THE CHOICE OF TECHNOLOGICAL VARIANTS OF SOIL TILLAGE AND SOWING FOR GROWING CEREALS

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Abstract

The article deals with a method for economically justified choice of machinery for the cultivation technologies of agricultural crops, cereal production being used as an example. The essence of the method is that minimum specific costs are determined for the discussed technological variants taking into account the amount of the performed work as well as the assessment of the selected tractor aggregate by the economical expediency of its operational width. Besides, the price of the tractor, its share related to a unit of the performed work is considered. The discussed technological variants differ by their technical equipment and the way the technological operations, such as ploughing, soil preparation and sowing, soil tillage without ploughing, separate sowing and loosening soil to a different depth, soil tillage with simultaneous sowing, are performed. The limits of economical efficiency of the discussed variants of soil tillage and sowing technology are determined depending on the amount of the performed operations.

Key words: Technology, technical equipment, aggregate, specific costs.

Introduction

Introduction of new technologies means additional capital investments in the renewal of technical means, which, in its turn, increases the depreciation costs that are one of the main components in the prime cost of the product. For example, in the cost structure of grain production they constitute 11...15%. The value of the specific depreciation costs related to a unit of the performed work is inversely proportional to the amount of the performed work or the obtained product, and, consequently, is dependent to a great degree on the volume of output of agricultural crops on the farm. Therefore application of modern technical means and technologies requires their optimum economical correlation with the amount of the performed operations.

The article has the following **aims:**

- Working out a method for the assessment of various variants of technical equipment for the technology of soil tillage and sowing cereals;
- Evaluation of variants and the choice of an optimum variant by the criterion of minimum costs.

Materials and methods

In order to achieve these aims and solve the tasks of the research, the following materials were used: scientific publications, specialised literature, data from Central Board of Statistics and SIA Vaderstad.

The methods applied in the research: logical constructive, monographic, logical analysis, statistic and graphic methods.

The research methodology of the technologies for agricultural crop cultivation includes the following main parts:

- *Processing of the input data for the flow sheet.*

By using the existing basic flow sheets, a technology is drawn up for the proposed crop to be cultivated.

- *Selection of possible technological variants for the technical equipment of the cultivated crop and the expected crop capacity (e.g. 5 tons/ha) on the basis of the drawn up flow sheets.*

The technological variants for the cultivation of the selected crop are determined taking into consideration the existing resources of the farm. The drawn up flow sheet contains the technical means which should ensure the execution of the technological operations considering agro technical requirements, or their fulfilment as paid services, as well as the production materials (seeds, fertilisers, chemicals, etc.) which are necessary to obtain the preset yield.

- *Data processing*

The accepted technological variants determine specific costs depending on different amount of the performed work according to the economical and mathematical model of their calculation [1] presented further. The economical and mathematical model of specific costs has the following appearance:

$$Z = \sum_{1}^{n} \left(\left(\mathbf{A_i} + \mathbf{TP_i} \right) \mathrm{K_i}\ \Omega^{-1} + \left(\mathbf{A_{ij}} + \mathbf{TP_{ij}} \right) \Omega_{\mathbf{ij}}^{-1} \right) + \sum_{\mathbf{1}}^{\mathbf{n}} \mathbf{C_i} + \sum_{\mathbf{1}}^{\mathbf{n}} \mathbf{C_i^I}$$

where: Z-specific costs, \$/ha; A_i – depreciation deductions of the energetic means for the **i**-th technological operation, \$; TP_i **-** deductions for the maintenance and repairs of the energetic means for the **i**-th technological operation, \$; K_i - the share of work of the **i**-th technological operation in the annual amount of work performed by the energetic means; Ω^{-1} **-** the annual amount of work performed by the energetic means, ha; A_{ij} - depreciation deductions of the j-th agricultural machine in the **i**-th technological operation, \$; TP_{ij} - deductions for the maintenance and repairs of the j-th agricultural machine in the **i**-th technological operation, \$; Ω_{ij}^{-1} - the annual amount of work performed by the j-th agricultural machine in the **i**-th technological operation, ha; $\mathbf{C_i}$ - the costs of fuel and salaries in order to execute all the technological operations, \$/ha; $\mathbf{C_i^I}$ - the costs of seeds, fertilisers and chemicals, \$/ha; n- the number of the performed operations.

The account does not include the real estate tax, insurance of the machines and crops, maintenance of the melioration system, repayment of credits and their interests, etc.

Calculations are made by means of the Microsoft Excel programme.

Results and discussion

Several authors (Boruks A., et al., 1999, Betriebsplanung Landwirtschaft, 2006/07) were engaged in the study of technologies for the production of cereals, however these sources do no discuss the choice of an optimum ploughing and sowing aggregate.

Let us discuss the selection of the optimum economical technological variant by the example of grain production with different technical equipment for soil tillage and sowing depending on the production output. The calculated specific costs per hectare include: depreciation deductions; maintenance and repairs; fuel; salaries; the prices of seeds, mineral fertilisers and chemicals.

The proposed example discusses grain production technologies in four variants of technical equipment for soil tillage and sowing, the remaining components being constant. The data are presented in Table 1.

In the first variant the aggregate CASE MX 305+TopDownTD 500 was used which has the following operating tools: disks, looseners, levelling disks, a roller. It is used for soil preparation without ploughing with simultaneous sowing. The depth of loosening reaches 26 cm. The second variant: the aggregate McCORMICK ZTX 230 +Carrier CR 500, which is similar to the first aggregate, yet it has no looseners, the depth of loosening is 10...12 cm. The third variant: the aggregate McCORMICK ZTX 230 +Kverneland EG-85-300HD 6k (a reversible plough with six bodies). The fourth variant: the aggregate McCORMICK ZTX 230 +Rapid RD 400C – a combined seeder for sowing in the stubble, as well as after the soil is prepared, with the aggregates mentioned above. It has two rows of disks, a drag, compactors and looseners.

By using the above-mentioned economical and mathematical model it is possible to calculate the specific costs depending on the technologies with four variants of technical equipment for soil preparation and sowing. .

The data obtained as a result of calculation allow us to draw graphs (see Figure 1).

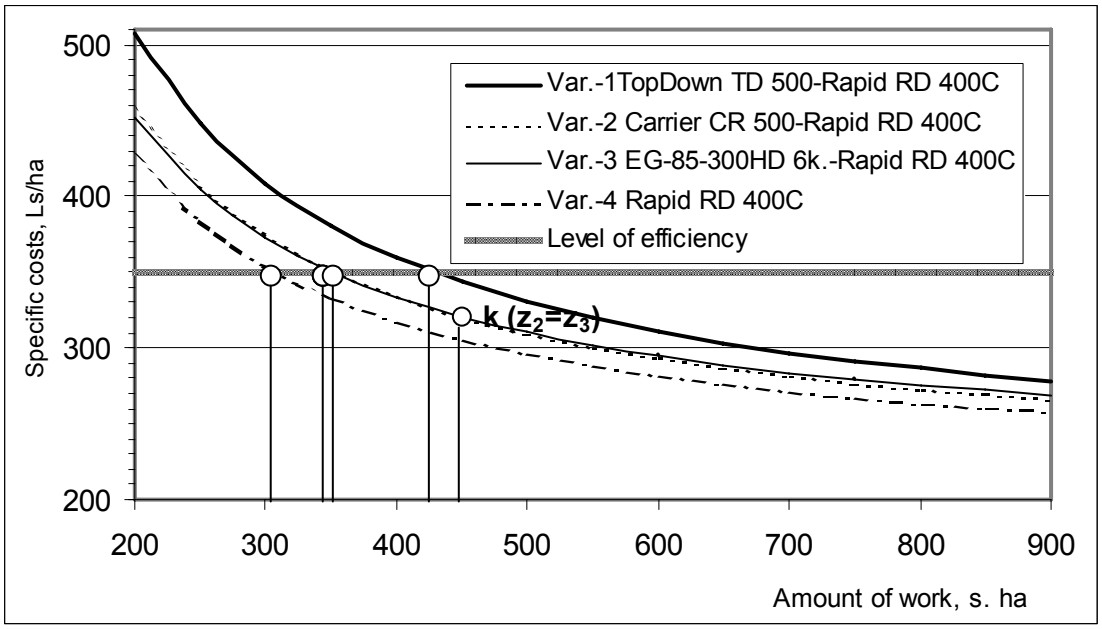

Figure 1. Variations of specific costs of the technology depending on areas under crop and different variants of soil preparation and sowing

It is evident from Figure 1 that the specific costs per hectare and, consequently, per ton of the produced grain decrease when the area under crop increases, and they have various values in the variants of technical equipment considered. The specific costs of the fourth variant within the whole range of the performed operations are less in comparison with the 1st, 2nd and 3rd variants. The greatest specific costs per hectare for the range of the performed operations under discussion are in the first variant. At cross point «K» of two curves of specific costs in variants 2 and 3 of the technical equipment of the technology the values of their specific costs are equal (Z_2=Z_3 if Ω = 450 ha). Variant 3 is more economical for the amount of the performed work Ω = 450 ha but, when Ω>450 ha, it is variant 2. Within the considered range of performed operations the average difference in the specific costs between variants 2 and 3 is ±1,9Ls /ha. It is also evident from Figure 1 that in case the curves of the specific costs for the variants of the technical equipment of the technology under discussion do not cross each other, the most economical in this case is only one variant in which the specific costs throughout the entire range of the discussed operations are less.

Figure 1 also shows the limits of the economical efficiency of the technology with the variants of soil preparation and sowing. A straight line is drawn from the axis of ordinates on which the meanings of individual specific costs are marked reflecting the income per hectare when the purchasing price of grain is 70 Ls/t (the typical price during the recent years) and the expected crop capacity of the technology under discussion is 5 t/ha (70 Ls/t x 5 t/ha =350 Ls/ha). This value is equal to the specific costs per hectare, which is the limit when profitability R=0. The cross points of the curves of the specific costs for the compared variants and their corresponding values on the axis of abscissa show the limit at which the discussed variant still has economical efficiency. Thus, when the first variant is applied, the economical efficiency starts from the amount of work 426 ha, that of the second variant – from 353 ha, the third variant – from 351 ha and the fourth variant – from 307 ha. The data indicate that each variant of the technical equipment of the technology to be considered has its limit of economical efficiency depending on the amount of the performed work.

Variations in the specific costs of the technology, on the whole, and the discussed variants of technical equipment for soil preparation and sowing depending on the amount of work are presented in Figure 2.

It is obvious from Figure 2 that it is the first of the four considered soil preparation and sowing technological variants which has the highest specific costs. In variants 2-3 they differ insignificantly, but the fourth is the most economical among the four variants under discussion.

Table 1

Variants of technical equipment for soil tillage and sowing of cereals

Variants of technical equipment	I	II	III	IV
Tractors	CASE MX 305, McCormick ZTX 230, MTZ -1025	McCormick ZTX 230, MTZ -1025	McCormick ZTX 230, MTZ -1025	McCormick ZTX 230, MTZ –1025
Prices of tractors, Ls	187940	88820	88820	88820
Agricultural machines	Combined aggregate for soil preparation **Top Down TD 500, combined seeder RD 400C,** sprayer HARDI, trailer 2PTS-4, combine harvester MF-36 RS 5.45 m, grain cleaner VS-1, dryer GK-1.	Combined aggregate for soil preparation **Carrier CR 500, combined seeder RD 400C**, sprayer HARDI, trailer 2PTS-4, combine harvester MF-36 RS 5.45 m, grain cleaner VS-1, dryer GK-1.	**Plough EG-85-300HD 6k., combined seeder RD 400C**, sprayer HARDI, trailer 2PTS-4, combine harvester MF-36 RS 5.45m, grain cleaner VS-1, dryer GK-1.	**Combined seeder RD 400C**, sprayer HARDI, trailer 2PTS-4, combine harvester MF-36 RS 5.45m, grain cleaner VS-1, dryer GK-1.
Prices of agricultural machines, Ls	191640	161259	156273	139017
Seeds, mineral fertilisers, chemicals	Seeds – 0.23 t/ha , KEMIRA POWER – 0.6 t/ha, Grandstars – 0.015 kg/ha, Citovets – 0.1lt/ha, LONTRELS – 0.2 l/ha, Raundaps - 2.5 l/ha, BI –58 - 1 l/ha, Alto- 0.2 l/ha.			
Prices of seeds, mineral fertilisers and chemicals, Ls/ha	167.1			

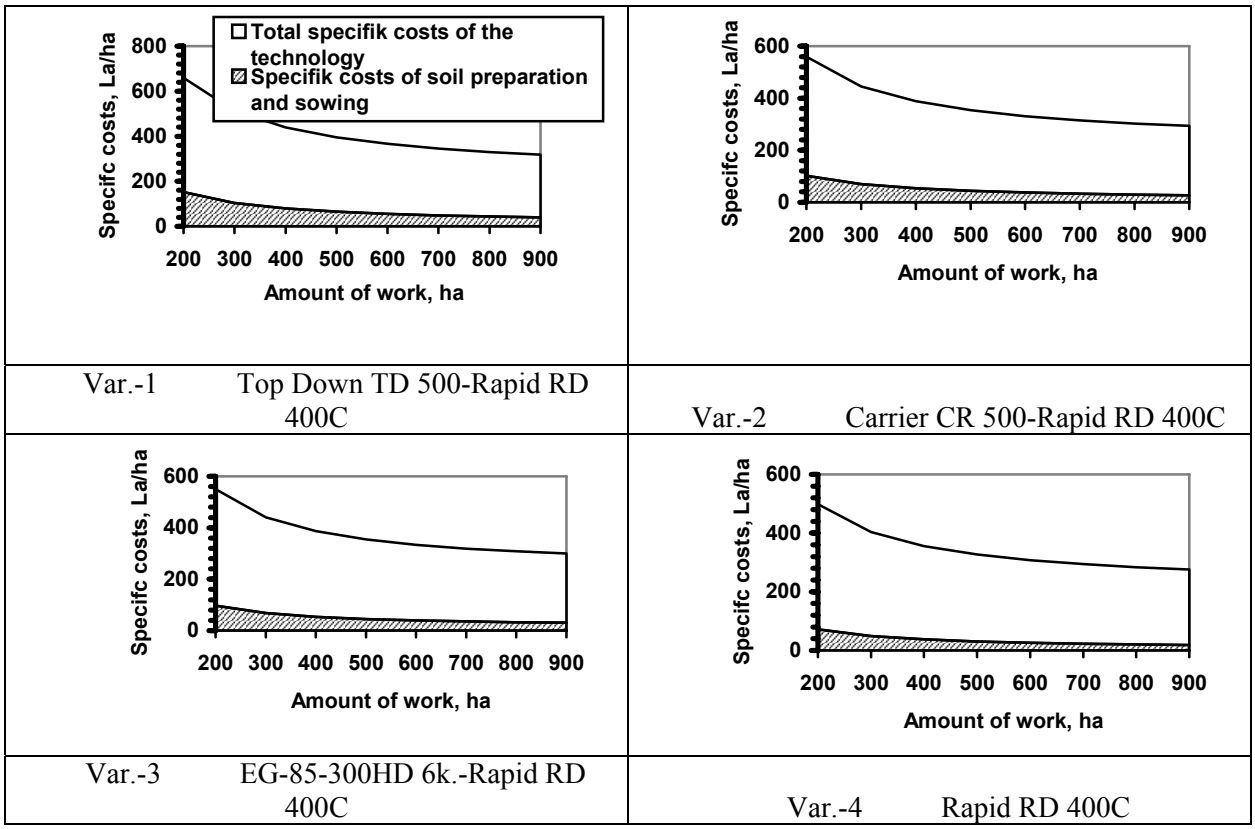

Figure 2. Variations in the specific costs of the technology and the variants for soil preparation and sowing depending on the amount of work

Variations in the specific costs of the technology and technological operations of soil preparation and sowing within the discussed range of the performed work at its maximum and its minimum values are presented in Table 2.

Table 2

Variations in the specific costs of the technology and technological operations of soil preparation and sowing

Variants of soil preparation and sowing technologies	Total costs of the technology, Ls/ha		Costs of soil preparation and sowing* from the total, in %	
	Areas under crop, ha		Areas under crop, ha	
	200	900	200	900
TopDown TD 500-Rapid RD 400C	506.87	278.47	30.09	14.28
Carrier CR 500-Rapid RD 400C	456.83	266.19	22.43	10.32
EG-85-300HD 6k.-Rapid RD 400	452.03	269.24	21.60	10.21
Rapid RD 400C	426.59	257.49	16.93	7.29

*the sowing costs do not include the price of the seeds

In this example preference is given to the fourth variant of soil preparation and sowing (see Table 2). If the annual amount of work is 200 ha, the specific costs of the technology are by 15.8%, but at the amount of 900 ha – by 7.5% less than in the first variant. Besides, the percentage of the specific costs of soil preparation and sowing is respectively by 13.2 and 6.9% less. The data also indicate that this difference decreases when the amount of the performed work grows.

Taking into account the circumstance that there is an economically expedient working width of the aggregate for each amount of work, let us define the amount of work for the above-mentioned tractor

aggregates with minimum costs using the economical model presented in [2]. The calculated data are given in Table 3.

Table 3

Optimal costs of the aggregates under discussion

Name of the aggregate	Working width, m	Price of the agric. machine, Ls	Price of the tractor, Ls	Amount of work, ha	Costs, Ls/ha
CASE MX 305+TopDown TD 500	5	52623	99120	2000	8.58
McCORMICK ZTX 230 +Carrier CR 500	5	22242	78470	1200	6.33
McCORMICK ZTX 230 +Rapid RD 400C*	4	41262	78470	1350	10.35
McCORMICK ZTX 230 +Kverneland EG-85-300HD 6k	2.4	17256	78470	300	19.34

* direct sowing
Note. The costs of maintenance and repairs are not included into the calculation.

If we take the first variant of the technology with the technical equipment which includes the soil preparation aggregate CASE MX 305+TopDown TD 500 and increase its annual load to 2000 ha (at the expense of offering services), which corresponds to the minimum costs for the given aggregate, then the percentage of the specific costs of soil preparation and sowing will decrease by 14.8%, and by 3.6% in comparison with the load when the amount of work is 200 and 900 ha, presented in Table 2. Besides, the limit of economical efficiency by the amount of the performed work in the first variant of technical equipment of the technology will not be 426 ha, but 325 ha if only the soil preparation aggregate CASE MX 305+TopDown TD 500 has the annual load less than 2000 ha.

The data show that in case the technical equipment of the technology is formed, it is important to take into account the fact that such parameters of the tractor aggregate as its working width are closely connected with the amount of the performed work, the price of the energetic means, fuel and salaries. Therefore the working width has a definite optimum economical value for the amount of the performed work.

Conclusions

The discussed method for the choice of different variants of the technical equipment of the technology shows that the costs of soil preparation and sowing at the preset limit of its economical efficiency constitute 13.7...21.5% of the total costs of the implemented technology.

The economical efficiency of the variants of technical equipment considered here starts from the amount of 426 ha of the performed work in the case of soil preparation without ploughing, deep loosening and separate sowing, but with the deep loosening of soil to the depth of 10...12 cm – 353 ha; in the case of ploughing with separate sowing the amount of work is 351 ha, and with direct sowing – 307 ha.

The present method for the choice of the technical equipment of the technology allows selecting the economically most justified variant of soil preparation and sowing, as well as other variants.

When the technical equipment of the technology is formed, it is necessary to take into account that each set of the applied aggregates has an optimal economical value of its basic parameters.

Among the variants discussed above the economically efficient is a variant which combines the technological operations of soil preparation and sowing in contrast to soil preparation without ploughing and separate sowing. The specific costs are reduced by 15.8% if the annual out is 200 ha, and by 7.5% if the annual output is 900.

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