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COMPARISON OF TECHNICAL-ECONOMICAL PARAMETERS OF MACHINE UTILISATION IN DIFFERENT BRANCH OF PLANT PRODUCTION

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Abstract: The present study is a comprehensive survey covering the analysis of the development of the machine stock and the use of the machines of field crop producing, field vegetable growing and plantation cultivating farms by the application of the means of computer-guided modelling. The characteristics of the machines demanded by the production of different plants are taken into account and special attention is paid to the application of machines with reasonable capacity and technical level in respect of cost by different farm sizes.

Our aim is to stipulate the range of farm size under which the development and operation of an own machine stock is not even with additional machine cost offering worth in the branches surveyed. By this the farm size limit under which the use of the logistically more defenceless lease work is reasonable in order to keep the cost of machine work at an acceptable rate will be defined. This limit varies from branch to branch. This way the fact that the mechanization of the individual branches is highly dependent from the farm size and the diversity of parameters effecting mechanization can be pointed out.

Key words: *mechanisation of different sized farms, machine utilisation in different branch of plant production, machine fleet planning, machine investment and utilisation cost.*

INTRODUCTION

Work done by an efficiently developed machine system is a significant condition of the fruitfulness of farming. The machine prices and the cost of their utilization are extremely high and all these result in extraordinarily high production costs. *Rational machine utilization* is a definitive factor of the efficiency of venture-farming. According to our experiences the machine stock of a venture and the way and rate of utilization of same are reserves which can substantially contribute to the increase of corporate income.

Contrary to former practice the concept of “optimal machine system” is not to be interpreted within the framework of corporate enterprise only but we are to find a solution for solving the mechanization problems and planning the machine utilization of *small and medium size farms* as well (Fenyvesi et al. 2003). The wide range of enterprise sizes characteristic nowadays and the great number of power and working machine types available are also to be considered. Most of the machine producers already have power machine lines holding *the total performance scale as well as all the harvesting functions*. Consequently, instead of planning a power machine system characterised by specific machine types the creation of a machine system determined by *performance category and function* is sufficient. This can be realized by any *machine type ad-libitum* according to the local facilities and production circumstances. A further important point is that the planning of mechanization cannot be limited to determining the number of machines. There is a rightful demand for the determination and consideration of the economic parameters of the power and working machines of different types and performance categories developed by diverse enterprise sizes. The acquisition and afterwards use of valuable equipment necessitates well-grounded economic decisions (Takácsné György K. - Takács E. - Takács I. 2008). [1; 7]

All the above apply first of all to **power machines** as those need closer attention due to their high acquisition and utilization costs. The aim is, therefore, to promote the development and utilization of an efficient power machine stock. This can be achieved by a mechanization model considering the present property structure, the wide selection of machines, the utilization cost level of diversely exploited power machines, and, furthermore, which is apt to determine the structure, investment- resp. utilization costs of a machine system composed of the power machines of different machine families adaptable to diverse farm size with the lowest utilization costs.

Considering the shift-hour performance of the machines under given production circumstances an overall system for building up a machine system adapted to small, medium and large farm size can be developed. The *areal size limits and cost of the utilization* of self-owned power machines of different performance level and harvesting machines of diverse functions can be determined as well as the *number of shift-hours to be performed* which also effects the efficiency and cost of machine utilization. In case of power machine families representing different quality, resp. cost level the cost level of the given power machines carrying out the individual work operations at different farm sizes can be determined.

THE METHOD

The crop growing branches surveyed

The surveys can be conducted by *modelling* the machine working processes of agricultural production. In the case of field crop production a crop plan including cereal plants for human consumption, maize for animal breeding and for energy production purposes and oil seeds – as sunflower and the nowadays very popular crucifer - appropriate for human consumption and energy production as well and reflecting the special features of production in Hungary has been applied. Our calculations have been based on a crop plan including cereal plants, sweet corn, onion and root vegetables in case of field vegetable growing while in case of plantation cultivation the data of a vine growing farm have been taken into account. Depending on farm size the proportion of the crop area of the individual plants has been stipulated in view of the agronomical and production technological conditions.

The machine families applied, the parameters of model calculations

Basically the cheapest power machine families used in Hungary on the one hand and the ones with the highest possible investment cost demand available on the market of agricultural machinery on the other have been the subject of the survey. While in case machines with low historical cost the costs of machine utilization are low as well owing to the meagre amortization cost, a substantial amortization cost is to be calculated in case of high price power machines. In the latter case the price difference can be compensated by the lower specific fuel consumption due to the more modern construction, the easy handling, the quality of work done, and the ergonomically more advantageous design. The life expectancy of the high investment cost machines is also longer. This can, though, not easily be denoted in figures as the life expectancy of a lower cost machine can be lengthened several times by a low cost overall renewal. The spare part costs of these machines-equipment are mostly favourable and the costs of the additional repairs are also not considerable on the whole compared to the purchase price of a modern machine.

The basic figures of machine utilization have been determined with the help of the data base of the Hungarian Institute of Agricultural Engineering. [2]

The *model-calculations* have affected the determinative farm size points of machine stock development in a farm size range of 2-1000 ha depending on branch. On this basis we can come to statements affecting a wider segment of the agricultural property structure, resp. to conclusions concerning mechanization and machine utilization.

RESULTS

The conclusions arising from the results of the model calculations concerning the composition of the power machine system and the shift hour performance of the power machines

The composition of a machine system with minimal utilization cost by power machine categories depending on farm size in the different crop growing branches.

The multi-purpose power machines have been classified according to *engine performance* during the survey, moreover the self-propelled grain harvesting machine *function* has also been considered. The composition of the power machine systems assigned to the individual areas has been determined by *power machine categories*. Under given machine working conditions as sowing structure and production technology characteristic of the special features in Hungary *regular coherences* can be stated considering the composition by categories of a *cost efficient power machine system* developing according to farm size.

In case of *field crop production* the power machine system applicable to the smallest farm size included in the survey is “built up” in case of tractors of the 40 kW performance ones minimally necessary for quality cultivation. Parallel with the growing of the territory first the performance level (from 30 ha on the use of 60 kW tractors is reasonable) and later also the number of the *tractors* composing the machine system grows. Thus from a farm size of 100 ha on the 40 and 80 kW performance tractors are *both* included in the machine system. From a farm size of 300 ha the role of the above mentioned power machines is taken over by 60 and 120 kW performance tractors the capacity of which is appropriate for the increasing labour demand. From a 500 ha farm size on the number of these tractors grows in the proportion of the increase of capacity demand. (Magó 2008). [6]

It is worth mentioning that in case of large size farms the cost level of machine utilization can be decreased further by increasing the number of the applied power machine performance categories and by optimizing the allocation of operations among the machine combinations of different capacity (Magó – Hajdú - Nagy 2005). [3]

It is also reasonable to apply tractor and trailer for solving **transport** tasks in order to increase utilization.

The use of an own minor capacity **grain harvesting machine** may become reasonable from a farm size exceeding **100 ha**. From a farm size of 500 ha on a harvesting machine with a bigger throughput can be applied due to the great deal of machine work demand. According to calculations in a 1000 ha farm it is highly recommended to operate at least two grain combines.

In case of **field vegetable production** a tractor of 60 kW performance is appropriate for small size farming, for quality cultivation and for the fulfilment of the individual harvesting functions. Together with the increase of farm size the performance level (from 30 ha on the use of 80 kW tractors is reasonable) and also the number of (the 40 kW auxiliary tractor appears) **tractors** composing the machine system grows. The 40 and the 80 kW performance tractors are already present *together* in the machine system from 50 ha on. At a farm size of over 200 ha the tasks of the power machine cultivation is done and the tugged harvesting machine is operated by are taken over by a 120 kW performance tractor, and the number of auxiliary tractors apt for fulfilling plant protection, nutrient supply and transport tasks grows, thus the capacity of the power machines is sufficient for the increasing labour demand.

The use of an own lower performance **grain combine harvester** for harvesting cereals ensuring crop rotation is reasonable in case of a property size of over **300 ha**.

In case of **plantation cultivation** the performance of the tractor applicable to the smallest farm sizes is 20 kW which is sufficient for the necessary cultivation works as well. In case of this farm size a further 45 kW power machine is needed for the operation of the vine harvesting machine taken by lease. The performance level (from 10 ha on the use of a 45 kW tractor is reasonable) and the number (from 50 ha on the necessary cultivation and harvesting works are already done by two power machines of equal performance level) of the plantation cultivating tractors grows together with the growth of the area.

The number of shift-hours performed subject to power machine category and farm size in the different branches of crop production.

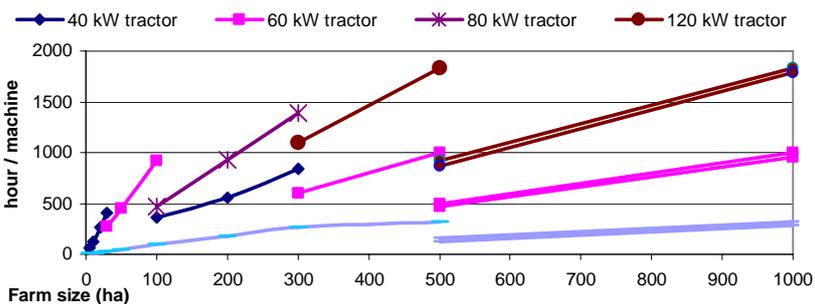


Figure 1.: The shift-hour performance of power machine categories subject to farm size based on model calculations in case of field crop growing

The number of shift-hours achievable by different farm sizes effects the composition by category of the power machine system. (Magó 2007b). [5]

- In case of **field crop growing** considering the *smallest farm size (max. 50 ha)* the *utilization level* of the tractors is *low*: maximum 400-500 shift-hours annually.

- In case of *medium size farms (50-300 ha)* this quantity is *bigger*: 800-1400 shift-hours per year.

- In case of *large size farms (over 300 ha)* the performance (1000-1800 shift-hours a year) of the tractor categories is already significant (Figure 1).

A grain harvesting machine with rationally chosen capacity achieves *good* utilization by farm sizes **over 300 ha** with a shift-hour performance of about 300/year and an *acceptable* operational cost hereby.

The number of calculated shift-hours achievable in case of **field vegetable growing** subject to farm size is as follows: (Figure 2)

- By the smallest farm size surveyed (**max. 20 ha**) a *low level of utilization* of tractors can be achieved: maximum 500 shift-hours a year.

- In case of *medium farm sizes (20-100 ha)* the number of shift-hours is already remarkable: 500-1000 shift-hours per year.

- In case of *large farm sizes (over 100 ha)* the tractor categories may already have a significant performance (1000-1800 shift-hours per year).

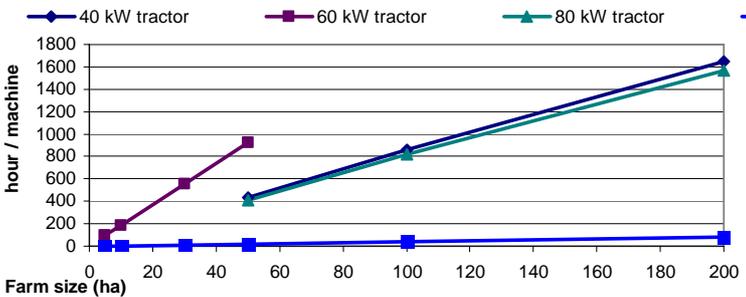


Figure 2: The shift-hour performance of power machine categories subject to farm size based on model calculations in case of field vegetable growing

The level of shift-hour performance by **plantation cultivation** (Figure 3)

- By the *smallest plantation sizes* surveyed (**max. 20 ha**) only a *low level of utilization*, maximum 600 shift-hours a year can be achieved even if a low capacity power machine is applied.

- In case of *medium and large size plantations (over 20 ha)* this quantity grows and the tractors may have a remarkable (600-1250 shift-hours annually) performance.

The number of shift-hours per *unit of area* decreases with the increase of farm size. In case of **field crop production** on *small size farms* 10-15 shift-hour/ha/year is performed. In the size range of 30-300 ha a shift-hour performance of 8-10/ha can be calculated, *from this size on* an annual figure of about **6 shift-hours per hectare** becoming constant with the realization of an *efficient labour plan* can be observed. (Figure 4)

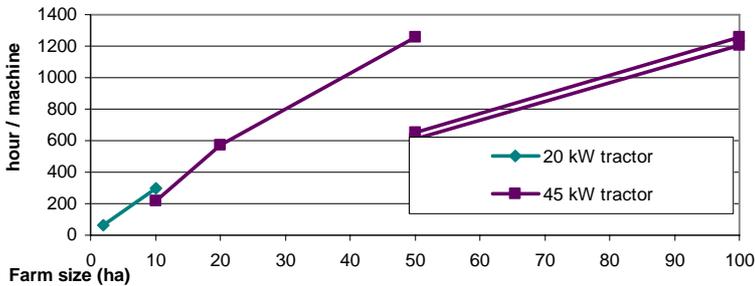


Figure 3: The shift-hour performance of power machine categories subject to farm size based on model calculations in case of plantation cultivation

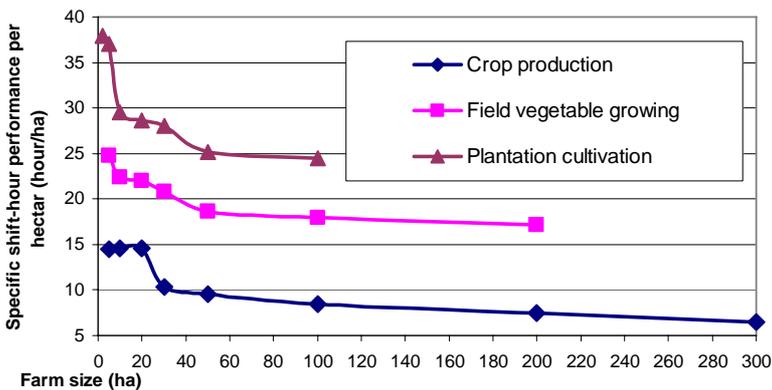


Figure 4: The total shift-hour performance of power machines subject to farm size in the different branches

In case of **field vegetable growing** by the *small farm sizes* 20-25 shift-hours per hectare per year are realized. In the size range of 30-200 ha 18-20 sh/ha can be calculated but with the *increase of labour effectivity* even the favourable **15 shift-hours per hectare** performance can be achieved.

By **plantation cultivation** in case of *small farm sizes* 35-40 sh/ha can be achieved. In the size range of 10-50 ha shift-hours per hectare are performed, *from this size range* on the still significant annual figure of **24 shift-hours per hectare** becomes constant.

The above figures are characteristic of the utilization of the low investment cost power machines and they alter a bit if high investment cost power machine families are used. The more up-to-date power machine-working machine connections need shorter time for executing their labour tasks and this is also reflected in the above mentioned specific index. In field crop production, for instance the utilization of the more expensive and higher technical level results in a benefit of 0,3-0,5 shift-hour per hectare annually. But presuming internal home work only this benefit is a disadvantage considering utilization as the annual shift-hour performance of the individual machines decreases and hereby their specific utilization cost increases.

It can be stated that the most machine working hour demanding branch for the cultivation of one hectare is the plantation cultivation, field vegetable growing comes next, and the last one in the row is the field crop production. Obviously farms producing grain and oilseeds have the lowest machine working hour input demand. With the growth of the farm size the specific number of machine working hours necessary for the cultivation of one hectare area decreases in each branch and the figures are nearly halved in case work is done under more favourable and more efficient large scale farming conditions with high performance machinery.

The great number of hours experienced by small farm sizes increases the living labour expenditure as well. Though for farm of this size category the application of mainly low performance machines is characteristic due to the limited level of machine utilization the general expenses and, therefore also the operational costs are high.

Consequently it can be stated that in spite of the reasonably chosen power machine capacity there is no technical solution which could acceptably solve the cost problem of farms smaller than about 16-20 ha in case of field crop production, 9-12 ha in case of field vegetable growing and 5-7 ha in case of plantation cultivation.

It must be pointed out that under the indicated farm size limits the development of an own new invested machine stock is not economical if there is no lease-work possibility besides home labour whereby the machine utilization can be increased, the period of returning of machine investments can be shortened and a more fruitful farming can be achieved.

CONCLUSION

The aim of our research work and the exposition of its results are the professional support of the machine investment decisions and the machine utilization practice of the different size farms promoting hereby the creation of the conditions of fruitful farming and rational machine investment decisions.

In the present study we have tried to offer a general guideline considering a general crop plan and production technology characteristic of several branches with an overview of the composition of machine stock from the use of the lowest cost level to the highest technical level machinery, the machine demand and the utilization level of those together with investment and utilization costs which may serve as a basis and may open further research perspectives for the reduction of machine utilization costs both for the producers and for the professional organizations.

On the basis of the experiences of farm surveys it can be stated that the power and working machines appearing in small and medium size farms as new investments are adapted to the presented cost efficient machine system modelled subject to farm size (Magó 2007a). [4]

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UPOREĐIVANJE TEHNIČKO-EKONOSKIH PARAMETRA MAŠINA U RAZLIČITIM VRSTAMAMA BILJNE PROIZVODNJE

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Sadržaj: Određivanje najefikasnijeg sastava mehanizacije za svaku farmu je vrlo značajno u današnje vreme. Neophodno je izraditi matematičke modele za planiranje sastava mehanizacije za male, srednje i veće veličine farmi za ratarsku, povratarsku i vinogradrsku proizvodnju.

Određivanje strukture i iskorišćenost mašina koje se može primeniti na farmama različite veličine, utiče na ekonomske informacije vezane uz mahanizaciju proizvodnje.

Uzimajući u obzir sadašnju fragmentiranu strukturu farmi, postavljen je cilj da se odredi najefikasnija kombinacija mašina, koja bi se koristila različitim vrstama biljne proizvodnje a različitim farmskim veličinama. Pored toga, pokušali smo da označimo tu farmsku veličinu u ratarskoj, povratarskoj i vinogradrskoj proizvodnji ispod kojeg izgradnja spostvenog mašinskog sistema ekonomski nije opravdano.

Ključne reči: mehanizacija farmova različite celičine, planiranje sastava mašinskih sistema, iskorišćenost mašina, mehanizacija sa niskim troškovima.