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Authors: Piotr Szczyglak

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COMPARISON OF PLOUGHING VS. PLOUGHLESS CULTIVATION IN TERMS OF ENERGY EXPENDITURE AND QUALITY

Piotr Szczyglak
ORCID: 0000-0002-8218-1540
Department of Vehicle and Machinery Construction and Operation
University of Warmia and Mazury, Olsztyn

Abstract

The article discusses the basic technologies of soil cultivation and presents the results of analyses of the effectiveness of the product resource base of ploughless cultivation machines manufactured in Poland. The study also describes the design of a prototype MultiCat 6HD aggregated tillage unit, which should be regarded as innovative, and presents the methodology of experimental research focused on the aggregated unit and machines for traditional plough tillage. The experiment determined fuel consumption, effective and operational efficiency, the depth of placing and mixing of crop residues and the indicator of crop residue surface embedding. Based on the conducted analyses, it was found that ploughless cultivation required approx. 30% less expenditure for fuel as compared to the traditional plough tillage. In addition, a more favourable distribution of plant material within the soil profile was found along with almost identical embedding of crop residues, as compared to the plough tillage. It was demonstrated that the application of ploughless cultivation based on the MultiCat 6HD aggregated unit would improve agricultural farm competitiveness.

Keywords: ploughless cultivation, aggregated tillage unit, innovative machine

Introduction

An improvement in agricultural farm competitiveness is one of the objectives that are being fulfilled as part of the general agricultural policy. An important element for its shaping is the possibility for agricultural farms and enterprises operating in the agricultural sector to use the funds from the pool of European resources for innovation (GORYŃSKA-GOLDMANN & WOJCIESZAK, 2017). At the agricultural farm level, an improvement in competitiveness is most often achieved through introducing innovative production technologies which require dedicated machinery. The technologies being introduced are characterised by better economic and quality indicators (e.g. lower fuel consumption, lower energy inputs, better mixing of fertilisers with the soil and better embedding of crop residues, etc.).

One of the working processes most frequently carried out in agriculture is tillage, i.e. a set of agrotechnical treatments aimed at providing the crops under cultivation with optimal
sowing and growth conditions. Classical tillage involves the ploughing treatment and the pre-sowing soil preparation, most frequently using an aggregated tillage unit (PRZYBYŁ et al., 2009). These treatments are sometimes preceded by post-harvest tillage (PIEKARCZYK, 2006). The ploughing treatment itself requires considerable energy inputs, ranging from 115.4 to 198.1 kJ·m² and the pre-sowing tillage treatment consumes from 57.6 to 75.3 kJ·m² of energy (SEK & PRZYBYŁ, 1993). During ploughing, there is approx. 150 Mg of lifted and inverted soil per each centimetre of working depth per 10,000 m², and the fuel consumption accounts for 30-60% of the inputs of fuel used in the entire crop production process (KUŚ, 2007).

A change in soil cultivation technology should reduce energy inputs and improve efficiency while preventing a deterioration in crop growth conditions (GOLKA & PTASZYŃSKI, 2014). For many years, alternative tillage technologies have been promoted, which include (SMAGACZ, 2013):

- simplified tillage (which involves reducing the number of cultivation treatments carried out, or reducing the cultivation depth),
- conservation tillage (comprising ploughless cultivation and zero tillage).

A considerable reduction in energy inputs consumed in the crop cultivation process is ensured by ploughless cultivation and zero tillage systems. For the former, the ploughing treatment is replaced by treatments aimed at loosening the soil without inverting it (FISZER et al., 2006). However, zero tillage involves the elimination of separate soil-loosening treatments from the cultivation process (SMAGACZ, 2013).

Worldwide, conservation tillage is most widespread in South America (60% of the land under cultivation). In Europe, the proportion of land under conservation tillage is only 2.8% and an increase in the interest in this technology is to be expected in the years to come (KASSAM et al., 2015).

Zero tillage requires significantly greater expenditures on plant protection products, which has an adverse effect on the environment. Therefore, the application of ploughless cultivation is a better solution which offers the following advantages (GOLKA & PTASZYŃSKI, 2014; SMAGACZ, 2013):

- a reduction in losses of soil organic matter,
- an increase in the organic carbon sequestration in the soil,
- an enhancement in the soil’s infiltration properties,
- a reduction in unproductive water losses from the soil,
− a reduction in runoff and leaching of fertiliser components,
− better housing conditions for living organisms (KOSEWSKA, 2018; TOPA, 2020),
− a reduction in cultivation costs and greenhouse gas emissions.

The disadvantages of this technology include the risk of weed development and plant diseases and pests (JAKUBOWSKA & MAJCHRZAK, 2013). The risk is particularly high where the aggregated tillage units used are provided with no appropriate design solutions to ensure a sufficiently deep embedding of plant material residues covering the soil surface.

At the Department of Vehicle and Machinery Construction and Operation of the University of Warmia and Mazury in Olsztyn, commercial offers provided by 75 domestic manufacturers of machines for the agricultural sector were analysed while searching for an offer for ploughless cultivation aggregated units that enable the introduction of this technology (the status valid as of 2016). It was found that ploughless cultivation aggregated units with the following design characteristics are not manufactured in Poland:
− a disc section with hydraulic overload protection devices,
− teeth for deep loosening with a hydraulic overload protection device (hydraulic protection systems enable a significantly more rapid return of an operating part to the nominal working position, which ensures a higher quality of soil cultivation),
− a three-point suspension system with positioning control (an opportunity to aggregate any working sections that require the additional weight of the aggregate unit’s frame to be added),
− a disc section preceding the tooth section,
− loosening of soil to a depth of 0.4 m using machines aggregated with high-power tractors (over 300 kW).

Based on the guidelines provided above, a domestic manufacturer has constructed a prototype of an aggregated unit for ploughless cultivation known as MultiCat 6HD. On the national scale, this is an innovative design.

The MultiCat 6HD aggregated tillage unit has a working width of 6 m and is dedicated to be aggregated with tractors with an engine power of at least 310 kW (Fig. 1). It was constructed in a trailing version. The aggregated tillage unit has four sections performing operating functions. The first two sections are permanently attached to the frame bearer supported with rubber tyre ground wheels. A coupling system was attached to the front part of the frame, while to the back part, a three-point suspension system is attached, dedicated to aggregate sections 3 and 4 which are equipped with an independent frame bearer. The
MultiCat 6HD aggregated tillage unit is intended for performing a multi-functional operating process. Its four sections have the task of preparing the soil before sowing while omitting plough tillage. The first section comprises two rows of toothed discs with a diameter of 0.68 m. The discs are grouped into four segments, with two segments in a row. Each segment has a common, self-aligning beam to which seven discs have been attached using brackets. This type of disc assembly ensures a constant rake angle of 17°. Each of the four segments has a hydraulic overload protection device. The functions performed by the first section include: cutting the field surface and crop residues, embedding them into and mixing with the soil, and undercutting the roots. The maximum working depth of the first section is 0.2 m. Another first section task is to initially loosen the soil to decrease the working resistance of the second section and to reduce the likelihood of its being clogged. The second section comprises four rows of teeth intended for deep loosening of the soil. Such an arrangement of teeth effectively prevents the section from getting clogged with crop residues (the spacing between the teeth is 0.365 m). Each tooth has been equipped with a hydraulic overload protection device. The functions performed by the second section include the loosening of subsoil and mixing the subsoil with the top layer soil. The maximum working depth of the second section is 0.4 m.

The third section comprises two rows of toothed discs with a diameter of 0.51 m. A total of 48 discs were attached to two rigid beams divided into two segments using supports and brackets. This type of disc assembly ensures a constant rake angle of 17°. Each disc has an independent rubber shock absorber mounted in the support. The functions performed by the third section include cutting crop residues, embedding and mixing them into the soil and levelling the field surface following the deformations caused by the effects of the second section. The maximum working depth of the third section is 0.15 m. The spacing between discs is 0.25 m, which effectively prevents them from becoming clogged with plant material.

The fourth section is comprised of a string roller with a diameter of 0.61 m, divided into two segments. The functions performed by the fourth section include the light compaction of the soil and lump crushing. After the tillage treatment using a string roller, a sowing-deep, loosened and pulverised soil layer is formed, under which a lightly compacted layer is found.

This study is aimed at comparing the energy and quality indicators determined based on study results recorded during ploughless cultivation (a prototype of MultiCat 6HD aggregated tillage unit) and traditional cultivation (a plough and disc harrow).
Materials and Methods

During the study conducted in 2016, a passive experiment option was adopted. The working process parameters were set by an agricultural farm owner on whose premises the study was conducted. It was aimed at determining the energy and quality indicators based on real data (a change in the cultivation technology with no interference of external agents). The experimental study was conducted on a hilly plot with a mosaic soil and an area of approx. 20·10^4 m². It was a site after combine-harvested spring wheat (three weeks earlier). In the harvesting process, the straw was cut, pulverised and evenly distributed all over the field surface. The plot was slightly weed-infested, with periodically damp and wet places as well as tree and shrub clusters. During the field research, no precipitation was noted, the weather was continuously sunny with light overcast and the temperature during the day ranged from 20ºC to 25ºC. The study observed the process of ploughless cultivation using the MultiCat 6HD tillage unit aggregated with a New Holland T9.670 tractor equipped with twinned wheels (Fig. 2).

In addition, the process of plough tillage, carried out in two stages, was observed as well. In the first stage, the ploughing was carried out using a tractor-pulled aggregated unit comprised of a New Holland T8050 tractor and a Rabe Werk Marabu- Avant 180C plough. in the second stage, the soil was prepared for the spring sowing using a disc harrow aggregated
with a New Holland T8050 tractor. The disc harrow was disassembled from the MultiCat 6HD aggregated unit for ploughless cultivation (sections 3 and 4).

Fig. 2. A view of the MultiCat 6HD tillage unit aggregated with a New Holland T9.670 tractor

Measurement of the degree of crop residue surface embedding was performed on three locations of each measurement plot. To this end, a frame was used which covered an area of 1 m², from which crop residues were collected and weighed. This operation was carried out two times for the surface before and after tillaging. The arithmetic mean of three measurements was assumed to be the degree of crop residue surface embedding. The indicator of crop residue surface embedding $R_r$, expressed in %, was determined using the following formula:

$$R_r = \left( \frac{m_p - m_k}{m_p} \right) \times 100 \%$$  \hspace{1cm} (1)

where: $m_p$ – weight of plant residues collected from an area of 1 m² prior to cultivation [kg],

$m_k$ – weight of plant residues collected from an area of 1 m² after cultivation [kg].

The collected plant material was weighed using a STEINBERG SYSTEMS SBS-LW-7500A LCD electronic scale with an accuracy of 0.001 kg.

The assessment of the depth of placing and mixing crop residues was carried out based on uncovered portions of loosened soil after the tillage treatment. The depth of placing crop residues was measured using a measuring ruler with an accuracy of 0.01 m and measuring instruments. During the soil uncovering, a fragment with dimensions of 0.3 x 0.3 x 0.3 m was selected and three layers were then separated from it (0-0.1 m, 0.1-0.2 m, and 0.2-0.3 m). Plant material was separated from each layer using a sieve and then weighed. Crop residues were weighed using a STEINBERG SYSTEMS SBS-LW-7500A LCD electronic scale with an accuracy of 0.001 kg.

Correspondence: Piotr Szczyglak, Department of Vehicle and Machinery Construction and Operation, Faculty of Technical Sciences, University of Warmia and Mazury, ul. M. Oczapowskiego 11, 10-957 Olsztyn e-mail: piotr.szczyglak@uwm.edu.pl.
Fuel consumption measurements were carried out by the “full tank” method. Before commencing the tillage at the test site, fuel in the tank was topped up to the maximum level. During the refuelling, attention was paid to the proper venting of the tank and the machine levelling. After the refuelling, the tractor-pulled aggregated unit carried out the working process over an area of at least \(2.8 \times 10^4\) m\(^2\). After the completion of the tillage treatment, the fuel in the tank was topped up to the level established before the treatment, and with the same assumptions. The amount of consumed fuel was measured using a glass cylinder with a scale with a 0.002 dm\(^3\) accuracy. During the measurements of the fuel consumption by the “full tank” method, use was made of a system for monitoring the working parameters of tractor-pulled aggregated tillage units designed and manufactured at the Department of Vehicle and Machinery Construction and Operation at the University of Warmia and Mazury in Olsztyn. The system enables GPS technology-based determination of the working process duration and the condition of the machine (work-auxiliary operations) and measurement of the area under cultivation.

Fuel consumption \(Q_p\) per unit of performed work was determined using the following formula:

\[
Q_p = \frac{10000 \cdot Q_t}{s_e \cdot a} \quad [\text{dm}^3 \cdot 10^{-4} \cdot \text{m}^{-2}]
\]  

(2)

where: 
- \(Q_t\) – fuel consumption during the cultivation treatment [dm\(^3\)],
- \(s_e\) – effective distance (when the working tool is cutting the soil) [m],
- \(a\) – working width of the machine [m].

Hourly fuel consumption \(Q_g\) determined using the following equation:

\[
Q_g = \frac{Q_t}{t} \quad [\text{dm}^3 \cdot \text{h}^{-1}]
\]

(3)

where: 
- \(Q_t\) – fuel consumption during the cultivation treatment [dm\(^3\)],
- \(t\) – duration of the tillage treatment [h].

Table 1 presents the plan of the experimental study.

Correspondence: Piotr Szczygłak, Department of Vehicle and Machinery Construction and Operation, Faculty of Technical Sciences, University of Warmia and Mazury, ul. M. Oczapowskiego 11, 10-957 Olsztyn e-mail: piotr.szczygak@uwm.edu.pl.
Table 1. The plan of operational testing

| Item | Soil condition          | Tests conducted                                                                 |
|------|-------------------------|----------------------------------------------------------------------------------|
| 1    | Before tillage          | Measurement of the soil volumetric moisture content (VMC) – 5 measurements       |
| 2    | Stage 1                 | Measurement of the degree of crop residue surface embedding – 6 measurements     |
| 3    | After ploughless cultivation* | Measurement of the degree of crop residue surface embedding – 3 measurements |
| 4    | Fuel consumption measurement by the “full tank” method – 1 measurement |
| 5    | Assessment of the depth of placing and mixing crop residues – 1 soil test pit |
| 6    | Stage 2                 | Measurement of the degree of crop residue surface embedding – 3 measurements     |
| 7    | Fuel consumption measurement by the “full tank” method – 1 measurement |
| 8    | Assessment of the depth of placing and mixing crop residues – 1 soil test pit |

* - tillage using the MultiCat 6HD aggregated tillage unit
** - two-stage tillage using a plough and disc harrow

**Results and Discussion**

The results of measurements and calculation of the degree of crop residue surface embedding are presented in Table 2.

The degree of crop residue surface embedding has a considerable effect on the spread of plant diseases. When the infected, non-decomposed residues cover the cultivated soil, the diseases will likely be transferred from them to the emerging crops, which will decrease the yield while increasing the expenditure on plant protection products. The degree of crop residue surface embedding of 94.87% obtained during the testing of the MultiCat 6HD aggregated tillage unit is a very good result. This is due to the arched shape of the teeth which dig out the soil from deeper layers of the soil profile and the disc section No 3 which evenly distributes the extracted material over the entire area of the field under cultivation. In comparing the results obtained for ploughless cultivation and plough tillage, it was found that they were similar. Since the distance was only 4.38%, the tillage using the MultiCat 6HD aggregated tillage unit does not differ significantly from plough tillage and ensures safe growth of crops (a decrease in the likelihood of infecting the crops with diseases).

The results of the assessment of the depth of placing and mixing crop residues are presented in Table 3. The accumulation of plant material in the soil profile top layer offers many benefits: it increases the biological activity of the soil and its colonisation by varied soil fauna, reduces the losses of soil organic matter as well as water and wind erosion, increases soil porosity, reduces the tendency for soil crust to be formed and enhances the buffer properties of the soil (SMAGACZ, 2013). The conducted analyses demonstrated that only under ploughless cultivation is the plant biomass accumulated in the top layer of the soil (0-0.1 m). As much as 84.75% of all plant material is evenly distributed throughout this layer.

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On the other hand, following the plough tillage, only 2.44% of crop residues are found in the top layer (0-0.1 m). In this case, up to 84.15% of plant material is found in the layer of 0.2-0.3 m. In this case, a strip distribution with the accumulation of material at a depth of 0.2-0.24 m is involved. For this reason, it can be considered that the distribution of crop residues within the soil profile is beneficial only for ploughless cultivation.

Table 2. The results of measurements and calculation of the degree of crop residue surface embedding

| Measurement | A view before tillage | A view after tillage | Measurement and calculation results | Average value |
|-------------|-----------------------|----------------------|------------------------------------|---------------|
| No 1*       | ![Image](image1.png)   | ![Image](image2.png) | $m_p = 1.251 \text{[kg]}$
$m_k = 0.052 \text{[kg]}
R_r = 95.84 \text{[%]}$ |               |
| No 2*       | ![Image](image3.png)   | ![Image](image4.png) | $m_p = 1.376 \text{[kg]}$
$m_k = 0.057 \text{[kg]}
R_r = 95.85 \text{[%]}$ | $R_r = 94.87 \text{[%]}$ |
| No 3*       | ![Image](image5.png)   | ![Image](image6.png) | $m_p = 0.863 \text{[kg]}$
$m_k = 0.058 \text{[kg]}
R_r = 93.27 \text{[%]}$ |               |
| No 1**      | ![Image](image7.png)   | ![Image](image8.png) | $m_p = 1.421 \text{[kg]}$
$m_k = 0.014 \text{[kg]}
R_r = 99.01 \text{[%]}$ |               |
| No 2**      | ![Image](image9.png)   | ![Image](image10.png) | $m_p = 1.155 \text{[kg]}$
$m_k = 0.005 \text{[kg]}
R_r = 99.56 \text{[%]}$ | $R_r = 99.25 \text{[%]}$ |
| No 3**      | ![Image](image11.png)  | ![Image](image12.png) | $m_p = 0.988 \text{[kg]}$
$m_k = 0.008 \text{[kg]}
R_r = 99.19 \text{[%]}$ |               |

* - tillage using the MultiCat 6HD aggregated tillage unit, ** - two-stage tillage using a plough and disc harrow

Analysis results for the data collected during the fuel consumption measurement are presented in Table 4, while an example of the passage map is presented in Figure 3.

Correspondence: Piotr Szczyglik, Department of Vehicle and Machinery Construction and Operation, Faculty of Technical Sciences, University of Warmia and Mazury, ul. M. Oczapowskiego 11, 10-957 Olsztyn

e-mail: piotr.szczyglik@uwm.edu.pl.
Table 3. The results of the assessment of the depth of placing and mixing crop residues

| Tillage          | Soil layer | Weight       | Distribution of plant material |
|------------------|------------|--------------|--------------------------------|
|                   | 0.0-0.1 m  | 0.15 [kg]    |                                |
|                   | 0.1-0.2 m  | 0.026 [kg]   |                                |
|                   | 0.2-0.3 m  | 0.001 [kg]   |                                |
| Ploughless cultivation | 0.0-0.1 m  | 0.004 [kg]   | Material evenly distributed over the entire working width. Plant material evenly mixed with the soil. |
|                   | 0.1-0.2 m  | 0.022 [kg]   |                                |
|                   | 0.2-0.3 m  | 0.138 [kg]   |                                |
| Plough tillage    | 0.0-0.1 m  | 0.004 [kg]   |                                |
|                   | 0.1-0.2 m  | 0.022 [kg]   |                                |
|                   | 0.2-0.3 m  | 0.138 [kg]   |                                |
Table 4. The results for the data collected during the fuel consumption measurement

| Parameters                                      | Ploughless cultivation | Ploughing | Pre-sowing tillage |
|------------------------------------------------|------------------------|-----------|--------------------|
| Tillage duration                               | 1.3275 [h]             | 1.3816 [h]| 0.6132 [h]         |
| Effective duration                             | 1.0938 [h]             | 1.1878 [h]| 0.5610 [h]         |
| Auxiliary duration                             | 0.2337 [h]             | 0.1938 [h]| 0.0522 [h]         |
| Set engine crankshaft speed                    | 1.730 [rpm]            | 1.730 [rpm]| 1.730 [rpm]        |
| Transmission ratio                             | Gear #7                | Gear #10  | Gear #10           |
| Set speed                                      | 8 [km·h⁻¹]             | 8.8 [km·h⁻¹]| 8.8 [km·h⁻¹]      |
| Average speed                                  | 7.501 [km·h⁻¹]         | 7.57 [km·h⁻¹]| 8.52 [km·h⁻¹]     |
| Average driving speed during the               | 7.508 [km·h⁻¹]         | 8.03 [km·h⁻¹]| 8.49 [km·h⁻¹]      |
| performance of working process                 |                        |           |                    |
| Average driving speed during the               | 7.46 [km·h⁻¹]          | 4.73 [km·h⁻¹]| 8.75 [km·h⁻¹]      |
| performance of auxiliary operations.           |                        |           |                    |
| Working width                                  | 6 [m]                  | 3 [m]    | 6 [m]              |
| Set working depth                              | 0.4 [m]                | 0.22 [m] | 0.12 [m]           |
| Distance covered                               | 9.958 [m]              | 10.466 [m]| 5.225 [m]         |
| Effective distance                             | 8.213 [m]              | 9.548 [m] | 4.768 [m]          |
| Effective surface area Pₚ                      | 4.9278 [m²]            | 2.8644 [m²]| 2.8608 [m²]       |
| Effective efficiency W₁                        | 4.5095 [10⁴·m²·h⁻¹]    | 2.4115 [10⁴·m²·h⁻¹]| 5.0994 [10⁴·m²·h⁻¹] |
| Operational efficiency W₀₂                     | 3.712 [10⁴·m²·h⁻¹]     | 2.235 [10⁴·m²·h⁻¹]| 4.665 [10⁴·m²·h⁻¹] |
| Fuel consumption during the cultivation treatment Qₜ | 84 [dm³]              | 49.24 [dm³]| 20.53 [dm³]       |
| Unit fuel consumption Qₒ                       | 17.046 [dm³·10⁻⁴·m⁻²]  | 17.192 [dm³·10⁻⁴·m⁻²]| 7.176 [dm³·10⁻⁴·m⁻²] |
| Hourly fuel consumption Qₑ                     | 63.276 [dm³·h⁻¹]       | 35.639 [dm³·h⁻¹]| 33.480 [dm³·h⁻¹]   |
| The number of working passages                 | 27                     | 24        | 12                 |
| Average length of the plot under cultivation   | 304.2 [m]              | 397.8 [m] | 397.3 [m]          |

Fig. 3. A view of a recorded map of tillage conducted using the MultiCat 6HD aggregated tillage unit (green colour – effective work, red colour – returns)

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The unit fuel consumption for ploughless cultivation was 17.046 dm$^3 \cdot 10^{-4} \cdot m^{-2}$. This value is slightly lower than that of the fuel consumption for ploughing. Having compared these two values, it can be concluded that the simplified tillage using the MultiCat 6HD aggregated tillage unit is more economical than conventional tillage. Since after ploughing the soil needs to be prepared for the spring sowing and planting, unit fuel consumption during the plough tillage was 24.36 dm$^3 \cdot 10^{-4} \cdot m^{-2}$. The comparison of both technologies reveals that the unit fuel consumption for the ploughless cultivation was lower by 30.04% than that for the ploughing technology. At the same time, simplified tillage using the MultiCat 6HD aggregated tillage unit was conducted with almost three times higher efficiency. During the testing, the actual working speeds during the ploughing and preparing the soil for the spring sowing were higher than the speeds obtained for the MultiCat 6HD aggregated tillage unit. This affected fuel consumption, however, as regards the ploughless cultivation, due to the short length of the test plot (an average of 304.2 m), the proportion of the distance covered during the performance of working operations was more unfavourable and amounted to 17.52%, and for the ploughing and pre-sowing tillage, to only 8%. These differences compensate for the increased fuel consumption due to the greater speed obtained by the tractor-pulled aggregated units during the plough tillage. It should be stressed that the fuel consumption is considerably affected by the engine crankshaft rotational speed, which in all cases was 1,730 rpm. At the same rotational speed and different transmission ratios in the tractors used, it was not possible to set the same driving speed. In conclusion, the simplified tillage using the MultiCat 6HD aggregated tillage unit is much more economical and efficient than the comparable plough tillage.

Figure 4 shows the unit fuel consumption values determined during the testing.

During testing, the absolute soil moisture content was 15.3% on average (using five measurements).

Other studies (Zbytek, 2010) determined the degree of crop residue surface embedding for ploughless cultivation. During the cultivation of the stubble field using a tooth-harrow plough (subsoiler, cultivator, discs, string and ring roller), a result of 68% was obtained, while for the aggregated unit for ploughless cultivation (subsoiler, cultivator, leveller, string roller), the degree of crop residue surface embedding ranged from 54% to 81%. These results are worse than those obtained for the MultiCat 6HD aggregated unit. The depth at which the crop residues were placed for a tooth-harrow plough was the same and the fuel consumption was over 25% more than the consumption measured for the MultiCat 6HD aggregated unit.

Correspondence: Piotr Szczyglak, Department of Vehicle and Machinery Construction and Operation, Faculty of Technical Sciences, University of Warmia and Mazury, ul. M. Oczapowskiego 11, 10-957 Olsztyń e-mail: piotr.szczyglak@uwm.edu.pl.
Moitzi et al. (2006) determined the fuel consumption for a heavy cultivator that can be used in ploughless cultivation. At a working depth of only 0.15 m, it amounted to 21.55 dm$^3 \cdot 10^{-4} \cdot$m$^2$. This value is 26% more than the fuel consumption value obtained for the MultiCat 6HD aggregated unit.

A study by Jaskulski et al. (2016) provides the values of fuel consumption for the measures carried out in ploughless cultivation (grubbing, pre-sowing tillage using an aggregated unit). The consumption was, on average, more than 30% higher than that measured for the MultiCat 6HD aggregated unit.

![Fig. 4. Unit fuel consumption determined during the testing](image)

**Summary**

Ploughless cultivation is a technology with development potential and it will gradually replace the traditional plough tillage due to lower energy inputs. Moreover, the elimination of ploughing and the loosening of soil to a depth of 0.4 m effectively prevent the formation of a plough pan. Ploughless cultivation using the MultiCat 6HD aggregated tillage unit ensures the embedding of post-harvest residues that is similar to that in traditional plough tillage, which effectively prevents crops from being infected by diseases at an early stage of development. This is due to the design of teeth which dig out the soil from the deeper layers, which is subsequently distributed over the entire surface of the field by section No 3 (disc harrow). The distribution of crop residues within the soil profile is favourable only for ploughless cultivation (84.15% in the layer up to 0.1 m), which reduces the losses of soil organic matter as well as water and wind erosion, increases porosity, reduces the tendency for a soil crust to form.
be formed and enhances the buffer properties of the soil. The operating parts of the MultiCat 6HD aggregated tillage unit during the performance of the working process were not clogged with the plant material, because a disc section was applied in the front of the tooth section to effectively pulverise this material. The simplified tillage using the MultiCat 6HD aggregated tillage unit reduces fuel consumption by 30% while increasing the effective efficiency by 63%. Such an improvement in the indicators due to changes in cultivation technology will certainly ensure an increase in agricultural farm competitiveness.

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Correspondence: Piotr Szczyglak, Department of Vehicle and Machinery Construction and Operation, Faculty of Technical Sciences, University of Warmia and Mazury, ul. M. Oczapowskiego 11, 10-957 Olsztyn e-mail: piotr.szczyglak@uwm.edu.pl.
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