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ASSESSMENT OF OPERATION EFFICIENCY OF THE SELECTED TRANSPORT MEANS IN THE FARMS OF SOUTHERN POLAND

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Abstract. The objective of the paper was to determine the efficiency of transport means on the example of the selected farms of the southern Poland. Operation efficiency of means was expressed through performance of transports and the amount of work time and labour inputs. The research covered 9 farms located in Małopolska region. Based on the analysis of work time structure and labour inputs and performance of transport means operation, one may clearly state that the work efficiency of the selected means for the transport of the analysed load is very low. The highest labour inputs were incurred for the transport of vegetables with a tractor with a tractor wagon and the lowest for transport of fertilizers with a tractor with a trailer. The set composed of a tractor and two trailers achieved the highest performance among the analysed means through high loading capacity and a high index of load capacity use.

Key words: transport, transport means, assessment, efficiency, inputs, performance

Introduction

Agricultural production is irretrievably related to the constant relocation of production means as well as produce not only within the farm but also outside it. Specification of agricultural production causes that transport belongs to the most difficult link of supply and distribution (Parafiniuk, 2006; Kuboń, 2008). The number and assortment of transport means depends on the used machines, technology of production as well as a seasonal character of works. Appropriate selection of transport means at proper organization of works and rational determination of demands and inputs related to the performance of transport constitutes a basis for the correct functioning of agricultural production. Taking into consideration the fact that mainly farms themselves execute transport tasks - which forces them to have their own transport means – it is justifiable to constantly deal with the issue of

efficiency of operation of the said means. Present economic reality forces farmers to make compromise between the quality and efficiency of the machine labour and the costs of its purchase, therefore it is very important to rationally use the owned transport means. Lowering the costs of agricultural production including the costs of transport service at ensuring the proper quality of produce relocation is especially significant.

According to the literature sources, inputs incurred in a farm for transport constitute 40-60% of the total time of mechanical tractive force labour and 30-40% of total labour inputs. Simultaneously, mechanization of loading activities becomes significant in transport works as these works absorb even 60-70% of labour inputs and 40-50% of work time of tractive force in the transport (Kokoszka et al., 2002; Parafiniuk, 2006; Kuboń, 2008). According to the research of Kokoszka and Kuboń (2002b; 2005a,b) increase of the index of loading works mechanization by 10% causes decrease of inputs of work time of the means by 3.71% and labour at the average by 6.65%. According to the same authors (1999a, b) increase of the load capacity use from 0.3 to 1.0 causes the decrease of work time inputs per one tonne of the transported load by 65% and lowering the costs of transport by 70%. Load capacity of the transport means as well as transport distance are significant in the size of the inputs incurred for transport. For example increase of the load capacity of the tractor set from 1.5 to 8 tonnes causes the decrease of work time inputs per one tonne of the transported load by 82.3% and lowering the costs of transport by 75.90%.

Previous research concerning agricultural transport simultaneously shows that the assessment of efficiency of transport means exploitation in agricultural farms meets numerous obstacles (Kuboń, 2005a). Complexity of the problem results mainly from the difficulties of determination of basic indices of effectiveness related to the wide assortment of the transported loads, specific conditions of performing transports and varied distance of transport.

The objective and scope of the paper and research methodology

The objective of the paper was to assess the efficiency of operation of transport means in the selected farms of the Southern Poland. Efficiency of the operation of means was expressed through performance of transports and the amount of work time and labour inputs at the transport of the selected groups of goods..

The scope of research covered 9 farms located on the territory of 3 communes of Tarnowski province in Małopolskie Voivodeship. Objects for research were selected randomly but the main criteria of selection was whether a farm owned transport means (a tractor wagon,a trailer, a delivery car or a truck).

Research was carried out at the turn of 2010/11 and consisted in two parts: first part – survey – concerned general characteristic of a farm, the second included detailed timings of operation time of the selected transport means.

The research covered 5 the most frequently occurring transport sets, which were compared on account of transport efficiency and incurred inputs. Transport means differed from each other with technical, exploitation parameters and with structure. Load capacity may be, inter alia, included to the first group and the mass of the transported load and the speed with which the load is transported to the second group. Mass of the transported load

in connection with the load capacity reflects the use of potential technical means whereas in connection with the transport speed decides on the performance.

The following transport sets were analysed:
- SET A – tractor + tractor wagon (grains – 10 repeats, root crops – 12 repeats, green forage – 6 repeats, fertilizers – 9 repeats);
- SET B – tractor + trailer (grains – 26 repeats, root crops – 18 repeats, green forage – 10 repeats, fertilizers – 12 repeats),
- SET C – tractor + two trailers (grains – 20 repeats, root crops – 18 repeats),
- SET D – tractor + spreader (grains – 16 repeats, root crops – 14 repeats, green forage – 11 repeats, fertilizers – 6 repeats),
- SET E – truck (wheat – 6 repeats, root crops – 13 repeats, fertilizers – 10 repeats).

Characteristics of the transport process

Effectiveness of the transport means exploitation in farming is measured with various indices. It depends, inter alia, on the equipment with transport means, organization of work and conditions of performing transports. Transport performance, which results from cooperation of many factors of technical nature (type and characteristic of the transport means), organizational (organization of means operation) and exploitation (conditions of means operation) belong to the basic measures allowing assessment of effectiveness of the used transport means. Time of the means operation is one of the basic elements which affect the efficiency and results of work. On account of the specific agricultural transport features (inter alia the seasonal character of transports), inputs of the work time of means and people are particualrly high, whereas the use of means throughout the whole year is small and varied depending on work conditions and the size of an agricultural farm (Kuboń, 2002a). Table 1 presents the basic parameters characterising the transport process and table 2 an average time of duration of the transport cycle of the accepted transport sets with division into particular loads. The highest load capacity was reported for C set – 8.29, the lowest for the set A – 1.49. The table also presents the index of using the load capacity and the run of the means as indices, which also affect the work efficiency and at the same time decide on the costs of transport. The highest index of using the load capacity was reported in case of a truck (0.93) and the lowest for the set with a tractor and a spreader (0.16). The use of the run for all sets was at the level from 0.50 which proves that the loads were transported only in one direction. This phenomenon is unfavourable for performance of the transport process but is unavoidable in agriculture.

The longest average time of the cycle was for the transport of vegetables with a truck – 11.82 h. It results from very low level of mechanization of loading works and considerably higher transport distances. Whereas, the shortest average time of the cycle was reported at the use of a tractor with a wagon for transport of beets – 1.89 h.

Table 1.
Basic parameters, which characterize the transport process

Load type	Parameter	Type of the transport set				
		C+2P	C+P	C+R	C+W	SC
Sugar beets	Average load capacity of the set (t)	8.25	3.42	3.11	1.75	-
	Use of the load capacity (-)	0.81	0.89	0.89	0.84	-
	Use of the run (-)	0.5	0.5	0.5	0.5	-
Fertilizers	Average load capacity of the set (t)	-	3.32	2.94	1.7	6.0
	Use of the load capacity (-)	-	0.5	0.54	0.41	0.75
	Use of the run (-)	-	0.5	0.5	0.5	0.5
Vegetables	Average load capacity of the set (t)	-	4.38	3.33	1.83	5.83
	Use of the load capacity (-)	-	0.65	0.66	0.49	0.93
	Use of the run (-)	-	0.5	0.5	0.5	0.5
Grain seeds	Average load capacity of the set (t)	8.29	4.65	3.66	1.49	6.93
	Use of the load capacity (-)	0.74	0.72	0.65	0.67	0.7
	Use of the run (-)	0.5	0.5	0.5	0.5	0.5
Green forage	Average load capacity of the set (t)	-	3.64	3.83	2.0	-
	Use of the load capacity (-)	-	0.39	0.16	0.32	-
	Use of the run (-)	-	0.5	0.5	0.5	-

C+2P – tractor with two trailers; C+P – tractor with a trailer; C+R – tractors with a spreader; C+W – tractor with a tractor wagon; SC – truck

Table 2.
Average time of cycles of transport sets for particular loads (h)

Load type	Type of the transport set				
	C+2P	C+P	C+R	C+W	SC
Sugar beets	5.21	3.99	3.86	1.89	-
Fertilizers	-	2.87	2.5	2.35	3.38
Vegetables	-	6.54	4.98	2.26	11.82
Grain seeds	6	2.84	2.97	2.70	5.1
Green forage	-	3.21	2.95	2.53	-

Results of the research

Performance and the effects of transport means operation depend on the duration and effective use of the transportation cycle. By shortening and maximum use of the time of transport means operation we obtain specific economic advantages e.g. in the form of decreasing the incurred work time or labour inputs. Therefore, we also obtain immeasurable economic effects but equally significant affecting our work and well-being (Kuboń, 2002a).

Figure 1 presents the time structure of transport means operation, which transport determined loads. The following types of loads were accepted for research: fodder beet, fertilizers (agricultural limestone), vegetables, grains, green forage. Timings of work time of means prove that loading was the most time consuming activity. Loading fertilizers and

vegetables was the longest, it was approx. 57-58% of all loading activities and loading of beets was the shortest. For all loads stoppages lasted at the average 23% and the drive 19% in comparison to the loading activity. Unfavourable structure of work time results mainly from low mechanization of loading works, resulting from harvesting technology. In majority of farms, harvesting was manual.

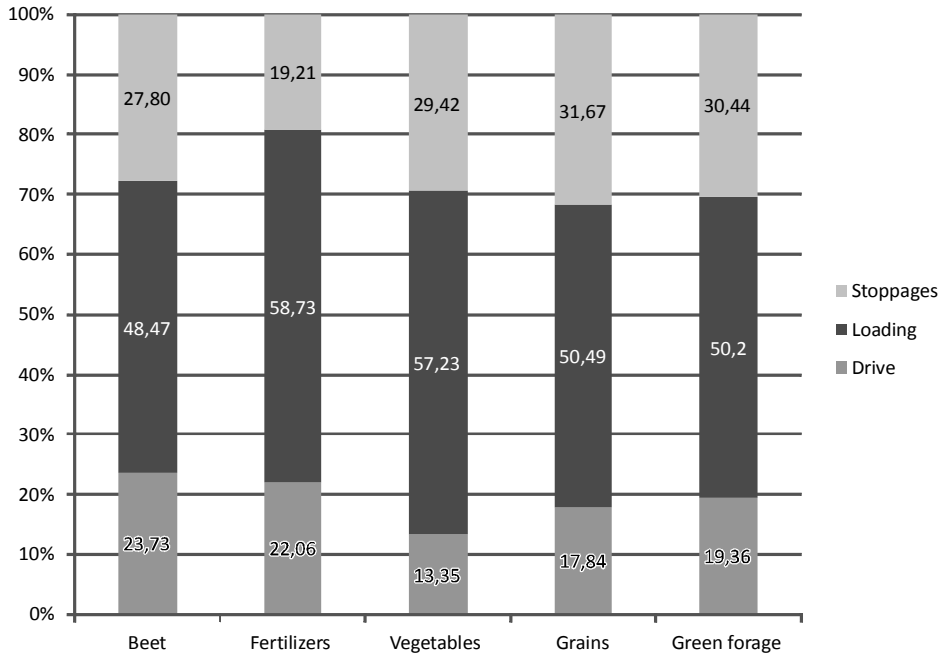

Figure 1. Structure of work time in the aspect of the transported load (%)

When analysing the structure of work time in the transport process in the aspect of the transport means type (fig. 2) similar relations and proportion as in case of the structure of work time for the transported loads were reported. The highest participation in the structure of work time was taken by loading activities (38.7-55.0%) and the lowest for halts (12.2-36.9%).

Effective time (T_1) means time, in which a machine operates according to its destination and its elements are loaded. Contrary to it, the exploitation time (T_{07}), next to the effective time includes also all losses of work time, resulting from reasons attributable and non-attributable to the method of the researched process.

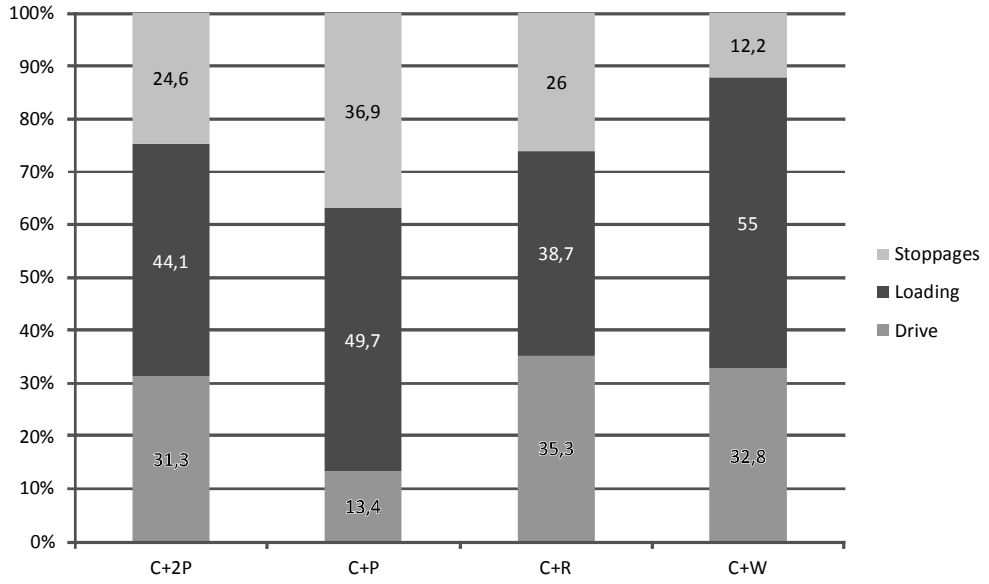

Figure 2. Structure of work time in the aspect of the type of the transport means of the load (%)

Table 3 presents the amount of the incurred inputs of time of transport means operation. Based on the given amounts, one may notice, that the highest differences between the particular transport means concern exploitation time T_{07}. The lowest work time inputs were reported for transport of beets with set A (1.89 h) and were by approx. 2.7 times lower than the transport of the same load with set C. The highest inputs of work time occurred in case of transport of vegetables with set E (11.82 h). For transports of fertilizers, differences between the lowest and the highest work time input were slight. The highest increase of input in comparison to the effective time (T_1) occurred in the operational time (T_{02}). The highest index of growth in time T_{02} was reported in case of a tractor with two trailers for transport of beets (16.2) and the lowest for a tractor with a tractor wagon for transport of fertilizers (4.4). In case of tractor wagons, loading is considerably simplified on account of low located and opened loading box. For the working time (T_{04}) the highest increase of the index was reported also in case of a tractor with 2 trailers in case of transport of beets (17.3) and the lowest for a tractor with a spreader in case of transport of fertilizers (5.6). Concluding, one has to state that from among transport means the highest increase of operation time ocurrs during transport of vegetables with a truck (11.82 h).

For effective course of operation processes, a high degree of use of the exploitation time, measured with high participation of the effective time in the exploitation time (K_{07}) is of significance. It is possible only when losses of time related to non-load crossings and

stoppages resulting from other reasons are limited to the minimum. Thus, value of this index depends slightly on the degree of the technical means itself.

Table 3.
Operation time of transport means in the aspect of transport means and the transported load

Load type	Transport means	Collective work time			
		T_1	T_{02}	T_{04}	T_{07}
Sugar beets	C+2P	0.20	3.23	3.46	5.21
	C+P	0.27	2.59	2.74	3.99
	C+R	0.21	2.31	2.48	3.86
	C+W	0.16	1.40	1.54	1.89
Fertilizers	C+P	0.38	2.06	2.37	2.87
	C+R	0.39	1.87	2.20	2.52
	C+W	0.33	1.46	1.96	2.35
	SC	0.33	2.38	2.53	3.38
Vegetables	C+P	0.36	3.29	4.84	6.54
	C+R	0.64	3.40	3.93	4.98
	C+W	0.10	1.53	1.72	2.26
	SC	1.06	6.95	9.32	11.82
Grains	C+2P	0.46	4.23	5.24	6.00
	C+P	0.30	1.96	2.53	2.84
	C+R	0.21	2.24	2.62	2.97
	C+W	0.27	1.86	2.23	2.70
	SC	0.62	2.85	4.18	5.10
Green forage	C+P	0.18	2.07	2.98	3.21
	C+R	0.11	1.72	2.62	2.95
	C+W	0.14	1.48	2.32	2.53

Table 4 presents inputs of labour per a tonne of the transported load for particular transport means. Labour inputs in the exploitation time were within 1.19 and 12.23 man hour per tonne of the transported load. The highest labour inputs were incurred for transport of vegetables with a tractor with a tractor wagon and the lowest for transport of fertilizers with a tractor with a trailer.

Table 4.
Labour inputs in the aspect of transport means and the transported load

Load type	Type of the transport means	T_1	T_{02}	T_{04}	T_{07}
		(man-hour·t^{-1})			
Sugar beets	C+2P	3.49	5.66	5.81	6.85
	C+P	1.61	2.31	2.38	2.78
	C+R	4.13	7.5	8.63	10.71
	C+W	2.17	3.28	3.44	3.63
Fertilizers	C+P	0.56	1.01	1.09	1.19
	C+R	2.51	4.05	4.05	4.52
	C+W	4.95	5.28	5.45	5.76
	SC	1.19	1.65	1.66	1.86
Vegetables	C+P	0,96	1,8	2,19	2,25
	C+R	1,87	3,01	3,32	3,97
	C+W	5,45	8,7	10,16	12,23
	SC	1,09	2,05	2,67	2,88
Green forage	C+P	1.47	2.22	2.28	2.79
	C+R	1.35	2.1	2.1	2.31
	C+W	3.66	5.8	6.34	7.21
Grains	C+2P	1.07	1.71	1.76	2.19
	C+P	1.69	2.74	3.11	3.32
	C+r	1.82	3.05	3.32	3.72
	C+w	5.12	7.82	9.15	11.31
	Sc	2.63	4.43	4.94	5.77

Performance is a ratio of the amount of the transported load to the duration of the transport cycle expressed in tonnes per hour. In order to show impact of duration of loading activities and stoppages, performance of transports was presented in the effective time (T_1), operational time (T_{02}) and exploitation time (T_{07}). Table 5 presents performance of transport of transport means in relation to the transported load.

Effective performance depends considerably on the driving time with a load, load capacity of the means and its use. A set C with a tractor and 2 trailers achieved the highest performance for transport of beets (35.64 t·h^{-1}), and a tractor with a tractor wagon the lowest for transport of fertilizers (2.57 t·h^{-1}). A tractor with two trailers achieved the highest performance among the analysed means through high loading capacity and a high index of the load capacity use. Operational performance W_{02} is affected in particular by loading works and technological stoppages related with it. Kuboń and Tabor (2005) confirm it in their research. For transport of grains and green forage, the biggest difference in the operational performance was reported. For transport of grains with a truck it was the highest value and was 2.37 t·h^{-1} and for green forage with a tractor with a spreader – the lowest value (0.35 t·h^{-1}).

Table 5.
Performance of transport of transport means

Load type	Type of the transport means	Performance ($t \cdot h^{-1}$)			
		W_1	W_{02}	W_{04}	W_{07}
Beets	C+2P	35.64	2.2	2.09	1.44
	C+P	18.45	1.33	1.26	0.97
	C+R	16.81	1.34	1.25	0.8
	C+W	12.05	1.14	1.04	0.94
Fertilizers	C+P	6.51	0.88	0.81	0.70
	C+R	6.07	0.95	0.87	0.74
	C+W	2.57	0.45	0.37	0.32
	SC	13.5	1.86	1.73	1.40
Vegetables	C+P	10.1	0.84	0.63	0.45
	C+R	6.60	0.76	0.71	0.58
	C+W	11.52	0.56	0.53	0.42
	SC	8.07	0.82	0.62	0.49
Grains	C+2P	19.81	1.56	1.19	1.02
	C+P	8.17	1.01	0.83	0.76
	C+R	12.52	1.07	0.96	0.87
	C+W	6.77	0.67	0.57	0.48
	SC	20.15	2.37	1.40	1.22
Green forage	C+P	9.61	0.69	0.52	0.48
	C+R	7.19	0.35	0.24	0.21
	C+W	5.28	0.41	0.26	0.24

Operational performance W_{04} is affected not only by loading activities but also technical stoppages and stoppages related to the removal of technical and technological faults. The biggest decrease of performance was reported at the transport of grains and green forage. In case of grains, decrease of performance was from 40.9% to 10.3% and in case of green forage from 36.6% to 24.6%. The lowest was in case of transport of beets and fertilizers - 17% to 5%.

Exploitation performance includes all time losses during the transport process and is the most reliable in comparative analyses. The highest exploitation performance was reported for set C (a tractor with two trailers) for transport of beets – 1.44 $t \cdot ha^{-1}$, which constituted 65% of operational performance and 4% of effective performance. The lowest was reported for set D (a tractor with a spreader) for transport of green forage – 0.21 $t \cdot ha^{-1}$, which constituted 60% of operational performance and 2.9% of effective performance. A visible, high decrease of performance of transports results mainly from a low level of loading

works, resulting from the applied harvesting technology and frequent stoppages caused by faults of technical means. Both in the first as well as in the second case, a manner of loading and unloading had significant impact on the obtained indices.

Conclusion

Based on the analysis of work time structure and labour inputs and performance of transport means operation, one may clearly state that the work efficiency of the selected means at the transport of the analysed load is very low. It results mainly from:
- low use of load capacity (0.16 to 0.93),
- low use of run - 0.5 for all sets,
- labour consuming technologies of harvesting,
- low mechanization of loading works,
- frequent faults of technical means (base machines as well as transport means).

Labour inputs in the exploitation time are within 1.19 and 12.23 man hour per tonne of the transported load. The highest labour inputs were incurred for transport of vegetables with a tractor unit and the lowest for transport of fertilizers with a tractor with a trailer. A tractor with two trailers achieved the highest performance for transport of beets (1.44 $t \cdot h^{-1}$), and a tractor with a tractor wagon the lowest for transport of fertilizers (0.32 $t \cdot h^{-1}$). For transport of grains and ferilizers, the biggest difference in the operational performance was reported. For transport of grains, the decrease of the operational performance in relation to effective was from 87.6 to 92.1% and fertilizers from 86.2 to 82.5%. Improvement of situation in this scope may be carried out through:
- modification of harvesting technology (more effective machines and full mechanization of load).
- increase of unit batches of load,
- increase of the use of transport means load capacity,
- the use of means with bigger load capacity and exploitation speed for transport,
- better organization of the machines and transport means operation.

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OCENA EFEKTYWNOŚCI PRACY WYBRANYCH ŚRODKÓW TRANSPORTOWYCH W GOSPODARSTWACH POLSKI POŁUDNIOWEJ

Streszczenie. Celem pracy było określenie oceny efektywności środków transportowych na przykładzie wybranych gospodarstw Polski południowej. Efektywność pracy środków wyrażono poprzez wydajność przewozów oraz wysokość nakładów czasu pracy i robocizny. Zakresem badań objęto 9 gospodarstw rolniczych położonych w rejonie małopolskim. Na podstawie przeprowadzonej analizy struktury czasu pracy i nakładów robocizny a także wydajności pracy środków transportowych można jednoznacznie stwierdzić, że efektywność pracy wybranych środków przy przewozie analizowanych ładunków jest bardzo niska. Największe nakłady robocizny ponoszono na transport warzyw ciągnikiem z wozem ciągnikowym, a najmniejsze na transport nawozów ciągnikiem z przyczepą. Zestaw ciągnik z dwoma przyczepami poprzez dużą ładowność oraz wysoki wskaźnik wykorzystania ładowności osiągnął wśród analizowanych środków największą wydajność.

Słowa kluczowe: transport, środek transportowy, ocena, efektywność, nakłady, wydajność

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