Towards the optimization in the technology of precision field crop production

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Abstract
Management based on efficient precision principles is based on optimizing resources (eg. machine capacity, labour etc.). By designing technology, time and capacity shortages can be avoided, which will later become a serious loss for farmers. By developing individual processes and operations, we can either mobilize the reserves in the implementation of the technology or modify certain processes or operations. These developments may result in optimized technologies in terms of machinery use and a certain level of logistics, considering the mix of enterprises of specific arable farms. In our research, we designed the resource capacity needs of an arable farm with 2100 hectares. The farm cultivates the main arable crops in Hungary such as wheat, rapeseed and sunflower. Operational costs, the share of logistical costs in operations, cost-benefit analyzes, and discounted value techniques were applied. There is a difference in income between the two cultivation technologies presented. The loss of income from lower FAO maize cultivation is HUF 19,976 thousand, while the income shortage resulting from the cultivation of traditional wheat is HUF 5,636 thousand. Taking into account the 7-year amortization period, the discounted loss is HUF 165,458 thousand.
Keywords: production technology optimization, mix of enterprises, sound management, payback period

Introduction
In today's field crop production, increasing the efficiency of environmentally conscious farming is becoming increasingly important in both input and machine work. Management based on efficient precision principles is based on optimizing resources (eg machine capacity, labour etc.). For technological design, a large amount of data is available on the operation, both for engineering and agronomical planning, from existing and "smart" machines to be procured. It is important that the intensive cultivation systems developed for the principles of precision farming are available with the appropriate machine capacity (at the optimum time). By designing technology, time and capacity shortages can be avoided, which will later become a serious loss for farmers.
Farmers working with arable crops are designed to safely carry out all work operations with minimal power and work equipment and labor. It is important that the sowing structure is constructed in such a way that the above-mentioned goal can be accomplished while meeting the biological optimum of plants. If the particular machine system is not purchased and farmers are not capable of performing current operations on time (eg autumn basic cultivations, logistics when harvesting, etc.), they may easily push the business into loss making situation.
To avoid this, farmers need to pay close attention to the factors influencing available resources and capacities, and the yearly combination of enterprises to produce as well. They need to know the basic business and financial management techniques. One of the well-proven techniques is so called partial budgeting, which takes up almost all farm management work and text (Kay-Edwards-Duffy, 2008). The same authors devote a separate chapter to characterizing farm management in the 21st century, drawing attention to the changes brought about by new technologies and information age. In his earlier work, Warren (1982) discusses the importance of labor and machinery planning by discussing practical solutions.
We regard the process of production as the central process of agricultural enterprises. The production processes are named after the products produced, often in the framework of an enterprise driven by the production technology, which basically influences the cost-profit relationships of the enterprises. By developing individual processes and operations, we can either mobilize the reserves in the implementation of the technology or modify certain processes or operations. These can affect machinery management and labor use, through the costs incurred and considered in each enterprise budgeting. These developments may result in optimized technologies in terms of machinery use and a certain level of logistics, considering the mix of enterprises of specific arable farms.

Materials and Methods
In our research, we designed the resource capacity needs of an arable farm with 2100 hectares. The farm cultivates the main arable crops of corn, wheat, rapeseed and sunflower. Farmers' goal is to do all the work in a timely manner with minimal machinery (power and work equipment). In addition, operational costs, the share of logistical costs in machine work, enterprise cost-benefit analyzes, and cost-efficiency calculations have been defined.
During the design of the technology, the operations, the hectare and the hours of operation were determined by each machine. We determined the incomes generated by the enterprise cost income analysis and summed them up at the level of the economy. In addition, revenue was derived from the surplus assets and machine systems required for the introduction of precision farming (both on the revenue and cost side). Finally, we assessed the investment in the scenarios described above using by internal rate of return, payback period, and net present value (Brealy-Mayers-Allan, 2016) as widely used measures. Our investigations also covered the analysis of effects of constraints (shortages of capacities).

Results and discussion
In the case of the virtual farm involved, we projected the resources (eg. equipment, machinery, labour) needed to implement cultivation in terms of production technology of the plants in the crop structure. In the year under review, a total of 55,600 hectares of machine work was carried out on 2100 hectares, which took approximately 7,800 operating hours (Table 1 and 2).
Taking into account the available data, we have prepared classical enterprise cost-profit analyzes for the plants in the crop structure. For all plants included in the simulation, a gross margin was calculated, which is the lowest of HUF 107 000 x ha (-1) for autumn wheat and HUF 139 800 x ha (-1) for sunflower. Gross margin for the total area is HUF 255,577 (Figure 1 and 2)

Table 1. Sample spreadsheet of power machine demand of crop production technology (in hectare units)

Hectar	Fertilizing	Top-dress	Pest controll	Magágy-készítés	Seeds planting	Cultivation	Discing	Logistic	Logistic 2	Harvest	Cultivation	Strip tillage	Forgatás	Vine pulping	Planting	Winter ploughing	Total
JD8370RT				2100			1050				525	700	1120				**5495**
JD8270R_1					1400	1050		1080							700	175	**4405**
JD8270R_2				0		1400	720	1214	144				280			175	**3933**
JD6215R_1	2101		7585						524								**10210**
JD6215R_2	1051		2100						524								**3674**
JD6215R_3	1051								524								**1574**
JD6145R_1					1400				144					180	700		**2424**
JD6145R_2		2100				2275			144					180	280		**4979**
Hagie STS12		2100	9685														**11785**
JDS690_1										1075							**1075**
JDS690_2										1075							**1075**
JCB	2101									2150					720		**4971**
Total	**6303**	**4200**	**19371**	**2100**		**4725**	**1770**	**2294**	**2003**	**4300**	**525**	**700**	**1400**	**360**	**2400**	**350**	**55600**

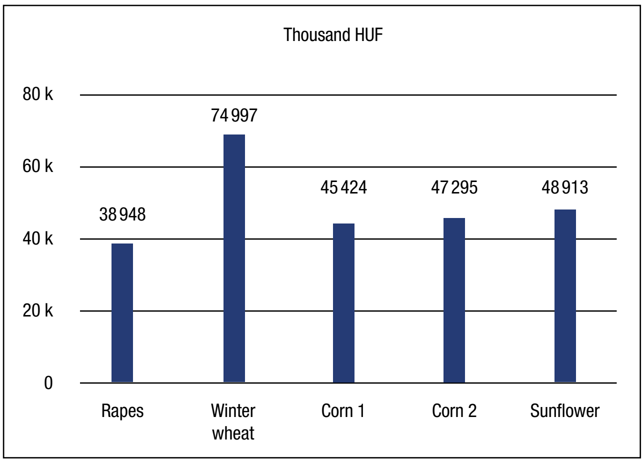
Source: own calculations

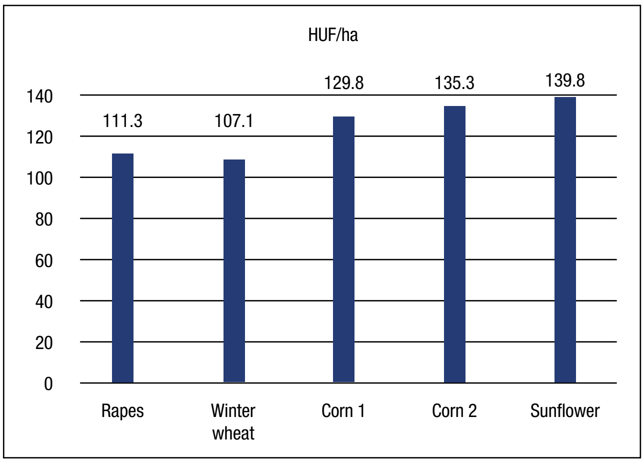
Table 2. Sample spreadsheet of power machine demand of crop production technology in machine-hour units

Workhours	Fertilizing	Top-dress	Pest controll	Magágy-készítés	Seeds planting	Cultivation	Discing	Logistic	Logistic 2	Harvest	Cultivation	Strip tillage	Forgatás	Vine pulping	Planting	Winter ploughing	Total
JD8370RT				265			231				154	250	264				**1164**
JD8270R_1					240	296		216							144	154	**1050**
JD8270R_2						416	198	170	120				110			154	**1168**
JD6215R_1	75		201						335								**611**
JD6215R_2	45		118						335								**498**
JD6215R_3	45								335								**380**
JD6145R_1					177				110					66	120		**473**
JD6145R_2		75	76		60	142			120					66	60		**599**
Hagie STS12		90	383														**473**
JDS690_1										386							**386**
JDS690_2										386							**386**
JCB	45									542					21		**608**
Total		**90**	**383**														**473**

Source: own calculations

Figure 1 and 2. Gross margin





Source: own calculations

Wheat-maize crop rotation in the projection

The anomalies of the Hungarian wheat-maize crop rotation were simulated. 700-700 hectares of wheat and corn are included in the sowing structure. Conventional technology induces the use of shorter breeding time (FAO 300) hybrids in the field of maize selection (50% in our case). This is necessary to ensure the autumn sowing of wheat in October. This results in a significant loss of yield (15-20%) in the maize enterprise and a loss of income. In the autumn wheat, as in September, maize still has to be considered in the area from the use of modern, new varieties and hybrids, leading to further loss of yield (10-15%) and income depression.

It follows that the resources (power machine, machine, human) should be taken into account in the preparation of the sowing plan in order to maximize the use of high-yielding varieties and hybrids (Figure 3).

Figure 3 illustrates that wheat sowing and corn harvesting overlap and that the result is that in areas where the corn produced right before the winter wheat farmers cannot use high-yield varieties and hybrid wheat only if they use additional resources to meet machinery demand although significant extra amortization will occur.

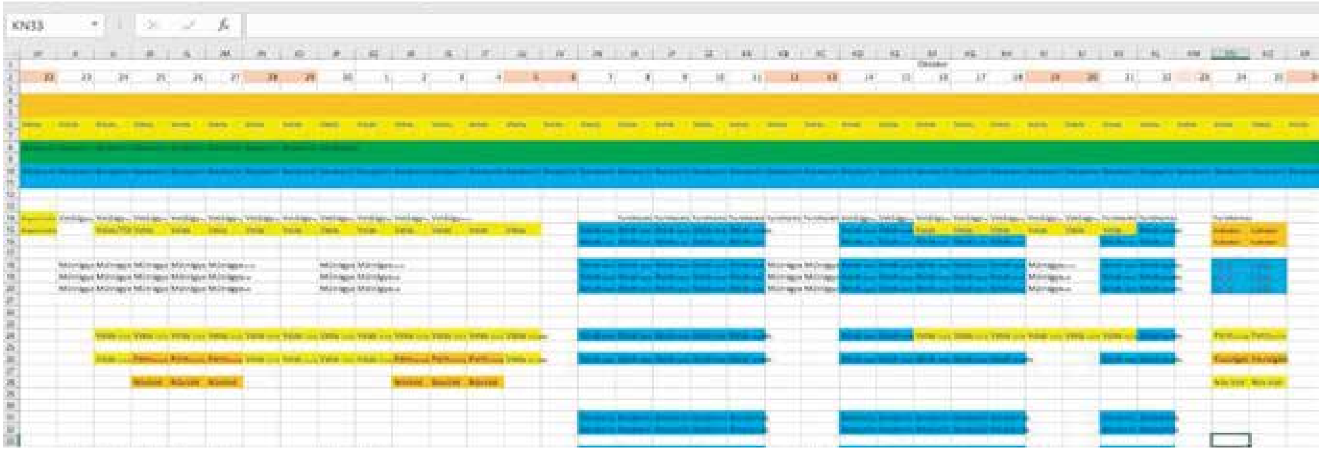
Based on the investment analysis we established that the NPV generated during the 7-year amorphous period is HUF 183,804 thousand, the dynamic payback period is 4 years, and the internal rate of return is 6%.

Table 3. Discounted measures of investment I.

measures	*non optimum technology*
NPV (thousand HUF)	183 804
DPP (year)	4
IRR (%)	6

Source: own calculations

Figure 3. Sample spreadsheet of machinery demand planning for crop production I.



Source: own calculations

Figure 4 clearly shows that, in the case of the reasonably compiled sowing plan, the resources planned for it can be used for the early sowing of autumn wheat and the implementation of the corn with longer growing season technology (thus, 50% of the maize sown area was subject to monoculture for one year).

The machine system necessary for the implementation of the cultivation technology should be made capable of precision farming, the cost of which is 170 814 thousand HUF. During the 7-year amortization period, the net present value of the investment is HUF 350,080 thousand, the dynamic payback period is 3 years and the internal rate of return is 33% (Table 4). Based on these, the proposed investment is recommended from an economic point of view.

Table 4. Discounted measures of investment II.

measures	*technology in optimum*
NPV (thousand HUF)	350 080
DPP (year)	3
IRR (%)	33

Source: own calculations

There is a difference in income between the two cultivation technologies presented. The loss of income from lower FAO maize cultivation is HUF 19,976 thousand, while the income shortage resulting from the cultivation of traditional wheat is HUF 5,636 thousand. Taking into account the 7-year amortization period, the discounted loss is HUF 165,458 thousand.

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Figure 4. Sample spreadsheet of machinery demand planning for crop production II.

Source: own calculations