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Efficient Machine Utilisation in Small and Medium Size Field Vegetable Production Farms

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Abstract: The diversified property structure of agricultural enterprises is not always coupled with efficient power and working machine system. 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 cost efficient machine systems with all the technical-technological advantages of the present era furthering improvingly effective farming.
To solve the present problems of agricultural mechanization 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.
The advantages of this approach of the problem appear both at large and at small farm sizes. While at large size farms, 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.
Based on the examinations it can be established that *in case of the smallest field vegetable production farms* (**under 50 hectares**) *moderate level of utilization* (700-900 operational hours per year) can be reached in case of tractors. *At medium farm sizes* (**50-200 ha**) the same index is *higher*: 500-1600 operational hours per year. *In case of large scale farms* (**over 200 hectares**) tractor categories have significant operational hours capacity (1000-1800 operational hours per year).
Key words: mechanisation of small and medium sized field vegetable production farms, machine fleet planning, machine utilisation, low cost machine fleet, machine investment and usage cost

INTODUCTION

It is essential to develop a cost effective fleet of machinery for the present day various standard sizes of plants *(**Fenyvesi et al**, 2003)*. 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 medium sized farms, which more favourable specific cost level *(**Baranyai – Takács**, 2007)*.

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 *(**Hajdú – Gockler,** 2005), (**Takácsné György – Takács,** 2003)*.

Taking into consideration the current partitioned structure of the farms the goal was established to determine that in the case of the *field vegetable production* on small and medium sized farms which combination of fleet of machinery can be used effectively.

METHOD

Testing of the mechanised processes of agricultural production was carried out using models. In the model a crop rotation plan was adopted which mirrors the Hungarian production characteristics using wheat and corn, onion, carrot. 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 Hungarian Institute of Agricultural Engineering *(**Gockler** 2007)*.

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 300 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

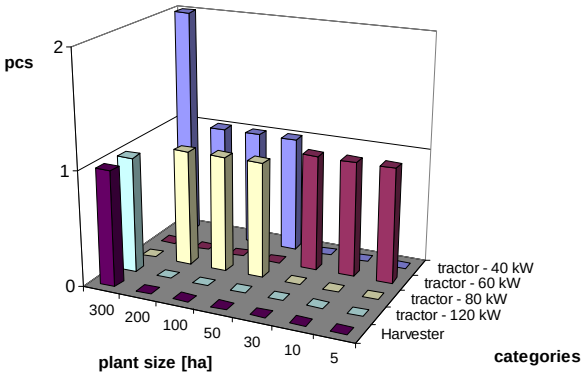

Figure 1. Number of machines of various power machine categories for the given plant size

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.

The surveyed power machinery system that can be rendered to the smallest plant size, in the case of ***tractors***, consists of machines of 60 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 50 hectares tractors with 40 kW and 80 kW performance are required), so the number of tractors increases. Thus, tractors of 40 and 80 kW performance are mentioned *together* in a machinery system for plant size of 50 hectares or upwards. From the plant size of 300 hectares the function of power machinery mentioned above is filled by two tractors of 40 kW and one tractor of 120 kW performance, which have sufficient capacity for the increased workload. For the plant size of 300 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,** 2004)*.

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 **300 hectares**.

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 fifty hectares**, we calculated with *one tractor*.

2) In the case of a plant size ranging from **fifty to two hundred hectares**, two tractors of different performance levels are required.

3) In the case of a plant size **exceeding two hundred hectares**, two or more tractors are required from both performance categories in order to carry out the work operations in time and in good quality.

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 economically most favourable value can be calculated ***over 100 hectares***, in this case a maximum of *one power machine* is sufficient for the cultivation of 100 hectares of land.

The specific performance of engines per hectare decreases substantially in the function of plant size. While on small plant sizes 2-12 kW/Ha engine performance is required for every hectare, in the case of medium sized plants this value falls within the range of 1-2,5 kW/Ha. In plants of large size the work operation may be carried out with a requirement of ***0.7 kW/Ha***.

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 50 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.

In connection to the above, **up to the plant size of 300 hectares**, the system of machinery is formed on the basis of power machines belonging to most of the performance categories. In the range of plant size **not exceeding 50 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 80-kW tractors becomes a part of the optimal machinery system **from 50 hectares upward**, 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 300 hectares**.

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

- 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)*

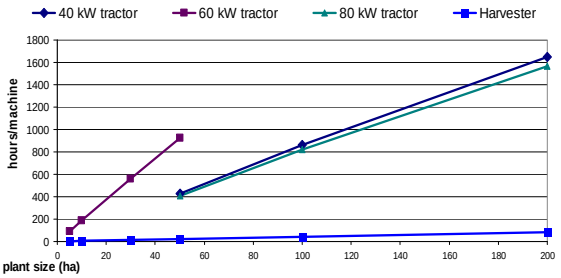

Figure 2. The performed hours run by the categories of power machines in the function of plant size

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; (**Figure 2**)

- In the case of the examined *smallest plant size* (**up to 50 hectares**) *medium exploitage* may be achieved with tractors: maximum 900 hours run per year.
- In the case of *medium size plant* (**50 to 200 hectares**) this quantity is *larger,* 500-1600 hours run per year.
- With *large size plants* (**above 200 hectares**) the various categories of tractors achieve significant performance (1000-1800 hours run per year).

The number of hours run projected on a *unit of area decreases* with the increase of plant size. *In small plant sizes* 22-25 hours run per year is realised. In medium plant sizes this value is between 20 and 22. *In the range of 50 to 200 hectares* this value is

17-19 hours run per year, and, *above this range*, a value of *15 hours run per hectare* can be observed when realising the *efficient work plan*. (**Figure 3**)

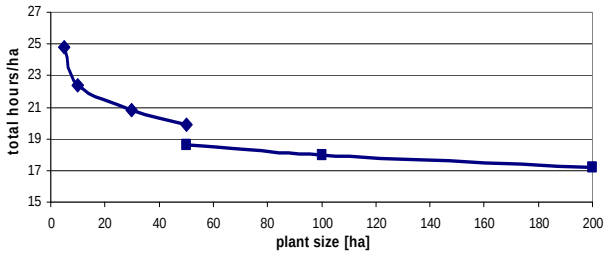

Figure 3. The total performance of hours run by power machines in the function of plant size

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 40 kW***. The performance of this significant labour time is achieved by the power machine of the given category, when sowing, nutrient supply, plant protection and transportation tasks are carried out. (See **Figure 4**)

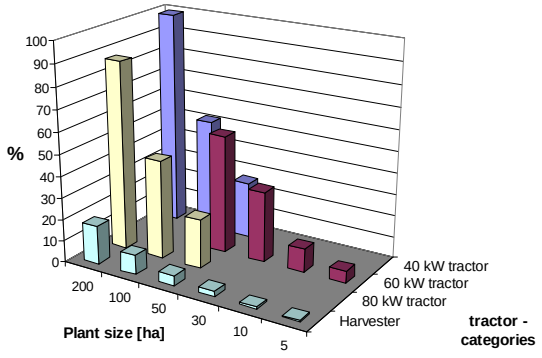

Figure 4. The extent of exploitation with the various categories of power machines in the case of the examined plant sizes

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*.

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 1000 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, 1500 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 1000-1600 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** 2007)*.

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