznych. *Inżynieria Rolnicza, 4*(122), 269-274.
Ustawa Prawo energetyczne z dnia 10 kwietnia 1997 roku. *Dz. U. Nr 54, poz. 348*, z późniejszymi zmianami.

ANALIZA ROZWOJU ELEKTROENERGETYCZNYCH SIECI ROZDZIELCZYCH NA TERENACH WIEJSKICH POLSKI CENTRALNEJ

Streszczenie. Przeanalizowano dynamikę zmian ilościowych i jakościowych wiejskich sieci elektroenergetycznych na tle sieci miejskich. Stwierdzono, że w latach 2006-2011 przy 18% wzroście zużycia energii elektrycznej przez gospodarstwa wiejskie nastąpił ok. 0,5% rozwój sieci, za pośrednictwem których gospodarstwa te zasilane są w energię elektryczną. Pomimo tego wartości wskaźników charakteryzujących jakość zasilania odbiorców nie uległy pogorszeniu. Stopień wykorzystania przepustowości linii jest w dalszym ciągu nieduży. Problemem z punktu widzenia przepustowości systemu elektroenergetycznego są niewielkie odcinki przeciążonych sieci rozdzielczych, których poprawę stanu upatruje się w pierwszej kolejności nie w rozwoju, a w intensyfikacji przepustowości sieci istniejących.

Słowa kluczowe: elektroenergetyczne sieci rozdzielcze, jakość energii elektrycznej

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APPLICATION REPORTING YIELD FORECASTS OF THE SELECTED CROPS IN POLAND[1]

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ABSTRACT

Since 2005, in IUNG-PIB [Institute of Soil Science and Plant Cultivation – State Research Institute] work on the construction of the "Decision support system in plant production" (DSSPP) has been conducted. The purpose of the system is to generate information for agricultural producers, advisers, administration, etc. The DSSPP includes the yield forecast module (YFM), which implements in SQL language the yield forecast models of the selected crops developed at the Institute. As a supplement to the YFM, an application for generation of reports on yield forecasts was built with the use of the models. Reports in text and spreadsheet form are sent by e-mail to designated recipients. The application extends the YFM functionality adjusting information to the recipient's needs (selection of crops and localities). The tests conducted on the application showed conformity of the results generated by the reporting application and the yield forecast module.

Introduction

In 2005 at IUNG-PIB a research project aiming at the construction of the "Decision support system in plant production" (DSSPP) intended for generation of information for agricultural producers, advisers, administration etc. was undertaken (Zaliwski, 2009). One of the elements of the system is a module of forecasting maize, potato, winter wheat and triticale yield. The construction of the module of yield forecast assumes the application of long-term research achievements of the IUNG-PIB's Department of Agrometeorology within the scope of investigating relations between the crop yield and the weather. The beginnings of the research works carried out in this area by the Department (transformed in 2000 into the Department of Agrometeorology and Applied Informatics) date back to 1971-1975. At that time they focused on the recognition of climatic requirements of the selected cultivation plants and development of the methodology of assessment of the effectiveness of the climate with regard to the yield formation potential (Demidowicz et al., 2013). In the

[1] Publication written as part of project 4.1. of the multi-year programme of IUNG-PIB Puławy.

later period, the emphasis was placed on the climatic variability of plant yielding and the improvement of the methodology for determination of the relation of plant development and yielding to the weather. Construction (in the spreadsheet) of yield models of a number of cultivation plants followed, making it possible to build the Internet "System of agricultural recommendations related to the weather" (IPO) in 2005 (Kozyra et al., 2009). For the system needs the yield models were implemented in SQL language. The interface of the IPO system was rebuilt during the development of its second version (the first one is still available in the Internet). Moreover, many elements which enable remote administration, automatic supply of weather data from IUNG-PIB's agrometeorological stations and upload of decade data from synoptic stations of IMGW [Institute of Meteorology and Water Management] were added. The intention of the constructors of the IPO system was to make the implemented yield models available to a wider circle of users.
The objective of the article is to present the application for generation of reports on yield forecasts of the selected crops and sending them by e-mail to specific recipients, such one that enables personalization of information (selection of crops and localizations).

Structure and operation of the application

The reporting application was written in C#3.0 language for the ASP.NET 3.5 Framework environment as a console program (for running in DOS window). The application has two work modes: manual and automatic. Selection of the work mode depends on the value of a respective argument provided in the command line or on the value of the respective parameter in the configuration file (fig.1). In a similar manner (from the command line or the configuration file) the application reads out the remaining settings: addresses to which e-mails are to be sent, crops and localizations of station, for which forecasts must be calculated. Absence of one of these settings aborts processing.

Manual start of the application is used mainly for testing of its operation on the local machine. In the automatic operation mode, the application is started by the Task Schedule and performs consecutive stages of processing in a loop (fig. 1). Iteration of processing stages may finish after the first run or it may be multiple. In the second case the application resides in the RAM memory and repeats the attempt of e-mail creation in specific time intervals up to the moment of success. The repetitions constitute a security measure against faults, such as a temporary unavailability of the database server. A successful readout of the information on stations, generation of the forecasts and sending an e-mail according to the settings (fig. 1) means a successful run of the application and releases the RAM memory.

The application operation and possible errors are tracked and registered in two text files: the work-progress registration file and the error registration file. After achieving a particular size they are compressed in the specified catalogue and removed from the hard disc. The compression procedures are ensured with the library SharpZipLib.dll (IC#Code, 2012).

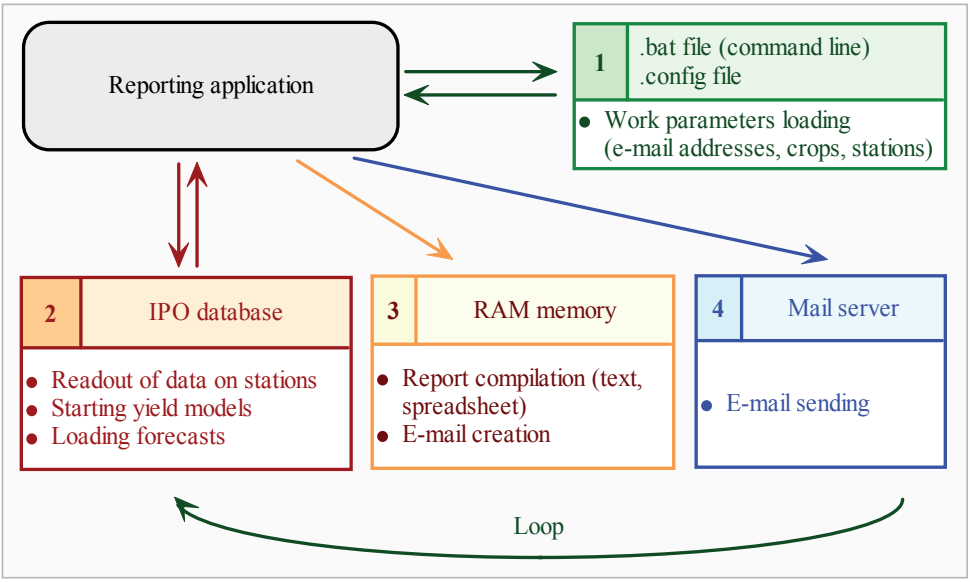


Figure 1. Task sequence of reporting application: 1 – work parameter loading, 2 – forecast loading, 3 – report and e-mail message creation, 4 – message sending

Implementation of yield models in SQL language

Yield models are started in the second stage of the application operation, which consists of three steps (fig.1):
– readout of data on synoptic stations from the IPO database,
– starting the yield models,
– loading yield forecasts for the crops and stations assigned.

Failure in the realization of one of these steps stops further operation of the application. In the automatic work mode it means repeating stages 2, 3 and 4 inside a loop (fig.1). When the yield models are started, the control switches to the database. The yield models were written as stored procedures in SQL language (Vieira, 2007) and are identical with the procedures used by the yield forecast module of the "System of agricultural recommendations related to the weather" (IPO, 2013; Kozyra et al., 2009).

The yield models (for winter wheat, winter triticale, maize and potato) were developed at the Department of Agrometeorology and Applied Informatics of the IUNG-PIB in Puławy. The author of the concept and methodology of their development and the author of three of them (winter wheat, maize and potato) is Tadeusz Górski (Górski et al., 1994, Górski et al., 1997). The model of winter triticale yield was constructed by Anna Nieróbca who drew on Górski's methodology. In order to make the use of the models in the yield forecast module of the IPO system they were adapted to the network database environment and rewritten as SQL stored procedures. Such a solution was dictated by an intensive communication of the models with the database (multiple data selection operations at subse-

quent calculation stages). Moreover, the implementation of models entirely in the database language makes them more universal (independent from the platform and the language used for application programming). In case of possible need to modify a model, there is only a necessity to change the stored procedure, provided that the interface remains unmodified (see fig. 2). Thus, an interference in the application code is averted. A confirmation of practical value of this solution would be probably particularly evident in the case of switching to a database of another manufacturer, different from the one in use with the YFM. Most probably it would require verification and revision of stored procedures, but the only modification necessary in the application *per se* would be a change of the database connection string in the configuration file.

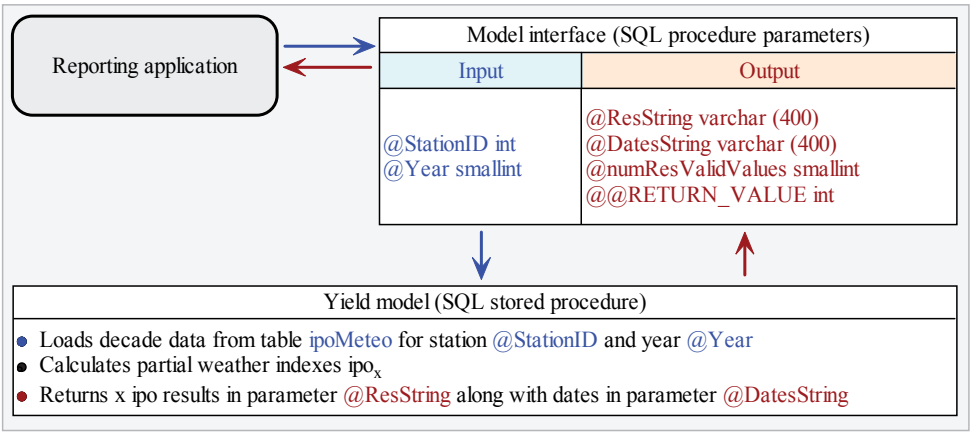


Figure 2. Interface of yield model (input and output parameters of SQL stored procedure)

Input parameters of the models (fig. 2) are: meterorological station index (@StationID) and the forecast year (@Year). The remaining parameters constitute the model output: they return the calculation results to the calling procedure. The essential results (values of weather indexes ipo$_x$ and forecast dates) are transferred in the parameters @ResString and @DatesString of string type. Such a solution was adopted because of a variable number of results, wich depends on the forecast date and completeness of weather data. It allowed the use of one interface for all models. The year of the beginning of the yield calculation of winter crops (winter wheat and winter triticale) is the year preceding the year provided in the parameter @Year; in other words it is @Year-1. Particular dates and values of weather indexes placed in strings are separated with the sign ^. Their extraction from a string does not present a problem.

In the parameter @@RETURN_VALUE (fig. 2) a code is returned – an integer belonging to the code set, which helps to describe all stages of the model operation. Based on the interpretation of the return code value a decision on further proceeding is made. In the case of lack of any calculations, the procedure generates codes with negative values (different for errors and "no data") (fig. 3). Such a situation occurs before 1st November of the previous year, when in the database the dataset necessary for calculating the first forecast is not complete (calculation of the weather index ipo$_1$). Positive values of the code are used for

notification that the model carried out a calculation of one of fractional weather indexes (ipo_1-ipo_{10}). Code 0 (zero) means, on the other hand, the end of the procedure run with a complete dataset, resulting in the full number of weather forecasts ipo_1-ipo_{11} (fig.4).

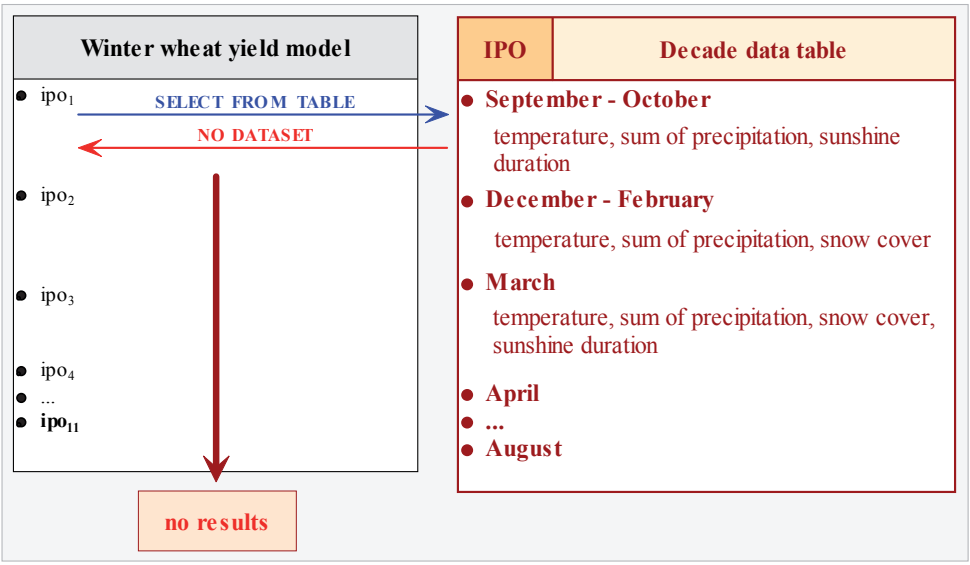


Figure 3. Yield model of winter wheat – no calculations. Markings: $ipo_{1\text{-}4\ ...}$ – partial weather indices, ipo_{11} – final weather index, NO DATASET – no weather data

Subsequent weather indexes constitute an yield assessment made on the basis of a series of the weather data from the consecutive periods; thus, the nearer the period draws to the cropping date, the more precise the approximation to the real values becomes. Consecutive indexes ($ipo_{2\text{-}11}$, except for ipo_1) are calculated acc. to the formula (1):

$$ipo_x = i_x + (ipo_{x-1} - 100) \quad (1)$$

where:

x – date of conducting a forecast,
ipo_x – fractional weather index for the date x, (%)
i_x – result of calculation of the weather index for date x, (%)
ipo_{x-1} – fractional weather index for the date preceding the date x, (%).

Each consecutive fractional weather index expresses then the impact on the yield of all the preceding indexes. Real values of yields may be obtained only after the harvest of winter wheat, which in Poland as a rule takes place not earlier than on 8th July and not later than 7th September (Cyfert et al., 2008; Najewski et al., 2012). These dates are of course approximate, because the date of harvest depends on the region and the weather in a given year.

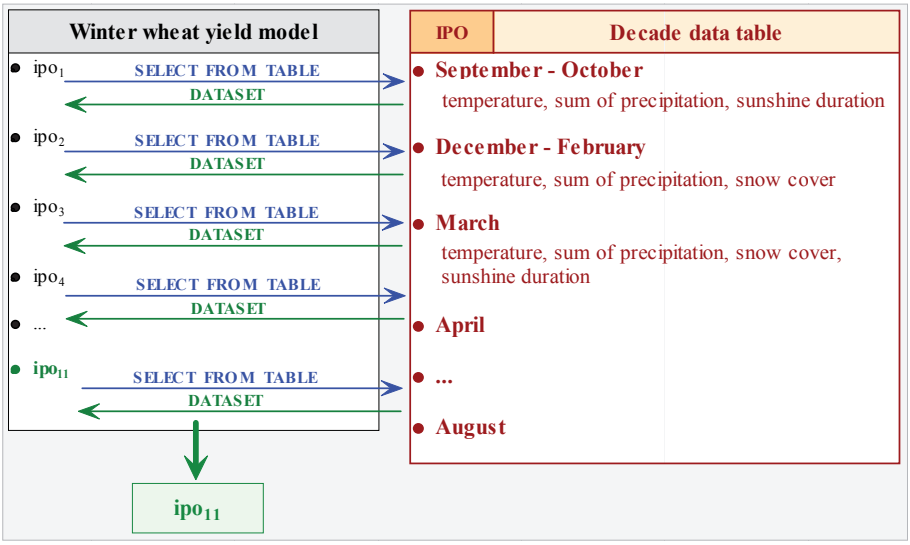


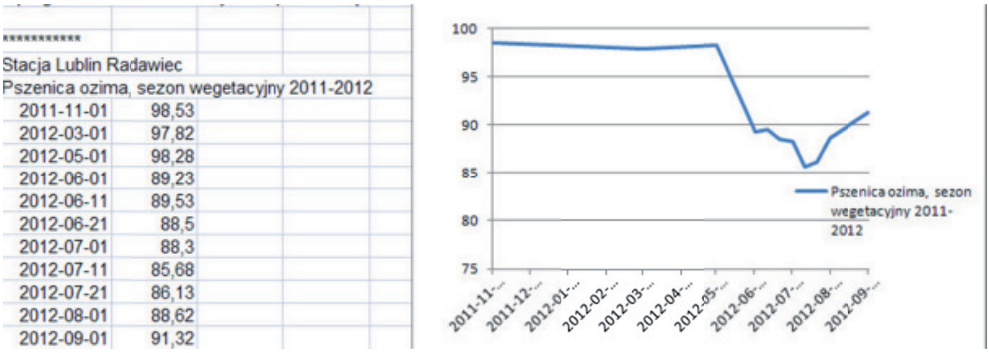
Figure 4. Yield model of winter wheat – calculation of final weather index. Markings: $ipo_{1\text{-}10}$ – partial weather indexes, ipo_{11} – final weather index, DATASET – query returns a dataset for calculations

Results of testing the reporting application

The reporting application was tested first on a local machine with a remote access to the database of the IPO system, and then on a remote server. The database was placed on the database server in IUNG-PIB. Tests were carried out for weather data in years 2011-2012 from 34 meteorological stations. The application allows sending messages about yields forecasts in text format and in a spreadsheet file attached as an enclosure to the e-mail. For creation and filling in the spreadsheet the application uses the library ExcelLibrary.dll (E-Infotainment, 2013) including classes that allow substituting the COM technology (COM, 2013). Thus, the installation of the Excel application is not required on the machine, on which the application is started.

Stacja Lublin Radawiec
Pszenica ozima, sezon wegetacyjny 2011-2012
2011.11.01 98,532
2012.03.01 97,826
2012.05.01 98,288
2012.06.01 89,23
2012.06.11 89,535
2012.06.21 88,502
2012.07.01 88,308
2012.07.11 85,683
2012.07.21 86,138
2012.08.01 88,621
2012.09.01 91,327
- prognoza OK: stosunek wyników prawidłowych/brakujących = (11/11)

Figure 5. Sample e-mail text message (fragment)



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Stacja Lublin Radawiec

Pszenica ozima, sezon wegetacyjny 2011-2012

2011-11-01	98,53
2012-03-01	97,82
2012-05-01	98,28
2012-06-01	89,23
2012-06-11	89,53
2012-06-21	88,5
2012-07-01	88,3
2012-07-11	85,68
2012-07-21	86,13
2012-08-01	88,62
2012-09-01	91,32

Figure 6. Sample message in spreadsheet attached to e-mail (fragment)

Fig. 5 presents a fragment of the text e-mail sent by the application and in the fig. 6 the corresponding fragment of the message in Excel file is shown. These are forecasts of the winter wheat yield for the locality of Lublin Radawiec in the vegetation season 2011-2012. Both mails include the same data. The format of the spreadsheet may be more suitable in case of further processing of the results. For instance, using the data placed in the sheet, it is easy to make a plot of the impact of weather conditions on yield. Such a plot (fig. 6) was made manually. It expresses considerably better than dry numbers (shown on the left side of the picture) a collapse of weather conditions, which took place from May 2012 to the first decade of July inclusively. The further course of the weather, up to the cropping, was favourable for the yield. Nonetheless, as one may conclude from the forecast results, the conditions were not sufficiently propitious as to make up for the losses.

A comparison of the forecasts generated by the reporting application with the forecasts made by the yield forecast module showed a full conformity of calculation results.

Conclusion

A possibility of automatic reporting of yield forecasts of the selected crops for a locality with the use of e-mail was verified in practice. A reporting application, created for this purpose, uses models of yields developed at IUNG-PIB and implemented in SQL language in the yield forecast module of the "System of agricultural recommendations related to the weather", supplied with decade weather data. The tests which were carried out proved a full conformity of results generated by the application and the YFM module.

Correctness of operation of the reporting application, as well as of the IPO system, depends on the timely update of the weather data. The application complements the system with a signalization function, transmitting information on forecasts to the recipients as soon as it becomes available.

References

COM. *Component Object Model Technologies*. Microsoft, 2013. Obtained from: http://www.microsoft. com/com/default.mspx.

Cyfert, R., Domańska, A., Najewski, A., Zych, J. (2008). *Wyniki porejestrowych doświadczeń odmianowych 2007. Zboża ozime 2007 (pszenica, żyto, pszenżyto, jęczmień)*. Nr 55. Słupia Wielka, COBORU.

C# Excel Library. E-Infotainment, 2013. Obtained from: http://e-infotainment.com.

Demidowicz, G., Wilkos, S., Zaliwski, A. (2013). *Historia Zakładu Agrometeorologii i Zastosowań Informatyki*. Puławy, IUNG-PIB. Obtained from: http://www.zazi.iung.pulawy.pl/Documents/ Historiazazipl .html.

Górski, T., Demidowicz, G., Deputat, T., Górska, K., Krakowiak, A., Marcinkowska, I., Spoz-Pać, W. (1994). *Empiryczny model plonowania ziemniaka w funkcji czynników meteorologicznych*. Materiały XXV Zjazdu Agrometeorologów, Olsztyn-Mierki, AR Olsztyn, 43-46.

Górski, T., Demidowicz, G., Deputat, T., Górska, K., Marcinkowska, I., Spoz-Pać, W. (1997). Empiryczny model plonowania pszenicy ozimej w funkcji czynników meteorologicznych. *Zeszyty Naukowe AR Wrocław*, *313*, 99-109.

IC#Code. The Zip, GZip, BZip2 and Tar Implementation For .NET, 2013. Obtained from: http://www.icsharpcode.net/opensource/sharpziplib/.

IPO. System zaleceń rolniczych związanych z przebiegiem pogody. IUNG-PIB, Puławy, 2013. Obtained from: http://www.ipm.iung.pulawy.pl/IPO/ipo.aspx.

Kozyra, J., Zaliwski, A.S., Nieróbca, A., Grabiński, J. (2009). System zaleceń rolniczych związanych z przebiegiem pogody. *Studia i Raporty IUNG-PIB*, *16*, 97-106.

Najewski, A., Skrzypek, A., Szarzyńska, J., Tokarski, P. (2012). *Wyniki porejestrowych doświadczeń odmianowych i rolniczych 2011. Zboża ozime 2011 (jęczmień, pszenica, pszenżyto, żyto)*. Nr 86. Słupia Wielka, COBORU.

Vieira, R. (2007). *SQL Server 2005. Programowanie*. Helion, Gliwice. ISBN: 978-83-246-0653-5.

Zaliwski, A.S. (2009). Ogólna koncepcja krajowego systemu wspomagania decyzji w zakresie produkcji roślinnej. *Inżynieria Rolnicza*, *6*(115), 323-329.

APLIKACJA RAPORTUJĄCA PROGNOZY PLONÓW WYBRANYCH UPRAW W POLSCE

Streszczenie. Od 2005 roku w IUNG-PIB prowadzone są prace nad budową "Systemu wspomagania decyzji w zakresie produkcji roślinnej" (SWDPR), przeznaczonego do generowania informacji dla producentów rolnych, doradców, administracji, itd. W skład SWDPR wchodzi moduł prognozowania plonów (MPP), implementujący w języku SQL modele plonowania wybranych roślin uprawnych opracowane w Instytucie. Jako uzupełnienie MPP zbudowano aplikację do generowania raportów o prognozach plonowania roślin uprawnych, wykorzystując modele pochodzące z MPP. Raporty w formie tekstowej i w arkuszu kalkulacyjnym są przesyłane drogą elektroniczną do określonych odbiorców. Aplikacja rozszerza funkcjonalność MPP umożliwiając dostosowanie informacji do potrzeb odbiorcy (wybór uprawy i miejscowości). Testowanie aplikacji pozwoliło stwierdzić zgodność wyników generowanych przez aplikację raportującą i moduł prognozowania plonów.

Słowa kluczowe: model plonowania, indeks pogodowy, implementacja modelu, SQL, aplikacja raportująca, e-mail

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UPDATING DATABASES OF THE INTERNET DECISION SUPPORT SYSTEM FOR CEREALS PROTECTION[1]

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ABSTRACT

The process of data updating in the databases of the Internet decision support system for cereals protection is presented. The system uses three kinds of data: on spring and winter wheat varieties, on plant protection products (fungicides and insecticides against wheat diseases and pests) and on product doses. It was found that it is possible to obtain all the necessary data for the updating from available web resources. Data sources for variety information are the COBORU materials and websites of agricultural plant breeders. The search engine of plant protection products available on the website of the Ministry of Agriculture and Rural Development is an essential source of the data on protection products and their doses. Other sources of these data are websites of plant protection product producers and online shops. In the data updating process the following stages were distinguished: owned-resources stocktaking, data quality criteria selection, credible data sources determination, data acquisition by the application of the criteria, data adaptation to the system requirements, data entry, data verification. Each one of the itemized stages contributes to the ultimate data quality after the updating. The stages of credible data sources determination, data acquisition and data adaptation to the system requirements were found to be labour intensive. About a triple reduction of labour input into the updating was achieved through the improvement of the data acquisition process, gaining proficiency in the database editors operation and the cumulative effect of build-up of specific data resources in the system. The adopted verification procedures for update correctness are described.

Introduction

"The Internet decision support system in cereals protection" (CP-DSS) constitutes an element of "The decision support system in the integrated plant protection" (Nieróbca et al., 2010; Zaliwski, 2009). The mentioned supersystem, being still in the prototype stadium was marked with the acronym IPM DSS (*Integrated Pest Management Decision Support*

[1] Publication written as part of project 4.1. of the multi-annual programme of IUNG-PIB Puławy.

System). IPM DSS was created as a result of realization of the foreign research-development project, carried out together with the Danish Institute of Agricultural Sciences. The main elements of IPM DSS are plant protection models generating recommendations on the need to carry out treatments based on precisely determined threshold values (Nieróbca, 2009). Economic thresholds are determined with regard to the percentage of plants with disease symptoms. Exceeding the threshold suggests the increase of the yield losses above the treatment costs which justifies the protection treatment. Both economic thresholds and doses of plant protection products, recommended by the system, are defined for the specific species, variety and growth stage.

The developed economic thresholds were verified in field experiments in various environmental conditions (Nieróbca, 2009). Field experiments carried out in 2001-2006 confirmed the usefulness, in Polish conditions, of winter and spring wheat protection models against the most important diseases: mildew of grasses and cereals, yellow rust, brown rust, eyespot and septoria as well as against pests: aphids and grain beetle larvae.

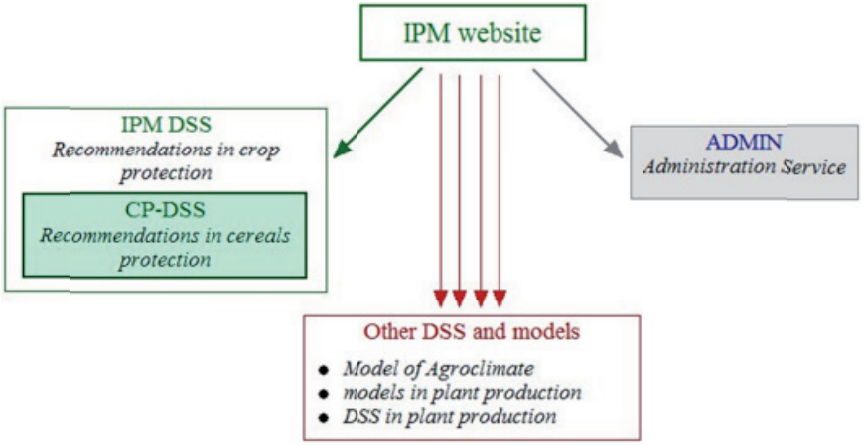

Figure 1. Organization of the IPM website

IPM DSS system was made available in the Internet in 2003 as an element of the website marked with the IPM acronym (fig. 1). PC back office programs for management of data bases are an important addition to the system, which was provided to the Polish team by the Danish party. They enabled a manual edition of the data on varieties, plant protection products, users and weather data. With their use, update of data was carried out to the moment of the IPM website migration to a new server in 2007. The change of the software environment (operational system, database) immobilized Danish back office programs, disabling data updating. So, soon a decision was made to develop own back office software (Zaliwski, 2009b; Zaliwski, 2014). Frameworks of the internet "Administration Service" (fig.1) were designed, designated for management of not only the IPM DSS databases but of all the internet decision support systems and models developed in the Department of Agrometeorology and Applied Informatics of the IUNG-PIB (Zaliwski, 2009a; Zaliwski and Nieróbca, 2013). The ambitiously envisioned programme of development of the

Administration Service, in comparison to the work team potential, resulted in a considerably late construction of the back office applications patterned after the Danish PC programs, held up till 2013-2014. These works were carried out simultaneously with the second migration of the IPM DSS system to the next server (Zaliwski and Nieróbca, 2013), which enabled removal of unnecessary data "inherited" from the Danish prototype.

When starting data update in a big system, a specific technology for this process should be assumed. Thorough update carried out for the first time requires preparation of data, tools for data edition and development of proper procedures.

The objective of the article is the presentation of the databases update process of the CP-DSS carried out in 2013-2014.

Preparation of database update

The main principle in the process of data entry to the system is a care for their high quality in the process of collection. Later verification and correction, after the entry has been conducted, is labour intensive, expensive and ineffective. Experts on the data and information quality, such as Larry P. English (1999; 2009) and Thomas C. Redman and A. Blanton Godfrey (1997) take the same view.

The first stage of data update is an inventory of the resources owned in order to know their structure and in order to find out the lacking elements. Such an inventory was quite easy to conduct with the use of the back office applications for edition of databases of the CP-DSS (Zaliwski, 2014). Inventory results (in a rough outline) are presented in figure 2.

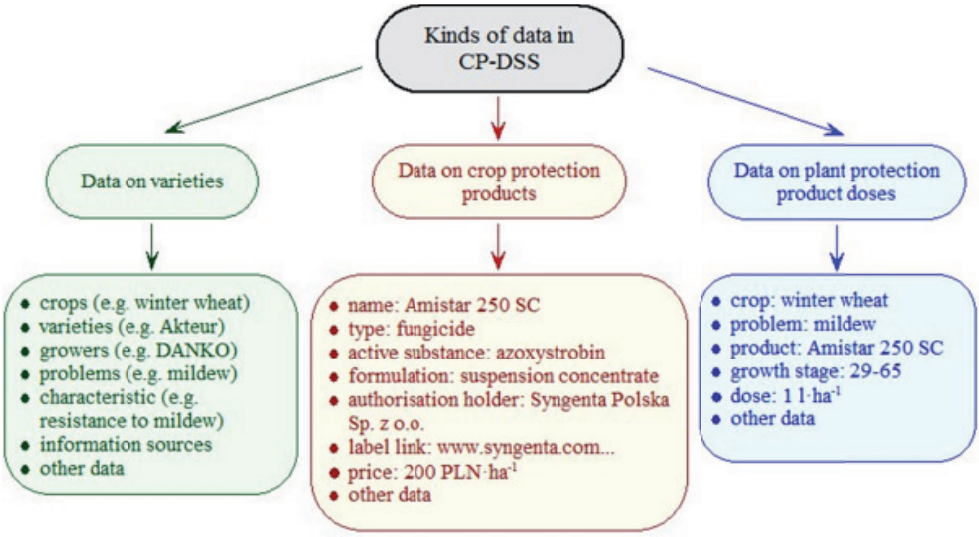

Figure 2. Kinds of data in Cereal Protection DSS

In the second stage credible data sources should be chosen. With reference to credibility Józef Oleński (2001) divides information sources into original, secondary and derivated. Original sources of information are real objects, phenomena and processes. Secondary

information sources are organizations (institutions) which use their own information systems for generation of information based on primary sources. Derivated information comes directly or indirectly from secondary sources. The bigger the number of intermediate stages, the further copy of the original we deal with and the more errors and inaccuracy may occur.

An example of the secondary source of data on varieties is "*The list of agricultural plants entered into the national register in Poland*" [Lista odmian roślin rolniczych wpisanych do krajowego rejestru w Polsce] (2013) and websites of crop variety growers. For data on plant protection products these are: "*Search engine of crop protection products*" [*Wyszukiwarka środków ochrony roślin*] (2014), which can be accessed on the website of the Ministry of Agriculture and Rural Development as well as labels and material safety data sheets of plant protection chemicals. Labels and safety data sheets are obtained from websites of producers or distributors of products (those who hold an authorisation to introduce a product on the territory of Poland). Online shops are an example of the secondary source of crop protection product prices. An online shop is not a relevant data source concerning characteristics of the crop protection product because it provides derivated data.

Data acquisition is the next stage. This stage is quite complex. One should compare the offer with the data quality criteria, such as the criterion of compatibility with the requirements of the system, completeness, timeliness and correctness. The compatibility criterion means that only those data are entered which will be used by the system. In the CP-DSS, the plants for which protection models have been implemented are determinants in this regard. Presently, there are only models for spring and winter wheat, which include the pests mentioned in the introduction. Meeting the conditions of completeness and timeliness means a necessity to omit the records, particular parts of which are incomplete and not up-to-date.

With reference to completeness a criterion "stiff" or "soft" may be assumed. The "stiff'" criterion means a necessity to fill the entire record without leaving anything out. The "soft" criterion differentiates between two parts of the record: an identification and calculation part and an informative part. Requirement of completeness concerns only those record fields, which are used for generation of recommendations (identification and calculation part). In the remaining fields (informative part) lack of data is admissible. For example, a crop protection product must have a name and type (fig. 2) because these are identification fields. Price and dose are also indispensable, because they are used for calculation of the treatment cost. However, many other data on the product, such as toxicity, threat to bees, optimal conditions for effectiveness, impact on the successive crops or the risk of immunization constitutes an additional piece of information, less or more significant to the user. The use of the soft completeness criterion of a varied degree of rigour makes it possible to omit specific data of informative nature. It is important from the practical point of view, because a full set of data on the plant protection product in the databases of the CP-DSS constitutes a set of 44 various attributes. Some data are difficult to acquire and they are less important to the user, e.g. the risk of immunization of the pest against an active substance. The use of the stiff criterion would foreclose the use of such a record, limiting in practice the update on account of numerous deficiencies in available data.

The criterion of data timeliness in the case of varieties takes into account the expiration date of the entry in the national register (Lista odmian roślin…, 2013). In the case of crop protection products, the date of product approval expiration is such an indicator (Wyszuki-

warka środków…, 2014). The search engine of crop protection products of the Ministry of Agriculture and Rural Development enables searching the ministry database on crop protection products according to different attributes. It enabled the construction of the list of fungicides and insecticides against diseases and pests of winter and spring wheat with the date of approval expiration later than 2014. The list enabled a systematic approach to updating of the databases on crop protection products of the CP-DSS (Zaliwski and Nieróbca, 2014) eliminating at the beginning the products soon to be withdrawn from use (soon to reach the expiration date) and those which are not useful for the system on account of the pests controlled.

Specific data, such as growth stages, most frequently referred to in source materials by name, required to be expressed in numerical scale. In this case a table from Wikipedia (Skale BBCH, 2014) was used. Expression of variety resistance to pests in the scale used in the CP-DSS was a more difficult task. Original data on resistance were obtained from the website of COBORU "*Post-registration variety testing and recommendation*" [Porejestrowe doświadczalnictwo odmianowe i rolnicze] (PDOiR, 2014), and then they required to be interpreted by an expert.

Data entry

Sets of data on varieties, crop protection products and doses were introduced to the databases of the CP-DSS manually with the use of three various back office applications (editors): "editvariety", "editchemicals" and "editdiseasepest" (Zaliwski, 2014). The most time-consuming was the entry of the data on crop protection products on account of extensiveness of the data set. In the initial period of update, the entry of one set of data took approx. 4 hours. Searching for a data source in the Internet consumed much time at the beginning (finding websites of producers and distributors of products, finding online shops).

The procedure of searching for data on crop protection products is as follows. After drawing a product from the list of products (prepared earlier pursuant to the expiration date and the pests controlled) its availability on the market is checked. Its price and the size of packages should be found in internet shops. Without these data, the product may be discarded outright as non-useful for the CP-DSS. In the end, a label and a safety data sheet is downloaded from the website of the producer or the distributor. After the collection of these data, the crop protection product may be entered into the database. The data are copied into the editor straight from the WWW pages as well as from labels and data safety sheets (available by default as PDF files). In case of non-editable PDF files they were converted to editable files.

It was found out that the main sources of significant work input of manual updating of the data on crop protection products were:

- large number of attributes (44),
- no strict standardization of labels and data safety sheets (difficulty in finding data),
- no rigour concerning the content of provided information (necessity of converting information to single format),
- difficulty in determination of the URL address of labels and data safety sheets or no data safety sheets,
- necessity of shortening the content in order to adjust the length to some fields in database,

– necessity to navigate through many pages of the editor (application "editchemcials" has e.g. 10 pages).

This last source of labour intensity of manual data update was the incentive for the attempt to automatize data entry with the use of „ipmDataLoader" program (Zaliwski, 2014). The program enables import to the databases of the CP-DSS entire variety and crop protection product data sets in one go. It was successfully used for import of data on varieties, whereas in the case of plant protection products the attempt was not successful. Before import the data require preparation in the text file, which took almost the same time as their copying into the editor "editchemicals".

Becoming skilled at searching for data and working with the application "editchemicals" allowed after some time approx. threefold increase in efficiency of product data entry. Of importance was an accumulative effect of build-up of specific data, which once entered, were available in the selection boxes.

Verification of correctness of the data entered

It should be noticed that the databases of the CP-DSS by themselves have basic control mechanisms of the correctness of the data being entered (e.g. minimum and maximum for numerical values, dates, etc.) However, a great number of data are in a text format. Construction of validation rules in this case would be very difficult on account of unpredictability of content. Thus, validation carried out by humans is required. Then, however, even the highest concentration and care do not guarantee complete elimination of errors during data input.

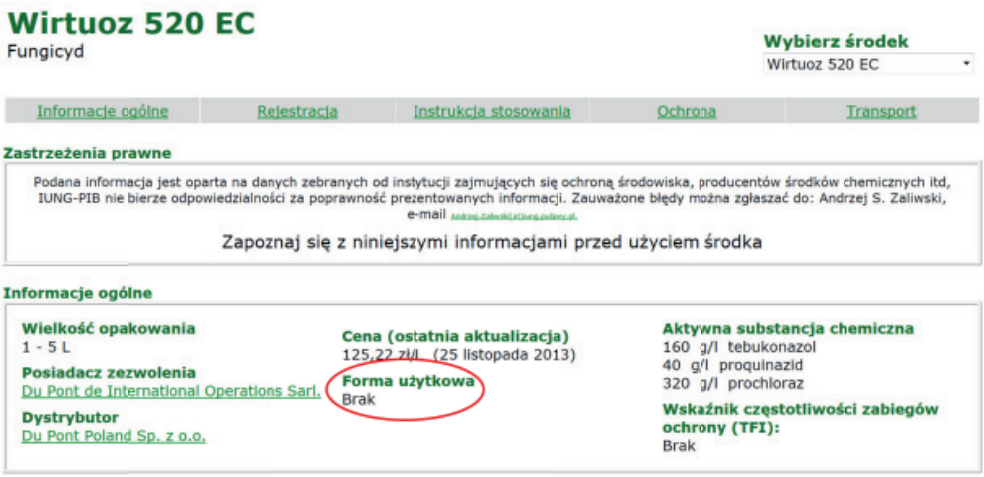

Figure 3. WWW page displaying characteristic of protection chemical

Data verification was carried out in two ways. First of all, just after the input, the input version was compared with the source. The second way was checking the manner of the input data display in the front office applications of the CP-DSS:

– on the recommendation-generating page,
– on the page displaying the chemical product characteristics.

Verification of data in the front office application allows finding out and correcting errors made during their entry and overlooked during the first verification. It requires comparing two pages. In the front office application, the data are verified and in the database editor the errors are corrected. Such work should be carried out at the workstation equipped with two screens. An example of finding out the missing datum "Formulation type" (marked with a red frame) in the application "Characteristics of protection chemical" of the CP-DSS system is presented in figure 3.

Summary and conclusions

The tasks which were carried out, with the aim to update the databases of the CP-DSS system make it possible to draw the following conclusions:

1. Generally available internet resources were a sufficient source for obtaining all necessary data for the CP-DSS update. Some data (e.g. plant resistance) required expert interpretation in order to adjust to the scale used in the system.
2. On account of the manner of obtaining the data (independent acquisition from the sources available in the Internet), the update was time-consuming at the beginning, which was caused by the necessity to find information sources and acquiring skills at searching for the necessary resources.
3. Main reasons of significant work input in the process of updating data on protection chemicals was the difficulty in determination of URL addresses of some products (non-intuitive construction of WWW pages), difficulty in finding data in the texts acquired (inconsequential use of the content standardization by information generators) as well as the necessity to shorten the data content (in adjustment to the restrictions of the CP-DSS databases).
4. Improvement of the process of data acquisition and their adjustment to the system needs, acquiring skills at editors operation and accumulative effect of specific data build-up in the system had great impact (approx. three times) on the reduction of labour input of the update.

The following stages of the update process of databases were distinguished in this paper: inventory of the resources owned, selection of credible data sources, selection of the data quality criteria, data acquisition with the use of the criteria, adjusting data to the system needs, verification of the data entered. Each of the mentioned stages affects the final (after-update) quality of data. When assessing the tasks carried out, one should bear in mind that after every effort has been made, errors may occur, which is proved by figure 3. However, working out a reliable update process has a great impact on their reduction. Thus, data update is a process, which should be constantly improved.

References

English, L.P. (1999). *Improving Data Warehouse and Business Information Quality: Methods for Reducing Costs and Increasing Profits*. New York, John Wiley & Sons. ISBN: 978-0-471-25383-9.

English, L.P. (2009). *Information Quality Applied: Best Practices for Improving Business Information, Processes, and Systems*. New York, John Wiley & Sons. ISBN: 978-0-470-13447-4.

Lista odmian roślin rolniczych wpisanych do krajowego rejestru w Polsce. Słupia Wielka, COBORU, 2013. Obtained from: http://www.coboru.pl.

Nieróbca, A. (2009). *Systemy wspomagania decyzji w ochronie roślin jako element integrowanej produkcji*. Studia i Raporty IUNG-PIB, 16, 31-44.

Nieróbca, A., Zaliwski, A. S., Horoszkiewicz-Janka, J. (2010). Rozwój internetowego systemu wspomagania decyzji w ochronie zbóż. *Inżynieria Rolnicza, 7*(125), 167-173.

Oleński, J. (2001). *Ekonomika informacji: podstawy*. Warszawa, PWE. ISBN 83-208-1311-5.

Pesticide Properties DataBase. Hatfield, Hertfordshire, UK, Agriculture & Environment Research Unit, University of Hertfordshire, (2013). Obtained from: http://sitem.herts.ac.uk/aeru/footprint/pl/index.htm.

PDOiR. *Porejestrowe doświadczalnictwo odmianowe i rolnicze*. Słupia Wielka, COBORU, (2014). Obtained from: http://www.coboru.pl/DR/index.aspx.

Redman, T. C., Godfrey, A. B. (1997). *Data Quality for the Information Age*. Artech House Publishers. ISBN: 978-0890068830.

Skale BBCH. Wikipedia, 2014. Obtained from: http://pl.wikipedia.org/wiki/Skale_BBCH.

Wyszukiwarka środków ochrony roślin. Warszawa, MRiRW, 2014. Obtained from: www.minrol.gov.pl/pol/Informacje-branzowe/Wyszukiwarka-srodkow-ochrony-roslin.

Zaliwski, A. S. (2009a). Ogólna koncepcja krajowego systemu wspomagania decyzji w zakresie produkcji roślinnej. *Inżynieria Rolnicza, 6*(115), 323-329.

Zaliwski, A. S. (2009b). *Organizacja modułu pogodowego krajowego systemu doradztwa w zakresie zrównoważonej produkcji roślinnej*. Studia i raporty IUNG-PIB, 16, 107-117.

Zaliwski, A. S. (2014). *Oprogramowanie narzędziowe portalu IPO*. Studia i raporty IUNG-PIB, 38(12), 89-114.

Zaliwski, A. S., Nieróbca, A. (2013). *Migracja portalu IPM do Windows Server 2008*. Studia i raporty IUNG-PIB, 33(7), 79-95.

Zaliwski, A. S., Nieróbca, A. (2014). *Aktualizacja danych systemu IPM DSS*. Studia i raporty IUNG-PIB, 38(12), 67-87.

AKTUALIZACJA BAZ DANYCH INTERNETOWEGO SYSTEMU WSPOMAGANIA DECYZJI W OCHRONIE ZBÓŻ

Streszczenie. Przedstawiono proces aktualizacji danych w bazach danych internetowego systemu wspomagania decyzji w ochronie zbóż. System wykorzystuje trzy rodzaje danych: o odmianach pszenicy jarej i ozimej, o środkach ochrony roślin (fungicydy i insektycydy przeciw chorobom i szkodnikom pszenicy) i o dawkach środków. Stwierdzono, że wszystkie niezbędne dane do aktualizacji można pozyskać z dostępnych zasobów internetowych. Źródłem danych o odmianach są materiały COBORU oraz strony internetowe hodowców roślin rolniczych. Istotnym źródłem danych o środkach ochrony roślin i ich dawkach jest wyszukiwarka środków ochrony roślin udostępniana na stronach Ministerstwa Rolnictwa i Rozwoju Wsi. Inne źródła tych danych to strony internetowe producentów środków ochrony roślin oraz sklepy internetowe. W procesie aktualizacji danych wyróżniono następujące etapy: inwentaryzacja posiadanych zasobów, wybór kryteriów jakości danych, ustalenie wiarygodnych źródeł, pozyskanie danych z zastosowaniem kryteriów, dostosowanie danych do potrzeb systemu, wprowadzanie, weryfikacja danych. Każdy z wymienionych etapów ma wpływ na ostateczną jakość danych po aktualizacji. Stwierdzono dużą pracochłonność etapów: ustalenia wiarygodnych źródeł, pozyskiwania danych i dostosowania danych do potrzeb systemu. Około trzykrotne zmniejszenie pracochłonności aktualizacji uzyskano na skutek ulepszenia procesu technologicznego pozyskiwania danych, zdobycie doświadczenia w obsłudze edytorów baz danych i kumulatywny efekt wzrostu zasobów określonych danych w systemie. Opisano przyjęte procedury weryfikacji poprawności wprowadzenia danych.

Słowa kluczowe: jakość danych, jakość informacji, aktualizacja danych, baza danych, system wspomagania decyzji

INŻYNIERIA ROLNICZA Z PERSPEKTYWY CIGR

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Wstęp

Inżynieria rolnicza to interdyscyplinarna (a) nauka i (b) wiedza zawodowa o konstruowaniu, budowie i eksploatacji urządzeń technicznych stosowanych w produkcji i przetwórstwie żywnościowych i nieżywnościowych surowców biologicznych (roślinnych i zwierzęcych)*. Inżynieria rolnicza to także (c) kierunek studiów, jakkolwiek w oficjalnym wykazie używana jest nazwa „technika rolnicza i leśna". Pozostając przy sprawach nazewnictwa warto przypomnieć, że w latach 50-tych i 60-tych ubiegłego (XX) wieku, inżynierią rolniczą nazywano ten zakres wiedzy – naukowej i zawodowej – jaki utożsamiamy był z melioracjami, budownictwem wodnym i geodezją. Ewolucja nazwy nie jest, jak się wydaje, sprawą zamkniętą, gdyż w uniwersyteckim środowisku uczelni rolniczych i przyrodniczych dyskutowana jest zmiana „techniki rolniczej i leśnej" na „inżynierię biosystemów" lub „inżynierię biosystemową". Do sprawy definicji inżynierii rolniczej i zmian nazewnictwa wrócimy jeszcze w dalszej części artykułu.

Jak w każdej dyscyplinie naukowej i zawodowej tak i w inżynierii rolniczej powoływane są organizacje zrzeszające osoby profesjonalnie związane z tą dyscypliną. W Polsce są nimi Polskie Towarzystwo Inżynierii Rolniczej (PTIR) i Stowarzyszenie Naukowo-Techniczne Inżynierów i Techników Rolnictwa (SITR). SITR jest członkiem Naczelnej Organizacji Technicznej (NOT). Porównanie celów działania tych dwóch organizacji wskazuje dużą zbieżność (por. www.ptir.org i www.sitr.pl). Wiele podobieństw w zakresach działania PTIR i SITR można zauważyć także porównując je z zakresem działania Komitetu Techniki Rolniczej (KTR) Polskiej Akademii Nauk (por. www.ktr.pan), który zrzesza przedstawicieli środowisk uniwersyteckich i instytutów badawczych. Komitet Techniki Rolniczej jest stowarzyszone z Międzynarodową Organizacją Inżynierii Rolniczej i Biosystemów (CIGR)**.

Wśród podstawowych, statutowych, kierunków działania wszystkich wymienionych wyżej, stowarzyszeń naukowo-inżynieryjnych są, m.in.: (1) inicjowanie i wspieranie badań z zakresu inżynierii rolniczej oraz ich praktycznych zastosowań, (2) organizowanie i wspieranie współpracy członków organizacji oraz (3) promocja osiągnięć inżynieryjnych w społeczeństwie.

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* Podręcznikowa definicja inżynierii rolniczej brzmi następująco: Agricultural engineering has been applying scientific principles for the optimal conversion of natural resources into agricultural land, machinery, structure, processes and systems for the benefit of man (por. CIGR Handbook of agr, eng.).

** CIGR – Commission International du Génie Rural, od 2008 r. International Commision of Agricultural and Biosystems Engineering. Brak jest oficjalnego tłumaczenia nazwy tej organizacji na język polski, stąd używane są określenia: „organizacja", „stowarzyszenie", „towarzystwo" i „komisja".

Warto w tym miejscu zwrócić uwagę Czytelnika, że stowarzyszenia inżynierów rolnictwa są w grupie wielu innych, inżynieryjnych, stowarzyszeń naukowych i zawodowych, a ich podstawowe, statutowe, kierunki działania są niemal, zawsze takie same, jak wymienione wyżej (chociaż niekiedy nieco inaczej sformułowane). Stowarzyszenia inżynierów rolnictwa wyróżniają się, spośród innych stowarzyszeń inżynierskich (np. budownictwa, elektrycznych, chemicznych itp.), zarówno specyficznym zakresem wiedzy, a także większą interdyscyplinarnością.

Znaczenie danego stowarzyszenia w środowisku krajowym i międzynarodowym – porównując je ze znaczeniem innych stowarzyszeń – wynika, przede wszystkim, z podejmowanych przedsięwzięć (naukowych i praktycznych), które w społeczeństwie są, w danym okresie, ważne z różnych względów. Poważanie, społeczne uznanie itd., jakim cieszy się dane stowarzyszenie inżynieryjne, zależą z pewnością, od aktualnych i planowanych problemów, jakie dane stowarzyszenie zamierza rozwiązywać dla dobra ludzi („…*for the benefit of man*" – por. CIGR-owską definicję inżynierii rolniczej).

W latach powojennych takimi ważnymi przedsięwzięciami dla inżynierii rolniczej było wytwarzanie wystarczającej ilości żywności dla biednej, wygłodzonej ludności w zniszczonej militarnymi działaniami Europie. Obecnie, przynajmniej na europejskim kontynencie, to przedsięwzięcie ma znaczenie drugorzędne, natomiast inne przedsięwzięcia, które zostaną przedstawione w dalszej części artykułu, nabierają większego znaczenia.

Definicja inżynierii rolniczej

Definiowanie pojęć ma podstawowe znaczenie dla porozumiewania się (przekazywania informacji) między ludźmi. Brzmi to banalnie, lecz przypomnienie tego jest ważnym, zwłaszcza w czasach, gdy manipulacja znaczeniem słów jest zjawiskiem powszechnym. Manipulowanie takie prowadzi do nieporozumień, lub zgoła braku możliwości dyskusji – w tym także dyskusji naukowych.

Brak jest jednej, powszechnie akceptowanej definicji inżynierii rolniczej, chociaż w środowisku inżynierów rolnictwa – mniej lub bardziej – podobnie rozumie się znaczenie tego określenia (tj. określenia inżynieria rolnicza). Mniej, gdy – przykładowo – przychodzi wyjaśnić różnicę pomiędzy kompetencjami zawodowymi inżyniera rolnictwa, absolwenta Wydziału Rolniczo-Ekonomicznego, a kompetencjami zawodowymi absolwenta Wydziału Inżynierii Produkcji i Energetyki Uniwersytetu Rolniczego. Przykładów takich można przytoczyć więcej i nie chodzi tu tylko o różnice w programach kształcenia ale, po prostu, kim są – w sensie zawodowym – inżynierowie tych, podobnych, kierunków studiów.

Potrzeba opracowania jednoznacznej dla wszystkich definicji – profesjonalistów i ludzi spora profesji „inżynieria rolnicza" – jest więc wyzwaniem jakie jest przed środowiskiem inżynierów rolnictwa. Potrzeba ta wynika także z nieco innego rozumienia „inżynierii rolniczej" w kraju i na świecie.

Inżynieria rolnicza, w Polsce, jest – w przybliżeniu – synonimem „techniki rolniczej i leśnej", „agroinżynierii" lub „mechanizacji rolnictwa", „maszynoznawstwa rolniczego", jeśli sięgnąć głębiej w historię tej współczesnej dyscypliny naukowej. W międzynarodowym stowarzyszeniu (CIGR) inżynieria rolnicza jest pojęciem znacznie szerszym. Dobrze wyjaśniają te różnice tytułu podręczników (Handbooks) inżynierii rolniczej, dostępne na stronie internetowej CIGR (por. www.cigr.org).

Tytuły te są następujące:

1. Land and water engineering (Inżynieria rolnicza i wodna),
2. Animal production and aquacultural engineering (Inżynieria produkcji zwierzęcej oraz upraw roślin w środowiku wodnym i chowu ryb),
3. Plant production engineering (Inżynieria produkcji roślinnej),
4. Agro-proccesing engineering (Inżynieria przetwórstwa surowców biologicznych),
5. Energy and biomass engineering (Energetyka rolnicza),
6. Information technology (Systemy informacyjne)

Bez trudu dostrzega się, że inżynieria lądowa (np. budowa dróg wśród pól), inżynieria wodna (zaopatrzenie gospodarstw rolnych i zakładów przetwórczych w wodę oraz utylizację ścieków), budownictwo inwentarskie, konwencjonalna i niekonwencjonalna energetyka, zarządzanie projektami inżynieryjnymi (połączone ze wspomaganiem systemami informacyjnymi) to także zakres inżynierii rolniczej. Część zagadnień z wyżej wymienionego zakresu (inżyniera lądowa, budownictwo, gospodarka wodna) jest dziś – mniej lub bardziej – związana z kształceniem (i badaniami) na wydziałach inżynierii środowiska (dawniej wydziałach melioracji i geodezji w Akademiach Rolniczych, lub wydziałach inżynierii sanitarnej politechnik). Zagadnienia gospodarki wodnej, niektóre problemy budownictwa rolniczego, są jednak – choć w mniejszym zakresie przedmiotem studiów (i badań) – na kierunku inżynieria rolnicza.

Amerykanin, czy Japończyk, a także Niemiec, gdy usłyszy od nas – Polaków – że jesteśmy „inżynierem rolnictwa", będzie rozumiał, że zakres naszej wiedzy zawodowej, jest taki jaki obejmują tytuły wspomnianych wyżej CIGR-owskich podręczników. Tak kształci się studentów w tych krajach kierunków, czy specjalności „inżynieria rolnicza", choć programy dydaktyczne różnią się od naszych*.

W wielu krajach wprowadzono do nazwy kierunku studiów (i nazw stowarzyszeń inżynieryjnych) określenie „inżynieria biosystemowa" lub „inżynieria biosystemów"**. Ta formalna koniungacja („inżynieria rolnicza i biosystemowa") oznacza merytorycznie poszerzenie zakresu wiedzy przekazywanej studentom oraz zwiększenie ich kompetencji zawodowych.

Niestety, te uzasadnione zmiany nazewnictwa komentowane są jako „chwyt marketingowy" lub temu podobnymi ironicznymi uwagami. Zamiarem autora tego artykułu (TJ) nie jest przytaczanie dyskusji i argumentacji, które skłoniły inżynierów rolnictwa do dodania określenia „inżynieria biosystemów" lub zgoła zastąpienia określenia „inżynieria rolnicza" określeniem „inżynieria biosystemów". Uczestnictwo w tych dyskusjach pozwala mi jednak stwierdzić, że wprowadzone zmiany są merytorycznie uzasadnione. Wpływ marketin-

* W ramach działalności CIGR-owskiej powołana została grupa robocza, której zadaniem jest standaryzacji programów kształcenia z zakresu inżynierii rolniczej. Przedstawicielem Polski w tej grupie, jest prof. Edmund Lorencowicz z Uniwersytetu Przyrodniczego w Lublinie. W przeszłości taką funkcję standaryzacyjną – poprzez międzynarodową akredytację kierunków studiów – pełniło FEANI (Europejskie Stowarzyszenie Organizacji Inżynierskich).

** Amerykańskie Stowarzyszenie Inżynierów Rolnictwa nosi obecnie nazwę American Society of Agricultural and Biological Engineering (ASABE). W USA bardzo wiele dawnych wydziałów inżynierii rolniczej przekształcono w wydziały „Agricultural and Biosystem Engineering". Podobne zmiany następują także w europejskich uniwersytetach.

gowy tej zmiany jest także pozytywny, ale tego żaden dziekan uniwersyteckiego wydziału, czy przewodniczący stowarzyszenia inżynierskiego, (nie mówiąc o absolwentach studiów i członach stowarzyszeń zawodowych i naukowych) wstydzić się nie powinien.

Obok opracowania definicji „inżynierii rolniczej" stoi więc także przed nami zadanie opracowania definicji „inżynierii biosystemowej" (i popularyzacja znaczenia tej definicji).

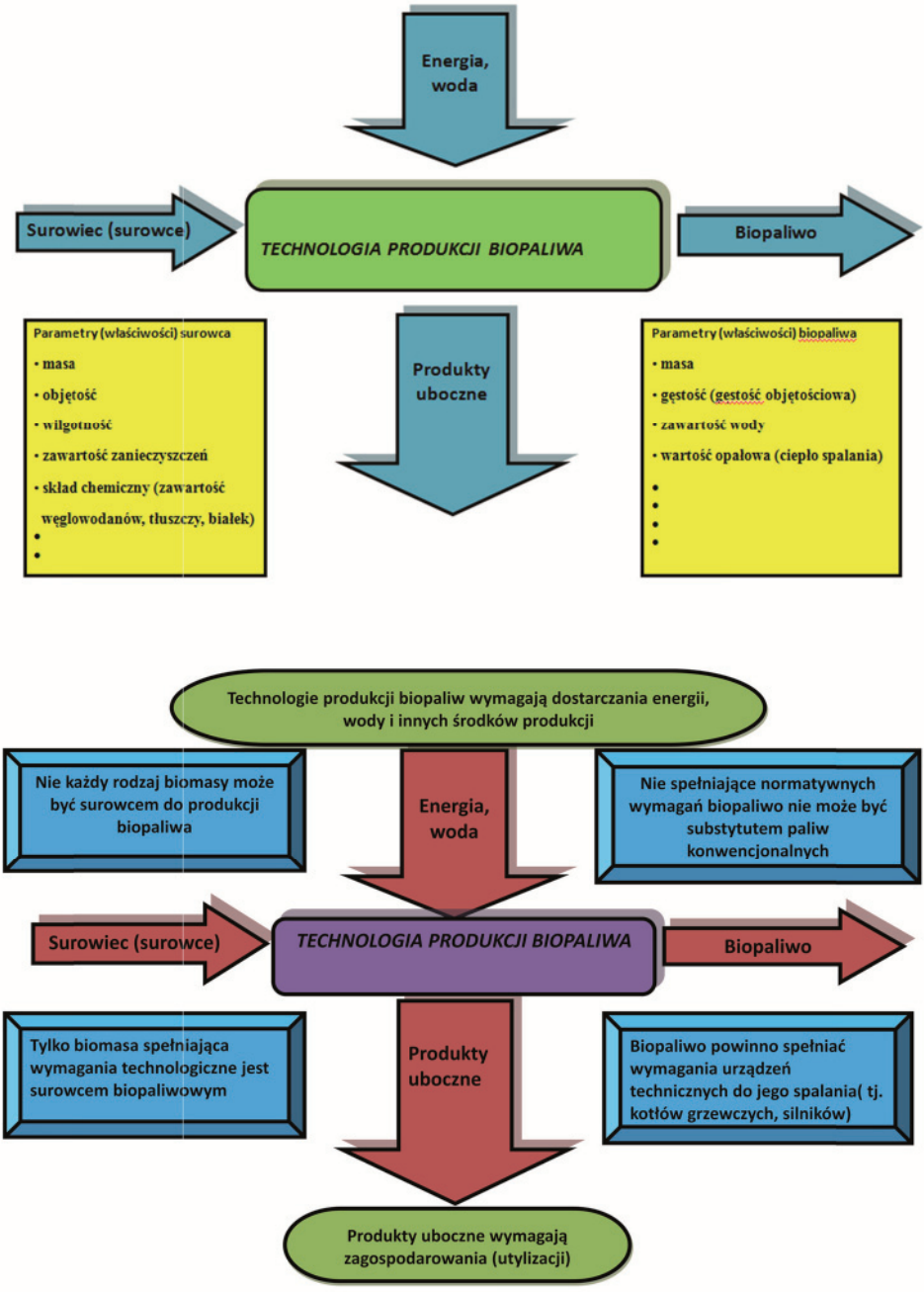
Zakres produkcji surowcowej i przetwórstwa surowców, którymi zajmuje się inżynieria rolnicza, ujmuje się – symbolicznie – skrótem 7F (*food, feed, feedstock, fertlizer, fibre, fuels, fine chemistry*). Oprócz surowców żywnościowych i paszowych lista produktów obejmuje także wiele surowców nieżywnościowych. Spośród surowców nieżywnościowych, produkowanych w rolnictwie i przetwarzanych w przemyśle rolno-spożywczym, lub innych gałęziach przemysłu można wymienić:

- drewno budowlane,
- skóry zwierzęce,
- wełnę i pierze zwierząt,
- włókna roślinne,
- biomasa na cele energetyczne,
- zioła na cele kosmetyczne i farmaceutyczne

Lista tych surowców jest, oczywiście, znacznie bardziej obszerna. Rozpowszechnianie się w społeczeństwie proekologicznych poglądów sprzyja produkcji, tych naturalnych, odtwarzalnych surowców. Poglądy te nie zawsze są jednak powiązane z przekonaniem, iż produkcja surowcowa – w tym przypadku surowców pochodzenia biologicznego – wymaga obszernej wiedzy zawodowej, gdyż tylko taka gwarantuje produkcję surowców o wymaganych – ilościowo i jakościowo – parametrach do przetwarzania w systemach produkcji przemysłowej (por. rys. 1 a i b)

Świadomość, że inżynierowie rolnictwa – i inżynieria rolnicza jako dyscyplina naukowa – przyczyniła się w przeszłości do usunięcia widma głodu w Europie, przyczynia się obecnie do zastępowania nieodtwarzanych surowców przemysłowych surowcami odtwarzalnymi, a w przyszłości może przyczynić się do zrównoważonego rozwoju społeczeństw, jest wciąż niewielka w społeczeństwie. To poważne nasze – inżynierów rolnictwa - zaniedbanie, że nie rozpowszechniamy szeroko i przekonywująco naszych osiągnięć zawodowych, tak jak to czynią inżynierowie z innych dyscyplin.

Warto w tym miejscu zwrócić uwagę, że ułatwienia w wymianie informacji (Internet) i podróżowania po świecie umożliwiają współcześnie, z jednej strony kształcenie inżynierów w niemal każdym miejscu na świecie (programy ERASMUS i inne programy stypendialne), a z drugiej strony także możliwość poszerzania wiedzy zawodowej (w tym także pracowników uniwersyteckich) o pozakrajowe uwarunkowania produkcji i przetwórstwa surowcowego. Szanse te stwarzają także stowarzyszenia inżynieryjne, w stopniu znacznie większym niż miało to miejsce w podzielonej Europie na dwa polityczne obozy jeszcze ćwierć wieku temu.



Rys. 1a,b. Poglądowe przedstawienie systemu przetwarzania surowców pochodzenia biologicznego w biopaliwa

Przewidywane kierunki badań

Przewidywanie przyszłości, w tym także kierunków badań naukowych jest zadaniem o podobnym prawdopodobieństwie pewności sukcesu jak przewidywanie pogody. O ile prognozy krótkookresowe (naukowe i pogodowe) są w miarę sprawdzalne, o tyle programy długookresowe sprawdzają się niezbyt często. Nie sposób jednak zaniechać przewidywania, gdyż planowanie pracy na przyszłość jest koniecznością związaną z wykonywaniem każdej profesji zawodowej (Hołownicki, 2013; International Conference TAE, 2013; Juliszewski, 2011). Autor przedstawi niżej swoje przewidywania, jakie wynikają z jego aktywności zawodowej od 40 lat, w tym także ze współpracy z krajowymi i międzynarodowymi organizacjami naukowymi* i zawodowymi. Łaskawy Czytelnik zechce ocenić ja z takim samym przeświadczeniem, jak ocenia przewidywania pogodowe meteorologów.

Wydaje się, że warte jest zwrócić uwagę na następujące problemy:

1) oszczędne gospodarowanie wodą, jako ograniczającym czynnikiem w produkcji surowców biologicznych i ich przetwórstwie,
2) nowe podejście do ekonomiki i organizacji pracy w rolnictwie, zwłaszcza w kontekście jego subwencjonowania,
3) budownictwo rolnicze,
4) rolnictwo ekologiczne, rośliny genetycznie zmodyfikowane,
5) biosurowce do produkcji biopaliw,
6) wielostronne, użytkowanie (także pozarolnicze) terenów górskich i podgórskich
7) zastosowania elektroniki w rolnictwie (Kaufmann, 2004) i produkcja biopaliw (Kampa, 2007).

Racjonalna gospodarka wodna jest, przed wszystkim, przedmiotem badań prowadzonych w obecnych wydziałach inżynierii i środowiska, przekształconych w nieodległej przeszłości z wydziałów melioracji i geodezji. W istocie badania takie prowadzone są, w mniejszym lub szerszym zakresie, także na innych wydziałach uniwersytetów rolniczych (przyrodniczych), np. wydziałach ogrodniczych (gospodarka wodna w szklarniach), wydziałach rolniczych (deszczowanie i nawadnianie roślin), dawnych wydziałach zootechnicznych (pojenie zwierząt, magazynowanie i zagospodarowanie gnojowicy). W zakresie inżynierii rolniczej prowadzone są także liczne badania; zwłaszcza odnośnie konstrukcji, budowy i eksploatacji urządzeń w produkcji surowcowej i urządzeń do deszczowania.

Problem racjonalnego gospodarowania wodą wynika bądź z jej niedoboru (susza) bądź z jej nadmiaru (erozja wodna podczas gwałtownych opadów). W przetwórstwie rolno-spożywczym woda ulega różnego rodzaju zanieczyszczeniom, które technicznymi, chemicznymi i biologicznymi metodami, muszą być utylizowane. Z przeglądu materiałów konferencyjnych dwóch minionych Kongresów CIGR (Proceedings…Bonn 2006 r., Proceedings…Quebek 2010 r.) jednoznacznie wynika, że racjonalne (oszczędne) gospodarowanie wodą, to nie tylko problem krajów Afryki, czy Azji, ale także krajów Europy, w tym też Polski. Inżynieria rolnicza może wnieść w tym zakresie, tj. racjonalnego gospodarowania

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wodą w produkcji surowcowej i przetwórstwie, wiele nowego, nie tylko w sensie naukowym, ale i utylitarnym – por. także Fuhrer et. al., 2013.

Ekonomika i organizacja pracy w europejskim rolnictwie określana jest w dużym stopniu systemem dotacji (subwencjonowania) (Moriz, 2007; Betriebsplannung…2004/2005; Rossier, 2004). Dominuje system subwencjonowania związany z powierzchnią uprawy danej rośliny (domyślnie: powierzchnię gospodarstwa). System ten jest kwestionowany, jako mało stymulujący postęp w rolnictwie. Alternatywne systemy subwencjonowania opracowano w Szwajcarii i Austrii, jednak ich wdrożenie napotkało na opór wpływowych grup wielkoobszarowych posiadaczy ziemskich, dla których dopłaty obszarowe są źródłem dużych dochodów (niezależnie od wielkości produkcji). W Szwajcarii, która nie należy do Unii Europejskiej, wprowadzono alternatywny system dotowania, który wiąże wielkość dotacji z nakładami czasu pracy na daną technologię uprawy rośliny (oraz z warunkami glebowo-klimatycznymi). W ogólnym zarysie system dotacji polega na przekazywaniu właścicielowi takiej kwoty (dotacji), która odpowiada „normatywnej" ilości godzin pracy przeznaczanej na daną technologię produkcji (uprawy). Rolnik, który zużyje mniej czasu osiąga, oczywiście, większy zysk niż gospodarz, który zużywa „normatywny" czas na produkcję, lub zużywa go więcej. System taki implikuje postęp (zachęca do unowocześniania produkcji, zwiększania wydajności pracy), a jednocześnie pozwala zachować parytet dochodów za 1 godzinę pracy w rolnictwie i przemyśle.

Standardy (normatywy) czasu pracy zastosowane w Szwajcarii (i zaakceptowane tam przez rolników), a także opracowane (choć nie wykorzystywane, jak dotąd) w Austrii i Niemczech są wynikiem pracy inżynierów rolnictwa. Wydaje się, że obecne dyskusje wokół racjonalizacji polityki agrarnej w Europie spowodują, że wzory subwencjonowania rolnictwa ze Szwajcarii przenoszone będą także do innych krajów.

Budownictwo rolnicze to chyba jedna z bardziej zaniedbanych dziedzin w naszym kraju. Zaniedbania te, widoczne gołym okiem, dotyczą przestrzennych planów zabudowy, dostosowania zabudowy do krajobrazu miejsca tej zabudowy oraz komunikacji drogowej (dróg dojazdowych do pól i dróg pomiędzy polami). Porównanie wiejskiego budownictwa w Austrii, Szwajcarii czy Niemczech – nie tylko mieszkalnego ale i inwentarskiego, czy magazynowego – z chaotycznym, często nieracjonalnym, budownictwem w naszym kraju jednoznacznie wskazuje na potrzebę podjęcia wyzwań przez inżynierów rolnictwa w tym zakresie (Mann, 2011; Schüppbach, 2009; Heinrich, 2006; Lauber, 2006). Dodajmy do tego także potrzebę modernizacji utwardzenia i zmiany przebiegu dróg polnych, odnowienie rowów do oprowadzania wody*, by podkreślić skalę potrzeb budowlanych. Nb. budownictwo drogowe, tj. budowa autostrad, dróg szybkiego ruchu itp., finansowane częściowo z funduszy unijnych, niemal w ogóle nie obejmuje budowy i modernizacji dróg dojazdowych do pól. Poruszanie się po tych nieutwardzonych, zbyt wąskich, drogach utrudnia lub niekiedy uniemożliwia, przemieszanie się wielkogabarytowych maszyn i pojazdów a także transport materiałowy.

Rolnictwo ekologiczne (Ferjani, 2010) wciąż wymaga opracowywania nowych maszyn i technologii by jego wydajność (w produkcji rolniczej, sadowniczej, warzywniczej czy zwierzęcej) mogła konkurować z wydajnością technologii, rolnictwa konwencjonalnego

* Jednym z oryginalnych rozwiązań inżynierii rolniczej jest w tym zakresie projekt maszyny do oczyszczania rowów melioracyjnych zaprojektowanej w Przemysłowym Instytucie Maszyn Rolniczych w Poznaniu (Szczepaniak, 2012).

(tradycyjnego). Wyniki badań, krajowe i zagraniczne, jednoznacznie wykazują, że ekologiczne metody produkcji rolniczej są mniej wydajne (mniejsze plony roślin), czego wynikiem są wyższe ceny rynkowe produktów uzyskiwanych tymi metodami. Jednak tylko tak długo, jak konsumenci będą akceptować wyższe ceny produktów ekologicznych, ta metoda produkcji będzie mogła być stosowana. Ponieważ, ze względów dietetycznych, środowiskowych i energetycznych, metody rolnictwa ekologicznego są warte dalszego rozwoju, zaangażowanie inżynierii rolniczej powinno być w tym zakresie większe niż do tej pory.

Stoimy także przed wciąż aktualnym problemem rozszerzania powierzchni upraw roślin genetycznie zmodyfikowanych (Niemirowicz-Szczytt, 2010; Bigler, 2008; Sanvido, 2006). Wyniki starcia producentów nasion roślin genetycznie zmodyfikowanych i przeciwników uprawy tych roślin są jeszcze nierozstrzygnięte. Doniesienia naukowe wykazują bowiem zarówno negatywne jak i pozytywne aspekty uprawy tych roślin, lecz bilans ostateczny zysków i strat – zwłaszcza w bardziej ogólnym, środowiskowym, ujęciu nie może być wciąż jednoznacznie ustalony. Wydaje się, że dużym osiągnięciem inżynierii rolniczej mogłoby być opracowanie metod i urządzeń, które pozwalałyby szybko (i tanio) rozróżniać produkty (roślinne i zwierzęce) uzyskiwane z organizmów genetycznie zmodyfikowanych i niezmodyfikowanych. Wykorzystanie takich metod i urządzeń w działaniach instytucji kontrolnych, ale i także przez konsumentów, znalazłoby szerokie zastosowanie.

Użytki rolne (łąki, pastwiska a niekiedy i pola uprawne) w warunkach podgórskich i górskich wykorzystywane są coraz częściej, oprócz produkcji rolniczej, także do prowadzenia działalności rekreacyjnej i turystycznej. Typowym przykładem takiego wykorzystania może być tu zimowe, naśnieżanie stoków i ich narciarskie użytkowanie. Do tego dochodzi montaż i eksploatacji wyciągów narciarskich, budowa parkingów i zaplecza gastronomicznego. Konstrukcja i eksploatacja specyficznych maszyn i pojazdów do mechanizacji prac rolniczych w warunkach górskich poszerzona jest więc o grupy urządzeń (i budynków), jakie dotychczas rolnicy nie wykorzystywali (jako źródła swej dochodowej działalności), a których oczekują od inżynierów rolnictwa – w ogólnym zakresie kompetencji zawodowych tej grupy fachowców.

Podsumowanie

Inżynieria rolnicza, tak jak definiujemy ten zakres wiedzy naukowej i zawodowej, nieco różni się w Polsce od rozumienia tego zakresu w wielu krajach. Oprócz wykazania tych różnic, warto by także wykazywać podobieństwa i zachodzenie na siebie znaczenia takich pojęć jak: inżynieria rolnicza, inżynieria produkcji, inżynieria biosystemów, czy inżynieria biosurowcowa. Chodzi tu nie tylko o definiowanie dla potrzeb wyjaśnienia znaczenia poszczególnych pojęć zarówno w samym środowisku inżynieryjnym, jak i społeczeństwie, ale także podkreślania kompetencji zawodowych, jakie mogą uzyskać studenci tych kierunków (specjalności), a w efekcie, jakie ma obecnie liczne grupa tych absolwentów w naszym kraju.

W czasach, gdy przydatność wiedzy mierzy się bardziej jej praktycznymi zastosowaniami, niż jej posiadaniem, inżynieria rolnicza musi podejmować wciąż nowe wyzwania aby uzasadniać swą społeczną przydatność. Śledzenia kierunków podejmowanych badań na świecie i wskazywanie potrzeby ich podjęcia w kraju, jest między innymi powinnością krajowych i międzynarodowych stowarzyszeń inżynieryjnych. Wskazaliśmy w powyższym przeglądzie jakie to powinny być kierunki.

Literatura

Betriebsplanung Landwirtschaft 2004/05, Kuratorium für Technik und Bauwesen in der Landwirtschaft, KTBL-Datensammlun 2004.

Bigler, F. et al. (2008). Grundlagen für ein Umweltmonitoring unbewilligter gentechnisch veränderter Pflanzen im Kanton Zürich. *ART-Schriftenreihe 8*, Forschungsanstalt Agroscope Reckenholz-Tänikon ART.

CIGR Handbook of Agricultural Engineering. 1999. Vol. I - VI, Edited by CIGR – *The International Commission of Agricultural Engineering.* Published by the American Society of Agricultural Engineers 1999.

Ferjani, A.; Reissig, L.; Mann, S. (2010). Ein- und Ausstieg im Biolandbau. *ART-Schriftenreihe 13*, Forschungsanstalt Agroscope Reckenholz-Tänikon ART.

Fuhrer, J. et al. (2013). Water Demand in Swiss Agriculture – Sustainable Adaptive Options for Land and Water Management to Mitigate Impacts of Climate Change, *ART-Schriftenreihe 19*, Agroscope.

5th International Conference TAE 2013, Trends in Agricultural Engineering. Czech University of Life Sciences, 2013. Prague; Faculty of Engineering.

Kampa, A.; Wolfensberger, U. (2007). Biotreibstoffe, Grundlagen für die Beurteilung aus Schweizer Sicht, *ART-Schriftenreihe 5*, Forschungsanstalt Agroscope Reckenholz-Tänikon ART.

Lauber, S. (2006). Agrarstrukturwandel im Berggebiet, Ein agentenbasiertes, räumlich explizites Agrarstruktur – und Landnungsmodell für zwei Regionen Mittelbündes, *ART-Schriftenreihe 2*, Forschungsanstalt Agroscope Reckenholz-Tänikon ART.

Mann, S.; Gennaio, M-P. (2011). Wendepunkte in der Dorfentwicklung, *ART-Schriftenreihe 16*, Forschungsanstalt Agroscope Reckenholz-Tänikon ART.

Moriz, Ch. (2007). *Arbeitszeitbedarf für die Betriebsführung in der Landwirtschaft, Ein kausalempirischer Ansatz für die Arbeitszeitermittlung in der Milchproduktion*. Forschungsanstalt Agroscope Reckenholz-Tänikon ART.

Proceedings of the CIGR World Congress, Agricultural Engineering for a Better World. (2006). Bonn.

Proceedings of the CIGR World Congress, Sustainable Biosystems Through Engineering. (2010). Quebec.

Red. Heinrich, A.; Kaufmann, R. (2006). Landwirtschaftliches Bauen und Landschaft (BAULA), FAT-*Schriftenreihe Nr. 69*, Agroscope FAT.

Hołownicki, R.; Kuboń, M. (red.). (2013). *Współczesna inżyniera rolnicza – osiągnięcia i nowe wyzwania*. Monografia. Tom I. Polskie Towarzystwo Inżynierii Rolniczej, Kraków, ISBN 978-83-935020-2-8.

Juliszewski, T.; Kurpaska, S. (red.). (2011). *Współczesna inżynieria rolnicza – badania i zastosowania*. Monografia. ISBN 978-83-930818-1-3.

Niemirowicz-Szczytt, K. (red.). (2012). *GMO w świetle najnowszych badań.* Instytut Problemów Współczesnej Cywilizacji im. Marka Dietricha, Wydawnictwo SGGW, Warszawa. ISBN 978-83-7583-353-7.

Kaufmann (red). (2004). Elektronik in der Landtechnik, *FAT-Schriftenreihe Nr. 59*, Agroscope FAT.

Rossier, R. (2004). Familienkonzepte und Betriebliche Entwicklungspotionen, Entscheidungsmuster und Handlungsorientierungen von Bauernfamilien, *FAT – Schriftenreihe Nr. 61*, Agroscope FAT Tänikon.

Sanvido, O. et al. (2006). Ecological impacts of genetically modified crops. Experiences from ten years of experimental field research and commercial cultivation, *ART-Schriftenreihe 1*, Agroscope Reckenholz-Tänikon Research Station ART.

Schüppbach, B. et al. (2009). Ästhetische bewertung landwirtschaftlicher Kulturen durch die Bevölkerung, *ART-Schriftenreihe 10*, Forschungsanstalt Agroscope Reckenholz-Tänikon ART.

Szczepaniak, J.; Spadło, M., (2012). Problematyka szacowania trwałosci zmęczeniowej w projektowaniu maszyn rolniczych na przykładzie kombajnu do melioracji rowów. *Inżynieria Rolnicza,4*(139), t.1., 411-420.

CO DALEJ Z INŻYNIERIĄ ROLNICZĄ

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Wprowadzenie

Kolejny raz, tym razem na prośbę całego środowiska inżynierii rolniczej we Polsce, podejmuję problem domeny i przynależności inżynierii rolniczej w strukturze nauki. Problem powyższy był przedmiotem rozważań, zarówno moich jak i innych przedstawicieli z różnych ośrodków w Polsce. Pozornie przynależność do takiej lub innej dziedziny nauki może wydawać się mało istotna. Zważywszy jednak, że postęp nauki w każdej dyscyplinie zależy od obiektywnych kryteriów jej oceny, to tylko właściwa klasyfikacja może gwarantować optymalny dobór recenzentów, a tym samym publikowanie poprawnych z punktu widzenia epistemologicznego wyników badań. W niniejszym rozważaniu pominę semantyczne aspekty kwalifikacji nauki, gdyż były one już wielokrotnie rozważane, także w moich pracach (Michałek, 2008; 2010). Jednak dla zachowania pełnego i jasnego obrazu podjętego problemu, niektóre znane już fakty jestem zmuszony powtórzyć dla zachowania obiektywnej oceny prezentowanego stanowiska z przytoczonych względów celem niniejszego artykułu, który był przedmiotem wystąpienia na Zimowej Szkole Naukowej w Zakopanem (5 luty 2014r.) jest miejsce i zakres inżynierii rolniczej w nauce, jej ocena wg przyjętych parametrów jakościowych a także perspektywa jej rozwoju w bliższej i dalszej perspektywie, na co zresztą wskazuje tytuł pracy. Rangę problemu docenili organizatorzy cytowanej już Szkoły Zimowej w Zakopanem, gdyż przeznaczono na jego rozważanie oddzielną sesję naukową, w trakcie której zaprezentowano jeszcze dwa dodatkowe referaty. Przedstawili je: Tadeusz Juliszewski – prezes CIGR „Inżynieria Rolnicza z perspektywy CIGR” oraz Maciej Kuboń – sekretarz wydawnictwa „Agricultural Engineering” „Co dalej z wydawnictwami KTR PAN”. Po trzech wystąpieniach odbyła się bogata dyskusja, z udziałem nie tylko przedstawicieli inżynierii rolniczej, ale także innych dyscyplin naukowych, w tym ogrodnictwa (rektor UR Kraków Prof. Włodzimierz Sady) a także nauk teologicznych (Ks. Prof. Stanisław Rabiej). W wyniku przeprowadzonej dyskusji podjęto uchwałę dotyczącą miejsca inżynierii rolniczej w strukturze nauki polskiej. Stanowi ona załącznik do niniejszego artykułu.

Inżynieria rolnicza w strukturze nauki

Z pewnym uproszczeniem strukturę nauki można przedstawić jako system hierarchiczny, w którym wyrażone są wzajemne relacje, powszechnie używanych pojęć semantycznych (Powierża, 2003). Schemat takiego systemu przedstawia rys. 1. Najwyższą lokatę w systemie zajmuje dziedzina nauki.

Rysunek 1. System hierarchiczny nauk

Do niedawna brak było definicji dziedziny jako części struktury nauki. Wg Encyklopedii pojęcie to odnosiło się do obszaru w matematyce, bądź też starodawnej nazwy wsi (Encyklopedia, 2011). W najnowszym wydaniu encyklopedii dziedzina nauki to trwałe ukształtowana i wyodrębniona grupa dyscyplin naukowych w ramach, której nadawane są stopnie i tytuły naukowe. Z przytoczonej definicji wynika, że dziedzinę w nauce tworzą dyscypliny. Przytoczę trzy definicje dyscypliny. Encyklopedyczna (Encyklopedia, 2011) oznacza: „część dziedziny nauki, społecznie zorganizowana działalność badawcza nastawiona na tworzenie informacji w oparciu o studia i badania oraz stosowania rezultatów tej działalności w praktyce". Wg L. Krzyżanowskiego (1994) „dyscyplina nauki to usystematyzowany ze względu na przedmiot i cele procesu poznania oraz społeczne znaczenie jego rezultatów zbiór ukształtowanych i wyodrębnionych części zasobu wiedzy o rzeczywistości.

Matematyczną formułę dyscypliny przedstawił w swojej monografii prof. Leszek Powierża (2003):

$$DN = <D, I, P, R, W>$$

gdzie:

DN – dyscyplina nauki,
D – domena,
J – język,
P – zbiór praw,
R – zbiór reguł,
W – wiedza

Z przedstawionych parametrów wzoru wyjaśnienia wymagają język i domena.

Język dyscypliny definiuje On jako „zbiór celowo dobranych, przedmiotowo zorientowanych elementów powiązanych zbiorem relacji a zatem pewnym systemem funkcjonalnym, spełniającym funkcje narzędziowe czyli pewne instrumentarium danej dyscypliny. Elementami tego systemu są terminy zaczerpnięte z języka infrastruktury danej dyscypliny, uzupełnione terminami utworzonymi w jej ramach.

Można to wyrazić formułą:

$$TN = \{TI + TD\}$$

gdzie:

TN – zbiór terminów danej dyscypliny,
TI – zbiór terminów przyjętych z infrastruktury,
TD – zbiór terminów własnych dyscypliny.

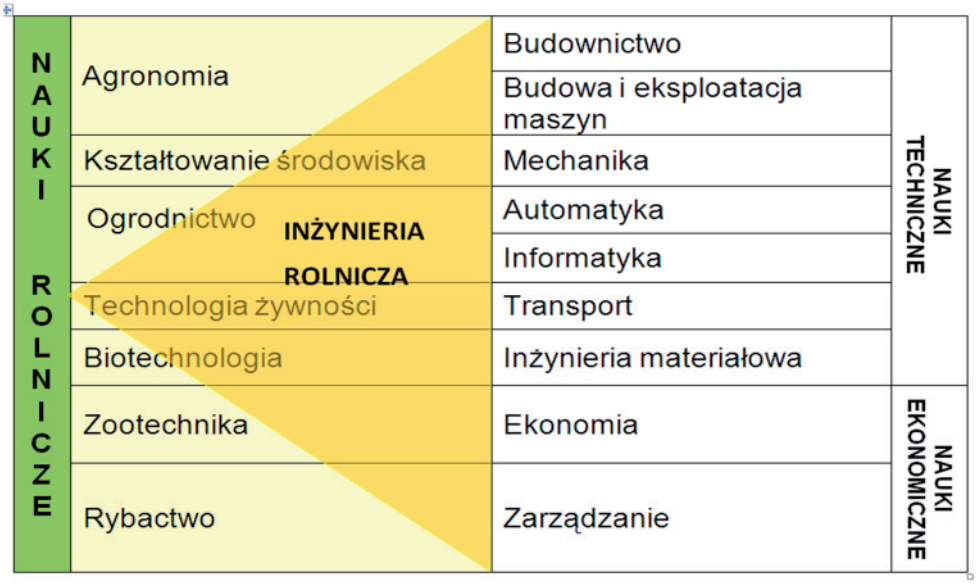
Poprawne rozumienie języka dyscypliny i jego struktury ma szczególne znaczenie przy ocenie merytorycznej prac naukowych.

Drugim pojęciem z formuły matematycznej dyscypliny nauki jest domena. Historyczne ujęcie domeny inżynierii rolniczej przedstawia się następująco:

- Mechanizacja produkcji roślinnej
- Mechanizacja produkcji zwierzęcej
- Mechanizacja produkcji ogrodniczej
- Inżynieria przemysłu spożywczego
- Organizacja i zarządzanie w inżynierii rolniczej
- Energetyka rolnicza
- Elektryfikacja i automatyka w rolnictwie
- Agrofizyka
- Transport w rolnictwie
- Budownictwo rolnicze
- Suszarnictwo płodów rolnych
- Mechanizacja rolnictwa w terenach górskich
- Modelowanie procesów produkcyjnych w rolnictwie
- Techniczna infrastruktura rolnictwa i jego otoczenia

Rozwinięciem tego zestawienia są kolejne, historyczne etapy rozwoju współczesnej inżynierii: maszynoznawstwo rolnicze – mechanizacja rolnictwa – technika rolnicza – inżynieria rolnicza. Taki układ jest moim autorstwem i przedstawiłem go w licznych pracach (Michałek, 2003; 2006a; 2007; 2010a,b). W wielu współczesnych opracowaniach autorzy unikają jak ognia przymiotnika rolniczy. Odnosi się to nie tylko do klasyfikacji nauki, ale także terminologii związanej z nazwami zespołów, zakładów, instytutów a nawet uczelni. Daliśmy temu wyraz w opracowaniu zbiorowym (Haman i in., 2012) stąd też pojęcie inżynieria rolnicza zastępuje się agroinżynierią lub bioinżynierią systemów, zwłaszcza to drugie jest szczególnie preferowane przez przeciwników rolnictwa, bo kojarzy się z biologią a ta staje się coraz bardziej atrakcyjna. To nic, że bioinżynieria jest znacznie zawężona w stosunku do agroinżynierii, gdyż ta oznacza całość problematyki rolniczej w powiązaniu z inżynierią. Poszukując dalszych przekształceń inżynierii rolniczej w grę wchodzi także połączenie trzech obszarów badawczych: agronomii, mechaniki i elektroniki i utworzenie perspektywicznej dyscypliny o nazwie agromechatronika. Nie sądzę aby to była odległa perspektywa.

Na zakończenie dotychczasowych rozważań odnośnie miejsca inżynierii rolniczej w strukturze nauki to wypowiadam się za obowiązującą aktualnie klasyfikacją ustanowioną zarządzeniem Ministra Nauki i Szkolnictwa Wyższego z 8 sierpnia 2011 roku (Dz. U. 2011 Nr 179, poz. 1065) w której jest trójczłonowy podział nauki na: obszary, dziedziny i dyscypliny. Inżynieria rolnicza została zakwalifikowana do obszaru nauk rolniczych, leśnych i weterynaryjnych i dziedziny nauk rolniczych. Szczegółowo jej miejsce przedstawia rys. 2, na którym zaznaczono jej miejsce w naukach rolniczych i powiązanie z wszystkimi jej dyscyplinami a dodatkowe istniejące styki z niektórymi dyscyplinami nauk technicznych i ekonomicznych.



Rysunek 2. Miejsce inżynierii rolniczej w strukturze nauki

Zasadniczym kryterium takiej klasyfikacji są względy merytoryczne przedstawione w definicji Krzyżanowskiego (1994). Spośród nich na plan pierwszy wyłania się przedmiot badań. Często metody są zbliżone lub identyczne, jak w naukach technicznych czy ekonomicznych a nawet ścisłych, jednak decydujące znaczenie winien mieć ze względu na problem badawczy przedmiot badań. Uważam równocześnie, że przy nadawaniu stopni naukowych, dziedzina nauki nie ma istotnego znaczenia i wystarczyłaby tylko dyscyplina nauki. Takie stanowisko przedstawiłem wielokrotnie (Michałek 2008, 2010; Haman i in., 2012). Równocześnie nie widzę przeciwwskazań, aby inżynieria rolnicza mogła występować, jak wiele innych dyscyplin, w dwóch dziedzinach tj. w naukach rolniczych i technicznych. Istnieje wiele specjalności naukowych w jej domenie, które są bliższe naukom technicznym jak np. automatyka, informatyka, elektronika itd. Zapewne te specjalności naukowe byłyby poprawniej oceniane przez specjalistów nauk technicznych. Jednak zdecydowanie wypowiadam się za administracyjnym przenoszeniem dyscypliny i zmianom stopni naukowych już wcześniej nadanych. Jest to metoda obchodzenia przepisów na skróty.

Inżynieria rolnicza jako przedmiot kształcenia

Tocząca się w całej nauce dyskusja na temat miejsca i zakresu dyscyplin naukowych wynika w dużej mierze z narastającego niżu demograficznego w Polsce i malejącego naboru kandydatów na studia. Tym bardziej jest to widoczne przy ogromnym rozroście struktury szkolnictwa wyższego, poprzez sieć wyższych szkół prywatnych. Procesem narastającego niżu demograficznego w dużym stopniu dotknięte zostały kierunki kształcenia rolniczego, bo jak wcześniej już wykazałem przymiotnik rolniczy stał się nieatrakcyjnym. Jest to m. in.

konsekwencją rozrostu inżynierii rolniczej, która spowodowała silny wzrost wydajności pracy w rolnictwie a tym samym malejące zapotrzebowanie na siłę roboczą. Temu procesowi towarzyszy malejący udział produkcji rolniczej w PKB (Raport…, 2012) jak również obniżone potrzeby na kadry inżynieryjne w całym kompleksie rolnictwa i gospodarki żywnościowej. Profesor Wilkin w ww. raporcie stwierdza"… Udział rolnictwa w PKB zmniejsza się i wynosi obecnie około 3%. Maleje też jego udział w zasobach produkcyjnych kraju. Nie oznacza to, że rolnictwo jest nieważne czy mało ważne. Jest to nadal jeden z kluczowych działów gospodarki, związany z dostarczaniem dobra podstawowego, jakim jest żywność, a także z dostarczaniem wielu dóbr i usług bardzo ważnych dla społeczeństwa, w tym dóbr publicznych". Inżynieria rolnicza, w jej poprzednich postaciach towarzyszyła zawsze programom kształcenia akademickiego na wszystkich kierunkach rolniczych począwszy od Studium Rolniczego Uniwersytetu Jagiellońskiego w Krakowie, uruchomionym w r. 1890 (Michałek, 2006b).

Wraz z rozwojem wyższego szkolnictwa rolniczego procentowy udział przedmiotów inżynierskich stopniowo wzrastał, co wynikało z procesu technicznej rekonstrukcji rolnictwa. Proces ten trwał do początku lat siedemdziesiątych XX w a więc do momentu uruchomienia we wszystkich uczelniach rolniczych w Polsce samodzielnego kierunku o obecnej nazwie: Technika Rolnicza i Leśna. Kierunek ten, pomimo słabej obsadzie kadry naukowej, cieszył się rosnącym zainteresowaniem ze strony Kandydatów na studentów. Równocześnie uruchamiany samodzielny kierunek z inżynierii rolniczej spowodował eliminację przedmiotów inżynieryjnych z pozostałych kierunków rolniczych, w szczególności rolnictwa, ogrodnictwa i zootechniki. W efekcie współcześni absolwenci tych kierunków nie mają żadnego przygotowania do pracy w uzbrojonym technicznie rolnictwie. Te przekształcenia w modernizacji planów i programów nauczania uznajemy za największą słabość w rozwoju inżynierii rolniczej w Polsce. Równolegle do pozostałych kierunków studiów spadło także wyraźnie zainteresowanie samodzielnym kierunkiem Techniki Rolniczej i Leśnej i to w momencie, gdzie we wszystkich ośrodkach nastąpił silny wzrost kadry naukowej. Dla pełnego jej wykorzystania dydaktycznego, uruchomiono równolegle drugi kierunek studiów o nazwie: Zarządzanie i Inżynieria Produkcji. Cieszy się on znacznie większym zainteresowaniem w porównaniu z Techniką Rolniczą i Leśną, ale ma silną konkurencję ze strony uczelni technicznych i ekonomicznych, bowiem w samej nazwie zawiera dwie dyscypliny należące do tamtych dziedzin nauki.

W ostatnich latach pod wpływem narastających potrzeb energetycznych w świecie w tym i w Polsce, nastąpiło zainteresowanie odnawialnymi źródłami energii. Proces ten jest także obawą przed skutkami ekologicznymi w nadmiernym zużyciu źródeł kopalnianych. Idąc za potrzebami gospodarki, uruchomiono kolejny nowy kierunek studiów z zakresu inżynierii rolniczej a mianowicie „Odnawialne źródła energii i gospodarka odpadami". Dotychczasowe obserwacje wskazują na pozytywne przyjęcie tego kierunku, zarówno przez studentów jak i przedstawicieli gospodarki narodowej.

Podsumowanie i wnioski

We wszystkich strukturach nauki w Polsce i świecie trwa dyskusja nad jej przyszłością w powiązaniu z rozwojem szkolnictwa wyższego. Przedstawiony artykuł dotyczy sytuacji w inżynierii rolniczej. Jest to dyscyplina stosunkowo młoda w strukturze nauk rolniczych

ale zarazem stanowiąca środowisko silnie zintegrowane i ciągle wprowadzająca nowe elementy w procesie unowocześniania procesu nauczania. Stale nurtującym nas problemem jest miejsce inżynierii w strukturze nauki w Polsce na tle porównań międzynarodowych jak również jej przyszłość w procesie kształcenia akademickiego. Przedstawiona w pracy analiza, także w ujęciu historycznym wykazała, że ze względu na przedmiot badań inżynieria rolnicza winna wchodzić w strukturę dziedziny nauk rolniczych, co nie stanowi przeszkody aby była równocześnie dyscypliną w obrębie nauk technicznych. Ukazując rozwój inżynierii rolniczej organizatorzy szkoły naukowej dokonali wymiany poglądów na temat jej miejsca w strukturze nauki, która jednoznacznie wskazywała jej powiązania z naukami rolniczymi.

Litaratura

Encyklopedia Powszechna. (2011). Państwowe Wydawnictwo Naukowe, Warszawa

Haman J., Hołownicki R., Michałek R., Żmija J. (2012). Misja nauk rolniczych w rozwoju polskiego sektora rolno-spożywczego. *Inżynieria Rolnicza, 4*(139), 465-483.

Krzyżanowski L.J. (1994). *O podstawach kierowania organizacjami*. Wydawnictwo Naukowe PWN, Warszawa, wyd. 2 poprawione.

Michałek, R. (2003). Miejsce i zakres inżynierii rolniczej w strukturze nauki polskiej. *Inżynieria Rolnicza, 3*(45), 7-14.

Michałek, R. (2006a). Pozycja inżynierii rolniczej w strukturze nauki polskiej. *Inżynieria Rolnicza, 11*(86), 15-22.

Michałek, R. (2006b). Powrót na uniwersytet. *Inżynieria Rolnicza, 11*(86), 31-38.

Michałek R., Kowalski J. (2007). *Od techniki do agroinżynierii*. Monografia. PTIR. Kraków. ISBN 83-917053-4-X.

Michałek, R. (2008). Głos w sprawie klasyfikacji nauki. *Nauka, 3*, 155-159.

Michałek R. 2010a. Przyszłość inżynierii rolniczej na tle projektowanych zmian w nauce i szkolnictwie wyższym. *Inżynieria Rolnicza, 4*(122), 7-13.

Michałek, R. (2010b). Domena i miejsce inżynierii rolniczej w strukturze nauki. *Inżynieria Rolnicza, 2*(120), 7-11.

Powierża L 2003. Semantyczne aspekty terminologii. *Inżynieria systemów Biologicznych, 2*, 2-3.

Raport Polska Wieś 2012. (2012). Fundację na rzecz Rozwoju Polskiego Rolnictwa. FDPA. ISBN 978-83-7383-572-6.

Co dalej z wydawnictwami KTR PAN

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Wprowadzenie

Każdy naukowiec ma swoje wyobrażenie i własną ocenę znaczenia czy rangi czasopism ze swojej dziedziny, zarówno w skali krajowej, jak i międzynarodowej. Są czasopisma wybitne, prestiżowe i wpływowe w skali światowej, są czasopisma dobre, a nawet bardzo dobre w skali krajowej, a niedostrzegane w skali międzynarodowej, są też czasopisma przeciętne i mierne nie tylko w skali krajowej, ale nawet lokalnej (uczelni czy ośrodka naukowego). Można przyjąć, że wszystkie one spełniają jakieś pożyteczne funkcje, jeśli ktoś chce je finansować, upowszechniać i zamieszczać w nich artykuły[1].

Rozwój nauki jest nierozerwalnie związany z przekazywaniem jej wyników uczonym zainteresowanym danym zagadnieniem, a także z ich rozpowszechnianiem jak najszerszej społeczności. Szybkość przekazania informacji jest szczególnie ważna w naukach przyrodniczych i dlatego w tym przypadku wzrasta rola czasopism jako miejsca publikacji najnowszych danych. Stworzenie czasopism elektronicznych jeszcze bardziej skróciło drogę między nadawcą a odbiorcą, gdyż w przypadku zamieszczania artykułów w elektronicznych wersjach czasopism (coraz częściej istniejących tylko w wersji elektronicznej) eliminuje się czas druku oraz przesłania każdego numeru do prenumeratora. Nawet pobieżne przejrzenie bibliografii załącznikowych dołączanych do artykułów ukazuje stale rosnącą pozycję czasopisma, jako środka komunikacji naukowej[2].

Rosnąca z roku na rok liczba tytułów czasopism zmusza do wszechstronnych ocen i weryfikacji jakości wydawnictw. Oceny takie stały się bardzo ważne dla różnych grup użytkowników, którzy ze względu na dużą liczbę tytułów muszą dokonać koniecznej selekcji. Rankingi czasopism, oparte na różnych metodach oceny wykorzystywane są do różnych celów. Zainteresowani chcą wiedzieć, co warto przejrzeć, aby śledzić na bieżąco informacje o badaniach znajdujących się w obszarze ich zainteresowań. Z drugiej strony ważne jest gdzie publikować rezultaty swej pracy, aby dotarły do jak najszerszego grona osób zajmujących się daną tematyką[3,4].

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1 Wilkin J. (2013). Ocena parametryczna czasopism naukowych w Polsce – podstawy metodologiczne, znaczenie praktyczne, trudności realizacji i perspektywy. Nauka, 1, 45-54.

2 Stefaniak, B. (1987). Use of bibliographic data bases for scientometrics studies. Scientometrics. No12, 149-161.

3 Drabek, A. (2001). Bibliometryczna analiza czasopism naukowych w dziedzinie nauk społecznych. Praca doktorska. Uniwersytet Śląski. Maszynopis.

Zmianie ulega także forma komunikowania się na płaszczyźnie materiał źródłowy-czytelnik. Użytkownik indywidualny stał się bardziej anonimowy niż dotychczas. Jest to wynik rozwoju nowych kanałów informacyjnych poszerzających dotychczasowe formy kontaktu z odbiorcą. Bezpośredni kontakt z użytkownikiem coraz częściej ustępuje miejsca pośrednim sposobom komunikacji. Współczesny użytkownik przeważnie oczekuje jedynie wskazówki, aby dalej samodzielnie kontynuować poszukiwania. Taką informacyjną wskazówką jest strona internetowa, informatory o bibliotece, bazach danych czy tez ulotki reklamujące poszczególne rodzaje usług w bibliotece. Najważniejszą zmianą w informacji naukowej widoczną na przykładzie wszystkich rodzajów informacji jest pojawienie się zasobów elektronicznych. Przełamały one bariery dostępności do światowych osiągnięć nauki, zmodernizowały warsztat pracy bibliotekarzy oraz skróciły czas oczekiwania na informację.

Czasopisma wydawane pod patronatem Komitetu Techniki Rolniczej PAN

Ważnym aspektem umożliwiającym rozwój kadry i jej awanse naukowe jest stworzenie powszechnego dostępu do publikacji w renomowanych czasopismach naukowych Polskiej Akademii Nauk.

Komitet Techniki Rolniczej PAN (KTR PAN) wspólnie z Polskim Towarzystwem Inżynierii Rolniczej (PTIR) wydają trzy periodyki: „Inżynieria Rolnicza", „Problemy Inżynierii Rolniczej" oraz biuletyn popularyzujący wyniki badań aplikacyjnych – „Nauka Praktyce Rolniczej". Dwa pierwsze są to czasopisma ściśle naukowe, w których publikowane są wyłącznie recenzowane prace, natomiast trzeci zawiera prace popularno-naukowe. Należy tutaj podkreślić, iż dwa pierwsze czasopisma stanowią jedną z podstawowych pozycji publikatorskich w dorobku naukowym pracowników w dyscyplinie inżynieria rolnicza.

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Zarówno Rada Programowa jak i poszczególne Komitety Redakcyjne czasopism realizują wspólne zasady wydawnicze ustalone przez Prezydium i były Wydział V PAN (obec-

[4] Michałek, R. (2007). Problemy wydawnicze inżynierii rolniczej. Inżynieria Rolnicza, 9(97), 7-12.

nie II Wydział). Czuwają także nad poziomem naukowym oraz zakresem merytorycznym publikowanych artykułów[5].

Kryteria i wymogi redakcyjne, opracowane i przyjęte przez Radę Programową są zamieszczone na stronach wydawnictw naukowych (http://ir.ptir.org; http://www.itp.edu.pl).

O przyjęciu do druku decyduje wstępna kwalifikacja przeprowadzana przez redaktorów tematycznych oraz pozytywna recenzja wykonana przez dwóch niezależnych specjalistów z danej branży. Aktualnie funkcję redaktorów tematycznych pełnią:

- prof. dr hab. Aleksander Szeptycki (ITP Falenty) – inżynieria produkcji roślinnej;
- prof. dr hab. Marian Wiercioch (UP Wrocław) – inżynieria produkcji zwierzęcej;
- prof. dr hab. Kazimierz Rutkowski (UR Kraków) – inżynieria produkcji ogrodniczej;
- prof. dr hab. Marek Tukiendorf (PO Opole) – inżynieria przetwórstwa rolno-spożywczego;
- prof. dr hab. Sławomir Kurpaska (UR Kraków) – ekoenergetyka;
- prof. dr hab. Kazimierz Dreszer (UP Lublin) – maszyny i urządzenia rolnicze;
- prof. dr hab. Stanisław Peroń (UP Wrocław) – suszarnictwo i przechowalnictwo;
- prof. dr hab. Józef Kowalski (UR Kraków) – ekonomika i organizacja produkcji i gospodarstw rolnych;
- prof. dr hab. Bogusław Cieślikowski (UR Kraków) – budowa i eksploatacja pojazdów rolniczych;
- prof. dr hab. Jerzy Dąbkowski (PK Kraków) – informatyka w inżynierii rolniczej;
- prof. dr hab. Tadeusz Juliszewski (UR Kraków) – ergonomia w rolnictwie.

Redaktorem języka polskiego jest mgr Mirosław Grzegorzek, języka angielskiego – dr Rafał Serafin a redaktorem statystycznym – dr Stanisława Roczkowska-Chmaj.

W tabeli 1 przedstawiono działalność wydawniczą Komitetu Techniki Rolniczej PAN na przestrzeni ostatnich 10-ciu lat. Jak można zauważyć wiodącą rolę wśród wydawanych periodyków pełni czasopismo „Inżynieria Rolnicza", a od roku 2014 „Agricultural Engineering" – średnio 9 zeszytów w ciągu roku. Tak duża liczba wydawanych zeszytów była konsekwencją dużej liczby konferencji i szkół naukowych organizowanych przez różne ośrodki naukowe pod wspólnym patronatem KTR PAN i PTIR. W sumie w ostatnim 10-leciu Wydawnictwo wydało 90 zeszytów, gdzie opublikowano 2756 artykułów, co daje średnio 31 artykułów na zeszyt. Redakcja wydawnictwa mieści się w Krakowie, a zasoby (streszczenia i pełne teksty artykułów) są udostępnione pod adresem: http:///ir.ptir.org.

Problemy Inżynierii Rolniczej są kwartalnikiem, ukazującym się regularnie 4 razy w roku. W ostatnich 10-ciu latach wydano w sumie 39 zeszytów z 580 artykułami, co w przeliczeniu na jeden zeszyt dało 15 artykułów. Ogólny nakład wyniósł 8350 egzemplarzy. Redakcja czasopisma od momentu połączenia się Instytutu Budownictwa, Mechanizacji i Elektryfikacji Rolnictwa z Instytutem Melioracji i Użytków Zielonych (1 styczeń 2010r.) – została przeniesiona do Instytutu Technologiczno-Przyrodniczego w Falentach. Zasoby Wydawnictwa są dostępne pod adresem: http://www.itep.edu.pl/wydawnictwo/, a wydania starsze 2005-2009 pod adresem http://www.ibmer.waw.pl/pl/zasoby_pir_instrukcja.html.

[5] Michałek, R. (2007). Komitety naukowe PAN w rozwoju kadry naukowej inżynierii rolniczej. Inżynieria Rolnicza, 7(95), 15-22.

Tabela 1.
Działalność wydawnicza Komitetu Techniki Rolniczej PAN w latach 2005-2014

Rok	Inżynieria Rolnicza/ Agricultural Engineering (2014)			Problemy Inżynierii Rolniczej		
	Liczba zeszytów	Liczba artykułów	Sumaryczny nakład	Liczba zeszytów	Liczba artykułów	Sumaryczny nakład
2005	15	468	3000	4	41	800
2006	13	461	2600	4	58	800
2007	10	273	2000	4	65	800
2008	11	396	2200	4	79	800
2009	9	238	1800	4	70	800
2010	7	259	1400	4	57	1000
2011	9	243	1350	4	67	1000
2012	6	165	900	4	64	950
2013	8	203	1200	4	55	800
2014	2	50	300	3	24	600
Razem	**90**	**2756**	**16750**	**39**	580	**8350**

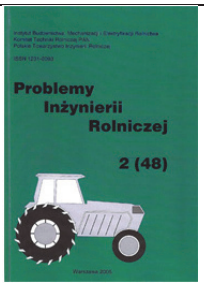
Poza czasopismami o charakterze czysto naukowym Komitet Techniki Rolniczej PAN wspólnie z Polskim Towarzystwem Inżynierii Rolniczej wydaje biuletyn informacyjny o charakterze aplikacyjnym „Nauka Praktyce Rolniczej". Czasopismo to ukazuje się nieregularnie. Ma ono zasięg ogólnokrajowy i rozsyłane jest do naszych ośrodków bezpłatnie. Periodyk ten cieszy się niską popularnością, stąd też częstotliwość jego wydawania jest bardzo mała. Redakcja również mieści się w Krakowie.

W tabeli 2 przedstawiam punktację czasopism KTR PAN według obowiązującej w danym roku listy czasopism punktowanych MNiSzW oraz sumaryczny wskaźnik oceny czasopisma wykonany przez Bazę Index Copernicus.

Poza czasopismami objętymi bezpośrednim patronatem Komitetu Techniki Rolniczej PAN i Polskiego Towarzystwa Inżynierii Rolniczej istnieją również inne periodyki z domeny inżynieria rolnicza. Poniżej przedstawiono polskie i zagraniczne czasopisma wraz z aktualną punktacją MNiSzW:

- Acta Agrophysica – 7 pkt.
- Acta Scientiarum Polonorum – Seria Technica Agraria – 3 pkt.,
- Annals of Warsaw University of Life Sciences – 2 pkt.,
- Electronic Journal of Polish Agricultural Universities" (EJPAU) – 7 pkt.,
- International Agrophysics – 25 pkt. (IF=1,142),
- Journal of Research and Applications in Agricultural Engineering – 5 pkt.,
- Motrol Motoryzacja i Energetyka Rolnictwai – 4 pkt.,
- Roczniki Naukowe Stowarzyszenia Ekonomistów Rolnictwa i Agrobiznesu – 8 pkt.
- Technika Rolnicza-Ogrodnicza-Leśna – 4 pkt.,
- Teka Komisji Motoryzacji i Energetyki Rolnictwai – 6 pkt.,
- Zeszyty Problemowe Postępów Nauk Rolniczych – 9 pkt.

Tabela 2.
Punktacja czasopism wydawanych pod patronatem KTR PAN w latach 2007-2014

	**Punktacja MNiSZW:** 2007: 4 2009: 4 2010: 6 2012: 5 2012: 5 2013: 5 2014: 5		**Punktacja MNiSZW:** 2007: 4 2009: 4 2010: 6 2012: 5 2012: 5 2013: 4 2014: 5
	Index Copernicus: 2001: 2,70 2002: 2,23 2004: 2,22 2005: 2,22 2011: 4,31 2013: 4,91		**Index Copernicus:** 2001: 2,10 2002: 2,60 2004: 2,59 2005: 2,59 2011: 5,63 2012: 4,77

Na szczególną uwagę zasługują czasopisma zagraniczne, o najwyższej randze naukowej, posiadające (IF) i umieszczone na tzw. Liście Filadelfijskiej. Z wymienionych wcześniej czasopism krajowych z zakresu inżynierii rolniczej, żadne niestety nie znalazło się na tej liście. Jedynie „International Agrophysics" jako czasopismo związane blisko z inżynierią rolniczą od 2010 roku widnieje na tej liście. Inżynieria rolnicza – jako stosunkowo młoda dyscyplina naukowa – o charakterze interdyscyplinarnym, ma też bardzo nieliczne wydawnictwa zakwalifikowane do tej listy. Aktualnie są to: Biosystems Engineering, Transactions of the ASAE oraz Canadian Agricultural Engineering.

Ocena parametryczna czasopism naukowych w Polsce

W nauce, podobnie jak i nieomal we wszystkich dziedzinach życia, trwa jednak rywalizacja o prestiż, siłę oddziaływania, a także o pieniądze. Ośrodki naukowe i poszczególni naukowcy coraz ostrzej rywalizują o pozycję w swoim środowisku naukowym (krajowym i międzynarodowym), a także o pieniądze na badania, kształcenie studentów i doktorantów oraz na poprawę warunków materialno-dochodowych, w jakich pracują. Konkurencja ta przybiera rozmiar globalny, co będzie odczuwane i częściowo już jest odczuwane, również w Polsce. Nie ma od tego ucieczki, więc jak najszybciej trzeba się do tego przygotować i stanąć w szranki owej rywalizacji, chroniąc jednocześnie „nierywalizacyjne" cele i wartości nauki. Bardzo ważną rolę w tej rywalizacji odgrywa naukometria, której narzędziem jest bibliometria, zajmująca się analizą przepływu informacji z wykorzystaniem publikacji naukowych. Bibliometria posługuje się zestawem metod ilościowych służących analizie i ocenie osiągnięć naukowych poszczególnych badaczy, a także czasopism, jednostek naukowych oraz krajów. Interpretacje bibliometryczne wychodzą z założenia, że im częściej cytowana jest publikacja, tym mocniej oddziałuje ona na postęp naukowy, a czasopisma drukujące poczytne artykuły są lepsze od tych, których artykuły cytowane nie są. Jest to szybko rozwijająca się dziedzina wiedzy, będąca swoistą „nauką o nauce". […] Ranking punktowy czasopism naukowych, podobnie jak i parametryzacja jednostek naukowych, jest

próbą obiektywizacji ich jakości i pozycji na potrzeby pragmatyki postępowania przy podziale środków finansowych na naukę. Chodzi o wypracowanie przejrzystych i obiektywnych podstaw podziału funduszy publicznych, służących finansowaniu jednostek naukowych, zespołów i projektów badawczych, a także ocenie osiągnięć naukowych, zarówno poszczególnych badaczy, jak i instytucji. Obecnie parametryzacja jednostek w dużym stopniu zależy od klasyfikacji czasopism. Z parametryzacją wiąże się kategoryzacja, za którą idą pieniądze budżetowe. Można przyjąć, że punkty przyznawane czasopismom stanowią istotną część fundamentu dobrobytu bądź przyczyn upadku jednostek naukowych. Głównym problemem oceny czasopism jest znalezienie możliwie największej liczby wspólnych elementów oceny, a następnie przyznanie tym elementom określonej wagi[6].

Sformułowana przez zespół prof. Banacha (poprzedni zespół do oceny czasopism naukowych) koncepcja oceny czasopism naukowych, opierała się na czterech założeniach:

– dążenie do wypracowania podstaw pełnej parametryzacji czasopism i wyeliminowania uznaniowości w tej dziedzinie (wyeliminowanie „ręcznego sterowania" i uznaniowego przydzielania punktów poszczególnym czasopismom);
– konieczność uporządkowania zasad publikowania artykułów i wprowadzenia wysokich, formalnych standardów w tym zakresie (zasady recenzowania, zapora ghost writing oraz wprowadzenie redaktorów tematycznych, językowych i statystycznych);
– preferowanie dostępności czasopism w sieciach internetowych (indeksowania w bazach danych, dostępność on-line itp.);
– silne umiędzynarodowienie polskich czasopism naukowych (streszczenia i artykuły w językach obcych, zwłaszcza w języku angielskim, zagraniczni autorzy, członkowie rad naukowych czy redakcyjnych, zagraniczni recenzenci, a także cytowania polskich publikacji w literaturze światowej).

Te założenia można było uznać za uzasadnione i godne kontynuacji, jednakże koncepcja ta była najsilniej krytykowana szczególnie przez przedstawicieli nauk humanistycznych i społecznych, jako nieprzystająca do specyfiki pracy naukowej i charakteru publikacji w tych obszarach nauk.

Po wielu dyskusjach nowy zespół (kierowany przez prof. Wilkina) postanowił nieco zmodyfikować zasady, kryteria i niektóre szczegółowe warunki oceny czasopism, zachowując jednak parametryczny charakter tej oceny i bazując na danych z wcześniej wypełnionych ankiet. Najważniejsze modyfikacje polegały na:

– ustaleniu nowego zakresu punktacji: w części A – od 15 do 50 punktów, w części B – od 1 do 10 punktów i w części C – 10, 12 i 14 punktów w zależności od grupy czasopism w bazie ERIH;
– wprowadzeniu tzw. stałej przeniesienia w wysokości 0,4, co oznaczało, iż znaczna część punktów wynika z poprzedniej punktacji (z 2010 r.). Pozwoliło to zmniejszyć rozpiętość między oceną tego samego czasopisma dokonaną w 2010 roku i 2012 roku;
– uznano jako minimalną liczbę kryteriów wstępnych 5 (z 9 możliwych), w tym obligatoryjnie – naukowy charakter czasopisma;
– silnym zróżnicowaniu wag poszczególnych kryteriów oceny, w tym PIF, na liście B w odniesieniu do jej trzech składników: ***nauk technicznych, ścisłych, medycznych i przyrodniczych (TZ)***, nauk społecznych (**S**) i nauk humanistycznych (**H**).

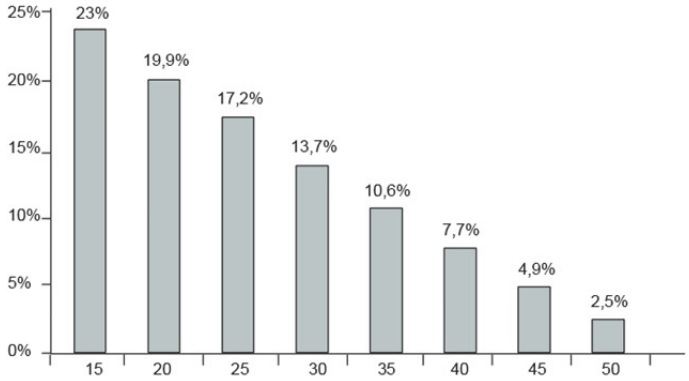
[6] Wilkin J. (2013). Ocena parametryczna czasopism naukowych w Polsce – podstawy metodologiczne, znaczenie praktyczne, trudności realizacji i perspektywy. Nauka, 1, 45-54.

Poniżej przedstawiono kryteria oceny czasopism naukowych kwalifikowanych do grupy nauk humanistycznych i społecznych oraz nauk ścisłych, przyrodniczych, medycznych i technicznych.

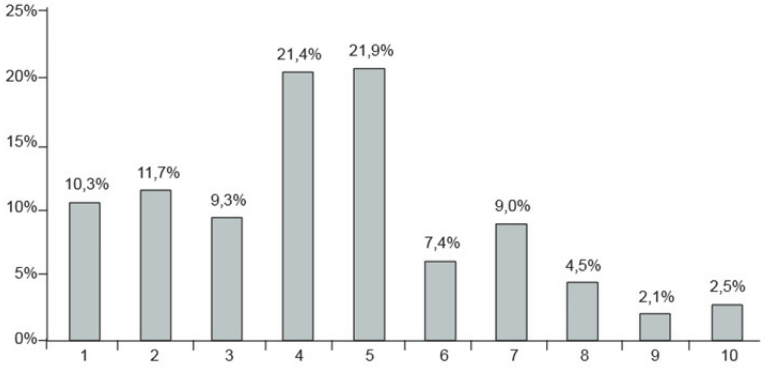
Kryteria oceny czasopism naukowych kwalifikowanych do grupy nauk humanistycznych i społecznych oraz nauk ścisłych przyrodniczych, medycznych i technicznych

Parametr oceny P	Kryterium	Wagi z grupy nauk ścisłych, przyrodniczych, medycznych i technicznych	Wagi z grupy nauk humanistycznych	Wagi z grupy nauk społecznych	Uwagi
1	2	3	4	5	6
P ustala wybrany podmiot	INDEKS CYTOWAŃ (*predicted impact factor*) PIF	0,35	0,10*	0,25	*dla nauk humanistycznych zamiast PIF oceniane jest indeksowanie czasopisma w *Arts & Humanities Citation Index*.
P = 1, jeżeli odsetek autorów z afiliacją zagraniczną w stosunku do całkowitej liczby autorów za ostatnie dwa lata >25%	Zagraniczna afiliacja autorów publikacji naukowych	0,05	0,20*	0,07	*dla nauk humanistycznych P=1, jeżeli procentowa liczba autorów z afiliacją zagraniczną wynosi 15%
Liczba P = 1, jeżeli liczba baz indeksacyjnych, w których czasopismo jest indeksowane ≥2	Indeksacja w bazach danych	0,10	0,05	0,15	
Liczba P=1, jeżeli średnia liczba publikacji naukowych za ostatnie dwa lata >24	Liczba prac naukowych publikowanych/rok	0,10	0,15	0,10	
Liczba P=1, jeżeli odsetek recenzentów międzynarodowych w stosunku do całkowitej liczby recenzentów w ciągu ostatnich dwóch lat >50%	Umiędzynarodowienie recenzentów	0,10	0,10*	0,10	Na dzień złożenia aplikacji. *dla nauk humanistycznych P=1, jeżeli odsetek recenzentów z afiliacją zagraniczną wynosi >25%
Liczba P=1, jeżeli czasopismo ukazuje się w sposób ciągły w formie *on-line*, bądź wydawane regularnie co kwartał lub częściej.	Częstotliwość wydawania	0,04	0,10	0,05	
Liczba P=1, jeżeli publikacje są w języku angielskim lub innym języku kongresowym (francuskim, hiszpańskim, niemieckim, rosyjskim)	Język publikacji	0,10	0,05*	0,15	*dla nauk humanistycznych P=1, jeżeli procent prac w pełnej wersji opublikowanych w ostatnich 2 latach w języku angielskim lub innym kongresowym ≥20%
Liczba P=1, jeżeli liczba członków zagranicznych rady naukowej jest większa niż połowa całkowitej liczby członków tej rady	Umiędzynarodowienie rady naukowej	0,05	0,10*	0,05	Na czas składania aplikacji. *dla nauk humanistycznych P=1, jeżeli odsetek członków rady naukowej z afiliacją zagraniczną wynosi >25%
Liczba P=1, jeżeli wszystkie artykuły naukowe dostępne są w internecie	Wersje *on-line*	0,05	0,10	0,02	
Liczba P=1, jeżeli teksty publikacji są weryfikowane przez osobę, dla której język publikacji jest językiem ojczystym (*"native speaker"*)	Redaktorzy językowi	0,02	0,05	0,02	Wymienieni z imienia i nazwiska
Liczba P=1, jeżeli na rzecz redakcji działa redaktor statystyczny	Redaktor statystyczny	0,02	0,00	0,02	Wymienieni z imienia i nazwiska
Liczba P=1, jeżeli na rzecz redakcji działają redaktorzy tematyczni	Redaktorzy tematyczni	0,02	0,00	0,02	Wymienieni z imienia i nazwiska
SUMA KONTROLNA		**1,00**	**1,00**	**1,00**	

W rezultacie przyjętych przez zespół założeń, kryteriów i wag punktowych rozkład punktacji czasopism na listach A i B, przy uwzględnieniu także trzech części listy B (TZ, S i H), wygląda następująco (na osi poziomej zaznaczona jest liczba punktów).



Rysunek 1. Rozkład ocen czasopism w ramach części „A" wykazu



Rysunek 2. Rozkład ocen czasopism w ramach części „B" wykazu – grupa „TZ"

W grupie (TZ) najwięcej czasopism otrzymało 4 lub 5 punktów, ale relatywnie nieco mniej uzyskało ocenę 6-8 punktów. Pamiętać jednak należy, iż czasopisma z tej grupy nauk (TZ), pochodzące z Polski, są częściej reprezentowane w części A listy (z ustalonym *Impact Factor*). Częściej są też indeksowane w różnych bazach danych, co sprawia, ze polskie publikacje z grupy TZ są bardziej widoczne i doceniane w międzynarodowym obiegu literatury naukowej niż publikacje z zakresu nauk społecznych i humanistycznych.

Działalność wydawnicza Komitetu Techniki Rolniczej PAN oraz Polskiego Towarzystwa Inżynierii Rolniczej

W ciągu 17-tu ostatnich lat działalności wydawnictwo „Inżynieria Rolnicza" wydało 152 zeszyty naukowe, z czego 31 to rozprawy habilitacyjne. Pierwszy zeszyt czasopisma „Inżynieria Rolnicza" został wydany w maju 1997 roku, w Warszawie. Zawierał on 25 artykułów naukowych, a jako pierwszy zamieszczono artykuł prof. Janusza Hamana pt.: „Co dalej z Inżynierią Rolniczą?". Minęło 17 lat od tego czasu a temat jest nadal aktualny. Swoje prace w zeszytach naukowych publikowało 1657 autorów z 127 ośrodków naukowych, w tym 29 zagranicznych. Najwięcej prac opublikowali przedstawiciele ośrodka krakowskiego – 29%, następnie lubelskiego – 18%, wrocławskiego – 15% i warszawskiego – 11%. Najmniejszy natomiast udział stanowiły publikacje z instytutów naukowych oraz jednostek branżowych. Wśród ośrodków zagranicznych największy udział ma Słowacki Uniwersytet Rolniczy w Nitrze oraz Czeski Uniwersytet Rolniczy w Pradze.

Przeprowadzona dwa lata temu ocena wydawnictwa „Inżynieria Rolnicza" wykazała rosnące z roku na rok zainteresowanie tym czasopismem. Wysokie indeksowanie w globalnej sieci Internet oraz w bazach danych czasopism technicznych Baz-tech, Index Copernicus, SIGZ, AGRIS, BazEkon, EPNP powoduje coraz większe zainteresowanie zarówno dyscypliną jak też samym czasopismem. Ciągłe zmiany MNiSW, dotyczące zasad i kryteriów oceny jednostek naukowych, pracowników oraz wydawnictw, jak również w Polskiej Akademii Nauk (groźba łączenia komitetów naukowych), stwarzają niepewną sytuację na rynku wydawniczym. Jednakże mimo licznych problemów wydawniczych i upowszechnieniowych nie powinniśmy rezygnować z wszelkich inicjatyw mogących podnieść rangę czasopism zarówno w kraju jak i za granicą.

Poniżej przedstawiam wyniki ostatniej ankiety aplikacyjnej złożonej do oceny czasopisma „Inżynieria Rolnicza". Ocena podzielona była na kryteria wstępne i obowiązkowe. Jak można zauważyć spełniamy większość z kryteriów, jednakże najwięcej punktów tracimy w kategorii kryteriów obowiązkowych – „Indeks cytowań PIF" oraz „umiędzynarodowienie recenzentów" i język publikacji". Od dwóch lat dokładamy wszelkich starań celem pozyskania zagranicznych recenzentów, a od roku 2014 publikujemy artykuły wyłącznie w językach kongresowych (angielski, niemiecki, francuski, rosyjski). Mamy nadzieję że nasze starania przełożą się na wzrost indeksu cytowań PIF. Pierwszym wymiernym efektem jest wzrost zainteresowania naszym czasopismem naukowców z zagranicy. Do redakcji napływają artykuły z Turcji, Niemiec, Norwegii i Czech.

KRYTERIA WSTĘPNE	Utracone punkty	Warunek (punkty => od)	Punkty z transkrypcji	Max punktów	Spełnienie kryterium ewaluacji	Przyznane punkty
Lista recenzentów	0.00	1	1	**1.00**	1	**1.00**
Procedura recenzowania	0.00	1	1	**1.00**	1	**1.00**
Strona internetowa	0.00	1	1	**1.00**	1	**1.00**
Recenzenci zewnętrzni	0.00	75	100	**1.00**	1	**1.00**
Naukowy charakter czasopisma	0.00	1	1	**1.00**	1	**1.00**
Streszczenie i tytuł w języku angielskim	0.00	1	1	**1.00**	1	**1.00**
Stabilność wydawnicza	0.00	1	1	**1.00**	1	**1.00**
Zapora ghostwriting	0.00	1	1	**1.00**	1	**1.00**
Deklaracja o wersji pierwotnej	0.00	1	1	**1.00**	1	**1.00**
KRYTERIUM OBOWIĄZKOWE	Utracone punkty	warunek (punkty => od)	Punkty z transkrypcji	Max punktów ewaluacji	Spełnienie kryterium ewaluacji	Przyznane punkty
Indeks cytowań PIF	**2.50**	X	X	3.50	1	1.00
Zagraniczna afiliacja autorów	**0.50**	25	4	0.50	0	0.00
Indeksacja w bazach danych	0.00	2	2	1.00	1	1.00
Liczba artykułów naukowych publikowanych/rok	0.00	24	487	1.00	1	1.00
Umiędzynarodowienie recenzentów	**1.00**	50	0	1.00	0	0.00
Częstotliwość wydawania	0.00	4	6	0.40	1	0.40
Język publikacji	**1.00**	100	8	1.00	0	0.00
Umiędzynarodowienie Rady naukowej	0.00	50	59	0.50	1	0.50
Wersje on-line	0.00	1	1	0.50	1	0.50
Redaktorzy językowi	0.00	1	1	0.20	1	0.20
Redaktor statystyczny	0.00	1	1	0.20	1	0.20
Redaktorzy tematyczni	0.00	1	1	0.20	1	0.20

Od roku 2007 wydawnictwo stworzyło swój własny portal (http://ir.ptir.org), na którym udostępnia swoje zasoby. Po raz pierwszy został on zaprezentowany na XIV Szkole Zimowej „Postęp naukowo-techniczny i organizacyjny w rolnictwie" w lutym 2007 (rys. 3.). Zawiera on pełną bazę artykułów (streszczenia w języku polskim i angielskim oraz pełne artykuły) z lat 2006-2014. Do bazy wprowadzono dotychczas 108 z 150 zeszytów naukowych, co stanowi 72% ogólnych zasobów.

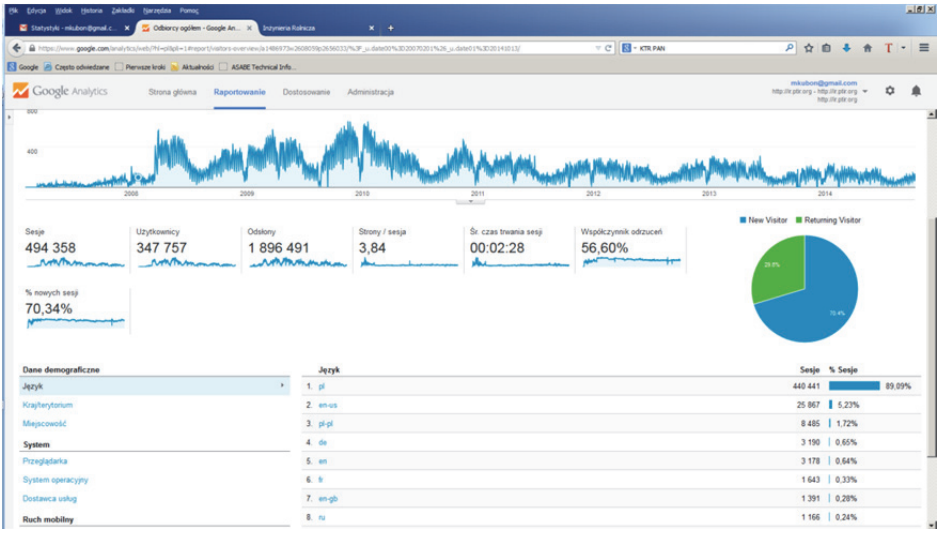
Rysunek 3. Panel główny portalu czasopisma Inżynieria Rolnicza

Kluczowe słowa służące do nawigacji po stronach portalu Wydawnictwa zostały przetłumaczone z polskiego na 3 inne języki: francuski, angielski, niemiecki. Zmiany dokonuje się poprzez wybranie jednej z flag. Zaletą portalu wydawnictwa „Inżynieria Rolnicza" jest bardzo przyjazny dla użytkownika interfejs. Istnieje możliwość szybkiego wyszukiwania artykułów po tytułach, słowach kluczowych, streszczeniach oraz autorach. Portal jest także źródłem informacji dotyczących funkcjonowania wydawnictwa: instrukcja dla autorów, procedura wydawnicza, wzory oświadczeń, druk recenzji, skład Rady Programowej, Komitetu Redakcyjnego oraz wykaz Redaktorów tematycznych.

W dzisiejszych czasach podstawowym źródłem pozyskiwania informacji jest globalna sieć Internet. Chcącym być zauważanym w kraju i na świecie konieczne było stworzenie portalu jak również odpowiednich procedur dającym nam odpowiednią pozycję wśród czasopism poszukiwanych w sieci. Dowodem naszych działań jest bardzo wysokie indeksowanie słów: „inżynieria" i „inżynieria rolnicza" w najpopularniejszej sieci Google.

Celem uzyskania informacji o atrakcyjności portalu, wykorzystania witryny, przeglądu użytkowników a także źródeł odwiedzin, w dniu 11 marca 2007 roku do portalu wydawnic-

twa dołączono moduł statystyk – Google Analytics. Zebrane i zaprezentowane statystyki pokazują, że od początku istnienia portalu Wydawnictwa stronę odwiedzono 494 358 razy z 217 krajów, z czego 93 786 wizyt przypadało tylko na rok 2010. Od 15 grudnia 2013 roku mamy własną stronę na portalu społecznościowym Facebook (https://www.facebook.com /pages/Wydawnictwo-Inżynieria-Rolnicza/ 778319618860909), gdzie prezentujemy najnowsze informacje dotyczące wydawnictwa jak też publikujemy wybrane materiały. Strona ta cieszy się dużą popularnością szczególnie wśród młodszych pracowników naukowych.



Rysunek 4. Dane z systemu Google Analytics – pulpit nawigacyjny [Google_analytics (online) 2014]

Jako jedni z pierwszych podpisaliśmy umowę z Interdyscyplinarnym Centrum Modelowania Matematycznego i Komputerowego Uniwersytetu Warszawskiego, który jest właścicielem i operatorem systemu informatycznego wykorzystywanego do prowadzenia i obsługi naukowej biblioteki cyfrowej „Domena Internetowych Repozytów Wiedzy" zwanej DIR. Blisko współpracujemy z Portalem Spożywczym (www. portalspozywczy.pl), pierwszym portalem rolnym (www.ppr.pl) oraz portalem AgroNews (www.agronews. com.pl). Celem tej współpracy jest promowanie naszego wydawnictwa poprzez wzajemne linkowanie stron portalu, pokrewnych wydawnictw naukowych i popularno-naukowych, wymiana logotypów jak również przedruk wybranych publikacji zarówno naukowych jak też popularno-naukowych.

I co dalej…

Jak każde Wydawnictwo, tak i nasze boryka się na co dzień z różnymi problemami. W naszym przypadku są to bardziej problemy natury upowszechnieniowej niż wydawniczej.

Jednym z podstawowych problemów polskich naukowców jest brak szerszego dostępu do wydawnictw z Listy Filadelfijskiej oraz niska punktacja czasopism spoza Listy. „Inżynieria Rolnicza" jako stosunkowo młoda dyscyplina naukowa o charakterze interdyscyplinarnym, ma bardzo ograniczony dostęp do czasopism z tej listy. Czas procesu wydawniczego jest długi, co zniechęca do publikowania tam swoich prac. Dlatego też niewielu autorom udaje się tam opublikować swoje wyniki badań..

Drugi bardzo istotny problem naszych wydawnictw to bardzo niski lub też brak wskaźnika cytowań RIF (ang. *Real Impact Factor*), co skutkuje niską punktacją – obecnie 5 pkt. w ocenie ministerialnej. Stanowi on podstawową barierą w uzyskaniu wysokiej parametrycznej oceny czasopism krajowych. Możemy to zmienić jedynie poprzez ograniczenie liczby wydawanych publikacji i zwiększenie liczby cytowań naszych wydawnictw w czasopismach z listy filadelfijskiej.

Kolejny problem to rosnące z roku na rok koszty procesu wydawniczego. Oprócz rosnących kosztów materiałów poligraficznych, od 2011 roku zmieniły się stawki VAT jak również klasyfikacja towarów podlegających zwolnieniu z tego podatku. Od roku 2013 wydawnictwo ponosi dodatkowo koszty korekty statystycznej i językowej, a od 2014 również koszty tłumacza języka angielskiego.

Niepokojącym zjawiskiem jest odchodzenie od badań empirycznych na rzecz badań symulacyjnych. W szybkim tempie rośnie liczba artykułów, w których wyniki badań oparte są nie na doświadczeniu lecz na symulacji komputerowej. Istnieje realne zagrożenie, że w niedalekiej przyszłości dojdzie do zaniechania wszelkich badań empirycznych i „sztucznym" odwzorowywaniu rzeczywistości i „prognostycznym" wyciąganiu wniosków. To efekt przede wszystkim ograniczenia nakładów finansowych na naukę, co przekłada się bezpośrednio na badania naukowe.

Na przestrzeni ostatnich lat widoczny jest obniżający się poziom merytoryczny i formalny nadsyłanych do wydawnictwa artykułów. Wiele z nadsyłanych prac to prace przyczynkowe, analizy przypadków lub prace popularno-naukowe. Bardzo często autorzy powołują się wyłącznie na własne publikacje lub też uzasadniają temat na podstawie jednej lub dwóch publikacji krajowych. Brak jest szerokiego (międzynarodowego) przeglądu literatury, a w dyskusji brak odniesienia do badań międzynarodowych. Rośnie liczba recenzji negatywnych, w roku 2013 w stosunku do roku 2007 liczba tego typu recenzji wzrosła o 18%. Nieprzestrzeganie instrukcji wydawniczej, brak staranności i skrupulatności w przygotowywaniu materiałów do druku, błędy w tabelach i na rysunkach oraz błędy w bibliografii to najczęściej spotykane niedociągnięcia formalne w nadsyłanych artykułach.

Ostatnim ale często poruszanym przy okazji organizowanych szkół i konferencji naukowych problemem wydawniczym jest długi czas trwania cyklu wydawniczego. Chciałbym tutaj powiedzieć, że Redakcja pełni jedynie rolę koordynatora poszczególnych etapów procesu wydawniczego, a zasadniczy czas trwania całego procesu zależy w głównej mierze od samych autorów i recenzentów. Co zrobić aby skrócić czas cyklu wydawniczego? Odpowiedź jest bardzo prosta i łatwa w wykonaniu – zwiększyć dyscyplinę czasową recenzentów i autorów a także dołożyć większych starań w przygotowanie publikacji do druku.

Jednakże mimo licznych problemów wydawniczych i upowszechnieniowych nie rezygnujemy z działań mogących podnieść rangę czasopisma zarówno w kraju jak i za granicą. W tym celu w najbliższym czasie skupimy się na:

- podniesieniu wartości merytorycznej i formalnej publikacji,
- jeszcze szerszym upowszechnianiu czasopism KTR PAN w bazach danych zarówno polskich jak i zagranicznych,
- powoływaniu się na prace publikowane w czasopismach KTR PAN w publikacjach wysyłanych do wydawnictw z listy filadelfijskiej,
- zachęceniu zagranicznych naukowców do publikowania w naszych periodykach naukowych,
- skróceniu procesu wydawniczego w czasopismach KTR PAN,
- obniżeniu liczby wydawanych artykułów (max. 25 artykułów w zeszycie), przy zachowaniu warunku >25% publikacji zagranicznych w 2 ostatnich latach),
- wydawaniu zeszytów naukowych w językach kongresowym,
- wydawaniu monografii tematycznych,
- opracowaniu nowej strony wydawnictwa opartej na nowych międzynarodowych standardach (*Open Journal Systems).*

Litaratura

Drabek, A. (2001). Bibliometryczna analiza czasopism naukowych w dziedzinie nauk społecznych. Praca doktorska. Uniwersytet Śląski. Maszynopis.

Michałek, R. (2007). Problemy wydawnicze inżynierii rolniczej. Inżynieria Rolnicza, 9(97), 7-12.

Michałek, R. (2007). Komitety naukowe PAN w rozwoju kadry naukowej inżynierii rolniczej. Inżynieria Rolnicza, 7(95), 15-22.

Stefaniak, B. (1987). Use of bibliographic data bases for scientometrics studies. Scientometrics. No12, 149-161.

Wilkin J. (2013). Ocena parametryczna czasopism naukowych w Polsce – podstawy metodologiczne, znaczenie praktyczne, trudności realizacji i perspektywy. Nauka, 1, 45-54.