

EXPENDITURE FOR HARVESTING AND ENSILING OF LOW STALK GREEN FODDER USING PRESS AND PICKUP TRAILER

Summary

The work was made to determine operational costs and cost-effective technologies for preparation of silage from low stalk green fodder, involving baler and various forms of storage systems marked as follows: ASW - wrapping single bales, ZOSZ - wrapping bales on the wrapping serial machine, ZOW - storage bales in a plastic bags using bale charger or collecting chaff in the silo by using pickup trailer - PS - or just storage chaff on the prism - PP. The lowest unitary fuel consumption was noticed in technology using pickup trailer and storage chaff in the silo - PS ($6.99 \text{ kg} \cdot \text{t}^{-1}$ dry matter), but the largest fuel consumption took place when using press for wrapping individual bales - ZOP ($12.24 \text{ kg} \cdot \text{t}^{-1}$ dry matter). The structure of fuel consumption in particular operations was presented by largest share in all technologies including mowing, tedding and raking. Technology showed the lowest labour input when collecting green fodder with pickup trailer and storage chaff in the silo - PS ($1.80 \text{ labour hour} \cdot \text{t}^{-1}$ dry matter), and the highest one was when using baler and wrapping single bales - ASW ($2.94 \text{ labour hour} \cdot \text{t}^{-1}$ dry matter). The lowest unitary costs of silage production was present when using pickup trailer and storing chaff on the prism - PP ($225.60 \text{ zł} \cdot \text{t}^{-1}$ dry matter), but the highest costs were when using technology with round baler and individual bale wrapping system - ASW ($353.80 \text{ zł} \cdot \text{t}^{-1}$ dry matter).

Key words: green fodder, harvesting, silage, press, wrapping, collecting trailer, fuel consumption, labour input, costs

NAKLADY PONOSZONE NA ZBIÓR I ZAKISZANIE ZIELONK NISKOŁODYGOWYCH Z ZASTOSOWANIEM PRASY I PRZYCZEPY ZBIERAJĄCEJ

Streszczenie

W pracy określono nakłady eksploatacyjne i ekonomiczne technologii sporządzania kiszonek z zielonek niskolodygowych z udziałem prasy zwijającej i różnymi formami składowania oznaczonymi odpowiednio: ZOP – owijanie pojedynczych bel, ZOSZ – owijanie bel na owijarce szeregowej, ZOW – ostanianie bel w worku foliowym przy użyciu ładowarki bel, oraz przyczepy zbierającej ze składowaniem siewki w silosie – PS lub na pryzmie – PP. Najmniejszym jednostkowym zużyciem paliwa charakteryzuje się technologia z przyczepą zbierającą i składowaniem siewki w silosie – PS ($6,99 \text{ kg} \cdot \text{t}^{-1} \text{ s.m.}$), a największym z prasą zwijającą i owijaniem pojedynczych bel – ZOP ($12,24 \text{ kg} \cdot \text{t}^{-1} \text{ s.m.}$). W strukturze zużycia paliwa największy udział we wszystkich technologiach przypada na operacje koszenia, przetrząsania i zgrabiania. Najniższą pracochłonność wykazywała technologia z przyczepą zbierającą i składowaniem siewki w silosie – PS ($1,80 \text{ rbh} \cdot \text{t}^{-1} \text{ s.m.}$), a najwyższą z udziałem prasy zwijającej i owijaniem pojedynczych bel – ZOP ($2,94 \text{ rbh} \cdot \text{t}^{-1} \text{ s.m.}$). Najniższe koszty jednostkowe produkcji kiszonek występują w technologii z przyczepą zbierającą ze składowaniem surowca roślinnego w pryzmie – PP ($225,60 \text{ zł} \cdot \text{t}^{-1} \text{ s.m.}$), a najwyższe w technologii zbioru prasą zwijającą i owijaniem pojedynczych bel – ZOP ($353,80 \text{ zł} \cdot \text{t}^{-1} \text{ s.m.}$).

Słowa kluczowe: zielonka, zbiór, kisonka, prasa, owijarka, przyczepa zbierająca, zużycie paliwa, pracochłonność, koszty

1. Introduction

The dominant trend in animal production consists in reducing costs while improving the quality of obtained product. This is accomplished by feeding dairy and fattening cattle by using valuable fodder, which is obtained by utilization of various technologies of harvesting, storage and distribution of feed to minimize both quantitative and qualitative losses. This applies in particular to feed, which are prepared by utilization of permanent pasture and then conserved feed in the form of hay and silage [14, 15].

Improving economic efficiency of grassland yield in our country, it is achieved by a systematic increase of silage utilization, because it has lower losses during preparation, and it is more secure from maintenance point of view than hay [8, 15]. In leading economic countries silage for many years is a dominant form of preservation of green fodder, and is prepared using traditional technologies, ie. chaff stored in prisms, flat silos or in accordance with the newer

trends using round baler press or piston press forming bulky bales of rectangular shape [1, 2, 5, 7, 10, 13, 14, 17, 18, 19].

In recent years there has been growing interest in pickup trailers specially designed for green fodder harvesting for silage preparation [16].

The share of feed costs in total cost of livestock production accounts for 70-75%. Effective preparation of feed through the use of appropriate technology with minimal losses can bring measurable benefits [12].

The aim of the study was to determine and compare the effort and costs occurred during collection and ensiling of pasture grass when various technologies were used on Experimental Farm in ITP Falenty.

2. Material and methods

In the study authors analyzed and evaluated the entire production technology, beginning from cutting and then to collection, transportation, unloading and protection feeding

material from air by development of new technological solutions, proper for conditions present on Experimental Farm in IMUZ Falenty (Table 1).

In all technologies, the initial operations of mowing, tedding and raking were carried out by using the same farm machinery, but changes took place during: collection, transportation and storage operations. Mowing was carried out by rotary mower equipped with swaths conditioner Class Disco 3050C mounted on a tractor Fendt 412 Vario. For tedding Tedder JF Stoll Z 555 was used. It was cooperating with tractor Ursus 3702. The same tractor was aggregated with rake JF Stoll R-420 to provide raking operation.

For harvesting wilted sward in compressed form fixed chamber round baler (forming bales at dimensions of 1.2 x 1.2 m) type METAL-FACH Z 562 was used. It worked in cooperation with a tractor Valtra 92A. Loader TUR 6 equipped with a bales caugther mounted on a tractor Fendt 412 Vario was utilized for loading bales on a means of transport, which was a platform to aggregate bales with a tractor New Holland TM 130. After bales transportation to a storage area, the same set of farm machinery was utilized for loading and unloading on equipment for covering bales by foil. Cylindrical bales were wrapped with foil using wrappers type Z 274 cooperating with the tractor Ursus 3702.

Unloaded bales from wrappers machine were provided automatically by tilting the table. Wrapped bales were transported for storage to a specially prepared flat and level ground. In addition to this basic variant named as ZOP, it was also considered two other options allowing to protect feed from getting air, namely using serial wrappers and loader to place bales into plastic bags. As the result, it occurred two new technology lines named as ZOSZ and ZOW.

In technologies which were using loading wagons (PS and PP) all operations: collection, transportation and unloading were carried out using trailer STRAUTMANN Super Vitesse II, which was cooperating with the tractor New Holland TM 130. In PS technology unloading of the trailer took place in a silo, but in technology PP unloading was executed on a prism. In this situation green fodder was chopped and then compressed by tractor Fendt 412 Vario, which was equipped with tractor loader TUR 6 and bulldozer. Then finally all feed was tightly covered using ensilaging foil.

During the analysis and evaluation of results from different types of harvesting and silage production from green meadow, the following criteria were taken into consideration:

- unitary fuel consumption [$\text{kg} \cdot \text{t}^{-1}$ dry matter]
- unitary labor expenditures [labour hour $\cdot \text{t}^{-1}$ dry matter]
- unitary cost of silage preparing, taking into account the costs of subsequent operations when harvesting forage in described technologies [$\text{PLN} \cdot \text{t}^{-1}$ dry matter].

Calculations of unitary operational costs and expenses occurred in particular technologies of harvesting and ensiling of low stalk green fodder were provided using computer program developed by Karwowski in 2011 [10]. By the way it was utilized results of previous own research and theoretical analysis [2, 3, 4, 5, 6, 7, 8, 18, 19].

Also for calculation values of parameters and technical-exploitational indicators connected with equipment and aggregates present during described research program were utilized, but especially it concerned foil for bales wrapping process [9, 11].

Basic technical parameters and purchase prices of tractors, machinery and equipment are presented in Table 2.

Table 1. Technological operations and technical measures in individual model of technology production lines
Tab. 1. Operacje technologiczne oraz środki techniczne w poszczególnych modelowych liniach technologicznych

Operation	ZOP	ZOSZ	ZOW	PS	PP
Mowing	Tractor Fendt 412 Vario + mover Class Disco 3050C				
Tedding Tractor Ursus 3702 + tedder JF Stoll Z-555					
Raking	Tractor Ursus 3702 + raker JF Stoll R-420				
Harvesting	Tractor Valtra 92A + round baler press MetalFach Z 562			New Holland Tractor TM130 + pickup trailer Strautmann	
Loading and bales transportation (green fodder)	Tractor Fendt 412 Vario + loader TUR-6 Tractor New Holland TM130 + platform for bales			Tractor New Holland TM130 + pickup trailer Strautmann	
Unloading and loading bales on wrapper	Tractor Fendt 412 Vario + loader TUR-6			-	-
Bale wrapping	Tractor Ursus 3702 + wrapper Z-274	Row wrapper STRECH-O-MATIC	Loader AG BAG BALLERINA	-	-
Raking and compressing o chaff	-	-	-	Tractor Fendt 412 Vario + loader TUR-6 with bulldozer	
Bales transportation from wrapping side to storage place	Tractor Fendt 412 Vario + loader TUR-6	-	-	-	-
Covering using foil	-	-	-	Handy job	Handy job
Storage	Single bales wrapped by foil	Bales in foil cone	Bales in foil bag	Silo	Prism

Source: own work / Źródło: opracowanie własne

Table 2. Technical parameters and purchase prices of tractors, machinery and equipment

Tab. 2. Parametry techniczno-eksploatacyjne i ceny zastosowanych ciągników maszyn i urządzeń

Farm machinery	Power [kW]	Parameters		Price [PLN]
		Working width [m]	Load [t]	
Tractor U 3702	37	-	-	92000
Tractor Valtra 92A	75	-	-	195200
Tractor NH TM 130	96	-	-	230000
Tractor Fendt 412 Vario	81	-	-	320000
Mower CLAAS Disco 3050C with swath conditioner	59	3,00	-	40200
Tedder JF Stoll Z-555	22	5,50	-	20000
Raker JF Stoll R 420	22	4,20	-	21000
Round baler press METALFACH Z-562	35	1,80	-	45500
Bales platform	50	-	9	45100
Front loader TUR-6 with catcher	-	-	1,6	21500
Bales wrapper Z-274	30	-	-	7800
Row wrapper Stretch-O-Matic	9,6	-	-	72000
Bales loader AG BAG BALLERINA	-	-	-	122000
Pickup trailer STRAUTMANN	75	1,80	28m ³	200000

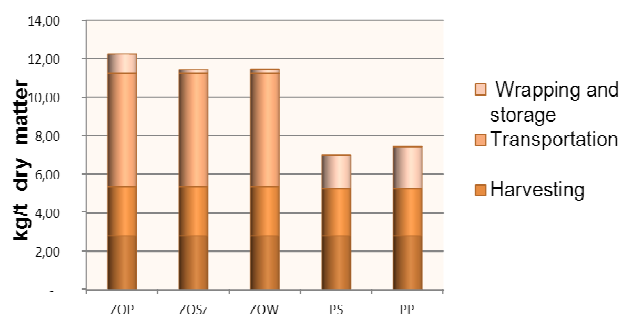
Source: own work / Źródło: opracowanie własne

Fuel prices as well as some other materials involved in described research program were taken according to the level of 2010 year. Besides that, authors made the following assumption: average yield of green fodder was equal to 15 t·ha⁻¹, green fodder moisture content during harvesting was equal to 80%, but during taking fodder from the field the same parameter was equal to 60%. Concerning costs of one working hour, it was equal to 12 PLN [10].

3. Research results

Fuel consumption capacity is the most often characterized by fuel consumption per area of planted fodder or unitary weight of wilted green forage during taking it from the field or based on the weight of dry matter of obtained fodder. Fuel consumption with respect to 1 tonne of dry matter weight per wagon varied and is presented on figure 1. The lowest fuel consumption technologies are characterized by PS and PP respectively, and equal to 6.99 kg · t⁻¹ of dry matter. and 7.43 kg · t⁻¹ of dry matter.

Fuel consumption for harvesting of green fodder



Source: own work / Źródło: opracowanie własne

Fig. 1. Fuel consumption for harvesting and ensiling forage using various technologies

Rys. 1. Zużycie paliwa na zbiór i zakiszanie zielonki według różnych technologii

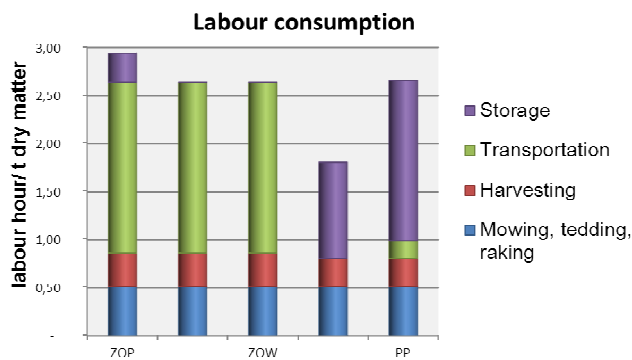
Whereas the most fuel consumption has proved to be ZOP technology, for which total consumption was equal to 12.24 kg · t⁻¹ of dry matter and it was due to many factors applied for ensilage of green fodder in the compressed form. Analyzing the structure of fuel consumption it can be seen, that the press baler technology with the largest share of total fuel consumption falls on operations related to loading and transportation of bales and is equal to 48.0% for technology ZOW, but for technologies ZOSZ and ZOW - approximately to 51.0% of overall fuel consumption, while technology with pick up trailer the following operations have the largest share: mowing, tedding and raking, respectively, and they are connected with technologies PS - 40.1% and PP - 37.7%.

Value of labor consumption provided during collection and maintenance of wilted green fodder, using different sets of machinery is shown in figure 2. On individual charts we can see that the biggest expenditures are present in ZOP technology - when wrapping a single bales and are equal to 2.94 labour hour · t⁻¹ dry matter, but the lowest are in technology PS - 1.80 labour hour · t⁻¹ dry matter or pick up trailer and storing chaff into silo, which were affected both by performance and the number of workers involved. Analyzing the structure of workload we can see that it varied in different technologies.

In technologies with round baler press, the largest share in total labour costs are allocated to operations of transportation and loading of bales and are equal: technology ZOP - 60.3%, but for technologies ZOSZ and ZOW approximately 67.0%. Concerning technologies with pick up trailer the largest share of total labour consumption is connected with storage operations, respectively for technology PS - 55.4% and for technology PP - 67.5%, as a result of need to recruit more people working on a prism than in a silo. Labour consumption for different technologies and different operations is presented in figure 2.

Expenses occurred for the operations of mowing, tedding and raking are equal to 0.52 labour hour / t⁻¹ of dry matter in all technologies. In contrast, labour input using set of round baler press are equal to 0.29 labour hour · t⁻¹ of dry matter, and pick up trailer - 0.27 labour hour · t⁻¹ of dry matter.

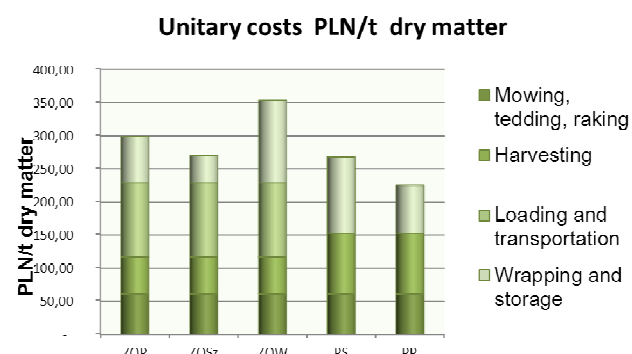
Unitary costs of silage production taking into account its structure of operations is illustrated in figure 3.



Source: own work / Źródło: opracowanie własne

Fig. 2. Labour consumption for tested technologies and labour input during individual operations

Rys. 2. Nakłady robocizny dla badanych technologii oraz udział nakładów robocizny ponoszonych na poszczególne operacje



Source: own work / Źródło: opracowanie własne

Fig. 3. The unitary costs of silage production using various technologies, but especially taking into account individual operations

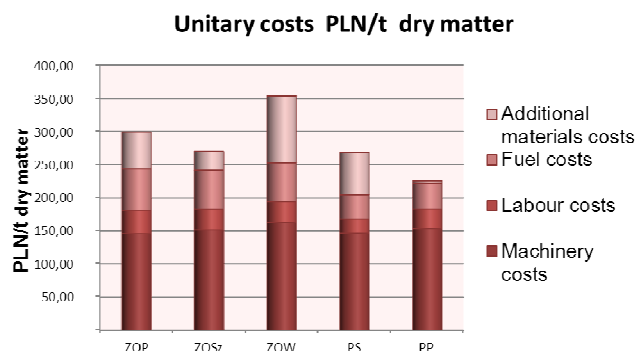
Rys. 3. Koszty jednostkowe produkcji kiszonek wg różnych technologii z wyszczególnieniem struktury uwzględniającej operacje technologiczne

As you can see the highest unitary costs are characteristic of technology ZOW (353.80 PLN · t⁻¹ of dry matter), and the lowest costs were presented by technology PP (225.60 PLN · t⁻¹ of dry matter). In technology ZOW dominating costs provided operations of wrapping and storage and amounted to 125,20 PLN · t⁻¹ of dry matter (35.4%), which in technology ZOSZ were the smallest ones and amounted to 41,50 PLN · t⁻¹ of dry matter, what makes approximately 15% of the total unitary cost. In the most popular technology in our country – ZOP, which represents costs for wrapping and storage of bales amounted to 70,40 PLN · t⁻¹ of dry matter, which represents 23.5% of the total costs equal to 299.0 PLN · t⁻¹ of dry matter. At this technology as well as technology ZOSZ the most predominant operations are: loading and transportation of bales, which represents costs equal to 111,90 PLN · t⁻¹ of dry matter.

In technologies PS and PP costs relating to collection and transportation of green fodder have been combined, because these operations are performed simultaneously by the same aggregate and are equal to 91,30 PLN · t⁻¹ of dry matter. However, costs associated with storage and covering of chaff in technology PP are equal to 72.70 PLN · t⁻¹ of dry matter and are lower than in the technology PS,

which is defined as 115.30 PLN · t⁻¹ of dry matter and they are slightly less than half of the total cost of this technology PS (268.19 PLN · t⁻¹ of dry matter). However, the costs of mowing, tedding and raking in these variants are identical to the other operations and equal to 61,60 PLN · t⁻¹ of dry matter.

Figure 4 shows total unitary costs occurred during collection and maintenance of low green stalk fodder, and also their structure divided into the costs of utilized machinery, technical equipment, labour, fuel and additional materials.



Source: own work / Źródło: opracowanie własne

Fig. 4. Unitary costs of silage production using different technologies, taking into account share of machinery input, labour consumption and finally fuel and auxiliary materials costs

Rys. 4. Koszty jednostkowe produkcji kiszonek wg różnych technologii z uwzględnieniem udziału maszyn, pracochłonności, zużycia paliwa i materiałów pomocniczych

With the values shown in the graphs you can see that costs of utilized machinery and equipment had the greatest impact in all tested technologies on overall costs and are in the range from the highest using technology ZOW and equal to 162,20 PLN · t⁻¹ of dry matter (45.8%) to the lowest ones in case of ZOP technology and equal to 145,60 PLN · t⁻¹ of dry matter which takes 48.7% of the total costs.

The highest cost associated with the use of auxiliary materials is presented in technology ZOW - 101.43 PLN · t⁻¹ of dry matter, which represents 28.7% of the total cost. It is influenced by the purchase price of a plastic bag to protect bales. The lowest cost was generated by auxiliary materials that can be seen in PP technology, it represents only 4,20 PLN · t⁻¹ of dry matter (1.9% of total costs). PS technology in a variant of cost of auxiliary materials amounting to 64,50 PLN · t⁻¹ of dry matter (24.1% of total cost), it is so high, because it was taken into account the high cost to build the flat silo for silage storage.

4. Conclusions

The lowest unitary fuel consumption is characteristic of technology with pick up trailer and storing chaff in the silo - PS (6.99 kg⁻¹ of dry matter), but the highest one was in case of technology with single bales wrapping system - ZOP (12.24 kg t⁻¹ of dry matter). The structure of fuel consumption has the largest share in all technologies which included operations of mowing, tedding and raking.

The smallest labour consumption was presented by technology with pick up trailer collecting and storing chaff in the silo - PS (1.80 labour hour · t⁻¹ of dry matter), but the highest

one was noticed in technology with round baler and wrapping bales by foil – ZOP (2.94 labour hour · t⁻¹ of dry matter).

The smallest unitary costs of silage production occurred when using pick up trailer in technology with collecting and storage of plant material in a pile - PP (225.60 PLN · t⁻¹ of dry matter), but the highest cost of technology was represented by single round baler and bale wrapping system - ZOP (353.80 PLN · t⁻¹ of dry matter).

In round baler technology operations related to storage plant material for silage have the highest share in total unitary costs - ZOW equal to 125,20 PLN · t⁻¹ of dry matter (35.4%). In two other technologies ZOP and ZOSZ dominant costs are: loading and transportation of bales and are equal to 111,90 PLN · t⁻¹ of dry matter. However in technologies PS and PP significant costs are: harvesting and transportation equal to 91,30 PLN · t⁻¹ of dry matter, but technology PS has the highest storage costs which are defined as 115.30 PLN · t⁻¹ of dry matter.

Machinery and equipment have the greatest share of labor costs in the structure of total unitary costs with regard to machinery, fuel consumption, work load and auxiliary materials in all technologies and are in the range from largest technology ZOW equal to 162,20 PLN · t⁻¹ of dry matter (45.8%). In case of smallest technology ZOP 145,60 PLN · t⁻¹ of dry matter which is equal to 48.7% of total costs. In addition, some technologies have high proportion of auxiliary material costs as in the technology ZOW - 101.43 PLN · t⁻¹ of dry matter but in technology PS is equal to 64,50 PLN · t⁻¹ of dry matter (24.1% of total costs) and it was taken into consideration the high cost of flat silo construction.

5. References

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