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ECOLOGIZATION OF FARMS BASED ON EXHAUST EMISSION STANDARDS OF AGRICULTURAL MACHINES USED IN KROTOSZYN COUNTRY

Summary

The interest in organic farming, due to the increasing demand for food free of residues of plant protection chemicals, mineral fertilizers and heavy metals, is getting bigger and bigger. However, it should be remembered that in addition to avoiding the use of chemical methods for plant protection and care, as well as growth stimulators and antibiotics in animal breeding, it is also important to reduce the negative effects on the natural environment. Therefore, the use of energy-efficient machines, which additionally do not pollute the environment excessively, is one of the elements of organic farming. In recent years, the issue of reducing nitrogen oxides and particulate solids emitted by engines in agricultural tractors is considered more and more rigorously. The aim of this study was to analyze motor agricultural machines used in farms in Krotoszyn County in terms of exhaust emission standards. The researches covered 30 randomly selected farms, in which 12 agricultural tractors were used. Analysis of the results showed that the majority of tractors used in agriculture in Krotoszyn County do not meet any exhaust emission standards and that these machines are obsolete.
***Key words**: exhaust emission standards, organic farming, mechanization of agriculture*

EKOLOGIZACJA GOSPODARSTW ROLNICZYCH NA PODSTAWIE NORM EMISJI SPALIN SILNIKOWYCH MASZYN ROLNICZYCH UŻYTKOWANYCH NA TERENIE POWIATU KROTOSZYŃSKIEGO

Streszczenie

Zainteresowanie rolnictwem ekologicznym, dzięki coraz większemu popytowi na żywność wolną od pozostałości środków ochrony roślin, nawozów mineralnych i metali ciężkich jest coraz większe. Należy jednak pamiętać, ze poza unikaniem stosowania chemicznych metod ochrony i pielęgnacji roślin oraz stymulatorów wzrostu i antybiotyków przy chowie zwierząt, ważne jest również ograniczenie wywierania negatywnych skutków na środowisko naturalne. Dlatego jednym z elementów rolnictwa ekologicznego jest stosowanie energooszczędnych maszyn, które dodatkowo nie zanieczyszczają nadmiernie środowiska. W ostatnich latach coraz bardziej rygorystycznie podchodzi się do kwestii ograniczania tlenków azotu i cząstek stałych emitowanych przez silniki w ciągnikach rolniczych. Celem pracy była analiza silnikowych maszyn rolniczych użytkowanych w gospodarstwach rolnych powiatu krotoszyńskiego pod kątem norm emisji spalin. Badaniami objęto losowo wybranych 30 gospodarstw rolnych, w których użytkuje się 112 ciągników rolniczych. Analiza wyników wykazała, że większość ciągników w badanych gospodarstwach nie spełnia żadnych norm emisji spalin i są to maszyny przestarzałe.
***Slowa kluczowe**: normy emisji spalin, rolnictwo ekologiczne, mechanizacja rolnictwa*

1. Introduction

The period of intensive development of technique in agriculture and implementation of new and intensive production technologies negatively affected the harmonious interaction of factors shaping the natural environment [3, 9]. The growing human population, depletion of many resources and the pressure on the environmental protection urge the Member States of the European Union to change the approach in terms of production, consumption, processing, storage, recycling and utilization of biological resources [17]. In view of growing negative impact of anthropogenic human activity on the natural environment, there is an urgent need for greening of science, technique and global awareness of human. The greening should be understood as the need to introduce pro-environmental changes in all areas of human activities. Pro-environmental activities should focus primarily on prevention, but also on elimination and compensation of anthropogenic threats. The most important threats include: atmospheric degradation, pollution and water shortages, shrinking of soil resources and deterioration of soil quality, disappearance of flora, impoverishment of animal world and excessive chemicalization of environment [10]. Organic farming is an alternative management system in relation to the conventional system. It combines the most environmentally-friendly farming practices, protection of natural resources, high level of biodiversity, the use of high standards concerning the animal welfare and the use of production methods based on natural substances and natural processes [5, 19]. Currently, organic farms include farms, which take advantage of tools and machines to improve of the soil structure and save energy. Moreover, these tools and machines do not overly affect the deterioration of the natural environment [24]. Integration of Poland with the European Union had a positive impact on the improvement of farming in the native agriculture. The introduction of direct subsidies, as well as rural development programs was an important factor supporting development [7, 8]. The changes that took place in agriculture after 2004 are the results of covering Poland with the common agriculture policy of the European Union [21]. Farms with the support of EU funds have modernized their machinery park. Modern machines introduced in recent years into the farms are a determinant of technical progress and

also contribute to the improvement of agricultural greening [14, 15, 16]. Implementation of modern environmental technologies is a kind of innovation that limits energy consumption, reduces material consumption, optimizes technological process, prolongs exploitation of machines and minimizes the quantity of produced waste [20]. The work of tractors and other machines equipped with internal combustion engines causes the exhaust emission. This leads to the pollution of the atmosphere. Additionally, in case of improper exploitation and negligence in the handling of used materials, such as engine oils, residues of plant protection products, empty product packaging, etc., soil and groundwater contamination occurs [18]. The greening of agriculture meets the rigorous exhaust emission standards that must be fulfilled by engines introduced into the market of agricultural machines. These standards focus primarily on the reduction of nitrogen oxides (NOx) and particulate solids (PM) emission. Currently, motor and non-motorized methods for the reduction of emission are used. The use of motor methods in this context is based on the optimization of the combustion process in terms of improvement of ecological properties. As a result, it helps to obtain a significant reduction in harmful exhaust gas compounds, and at the same time – it is very economically advantageous [1, 2, 6, 11, 13, 22]. The first exhaust emission standards for diesel engines above 37 kW (50 hp) used in non-road vehicles (including farm tractors) were introduced in 1999 – Stage I. Subsequently, more rigorous exhaust emission standards were determined, depending on engine power. In the years 2001-2002 Stage II standard, in the years 2006-2008 Stage IIIA, in the years 2011-2013 Stage IIIB standard and the currently applicable Stage IV standard was implemented in 2014. The transition to Stage IIIB was undoubtedly the most significant change – taking into account the previously implemented changes in exhaust emission standards, because it reduced the emission of particulates (PM) by 90% and the emission of nitrogen oxides (NOx) by 50% [4, 12].

2. Purpose, scope and methodology of researches

The aim of this study was to analyze the progress of greening of farms based on exhaust emission standards for agricultural machines used in farms in Krotoszyn County. The researches covered 30 randomly selected farms. Affiliations to particular exhaust emission standards in accordance with Table 1 were determined on the basis of the age and power of agricultural machines, combine harvesters and self-loading loaders. NOx is emission of nitrogen oxides, HC – emission of hydrocarbons, CO – emission of carbon monoxides, and PM - emission of particulates.

3. Results and analysis of researches

As a result of the performed researches, a set of agricultural tractors was obtained. Then on the basis of the year of production and power, machines were assigned to individual groups of exhaust emission standards. Detailed data about the number and total power of tractors were presented in Table 2.

Table 2. Agricultural tractors in the analyzed farms
Tab. 2. Ciągniki rolnicze w analizowanych gospodarstwach rolnych

Exhaust emission standard	Number of tractors	Total tractor power [kW]
No emission standard	61	2646.3
Stage I	3	183.1
Stage II	4	297.1
Stage III A	6	454.4
Stage III B	5	430.1
Stage IV	2	177.9

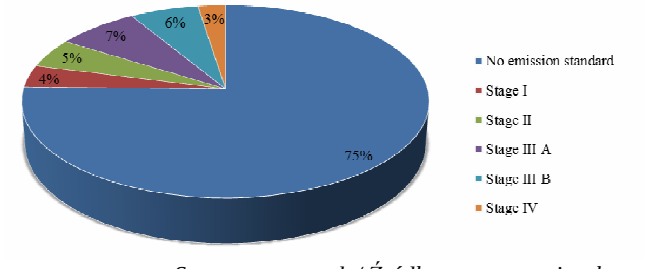
Source: own work / Źródło: opracowanie własne

Table 1. Permissible emission of non-road motor vehicles in accordance with EU-97/68/EC
Tab. 1. Dopuszczalna emisja pojazdów silnikowych niedrogowych według EU-97/68/EC

Power range [kW]	CO [g·kWh^{-1}]	HC [g·kWh^{-1}]	NO_x [g·kWh^{-1}]	PM [g·kWh^{-1}]	Implementation date
		NMHC + No_x			
Stage I					
37≤ P_{max}<75	6,5	1.3	9.2	0.85	1999
75≤ P_{max}<130	5	1.3	9.2	0.7	1999
130≤ P_{max}≤560	5	1.3	9.2	0.54	1999
Stage II					
18≤ P_{max}<37	5.5	1.5	8	0.8	2001
37≤ P_{max}<75	5	1.3	7	0.4	2004
75≤ P_{max}<130	5	1	6	0.3	2003
130≤ P_{max}≤560	3.5	1	6	0.2	2002
Stage III A					
19≤ P_{max}<37	5.5	7.5		0.6	2007
37≤ P_{max}<75	5	4.7		0.4	2008
75≤ P_{max}<130	5	4		0.3	2007
130≤ P_{max}≤560	3.5	4		0.2	2006
Stage III B					
37≤ P_{max}<56	5	4.7		0.025	2013
56≤ P_{max}<75	5	0.19	3.3	0.025	2012
75≤ P_{max}<130	5	0.19	3.3	0.025	2012
130≤ P_{max}≤560	3.5	0.19	2	0.025	2011
Stage IV					
56≤ P_{max}<130	5	0.19	0.4	0.025	2014
130≤ P_{max}≤560	3.5	0.19	0.4	0.025	2014

Source: own work based on [23] / Źródło: opracowanie własne na podstawie [23]

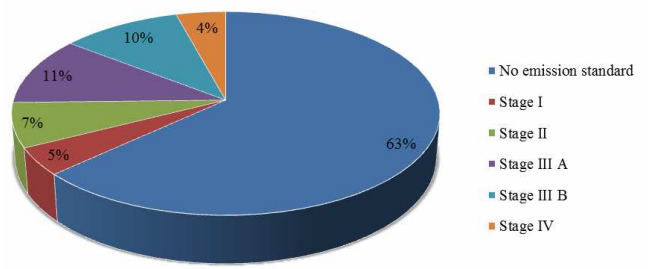
The majority of agricultural tractors operating in farms located in Krotoszyn County are not limited by exhaust emission standards. As shown in Fig. 1, 75% of tractors do not meet exhaust emission standards, while only 3% of tractors meet the latest Stage IV standard.



Source: own work / Źródło: opracowanie własne

Fig. 1. Percentage share of the number of tractors that meet individual exhaust emission standards
Rys. 1. Procentowy udział liczby ciągników spełniających poszczególne normy emisji spalin

Taking into account the total power of all agricultural tractors meeting the emission standards, the situation changes a little. The average power of agricultural tractors that do not meet any exhaust emission standard is lower than in the case of newer, more energy efficient and ecological tractors. The percentage share of the total power of tractors working in farms located in Krotoszyn County (depending on the exhaust emission standards) is presented in Fig. 2.



Source: own work / Źródło: opracowanie własne

Fig. 2. Percentage share of total power of tractors meeting individual exhaust emission standards
Rys. 2. Procentowy udział łącznej mocy ciągników spełniających poszczególne normy emisji spalin

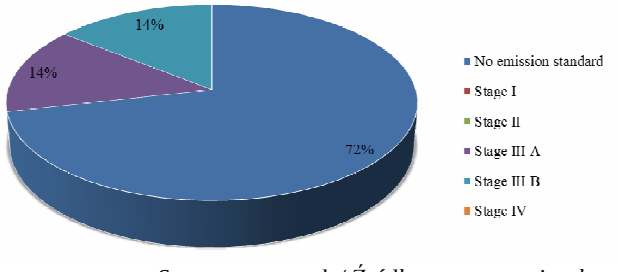
A similar analysis was made for combine harvesters, which according to the adopted methodology were assigned to particular groups of exhaust emission standards. A total number of 7 combine harvesters operate in the examined farms. The exact data are shown in Table 3.

Table 3. Combine harvesters in the analyzed farms
Tab. 3. Kombajny zbożowe w analizowanych gospodarstwach rolnych

Exhaust emission standard	Number of combine harvesters	Total power of combine harvesters [kW]
No emission standard	5	382.4
Stage I	0	0.0
Stage II	0	0.0
Stage III A	1	191.2
Stage III B	1	166.9
Stage IV	0	0.0

Source: own work / Źródło: opracowanie własne

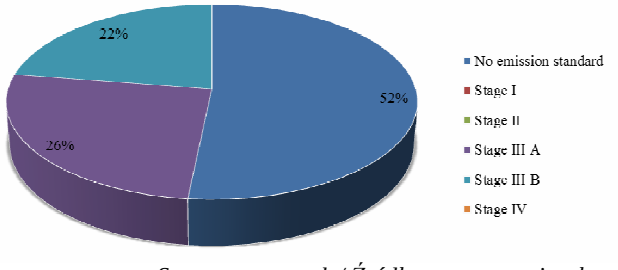
As in the case of agricultural tractors, the majority of combine harvesters operating in farms located in Krotoszyn County do not meet exhaust emission standards. In accordance with Table 2, the share of such machines is 72%.



Source: own work / Źródło: opracowanie własne

Fig. 3. Percentage share of the number of combine harvesters that meet individual exhaust emission standards
Rys. 3. Procentowy udział liczby kombajnów spełniających poszczególne normy emisji spalin

Furthermore, the analysis covered the total power of all combine harvesters that meet individual exhaust emission standards. The power of older combine harvesters operating in farms located in Krotoszyn County that do not meet any exhaust emission standards is significantly smaller than the power of newer combine harvesters. Therefore, the percentage share of total power for combine harvesters that do not meet exhaust emission standards was significantly reduced (52%) compared to the percentage share of such combine harvesters. Detailed data are presented in Fig. 4.



Source: own work / Źródło: opracowanie własne

Fig. 4. Percentage share of total power of tractors meeting individual exhaust emission standards
Rys. 4. Procentowy udział łącznej mocy ciągników spełniających poszczególne normy emisji spalin

The analysis carried out for self-propelled loaders is quite opposite than in previous cases. The total number of all self-propelled loaders in examined farms is 5 units, of which only one machine does not meet the exhaust emission standards (Table 4).

Table 4. Self-propelled loaders in analyzed farms
Tab. 4. Ładowacze samojezdne w analizowanych gospodarstwach rolnych

Exhaust emission standard	Number of self-propelled loaders	Total power of self-propelled loaders [kW]
No emission standard	1	47.8
Stage I	0	0.0
Stage II	1	88.2
Stage III A	1	73.5
Stage III B	2	161.8
Stage IV	0	0.0

Source: own work / Źródło: opracowanie własne

The highest percentage share (40%) of self-propelled loaders (in accordance with Fig. 5) meets Stage IIIB standard. These are the machines purchased in recent years. The purchase of self-propelled loaders by farms on a larger scale has increased in recent years, so the number of older machines compared to the number of machines purchased in the last ten years is much smaller.

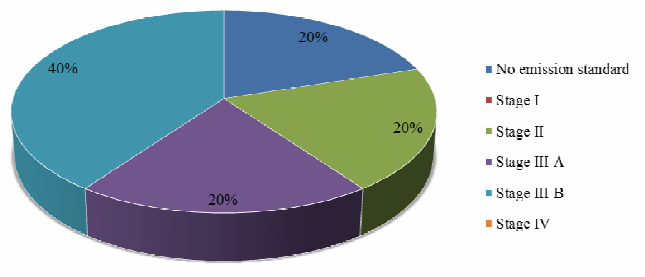


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Fig. 5. Percentage share of the number of self-propelled loaders that meet specific exhaust emission standards
Rys. 5. Procentowy udział liczby ładowaczy samojezdnych spełniających poszczególne normy emisji spalin

The smallest share of the total power of all self-propelled loaders (13%) is presented by machines that do not meet any exhaust emission standard, but as shown in Fig. 6-43% of machines meet Stage IIIB standard.

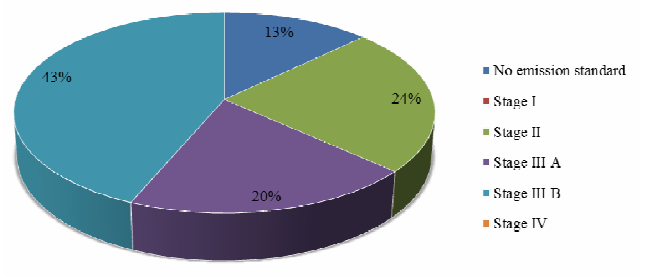

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Fig. 6. Percentage share of total power of loaders that meet individual exhaust emission standards
Rys. 6. Procentowy udział łącznej mocy ładowaczy spełniających poszczególne normy emisji spalin

4. Conclusions

The conducted researches and analysis of the obtained results enable to formulate the following conclusions:

- The majority of motorized agricultural machines operating in farms located in Krotoszyn County do not meet any exhaust emission standards. This results directly from the year of production of these machines.
- The total percentage of power of machines that do not meet the exhaust emission standards is smaller than the percentage of these machines. This results from the higher power of engines working with newer agricultural machines.
- Agricultural machines operating in farms located in Krotoszyn County are outdated, which negatively affects the natural environment and the process of agricultural greening.

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