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SUSTAINABILITY AND COMPETITIVNESS

FENNTARTHATÓSÁG, VERSENYKÉPESSÉG

LOW COST MECHANISATION ON SMALL AND MEDIUM SIZE PLANT PRODUCTION FARMS

MAGÓ, LÁSZLÓ

Abstract

It is essential to develop a cost effective fleet of machinery for the present day various standard sizes of plants. In the case of the small units it is essential to develop equipment and cost saving mechanical solutions, but there is also demand for the building up of systems of machinery with modern, cutting edge technology and profit improving attributes for the middle-sized farms, which more favourable specific cost level.

The changing and modernising of the Hungarian fleets of machinery, the majority of which is obsolete is unavoidable. Farmers working from different amounts of capital on farms, which provide different levels of mechanical development potential, have to develop mechanisation solutions using the wide range of types and price range of the power and work machinery.

Taking into consideration the current partitioned structure of the farms the goal was established to determine that in the case of the different branches of plant production on small and middle-sized farms which combination of fleet of machinery can be used effectively.

Keywords: optimal modernization level, tractor capacity.

Introduction

The diversified property structure characteristic at present of the Hungarian agriculture is not always coupled with efficient power and working machine system (Hajdú-Magó 2004, Hajdú-Gockler 2005). In case of small size farming units the up-to-date, means and cost sparing solutions are rarely to be found and even the medium size farms do not necessarily own the efficient machine systems with all the technical-technological advantages of the present era furthering improvingly effective farming [Baranyai, 2007; Fenyvesi et al., 2003; Hajdú – Gockler, 2005; Hajdú – Magó, 2004]

To solve the present problems of agricultural mechanization (changed farm structure, extended machine selection etc.), the optimal machine utilization and its construction can be approached from a new point of view. Extra emphasis has been laid on the level of utilization of the power machines, enabling hereby the optimum level of machine utilization cost. [Sadowski - Takács-György, 2005]

Fixed costs, mainly amortization and maintenance expenses, represent a considerable rate in the utilization costs of modern power machines with more expensive purchasing price. These cost types can be moderated by the rise of level of utilization. The applied tools are coupled on actual operation cost to each work task. This enables the observation of the influence of the completed operational hours on the expenses.

The advantages of this approach of the problem appear both at large and at small farm sizes. While at large size farm sizes, the completed operational hours influence mainly the number of power machines belonging to a given power category within the optimum machinery system, at small farm sizes the tractor with the highest level of utilizations shall be selected for the "leader" of machinery system of the given farm size [Magó 2007]

Methods

Testing of the mechanised processes of agricultural harvesting was carried out using models. In the model a crop rotation plan was adopted which mirrors the Hungarian production characteristics using wheat and oil plants. Depending on the size of the farm the proportion of the sewed area of each plant was established keeping in mind the agronomical and production technological conditions.

At the basic level the experiments were focused on the lowest investment cost power machinery range of products in Hungary. With this machinery because of the low investment cost the amortisation cost is less and thus the cost of utilisation is low. The determination of the basic data of the costs of machine utilisation has been carried out, based on the database of the FVM Hungarian Institute of Agricultural Engineering [Fenyvesi et al., 2003].

The *model calculations* involved the key plant size data of the formation of machinery systems in the range of plant size ranging from 5 to 1000 hectares. On the basis of these data, statements can be made regarding a larger segment of the estate structure, and conclusions may be drawn regarding machinery utilisation and mechanisation.

Results

Conclusions drawn regarding the composition of the power machinery system and the performance of hours run, based on the results of the model calculations

The composition of machine systems of minimal utilisation cost broken down in categories of power machinery depending on the sizes of plants

In the course of carrying out our survey the universal power machinery was categorised according to *engine performance*, as well as taking into consideration the *function* of being a cereal harvesting machine. The composition of the power machinery systems rendered to a particular area was determined on the criteria of *power machinery categories*. Taking into consideration the crop structure, growing technology, conditions of mechanised work typical of the Hungarian particularities and the composition of categories of *cost effective power machinery systems* which are formed on the criterion of plant size, *regular interrelations* can be established.

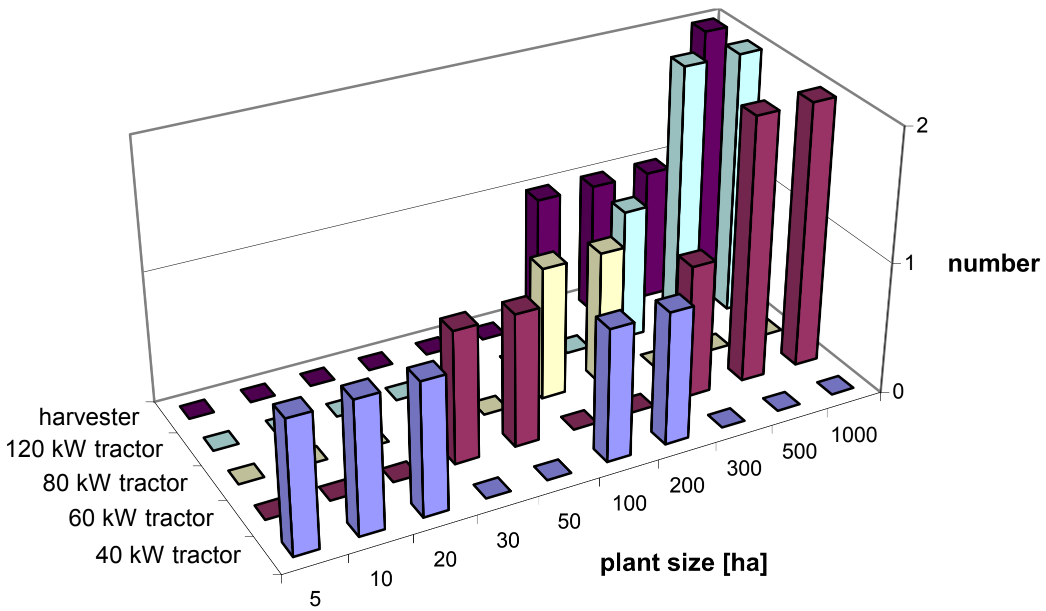

Figure 1: Number of machines of various power machine categories for the given plant size

The surveyed power machinery system that can be rendered to the smallest plant size, in the case of *tractors*, consists of machines of 40 kW, a performance that is the minimum requirement for the quality performance of soil work. If the size of the area is higher, then first the performance of the machinery making up the fleet (from the size of 30 hectares tractors with 60 kW performance are required), next the number of tractors increases. Thus, tractors of 40 and 80 kW performance are mentioned *together* in a machinery system for plant size of 100 hectares or upwards. From the plant size of 300 hectares the function of power machinery mentioned above is filled by tractors of 60 and 120 kW performance, which have sufficient capacity for the increased workload. For the plant size of 500 hectares or upwards the number of tractors increases in proportion to the growth of requirement for capacity (see Figure 1).

It is necessary to note that, in the case of large plant size, the cost level of machinery utilisation may be further decreased by increasing the number of performance-based categories and optimising the distribution of work among machinery connections of various performance levels. [Magó 2002]

In order to increase utilisation, *transportation* tasks should also be realised by the means of tractor-trailer connections.

The utilisation of an own, low capacity *cereal harvester* may be justified above the plant size of 100 hectares. In the case of a plant size exceeding 500 hectares, the large extent of the specialised mechanised work requires the utilisation of harvesters with larger delivery value. According to the calculations, a 1000-hectare farm requires the utilisation of at least two combine harvesters.

Optimal mechanisation levels concerning tractors, depending on plant size

The number of tractors required by plants of various sizes is as follows:

1) In the case of a plant size not exceeding one hundred hectares, we calculated with *one tractor*.
2) In the case of a plant size ranging from one to five hundred hectares, two tractors of different performance levels are required.
3) In the case of a plant size exceeding five hundred hectares, two tractors are required from both performance categories in order to carry out the work operations in time and in good quality.

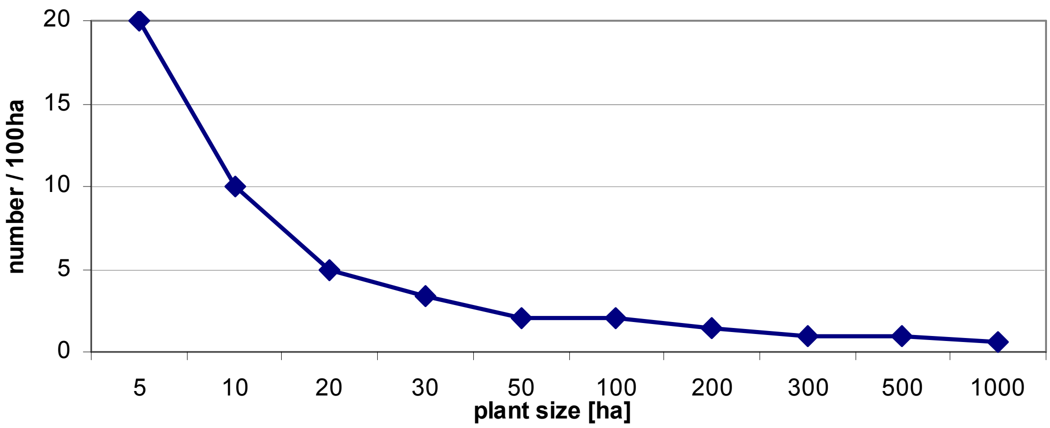

Figure 2: The number of specific power machines per one hundred hectares, in the cases of various plant sizes examined

When analysing the number of own power machines per *area unit* it can be stated that, in the case of a power machinery system of minimal utilisation costs, the *coverage* on farms of *over 50 hectares* is favourable. The economically most favourable value can be calculated *over*

200 hectares, in this case a maximum of *one power machine* is sufficient for the cultivation of 100 hectares of land. (Figure 2)

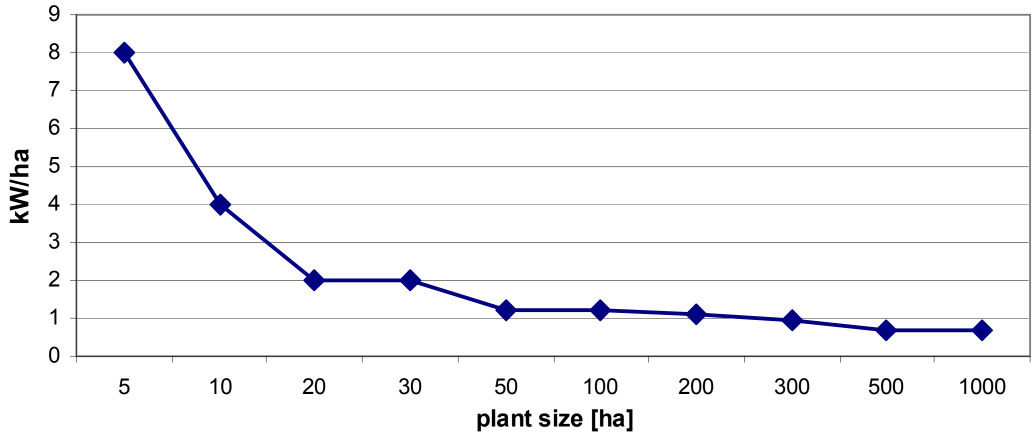

Figure 3: Required engine performance per hectare in the cases of plant sizes examined

The specific performance of engines per hectare decreases substantially in the function of plant size. While on small plant sizes 2-8 kW/Ha engine performance is required for every hectare, in the case of medium sized plants this value falls within the range of 1-2 kW/Ha. In plants of large size the work operation may be carried out with a requirement of *0.7 kW/Ha*. (Figure 3)

The ranges of plant sizes of the "activation" of the power machinery categories

The individual power machinery categories are "*activated*" when they first appear in the power machinery system developing in the function of the growing plant size. For the "activation" of each power machinery category this is a specific range of plant size. (For example: *80 kW performance category:* directly from 100 hectares and upwards, *120 kW performance category:* from 300 hectares and upwards. The attachment of a new category also influences the costs of utilisation and investment on the level of machinery systems. (see Figure 7).

In connection to the above, up to the plant size of 100 hectares, the system of machinery is formed on the basis of power machines belonging to each of the performance categories. In the range of plant size not exceeding 30 hectares, if we aim to utilise our own machines, in order to decrease the fixed costs, it is reasonable to utilise machines of the *lowest performance level and purchase cost*, which are still capable of performing the required workload. If the plant size and number of work tasks grow, the solution is the *increase of the level of performance* rather than the number of machines. Thus, the category of 60-kW tractors becomes a part of the optimal machinery system from 30 hectares upward. 80-kW tractors are part of the system from 100, whereas 120-kW tractors are part of the system from 300 hectares upward. It is necessary to point out that size in itself does not guarantee the fulfilment of the appropriate number of work hours and favourable utilisation.

The use of own *harvester* – depending on performance and delivery value – is economically justified over the plant size of 100 hectares.

It can be stated that the following issues must be consequently taken into consideration prior to the "activation" of a new machine: [Husti 2004]

- is it not possible to perform the tasks by the means of *internal redeployment* rather than by making a new purchase;
- can the missing capacity be covered by *machine rental* or other *external service*;

- is it possible to utilise the *surplus capacity* resulting from the new purchase (eg. lease work). [Husti, 2004]

The number of performed hours run in the function of plant size

With differing plant sizes the number of performable hours run has influence on the composition of categories of the power machinery system;

- In the case of the examined *smallest plant size* (up to 50 hectares) *low exploitage* may be achieved with tractors: maximum 400-500 hours run per year.
- In the case of *medium size plant* (50 to 300 hectares) this quantity is *larger,* 800-1400 hours run per year.
- With *large size plants* (above 300 hectares) the various categories of tractors achieve significant performance (1000-1800 hours run per year).

A cereal harvester with well-chosen capacity can achieve *good* exploitage at 300 hours run per year in the case of plant size *above 300 hectares*, by which the cost of operation becomes *reasonable*.

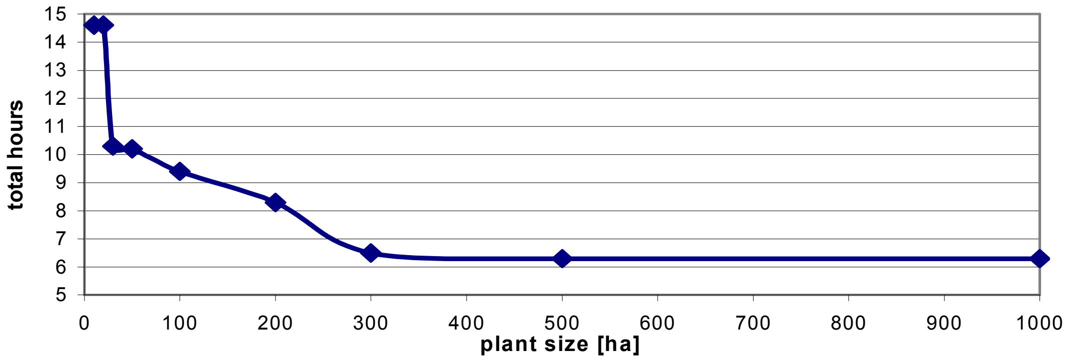

Figure 4: The total performance of hours run by power machines in the function of plant size

The number of hours run projected on a *unit of area decreases* with the increase of plant size. *In small plant sizes* 10-15 hours run per year is realised. *In the range of 30 to 300 hectares* this value is 8-10 hours run per year, and, *above this range*, a value of *6 hours run per hectare* can be observed when realising the efficient work plan. (Figure 4)

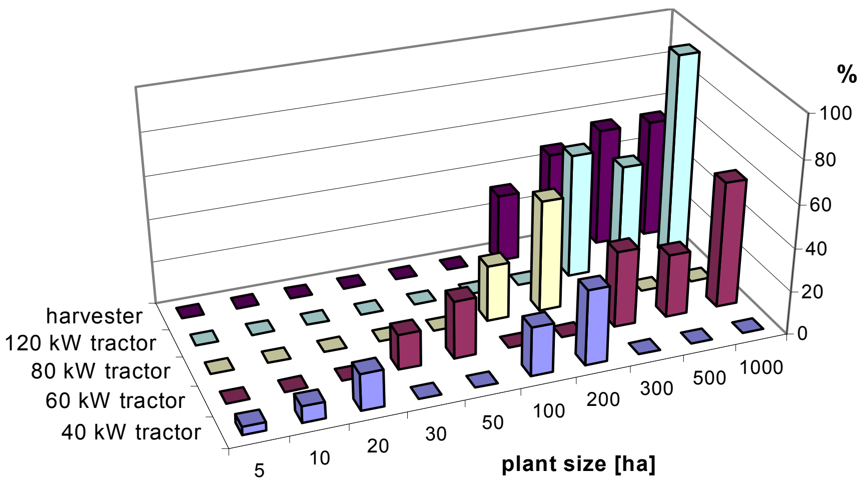

Figure 5: The extent of exploitation with the various categories of power machines in the case of the examined plant sizes

It can be observed that both in the number of machines and with regards to the performed hours run, the most *exploited tractor belongs to the category of 120 kW*. The performance of this significant labour time is achieved by the power machine of the given category, when both soil work and transportation tasks are carried out. (See Figure 5)

The costs of purchase and use of machines

The specifications of the function of investment and operation costs of machines projected on the size of plant

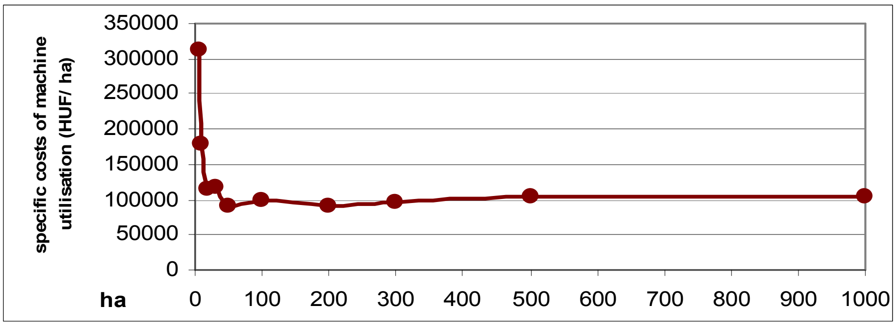

Figure 6: Specific costs of machine utilisation in the function of plant size

The result calculated for the specific *machine operation costs per hectare decreases hyperbolically* in the function of plant size (see Figure 6) and it borders the upper values of a real broken hyperbolic function [Takács 2000, Takácsné György-Takács 2003]. (see Figure 7)

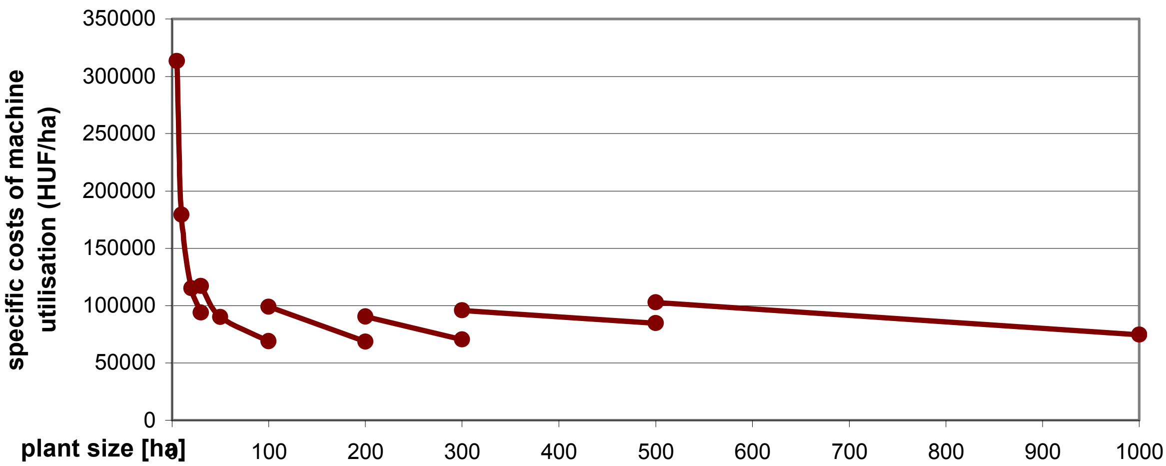

Figure 7: The broken function of the costs of specific machine utilisation per hectares, indicating the extra costs of switching to power machines of greater performance in order to increase capacity (1EUR = 250 HUF)

From the plant size of 100 hectares it gradually approaches an imaginary line that parallels the horizontal axis, thus indicating the operation cost level of a constant machinery system formed in the case of a large plant size.

In the case of the costs of machine utilisation with certain plant sizes (see 50 and 200 hectares) a more favourable value than the operation cost level of a constant machinery system formed in the case of a large plant size may be achieved. This may be due to the low operation cost of harvester doing lease work and working with efficient utilisation as well as to the appropriate utilisation of capacity of the tractors.

The composition of the utilisation costs of the machine system

- *Broken down in the cost of power and work machines*

Based on the survey it can established that the utilisation costs of the machine system is divided between power and work machines, depending on the plant size, at the ratio of 65-82 % and 35-18 %. In the case of smaller plant sizes, the utilisation cost of the power machines is proportionally too high, for in this case, the cost of power machines, due to the low level of their utilisation, is highly unfavourable, that is to say, very high. As for the work machines, we could calculate with low utilisation cost machinery of simple design and low technical standard, that could be adapted to low-performance power machines. (Figure 8)

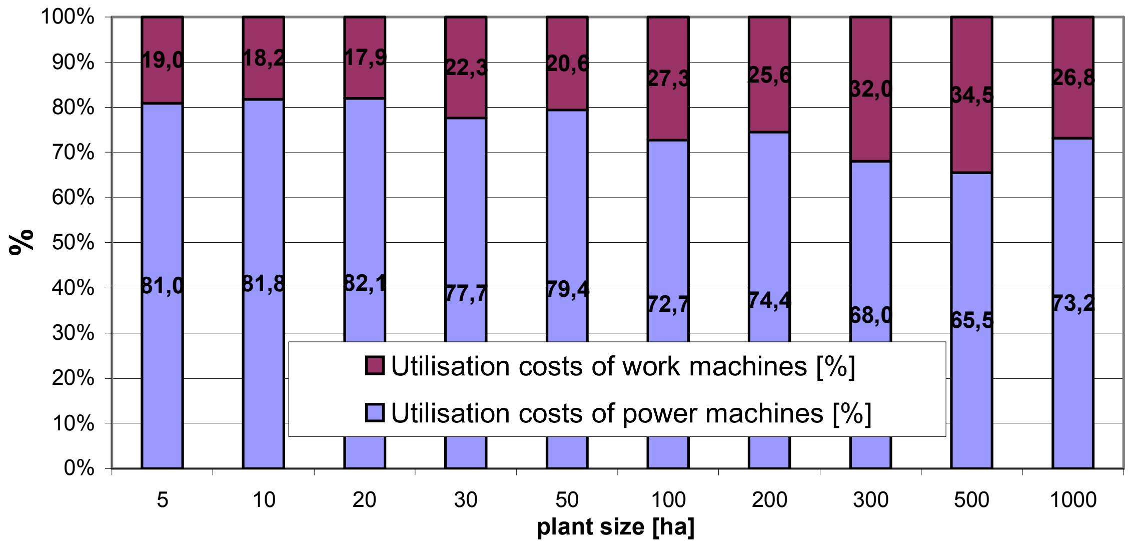

Figure 8: The proportion of work and power machines within the costs of machine utilisation in the function of plant size

- *Broken down into categories of power machines*

Figure 9 illustrates that in the case of very small plant sizes (5 to 10 hectares) the specific costs of power machine utilisation are rather high even if machines of the lowest possible performance but still appropriate work quality are utilised. From the plant size of 20 hectares and upwards the specific utilisation cost of a 40 kW tractor is reduced to the level of cost specific to the cost level of other power machines.

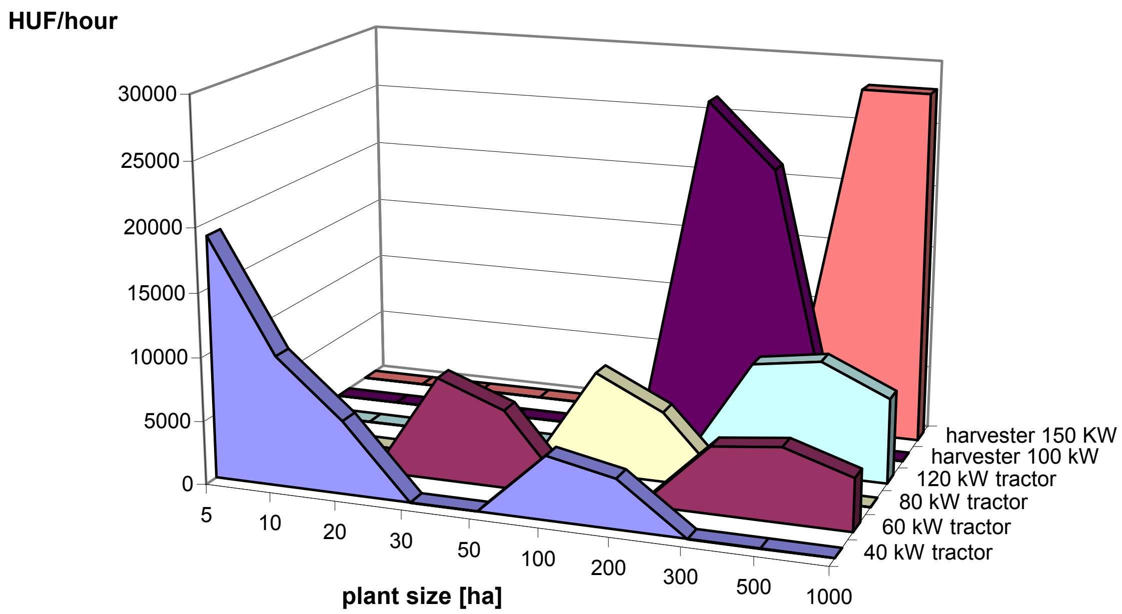

Figure 9: The specific utilisation cost per hours run for the various power machines in the plant sizes examined (1EUR = 250 HUF)

The utilisation costs of tractors used on over 20 hectares are at an acceptable level already at the time of the activation of the given power machine. With the increase of the plant size and the level of utilisation, this value decreases further.

The cost per hours run for the cereal harvesters is substantial. While the cost of utilisation decreases with the increase of the level of utilisation of low-performance combine harvesters, in the case of high-performance machines the number of machines increases together with the growth of the plant size, while the hour run per machine is unchanged, thus the specific costs of utilisation remain unchanged too.

It must be admitted that the utilisation of the own harvester solely for the own crops is not economical up to the plant size of 100 hectares, thus it is more favourable to perform the work tasks through the use of lease work.

When defining the real costs, it must also be taken into consideration that if, on a small plant, a power machine runs 100-200, or in a better case, 500 hours, then its machine life is expected to be not 10 year (this was the basic amortisation period we originally calculated with) but longer [Gockler, 2007]. This results in the decrease of machine utilisation.

Comparison of the utilisation costs of the elaborated model of machinery system of a small plant using high-performance power machines and the costs incurring when aging machines are used

The examinations also extended to cases when, in the case of small and medium sizes plants, not the most cost effective power machines are used for certain technological tasks, that is to say, our fleet consists of power machines of higher performance than justified.

We can confirm that in this case the value we calculated for the costs of machinery model introduced above is 4-5 times higher. (see Figure 10)

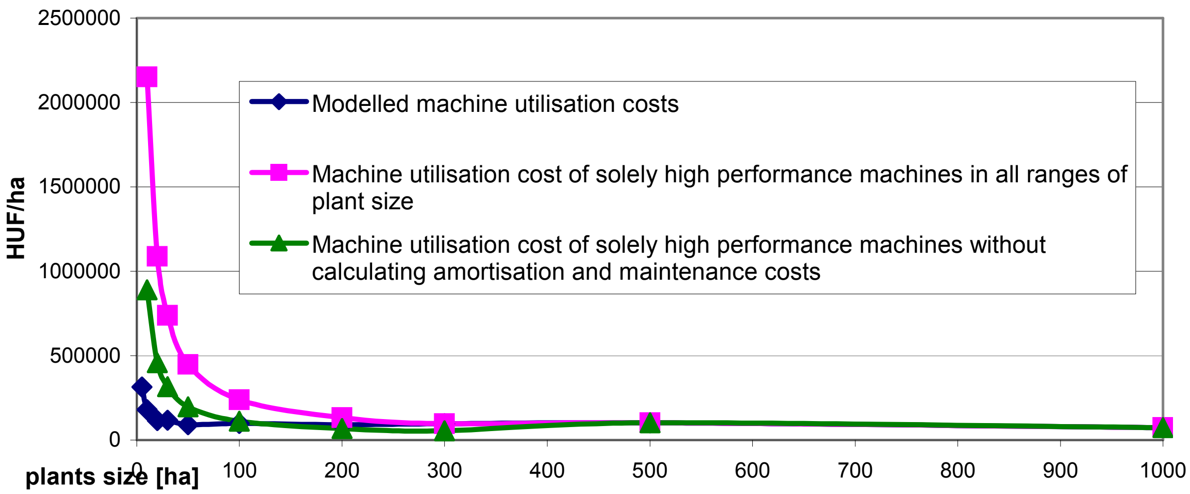

Figure 10: Comparison of costs of a model of machinery system elaborated for small and medium sized plants with the costs of high-performance power machines in a small plant and the costs of aging machines (without calculating amortisation and maintenance costs)

When the reason for using power machinery of higher performance than justified is that these are aging machines and no amortisation cost should be counted with, and there are no costs of regular maintenance under guarantee, and we only have to calculate with the replacement of low price level, post-manufactured spare parts as repair cost, then still, the cost of machine utilisation in the cases of the given sizes of plant are twice as high as in the cases of plants where the category of the power machines was optimally selected.

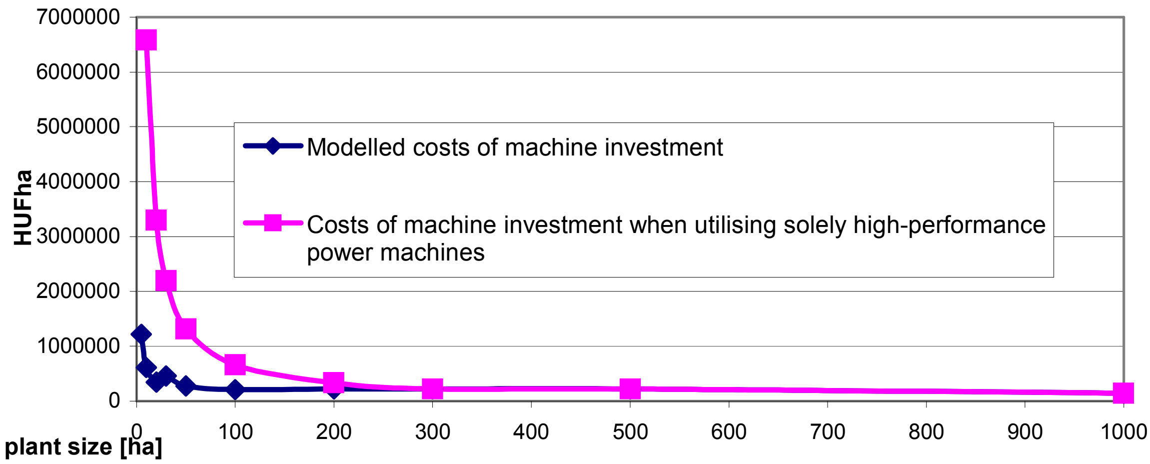

Figure 11: Comparison of investment costs of a model of machinery system elaborated for small and medium sized plants with the investment costs incurring when high-performance power machines are used in a small plant

If we regard the investment costs, we can find similar proportions. Al so in this cases we have to calculate with investment costs 4 and 5 times as high even if on the small and medium sized plants where that task are carried out not by the power machines of sufficient performance and the connecting work machines but by power machines of unreasonably high performance. (see Figure 11)

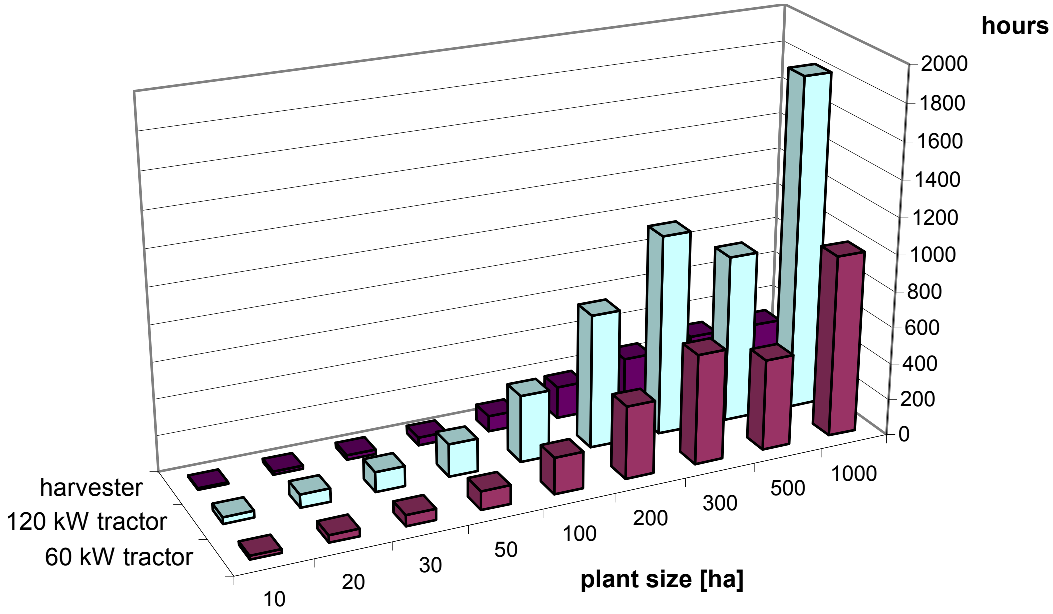

Figure 12: Performance of hours run by medium and heavy-duty universal power machine categories used in all plant sizes including small plants

Figure 12 illustrates well how the multiple costs of machine utilisation mentioned above develop. It demonstrates that 60 and 120 kW tractors achieve substantially less hours run per annum on plants under 200-300 hectares than expectable. This is also true of cereal harvesters. The low level of exploitage means drastic operation costs, as Figure 13 demonstrates. According to our calculations, for a 60kW power machine the cost of machine utilisation on a 10-hectare plant exceeds HUF 80.000/hour run, in the case of a 120kW power machine this value is over HUF 120.000/hour run.

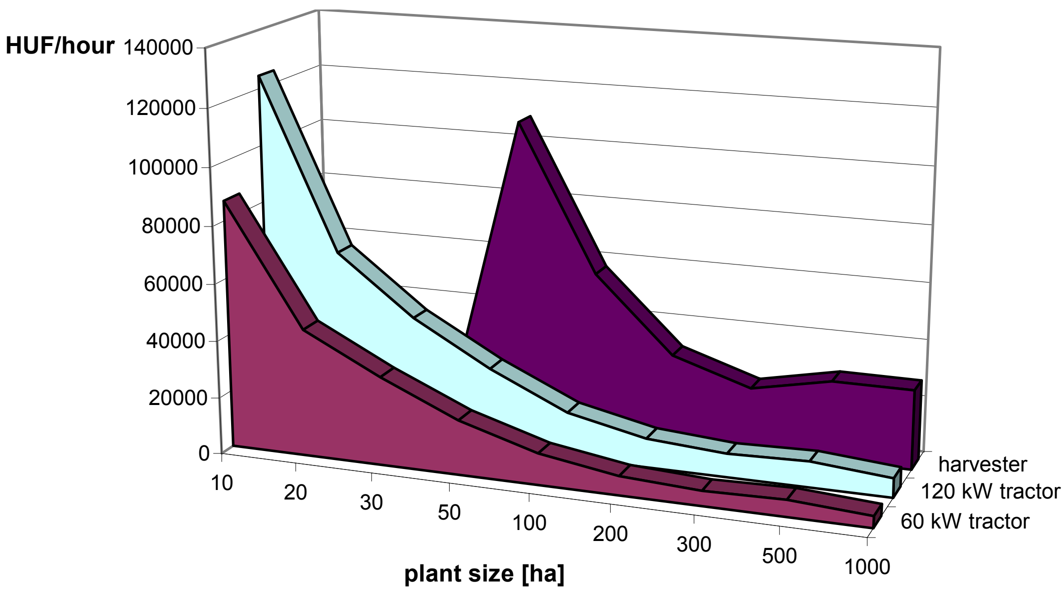

Figure 13: The specific utilisation costs per hours run for medium and heavy-duty universal power machine categories in the examined plant sizes including small plants

We did not even consider the situation if a farm smaller than 50 hectares decides to purchase a new combine harvester, therefore the specific cost of utilisation for harvesters was determined only up to this plant size, which is still over HUF 100.000/hour run.

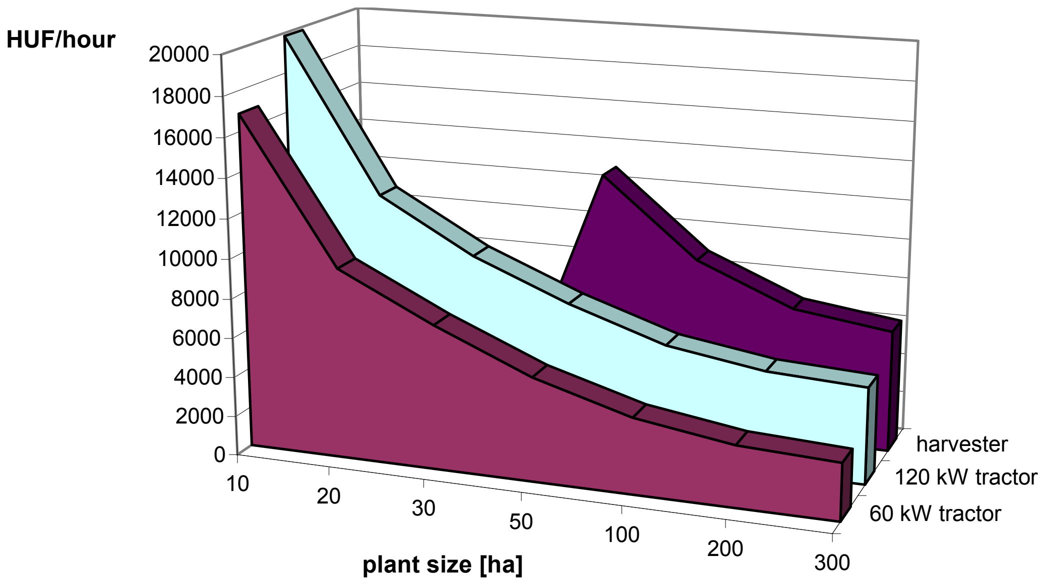

Figure 14: Corrected specific costs per hour run for the utilisation of medium and heavy-duty universal power machine categories in the examined plant sizes (without calculating amortisation and under-guarantee-maintenance costs)

Of course, the operation of low-repair-cost aging machines run without regular service background has more “favourable“ costs than the above substantial costs of machine operation. In this case cost per hour run for a power machine is about HUF 17-20.000, for a harvester, serving a plant of 50 hectares it is only HUF 13.000/ hour run (see Figure 14).
This is the reason for the fact that many farmers, who work on small and medium sized plants, carry out their work tasks with aging medium or heavy-duty universal tractors and do not experience a substantial excess of costs related to machine utilisation, for the amortisation burdens of the machines do not appear, and the maintenance of the machines is carried out by themselves at low costs.

Conclusions

The results of the calculations prove that every individual work operation should be performed by the machine connection that can be utilised to the maximum extent, which has sufficient capacity to carry out the given work task of the given plant size at the appropriate time and in adequate quality. By achieving this, the work can be performed at the *lowest operational cost*.
This system of conditions may be easily realised in plants of large size, however, in the case of small and medium size farms one has to be far more cautious and has to carefully analyse both the costs of investment and machine utilisation.
In the case of farms between 5-10 hectares it must be decided whether the work tasks should be performed by the own unutilised fleet of machines or low-cost lease work, which makes the management of the farm more vulnerable.
Our calculations proved that the mechanisation of small plants requires multiple costs. While the value of assets used for the mechanisation of a plant over the size of 50 hectares is HUF 210-220.000/hectare, the same value for a farm of a few hectares is over HUF

1.200.000/hectare, even if the tasks of sowing and harvesting are usually performed by the use of lease work on these small areas.

With regards to machine utilisation, these values are the following: whereas on plants over 20 hectares, on the basis of the model calculations, a machine utilisation cost of HUF 100-120.000/hectare may be realised, on the small plants this cost may triplicate and exceed HUF 300.000/hectare due to the low level of exploitage, even if part of the tasks are performed by lease work.

These figures were calculated presuming the best possible level of machine utilisation among the given conditions, and low technical level of machines.

In the case of small plants the power machines perform less than 500 hours run per annum. With efficient work organisation, professional, and sometimes tight arrangement of work order, on a medium sized plant one power machine may perform a substantial number of hours run. In this case, in our calculations, 1000 hours run per annum per power machine may be realised.

In the case of large size plants, the utilisation of a heavy-duty universal power machine performing mostly tillage tasks is favourable in the range of 1000-1800 hours run per annum, whereas the utilisation of a secondary tractor performing the tasks of sowing, nutrient supply and plant protection becomes acceptable in the range of 500-1000 hours run per annum.

On the basis of earlier national plant surveys it can be stated that in the small and medium sized plants the power and work machines that could be regarded as new investments are in line with the system of machines modelled in the function of plant size introduced above.

The farmers working on small plants mostly rely on one 40-60 kW power machine in their work, whereas power machines of the medium sized plants are in line with the machine system modelled in the course of the calculations, however, in order to meet the requirements of the production technology and the requirement of performance of the employed work machines, we can often see a primary tractor of higher performance or the number of secondary tractors is higher. (Magó 2006) [8]

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