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COMPARISON OF FODDER CARRIAGES WITH CUTTER DRUMS DURING PREPARATION AND FEEDING OF TOTAL MIXED RATION FOR CATTLE

Summary

The paper presents results of research on comparison of operational and economical two technologies of preparation and feed distribution of total mixed ration (TMR) for cattle. The research was carried out in two farms in Wielkopolska where the doses in an amount from 1195 to 4900 kg were prepared at once. Average operating efficiency of tested fodder carriages were 4,71 and 8,12 $t \cdot h^{-1}$. Labor expenditures related to 1 tonne of prepared and fed dose of TMR varied and amounted to 0,18 $rbh \cdot t^{-1}$ at the second technology and 0,25 $rbh \cdot t^{-1}$ at the first technology. The average cost of the machine works was smaller at the T1technology and amounted to 15,16 $zł \cdot t^{-1}$ and slightly higher than at the technology T2, where it amounted to 18.25 $zł \cdot t^{-1}$
***Key words**: fodder carriage, efficiency of fodder carriage, costs of preparing and feeding TMR*

PORÓWNANIE WOZÓW PASZOWYCH Z BĘBNAMI FREZUJĄCYMI PODCZAS PRZYGOTOWANIA I ZADAWANIA DAWKI PEŁNOPORCJOWEJ DLA BYDŁA

Streszczenie

W pracy przedstawiono wyniki badań dotyczące porównania eksploatacyjno-ekonomicznego dwóch technologii przygotowania i zadawania dawki całkowicie kompletnej (TMR) dla bydła. Badania były realizowane w dwóch gospodarstwach rolnych na terenie Wielkopolski, w których jednorazowo przygotowywano dawki w ilości od 1195 do 4900 kg. Średnie wydajności eksploatacyjne badanych wozów paszowych wynosiły 4,71 i 8,12 $t \cdot h^{-1}$. Nakłady robocizny odniesione do 1 tony przygotowanej i zadanej dawki TMR były zróżnicowane i wynosiły 0,18 $rbh \cdot t^{-1}$ w technologii drugiej i 0,25 $rbh \cdot t^{-1}$ w technologii pierwszej. Średni koszt wykonania prac maszynowych mniejszy był w technologii T1 i wynosił 15,16 $zł \cdot t^{-1}$, a nieznacznie większy niż w technologii T2, gdzie wynosił 18,25 $zł \cdot t^{-1}$.
***Słowa kluczowe**: wozy paszowe, wydajność wozów paszowych, koszty przygotowania i zadawania TMR*

1. Introduction

Fodder carriage are machines, which in the short time should precisely crush ingredients of total mixed ration regardless of the physical and mechanical properties of its components and next, mix effectively until achieving a uniform structure and meter evenly prepared TMR or PMR [1, 2, 3, 14]. The intensity of mixing and crushing the feed depends on the mixing system and the number of screws and their construction, speed and direction of rotation. The fodder carriages are usually used in systems with screws set vertically or horizontally. Mixing systems with horizontal mixing screws provide very high mixing performance and obtaining a homogeneous feed structure because they interact aggressively on the mixed ingredients. In turn, vertical mixing systems are characterized by versatility of simple construction regardless of the capacity of the tank and do not endanger excessive fragmentation and disruption of feed structure [9, 10].

The fodder carriages depending on the equipment can perform many technological features, such as weighing the components, mixing and crushing the ingredients, homogenization and distribution of the prepared doses of TMR or PMR [7, 8]. These machines differ not only in the capacity and shape of the tanks but also in an optional accessory that can be installed on the user's request. In some fodder carriages tanks are smooth and in the other ones intrinsically collapse of the walls appear, which prevents from rotating with the feed cutting screw. There are also various designs of screws which according to manufacturers should improve the efficiency of cutting and blending ration [9, 10]. The fodder carriages are also trailed by tractors or in self-propelled versions. Self-propelled machines are equipped with front pick up transporting cutters as standard or in a few cases as an alternative system of self loading. For trailed fodder carriages, some manufacturers give the opportunity to retrofit the model with a self loading system. However, mostly machines equipped with such devices are separate series where it is a standard [11, 12, 13]. Equipping the fodder carriages with devices for self loading gives them the opportunity to filling ingredients of total mixed ration without the use of other devices. It reduces the number of technical means used in the process of preparing the feed and feeding the animals.

It should therefore be assumed that considerable variation of machines construction and their accessories may affect the values of operational indicators. The available literature lacks current data relating to operational indicators of the fodder carriages with different systems of mixing and grinding with self loading. There were performed operational tests of the type of machine with their participation during technological processes. The study was conducted in a production conditions in farms focused on milk production and the results were the basis for determining the efficiency of machine units, labor expenditures, fuel consumption and operating costs.

2. Aim of the research

The aim of the research was to determine the operational indicators of technical means used in technologies of preparing the feed and feeding the milk cattle with total

mixed ration. The subject of research included 2 technologies of preparation and feeding the milk cattle with total mixed ration. In the assessed technologies there was used a fodder carriage trailed by the tractor with a horizontal system of crushing and mixing and self loading device (T1 technology) and self-propelled fodder carriage with vertical system of crushing and mixing self loading device (technology T2).

3. Materials and methods of research

Within the framework of operational tests there was carried out the timing of working time of the machine units used in the evaluated technologies which included four changes in the control and registration of the amount of work. On this basis the performance of machine units and operating indicators were estimated. Operational tests were carried out according to the standard BN-76/9195-01 [5], while the operational indicators were determined in accordance with the standard BN-77/9195-02 [6]. Fuel consumption was determined by a full tank method. The costs of the individual treatments at the technologies were calculated according to the method of IBMER [4]. For cost calculations there were used data obtained from farms and indicators determined on the basis of operational tests.

Research and analysis of the technology of preparation and feeding the cattle with total mixed ration was carried out under the following conditions:

- Technology no. 1 (T1) was applied on a farm in the village in Głuchów of Gostyń district. The main unit consisted of tractor John Deere 6620 125 hp and fodder carriage Kuhn Euromix with the self loading device with a capacity of 8 m^3 with three horizontal screws mixers. The main mixer - located at the floor of the tank has shreding knives over its entire length. Two more screws are placed above and they transport the feed to the rear of the carriage and mix ingredients. The machine was equipped with electronic scale, two-stage gearbox, one discharge window on the left side of the tank and hydraulically driven cross belt conveyor with adjustable discharge height. For loading the tank of fodder carriage the cutter placed in the rear of the machine, controlled by hydraulic cylinders was used.
- Technology no. 2 (T2) was carried out on a farm in the village of Szołdry. The main unit consisted of a self-propelled fodder carriage Faresin Leader's Double 2200 equipped with an engine of 210 hp and a reservoir with a capacity of 22 m^3 equipped with two vertical screw mixers and self loading device. The machine was characterized by a rich equipment, such as: electronic weighing system equipped with 6 sensors, temporal mixing system, 2-speed gearbox and a 2-speed feeding and mixing, hydraulically operated counter blades at the front and back of the tank, the discharge window on the left side and the cross conveyor.

4. Results and discussion

4.1. Operational tests

In the first technology (T1) TMR a herd amounted to 260 units of which 110 units were dairy cows and the rest consisted of the heifers and calves. Rations were prepared daily in the early morning hours and then served for three food groups: dry cows, heifers with calves and dairy cows (Table 1). The first portion of TMR was prepared for dry cows in the average amount of 2350 kg, which, after feeding the first group it was left approximately 820 kg of TMR as the feed to the second portion. Then to the remaining dose of TMR in the tank of the fodder carriage it was added 60 kg of straw and 300 kg of feed meaty, 400 kg of grass silage and 920 kg of corn silage, which accounted for a total of the 2nd dose. For the second dose in the tank machine it was left about 690 kg of prepared TMR and supplemented with about 50 kg of straw, 550 kg of roughage, 370 kg of sugar beet pulp, 260 kg of spent grains of barley and 1840 kg of corn silage, which accounted for a total of approximately 3760 kg of TMR in the third dose. The total preparation time of three doses was 75 minutes, and TMR rations in livestock buildings - 10 minutes.

In the second technology (T2) TMR was prepared twice a day for four dietary groups (Table 2). The first dose was prepared for up to 160 pieces and it consisted of 65 kg of straw, 1440 kg of corn silage, 320 kg of grass silage, 640 kg of alfalfa silage, 640 kg of beet pulp and 320 kg of roughage with a total weight of 3425 kg. The second dose was prepared for 180 cows of the following components: 70 kg of straw, 90 kg of hay, 1800 kg of corn silage, 270 kg of alfalfa silage, 500 kg of pickled corn seeds, 925 kg of roughage, 820 kg of sugar beet pulp, 450 kg of spent grains of barley, which together weighed 4910 kg. The third dose was prepared for a group of 140 animals and consisted of the same components as the second dose, but its weight was 4000 kg. The fourth dose was prepared for the 70 most productive dairy cows and consisted of 20 kg of straw, 750 kg of maize silage, 215 kg of alfalfa silage, 45 kg of rape pellets, 150 kg of sugar beet pulp, 15 kg of mineral additives, which together accounted for 1195 kg TMR. Total preparation time of four doses was 70 minutes. Feeding with TMR in livestock buildings took an average time of 12 minutes and took place on one side of the tank of fodder carriage. Animals were in several livestock buildings, which were associated with commuting to various places in order to dose the TMR.

4.2. Operating costs of tested technologies

The costs of operating machine units used for the preparation of TMR (Table 1 and 2) were determined based on data obtained from farms and indicators designated on the basis of own tests. Fuel consumption was admitted to the calculation in accordance with the results of the present study. The unit costs of machine units determined on the basis of the above for the preparation of TMR varied and amounted to an average of 71,09 zł • h^{-1} in technology T1 and 138,68 zł • h^{-1} in technology T2. Reduced unit costs of operating machine unit used in the T1 technology are mainly due to more than three times lower hourly fuel consumption than in the technology T2, which is related to the capacity of the machines tanks of 8 and 22 m^3. The annual use of tested machine units was 750 and 1300 hours a year. On the other hand, per unit of work, the smallest average costs characterizing the machine unit in T1 technology amounted to 15,16 zł • t^{-1}. In T2 technology there was used a self-propelled fodder carriage at which unit operating costs per unit of work amounted to an average of 18,25 zł • t^{-1}. The technology T2 was also found similar unit operating costs per unit of labor, amounting to 15,78 and 14,10 zł • t^{-1} in the preparation of doses of the largest masses of up 4000 and 4910 kg. In turn, use of the feed wagon Faresin 2200 for large capacity tank for preparing a dosage of low molecular weight (1195 kg) was much more expensive and amounted to 25,21 zł • t^{-1}.

Table 1. Test results of exploitation for John Deere 6620 + Kuhn Euromix – the average of the four control shifts
Tab. 1. Wyniki badań eksploatacyjnych agregatu maszynowego John Deere 6620 + Kuhn Euromix – średnie z czterech zmian kontrolnych dla przygotowywanych dawek

Parameter Parametr	Unit of measure Jednostka miary	Doses of TMR - Dawki TMR			
		dose 1 TMR - dawka 1	dose 2 TMR - dawka 2	dose 3 TMR - dawka 3	Average Średnia
Effective capacity Wydajność efektywna W_1	$t \cdot h^{-1}$	5,86	6,30	5,93	6,03
Efficiency in time T_{02} Wydajność operacyjna W_{02}	$t \cdot h^{-1}$	4,68	5,17	4,46	4,77
Efficiency in stright time T_{04} Wydajność robocza W_{04}	$t \cdot h^{-1}$	4,68	5,17	4,29	4,71
Operating output capacity Wydajność eksploatacyjna W_{07}	$t \cdot h^{-1}$	4,68	5,17	4,29	4,71
Efficiency in general time Wydajność w czasie zmiany kontrolnej W_{08}	$t \cdot h^{-1}$	3,82	4,26	3,84	3,97
K_{02}	$t \cdot h^{-1}$	0,80	0,82	0,75	0,79
K_{04}	-	0,80	0,82	0,72	0,78
K_{07}	-	0,80	0,82	0,72	0,78
K_{08}	-	0,65	0,68	0,65	0,66
K_{31}	-	1,00	1,00	1,00	1,00
K_{41}	-	1,00	1,00	1,00	1,00
K_{42}	-	1,00	1,00	1,00	1,00
Fuel consumption Zużycie paliwa	$l \cdot h^{-1}$; $L \cdot h^{-1}$	6,60	6,64	6,78	6,67
	$l \cdot t^{-1}$; $L \cdot t^{-1}$	1,73	1,56	1,77	1,69
Labour outlays A_{04} Nakłady robocizny A_{04}	$rbh \cdot t^{-1}$	0,21	0,20	0,23	0,21
Labour outlays A_{08} Nakłady robocizny A_{08}	$rbh \cdot t^{-1}$	0,26	0,24	0,26	0,25
Unit cost of the unit operation* Jednostkowy koszt eksploatacji agregatu*	$zł \cdot h^{-1}$	70,64	71,12	71,52	71,09
Cost of operation of the unit on a work unit* Koszt eksploatacji agregatu na jednostkę pracy*	$zł \cdot t^{-1}$	15,09	13,73	16,67	15,16

* koszty eksploatacji agregatu nie uwzględniają kosztów robocizny przy obsłudze maszyny i ciągnika;
* unit operating costs do not include labor costs when operating the machine and tractor

Source: own work / *Źródło:* opracowanie własne

Table 1. Test results of exploitation for Faresin Leader Double 2200 – the average of the four control shifts
Tab. 2. Wyniki badań eksploatacyjnych agregatu maszynowego Faresin Leader Double 2200 – średnie z czterech zmian kontrolnych dla przygotowywanych dawek

Parameter Parametr	Unit of measure Jednostka miary	Doses of TMR - Dawki TMR				
		dose 1 TMR - dawka 1	dose 2 TMR - dawka 2	dose 3 TMR - dawka 3	dose 4 TMR - dawka 4	Average Średnia
Effective capacity Wydajność efektywna W_1	$t \cdot h^{-1}$	13,14	15,25	16,68	4,05	12,10
Efficiency in time T_{02} Wydajność operacyjna W_{02}	$t \cdot h^{-1}$	8,9	10,05	10,43	3,75	8,14
Efficiency in stright time T_{04} Wydajność robocza W_{04}	$t \cdot h^{-1}$	8,9	10,05	10,43	3,56	8,12
Operating output capacity Wydajność eksploatacyjna W_{07}	$t \cdot h^{-1}$	8,9	10,05	10,43	3,56	8,12
Efficiency in general time Wydajność w czasie zmiany kontrolnej W_{08}	$t \cdot h^{-1}$	7,29	9,20	8,59	3,01	6,93
K_{02}	$t \cdot h^{-1}$	0,68	0,66	0,63	0,92	0,72
K_{04}	-	0,68	0,66	0,63	0,88	0,71
K_{07}	-	0,68	0,66	0,63	0,88	0,71
K_{08}	-	0,56	0,60	0,52	0,74	0,61
K_{31}	-	1,00	1,00	1,00	1,00	1,00
K_{41}	-	1,00	1,00	1,00	1,00	1,00
K_{42}	-	1,00	1,00	1,00	1,00	1,00
Fuel consumption Zużycie paliwa	$l \cdot h^{-1}$; $L \cdot h^{-1}$	26,64	26,49	24,08	12,16	22,34
	$l \cdot t^{-1}$; $L \cdot t^{-1}$	3,66	2,88	2,83	4,04	3,35
Labour outlays A_{04} Nakłady robocizny A_{04}	$rbh \cdot t^{-1}$	0,11	0,10	0,10	0,28	0,15

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Labour outlays A_{08} Nakłady robocizny A_{08}	rbh·t^{-1}	0,14	0,11	0,12	0,33	0,18
Unit cost of the unit operation* Jednostkowy koszt eksploatacji agregatu*	zł·h^{-1}	159,27	158,60	147,08	89,76	138,68
Cost of operation the unit on a work unit* Koszt eksploatacji agregatu na jednostkę pracy*	zł·t^{-1}	17,90	15,78	14,10	25,21	18,25

* koszty eksploatacji agregatu nie uwzględniają kosztów robocizny przy obsłudze maszyny;
* unit operating costs do not include labor costs when operating the machine and tractor

Source: own work / *Źródło:* opracowanie własne

5. Conclusions

Based on the study and analysis of the results, there can be found the following conclusions:

1. Average operational effectiveness of tested fodder carriages varied and ranged from 4,72 t • h^{-1} at T1 technology and 8,12 t • h^{-1} at T2 technology. The time of mixing the different doses of TMR had the biggest impact on mass performance of fodder carriages.

2. Unit operating costs of forager carriages used in the tested technologies were varied. The biggest impact on their level exerted the hourly fuel consumption and annual intensity of their use.

3. Operating costs per unit of work of machine unit used to prepare doses of TMR were smaller in T1 technology due to better use of the capacity of the tank of the forager carriage. The T2 technology were at a similar level for the preparation of doses of TMR with the greatest weight, which was also associated with better use of the capacity of the self-propelled tank of forager carriage.

4. Expenditures on labor to prepare and feed of one ton of TMR were lower in T2 technology and amounted to 0,18 rbh • t^{-1}. In the T1 technology the expenditures were approximately 39% higher and amounted to 0,25 rbh • t^{-1}.

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