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MODEL METHOD FOR ECONOMICALLY REASONABLE CHOICE OF AGRICULTURAL MACHINE

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A b s t r a c t

The model for estimation the operation costs of machine according to the price of machine, its repair costs and working capacity has been elaborated. The model enables to determine the effect of amount of work and the machine parameters like working capacity and rate of repair costs on operation cost of machines. Simulation studies carried on for 5 different types of harvester threshers have shown that the operation cost per hour of the work of machine growths as the working capacity and price of machine increases. The operation cost per hectare of cereal harvested decreases as the working capacity increases even if price of machine growths, but only under condition of sufficient annual use. Decrease of the area to be harvested cause that operation costs grow, both per one hour and per hectare. The rate of growth is the higher the higher is the working capacity of machines. Amount of work to be done is a significant factor that should be taken into consideration when choosing the type of machine for particular farm. Use of high capacity and expensive machines is economically justified only in a case of possibility to achieve their sufficient annual use.

METODA MODELOWA EKONOMICZNIE UZASADNIONEGO DOBORU MASZYN ROLNICZYCH

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S ł o w a k l u c z o w e: model, studia symulacyjne, kombajn zbożowy, koszt eksploatacji, dobór, metoda.

S t r e s z c z e n i e

Opracowano model umożliwiający szacowanie kosztów eksploatacji maszyn w zależności od ich cen, kosztów napraw i wydajności eksploatacyjnych. Studia symulacyjne przeprowadzone na przykładzie 5 różnych typów kombajnów zbożowych wykazały, że koszt eksploatacji odniesiony do godziny pracy maszyny rośnie w miarę zwiększania wydajności i ceny maszyny. Koszt eksploatacji w przeliczeniu na hektar powierzchni zbioru zbóż maleje w miarę wzrostu wydajności pracy mimo wyższej ceny maszyny, jednak pod warunkiem dostatecznego rocznego jej wykorzystania. Zmniejszanie powierzchni przeznaczonej do zbioru powoduje, że rosną koszty, zarówno w przeliczeniu na godzinę, jak i na hektar wykonanej pracy. Stopień tego wzrostu jest tym większy, im wyższa jest wydajność maszyn. Ilość pracy do wykonania jest znaczącym czynnikiem, który powinien być brany pod uwagę przy doborze typu maszyny dla konkretnego gospodarstwa. Zastosowanie wysokowydajnej i drogiej maszyny jest ekonomicznie uzasadnione tylko w przypadku możliwości uzyskania dostatecznie wysokiego jej rocznego wykorzystania.

Introduction

Rational choice of agricultural machines is necessary as a condition of high efficiency of farm mechanization. When making decision about purchasing of machine the potential buyer takes into consideration several factors. One of most important is the price of the machine. The price determines first of all the investment cost, but it also effects such elements of operation costs like depreciation, interest and storage. However, not always more expensive machine creates higher unitary costs. Sometimes operation costs of advanced, more reliable and productive machine are lower as compared to a less expensive, but also less reliable and less productive one. Therefore, the choice of machine should be preceded by a careful economic analysis.

The purpose of this paper is to present the model for estimation the operation costs of machine according to the price of machine, its repair costs and working capacity. Simulation studies will be carried on and discussed, using this model. Exemplary calculations will be made for 5 different types of the harvester thresher.

The model

Choice of machines suited to the needs of the farm concerned is an important step to successful mechanization. Therefore, before making decision about purchase of a machine the careful analysis of future results has to be made. Proper equipment in farm machinery is one of conditions to achieve high efficiency of the technological advance (MICHAŁEK, KOWALSKI 1993, MICHAŁEK et al. 1998). To make this analysis easier, the model basing on cost calculation methods (BUCKETT 1988, MUZALEWSKI 2004, 2005, PAWLAK 2006) has been elaborated. Operation costs of agricultural machines are the sum of depreciation, interest, storage and conservation, insurance, repair and maintenance and energy. They can be described by the following formula:

$$KE = \frac{Cm}{Tn} + \frac{0.5o \cdot Cm}{100Tr} + \frac{m \cdot Cm}{Tr} + \frac{p \cdot ks}{Tr} + \frac{U}{Tr} + \frac{k \cdot Cm}{Tn} + Zp \cdot Cp \cdot M \quad \text{(PLN/h)} \tag{1}$$

where:
KE – operation costs, PLN/h,
Cm – price of the machine, PLN,
Tn – hours of work during the useful life of the machine, hours,

Tr – yearly use of the machine, hours,
o – the interest rate, %,
m – coefficient of the conservation cost related to the price of the machine,
p – space occupied by the machine in the storage place, m^2 ,
ks – cost of the unit of surface of the storage place, PLN/m^2,
k – coefficient of repair costs related to the price of the machine,
U – rate of insurance, PLN/year,
Zp – unitary consumption of the fuel, kg/kWh,
Cp – price of the fuel, PLN/kg,
M – power of engine, kW.

The formula (1) can be simplified as follows:

$$KE = Cm\left(\frac{1}{Tn} + \frac{0.5o}{100Tr} + \frac{m}{Tr} + \frac{k}{Tn}\right) + \left(\frac{p \cdot ks + U}{Tr}\right) + Zp \cdot Cp \cdot M \text{ (PLN/h)} \quad (2)$$

Following assumptions have been made when building the model. The maximal hours of machine work during the useful life (Tn) amounts to 3000. 15 years standard useful life (n) has been assumed. Therefore, the annual use (Wr) of at least 200 hours was necessary so that each machine could work out 3000 hours during its useful life. In a case of annual use higher than 200 hours, the number of years of the useful life becomes relatively lower. Instead, in a case of a lower annual use of machines, the useful life can be prolonged up to maximum 30 years, followed by the increase of the coefficient k by 30%. This increase has to be assumed so that the growth of repair costs as a result of prolonging the useful life of machine could be taken into account. In the range from 15 to 30 years of the useful life the increase of value of the coefficient k fluctuates between 0% and 30%. The increase is proportional to the prolongation of the useful life. In a case of annual use lower than 100 hours, the cost of depreciation grows.

There are two reasons of the wear of machines. One is a waste of elements and damages during the work. Decrease of hours worked causes costs related to this factor to decrease. This fact has been taken into account in the model in the form of reduction of the value of the coefficient k, proportionally to the decrease of the annual use of the machine. Another reason is the deterioration of materials caused by environment factors. This has also been taken into account by above-mentioned increasing the value of coefficient k in a case of prolonging the useful life of machines.

Results and discussion

The model has been used for simulation studies of harvest unitary costs using different types of harvester threshers. Five types of harvester threshers have been taken into consideration. Their characteristics are presented in Table 1.

Table 1

Characteristics of harvester threshers

Specification	Harvester thresher				
	A	*B*	*C*	*D*	*E*
Price, PLN	207 000	248 400	289 800	372 600	414 000
Engine power, kW	58	74	88	99	15
Fuel consumption, kg/kWh	0.215	0.198	0.176	0.165	0.151
Value of the coefficient *k*	1.0	1.0	1.0	0.85	0.85
Operational capacity, W_{07}	0.40	0.66	0.87	1.13	1.35

Source: own assumptions

Three variants of situation have been analyzed. The only difference between them is yearly use of particular harvester threshers, assumed for calculations. In the first scenario (variant I) all types of machines could achieve the annual use of 200 hours. In the second (variant II) the assumption has been made that the amount of work to be done in all cases was equal: 80 hectares. As the particular harvester threshers have different working capacity, the annual use of each of them is also different. In the third variant the area of cereals to be harvested is equal, but it is by 50% lower as compared to the variant II.

Analysis of the first scenario shows that the operation cost per hour of the work of harvester thresher growths as the working capacity and price of machine increases. However, in a case of machines *D* and E the dynamic of growth of the cost is by 15 per cent lower than the rate of the increase of price. It is a result of the lower repair costs rate for harvester threshers *D* and *E* due to their higher quality. The operation cost per hectare of cereal harvested decreases as the working capacity and price of machine growths (Fig. 1).

When the area of cereals to be harvested is limited, the annual use of machines decreases as their operational capacity W_{07} growths (Table 2).

Drop of the annual use causes the useful life (n) of machines (in years) to increase and changes of values of the coefficient k. This was taken into account in the list of input data for calculations (Table 3).

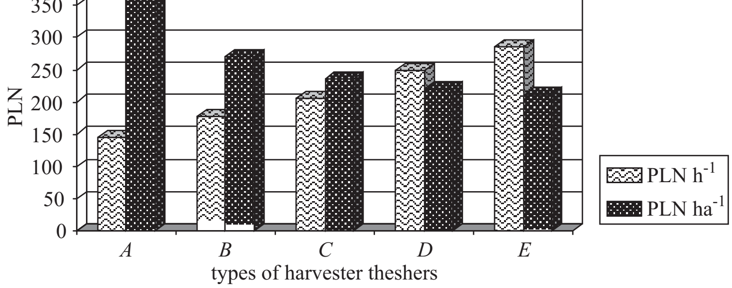

Fig. 1. Unitary operation costs of particular harvester thresher with annual use of 200 hours

Table 2

Annual use of harvester threshers in cases when area of cereals to be harvested is nit limited (variant I), when it is limited to 80 hectares (variant II) and when it is limited to 40 hectares (variant III)

Variants	Annual use in hours for harvester threshers				
	A (W_{07}=0.40)	*B* (W_{07}=0.66)	*C* (W_{07}=0.87)	*D* (W_{07}=1.13)	*E* (W_{07}=1.35)
I	200	200	200	200	200
II	200	121	92	71	59
III	100	61	46	35	30

Source: own calculations

Table 3

Input data for calculations

Symbols of data	Variants	Harvester threshers				
		A	*B*	*C*	*D*	*E*
n, years	I	15	15	15	15	15
	II	15	25	30	30	30
	III	30	30	30	30	30
k	I	1.00	1.00	1.00	0.85	0.85
	II	1.00	1.21	1.20	0.78	0.65
	III	1.30	0.79	0.60	0.39	0.33
o, %	I, II, III	5	5	5	5	5
m	I, II, III	0.04	0.04	0.04	0.04	0.04
p	I, II, III	24	34	36	40	45
ks, PLN	I, II, III	100	100	100	100	100

Source: own assumptions and calculations

Analysis of changes caused by 80 hectares limit of the harvested area (variant II) shows that operation costs both per one hour and per hectare grows. The rate of growth is the higher the higher is the working capacity of machines. The increase of the cost by 3% was registered in a case of the harvester thresher *C* and by 21% in a case of the harvester thresher *E*. Further decrease of the harvested area (variant III) causes increase of operation costs per hectare by 26% (machine *A*) and by 122% (machine *E*).

In all cases the cost per hour of the work of harvester thresher growths as the working capacity and price of machine increases. Still in the variant II the use of harvester threshers *B* and *C* creates operation costs by 13% and 12% lower as compared to the harvester thresher *A*. However, the use of machines *D* and *E* cause increase of the cost respectively by 3% and 14% (Fig. 2).

When the area of cereals to be harvested is limited to only 40 hectares, the increase of costs both per hour of work and per hectare increases as the working capacities and the prices of machines grow. The operation cost per hectare of the harvested area is in a case of harvester thresher *E* by 67% higher as in a case of the harvester thresher *A* (Fig. 3).

Above example show that the amount of work to be done is a significant factor that should be taken into consideration when choosing the type of

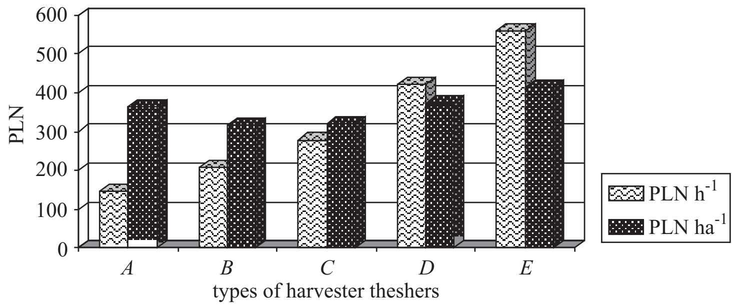

Fig. 2. Unitary operation costs of particular harvester thresher on farms with 80 ha of cereals and technologically similar crops

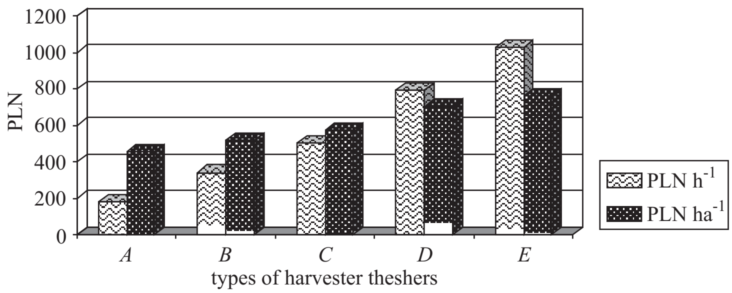

Fig. 3. Unitary operation costs of particular harvester thresher on farms with 80 ha of cereals and technologically similar crops

machine for particular farm. Use of high capacity and expensive machines is economically justified only in a case of possibility to achieve their sufficient annual use.

Conclusion

Examples of application of the proposed model for simulation studies show that it is useful for determination interdependencies between price and working capacity of machine and costs of its operation per hour as well as per unit of a work done. The model enables to determine the effect of amount of work and the machine parameters like working capacity and rate of repair costs on operation cost of machines.

Cost of operation per hour of work depends on price, rate of repair costs and the annual use of machine. Cost of operation per hectare of work depends on price, rate of repair costs, the annual use and working capacity of machine.

The operation cost per hour of the work of harvester thresher growths as the working capacity and price of machine increases.

The operation cost per hectare of cereal harvested decreases as the working capacity increases even if price of machine growths, but only under condition of sufficient annual use. Decrease of the area to be harvested cause that operation costs grow, both per one hour and per hectare. The rate of growth is the higher the higher is the working capacity of machines.

Amount of work to be done is a significant factor that should be taken into consideration when choosing the type of machine for particular farm. Use of high capacity and expensive machines is economically justified only in a case of possibility to achieve their high annual use.

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