MANAGEMENT ISSUES OF CROPPING WITH SORGHUM IN THE PRODUCTION STRUCTURE - A CASE STUDY OF HUNGARY

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Abstract: *One of the goals of the developments is to improve the efficiency of the activity by making the currently used traditional production structure more flexible and by making the necessary changes to the technology in the case of farmers with large agricultural land, having necessary machinery and equipments required. Farms with larger arables land are able to offset the effects of changes affecting efficacy and profitability. The main sector of Hungarian agriculture is crop production, so performance is largely determined by the annual output of the crop production sector and the price development of crop products. In the course of our analytical work, we defined a farm of 2100 hectares, for which we examined crop production, crop machinery and economic aspects. From the enterprise data, farm level results compiled according to the crop structure were calculated. Sorghum is suitable for replacing corn in the crop rotation in areas with unfavorable conditions, so a stably growing crop can be added to the crop rotation of autumn ears of corn, rape, and sunflower, instead of corn. It does not hinder the machinery modernization efforts either, since the precision tools and developments already started in corn production can be used well, and it does not require a special equipment park. At the same time, in light of the increasingly frequent negative climatic effects, sorghum's integration into the plant production structure is encouraging, because we have to count on 3-4 drought years in a decade. Based on our analysis, the inclusion of sorghum in the crop structure does not significantly reduce the available income, which is acceptable in the given economic environment. However, its stability can significantly contribute to improving the resilience of farming, especially in comparison with corn.*

Keywords: *crop production structure, sorghum, machinery, operations, cost, profit*
(JEL Code: Q12)

INTRODUCTION

One of the goals of the developments is to improve the efficiency of the activity by making the currently used traditional production structure more flexible and by making the necessary changes to the technology in the case of farmers with large agricultural land with the help of the acquired tools. Efforts to improve the efficiency of farming must be present as a constant demand (SZŰCS-FARKASNÉ FEKETE, 2008), but only taking into account the environmental effects as it was highlighted by KOVÁCS (2011) discussing agri-product evaluation and biodiversity measurement as a tool to reveal effects. In order to complete all tasks in an optimal time, it is necessary to assess the available power and machine capacity, as well as to plan the extra machine capacities essential for the implementation of the technology. SMUK et al. (2009) established that there is a close correlation between the return on investment for the introduction of precision farming as a modern approach and asset structure and the plant sizes. In addition to the assumed five- and six-year payback, plants with larger areas are able to offset the change in yield or the expected interest level. KALMÁR et al. In his article published in 2004, he states in relation to precision

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plant protection technology that the technology can actually only be an alternative for farms larger than 1000 ha. KEMÉNY et al. (2017) their investigations also covered farms cultivating areas larger than 1,000 hectares and smaller, emphasizing that we can expect returns for those cultivating smaller areas as well. This is of particular importance in our country, since the main sector of Hungarian agriculture is crop production, so performance is largely determined by the annual output of the crop production sector and the price development of crop products (POPP et al., 2018). This is also why it is important to change our production structure by adapting to the framework given by the natural-economic environmental factors. This belongs to the flexibility of company operations, which is an increasingly significant expectation in the agri-food sector as well (YOUSUF et al. 2022). A more flexible operation should be a constant aspiration for the productivity of the plant growing sectors and to increase their competitiveness (FELFÖLDI, 2013).

The place of grain sorghum in the crop structure is ensured by its beneficial properties. It is an excellent drought and stress tolerant plant. One of the advantages of sorghum is that it can be grown successfully in areas with poor conditions, prone to drought and stress, where traditionally produced field crops are no longer AGROSZEMEK (2019). Crops that can be grown successfully in regions where other crops cannot be grown economically are particularly important for rural development, as they contribute to maintaining the rural population and increasing income-generating capacity (BORSOS-BITTNER, 2004; BITTNER et al, 2009). It has outstanding stability even on average and poor growing sites, and its productivity in intensive conditions can be up to 12 t/ha. It is characterized by very good adaptability. Its yield stability is outstanding even in dry conditions (KITE, 2021). Support for logistics is indispensable, and a basic condition for the technology is the available transport capacity of the right size. The number of hours suitable for work on each day is important knowledge, but the possibility of the frequency of technical problems and the time intervals for their elimination must also be taken into account (HUSTI, 2007). In the case of companies engaged in crop cultivation, the problem exists in many cases of having to transport large quantities of crops over long distances, which requires the setting up of significant additional capacities (HUSTI 2007). To determine the appropriate number of power and work machines, we calculate the ratio of theoretical and actual area performance. The improvement of the actual field performance can be achieved by organizing several shiHUFs, by cultivating under optimal conditions or even by blocking (HUZSVAI et al, 2012). If we do not carry out plant cultivation technology interventions at the right time, we may have loss of yield and income.

MATERIALS AND METHODS

In the course of our analytical work, we defined a farm of 2100 hectares, for which we examined crop production, crop machinery and economic aspects. We based our data on cultivation technology and enterprise management data for the years 2019-2021, in order to evaluate the profitability and efficiency of production by a complex economic analysis of its technological process (APÁTI et al. 2010; SULYOK et al. 2013). Efficiency can be measured in different ways, with different levels of indicators (NÁBRÁDI et al., 2008). During We determined the cropping structure consisting of maize (16.5%), sorghum (16.5%) and winter cereals (33%) that play a decisive role in the sowing structure, as well as the oil crops such as rape (16.5%) and sunflower (16.5%). The machinery system necessary to ensure proper cultivation was put together and assigned to the technological operations of each crop enterprise.

Taking all of this into account, we determined the machinery work costs required for the implementation of the entire plant cultivation technology in the case of the developed technologies. These cost calculations covered both the specific operational costs and the logistics activities that serve them. The material costs were adjusted to the level necessary for the agreed high production level, in addition, direct personnel costs (e.g. plant protection engineering services) and other costs (e.g. nutrient supply consulting services) were accounted for. Knowing the material costs, machine work costs, labor costs and other direct costs, the sectoral cost-income analysis was carried out for all plant and cultivation technology variants. From the enterprise data, farm level results compiled according to the crop structure were calculated (KAY et al.1994).

RESULTS AND DISCUSSION

The costs of machinery work in field crop production technologies

Successful cultivation is influenced by the quality of the pre-crop. Winter wheat is sown after a pre-crop of rape or sunflower. If sown after rape, then stubble stripping is done in July and chemical stubble care in August. Soil cultivation with no ploughing takes place in the second half of August. In September, basic fertilizers are spread, and seed bed formation and sowing are excuted. In the case of varietal wheat, sowing is postponed to October. Sowing is followed by an autumn weeding operation. Top fertilization takes place in March and April. Plant protection works are carried out in April-May. In July, the work operations of harvesting and collecting grains are carried out (Table 1). The cost of machinery work for the entire cultivation technology of winter wheat is HUF 101,564/ha, of which the cost of logistics is HUF 28,961/ha (28%).

Table 1: Cost of machinery work for the winter wheat enterprise (HUF/ha)

winter wheat				
month	**operation**	**machinery cost of operation**	**logistics cost of operation**	**cost of machinery work**
july	stubble stripping	9 285	0	9 285
august	chemical stubble care	1 634	1 135	2 769
august	soil cultivation with no ploughing	10 941	0	10 941
september	fertilization	1 257	2 972	4 229
september	seed bed formation	9 562	0	9 562
september	sowing	9 498	2 035	11 533

october	spraying	1 634	1 135	2 769
march	top fertilization	1 634	1 135	2 769
april	top fertilization	1 634	1 135	2 769
april	spraying	1 634	1 135	2 769
may	spraying	1 634	1 135	2 769
july	harvesting	22 256	0	22 256
july	collecting grains	0	17 144	17 144
total		**72 603**	**28 961**	**101 564**

Source: Author's own construction

The rape is entered into the sowing structure following the winter wheat harvested. In July, stubble stripping takes place, then in August, chemical stubble care, fertilization, stripped cultivation are carried out. Sowing takes place at the beginning of September, followed by two plant protection interventions. In October, a new plant protection is carried out, followed by inter-row cultivation. Top fertilization and plant protection are carried out in March. In April, another row cultivation and plant protection work are executed. Plant protection intervention is required twice in May and once in June. Harvesting and collecting grains take place in June (Table 2). The cost of machinery work for the presented technology of rape is HUF 101,755/ha, of which the cost of logistics is HUF 31,430/ha (31%).

Table 2: Cost of machinery work for rape enterprise (HUF/ha)

rape				
month	**operation**	**machinery cost of operation**	**logistics cost of operation**	**cost of machinery work**
July	stubble stripping	9 285	0	9 285
August	chemical stubble care	1 634	1 135	2 769
August	fertilization	1 257	2 972	4 229
August	stripped cultivation	10 059	0	10 059
September	sowing	7 135	2 798	9 933
September	spraying	1 634	1 135	2 769
September	spraying	1 634	1 135	2 769
October	spraying	1 634	1 135	2 769
October	cultivating	7 321	1 621	8 942
March	top fertilization	1 257	2 972	4 229
March	spraying	1 634	1 135	2 769
April	cultivating	7 321	1 621	8 942
April	spraying	1 634	1 135	2 769
May	spraying	1 634	1 135	2 769
May	spraying	1 634	1 135	2 769
June	spraying	1 634	1 135	2 769
June	harvesting	11 984	0	11 984
June	collecting grains	0	9 231	9 231
Total		**70 325**	**31 430**	**101 755**

Source: Author's own construction

The pre-crop of the sunflower is corn. Stripped cultivation takes place at the end of October. Plant protection works are carried out in March. Sowing takes place in April, copleted by a plant protection intervention and inter-row cultivation with a nutrient cultivator. Plant protection work takes place twice in May, followed by the stock drying operation at the beginning of September. Harvesting and collecting grains takes place in September, and this is also when we have to perform the stem crushing operation (Table 3). The cost of the machinery work of the sunflower production technology is HUF 70,966/ha, of which logistics is represented by HUF 19,325/ha (27%).

Table 3: Cost of machinery work for sunflower enterprise (HUF/ha)

sunflower				
month	**operation**	**machinery cost of operation**	**logistics cost of operation**	**cost of machinery work**
October	stripped cultivation	10 059	0	10 059
March	spraying	1 634	1 135	2 769
April	sowing	7 135	2 798	9 933
April	spraying	1 634	1 135	2 769
April	cultivating	7 321	1 621	8 942
May	spraying	1 634	1 135	2 769
May	spraying	1 634	1 135	2 769
September	spraying	1 634	1 135	2 769
September	harvesting	11 984	0	11 984
September	collecting grains	0	9231	9 231
September	stem crushing	6 972	0	6 972
Total		**51 641**	**19 325**	**70 966**

Source: Author's own construction

In the case of corn produced by applying soil loosening technology, the pre-crop is winter wheat. In Stubble stripping in July and chemical stubble care, spreading of basic fertilizers, basic cultivation with soil loosening take place on the production area in August. In March, weed control activities adapted to the technology are carried out, followed by sowing, plant protection and a row cultivation operation in April. In May, the second inter-row cultivation and top fertilization operation takes place. In June, if necessary, a third top fertilization must be carried out in order to achieve higher yield. harvest. Harvesting, collecting grains and drying are carried out in October (Table 4). The cost of the machinery work of the corn production technology based on soil loosening is 159,478 HUF/ha, of which the cost of logistics is 39,495 HUF/ha (25%).

Table 4 . Cost of machinery work for corn enterprise (HUF/ha)

corn				
month	**operation**	**machinery cost of operation**	**logistics cost of operation**	**cost of machinery work**
July	stubble stripping	9 285	0	9 285
August	chemical stubble care	1 634	1 135	2 769
August	fertilization	1 257	2 972	4 229
August	soil loosening	10 458	0	10 458
March	spraying	1 634	1 135	2 769
April	sowing	7 135	2 798	9 933
April	spraying	1 634	1 135	2 769
April	cultivating	7 320	1 621	8 941
May	cultivating	7 320	1 621	8 941
June	top fertilization	2 066	703	2 769
October	harvesting	34 240	0	34 240
October	collecting grains	0	26 375	26 375
October	drying	36 000	0	36 000
Total		**119 983**	**39 495**	**159 478**

Source: Author's own construction

In the case of grain sorghum sown after corn, fertilization and plowing take place in October. In the spring, seed bed formation takes place, which is followed by sowing, plant protection operations and inter-row cultivation in April, supplemented with the first top fertilization in May. The second top fertilization and inter-row cultivation take place in one run, followed by the third top fertilization in June if necessary (Table 5). Harvesting, collecting grains and drying are the tasks of the month of October. The cost of machinery work for grain sorghum cultivation technology is HUF 129,726/ha, of which the cost of logistics is HUF 27,994/ha (22%).

Table 5 . Cost of machinery work for sorghum enterprise (HUF/ha)

sorghum				
month	**operation**	**machinery cost of operation**	**logistics cost of operation**	**cost of machinery work**
October	fertilization	1 257	2 972	4 229
October	ploughing	24 224	0	24 224
March	seed bed formation	9 562	0	9 562
April	sowing	7 135	2 798	9 933
April	spraying	1 634	1 135	2 769
April	cultivating	7 321	1 621	8 942
May	cultivating	7 321	1 621	8 942
June	top fertilization	2 066	703	2 769
October	harvesting	34 240	0	34 240
October	collecting grains	0	17 144	17 144
October	stem crushing	6 972	0	6 972
Total		**101 732**	**27 994**	**129 726**

Source: Author's own construction

In summary, the largest cost of machinery work is HUF 156,713/ha that is incurred in the course of corn production. The reason for this is drying, which is necessary in general, and corn gives a heavy bulky product to be harvested and moved. Sorghum has a slightly higher machine labor cost than the other three crops. In the case of winter cabbage and winter wheat, the machinery labor costs are roughly the same: winter wheat 101,567 HUF/ha, winter cabbage 104,527 HUF/ha. In the case of rapeseed, more plant protection interventions are needed, but the amount of the crop is less than in the case of wheat, which has transport and harvesting costs.

Enterprise costs and revenue

For the winter wheat, we established that the cost of input materials (fertilizer, plant protection agent and seed) per hectare is HUF 110,000 (50% of all direct costs), the cost of machinery work is HUF 101,567/ha (46%), personnel costs are HUF 5,000/ha (2%), other direct costs are HUF 5,000/ha (2%), (Table 6). With a yield of 6.5 t/ha and a sales price of 50,000 HUF/t typical for 2019, sales revenue is 325,000 HUF/ha, and the margin is 103,433 HUF/ha. The break-even yield is 4.9 t/ha, the cost of production is HUF 37 538/t.

Table 6: Cost and revenue for the winter wheat enterprise

winter wheat		
Cost of input materials (HUF/ha)	110 000	50%
Cost of machinery work (HUF/ha)	102 000	46%
Personnel cost (HUF/ha)	5 000	2%
Other cost (HUF/ha)	5 000	2%
Direct cost (HUF/ha)	222 000	100%
Total cost (HUF/ha)	244 000	
Yield (t/ha)	6.5	
Sales price (HUF/t)	50 000	
Sales revenue (HUF/ha)	325 000	
Gross margin (HUF/ha)	103 000	
Break-even yield (t/ha)	4.9	
Average total cost (HUF/t)	37 538	

Source: Author's own construction

As part of the cost-income analysis of the rape enterprise, the different types of costs were first taken into account. The costs of input materials are HUF 158,233/ha, 58% of all direct costs, the cost of machinery work is HUF 102 000/ha (38%), personnel costs related to the rape technology (e.g. plant protection consulting service) HUF 5,000 /ha (2%), other direct costs (e.g. soil sampling, precision data processing, data analysis and differential application mapping services) HUF 5,000/ha (2%) were taken into account (Table 7). The total direct costs were HUF 269,760/ha. With a yield of 3.5 t/ha and a typical market price of HUF 112,000/t during the examined period, the sales revenue was HUF 392,000/ha. The gross margin is HUF 122,000/ha, the break-even yield is 2.7 t/ha, the cost of production is approx. 85 000 HUF/t.

Table 7: Cost and revenue for the rape enterprise

rape		
Cost of input materials (HUF/ha)	158 000	58%
Cost of machinery work (HUF/ha)	102 000	38%
Personnel cost (HUF/ha)	5 000	2%
Other cost (HUF/ha)	5 000	2%
Direct cost (HUF/ha)	270 000	100%
Total cost (HUF/ha)	297 000	
Yield (t/ha)	3.5	
Sales price (HUF/t)	112 000	
Sales revenue (HUF/ha)	392 000	
Gross margin (HUF/ha)	122 000	
Break-even yield (t/ha)	2.7	
Average total cost (HUF/t)	84 857	

Source: Author's own construction

Table 8: Cost and revenue for the sunflower enterprise

sunflower		
Cost of input materials (HUF/ha)	127 000	58%
Cost of machinery work (HUF/ha)	71 000	38%
Personnel cost (HUF/ha)	5 000	2%
Other cost (HUF/ha)	5 000	2%
Direct cost (HUF/ha)	221 000	100%
Total cost (HUF/ha)	243 000	
Yield (t/ha)	3.5	
Sales price (HUF/t)	103 000	
Sales revenue (HUF/ha)	360 500	
Gross margin (HUF/ha)	139 500	
Break-even yield (t/ha)	2.4	
Average total cost (HUF/t)	69 430	

Source: Author's own construction

Regarding the analysis of the cost-revenue relationships of the sunflower enterpise, we found that the total direct costs are HUF 220,297/ha (Table 8). The cost of input materials (fertilizer, plant protection agent, seed) is HUF 126,999/ha, 58% of the total cost. The cost of machinery work is HUF 71 000/ha (38%), personnel costs are HUF 5,000/ha (2%), other costs are HUF 5,000/ha (2%). With an average yield of 3.5 t/ha and a sales price of HUF 103,000/t, the sales revenue is HUF 360,500/ha, the gross margin is cca. HUF 140,000/ha, the break-even yield is 2.4 t/ha. This enterprise produced HUF 69 430 /t as cost of production.

In the case of corn cultivation technology, the total direct costs are HUF 313 000/ha, of which the cost of input materials is 142,573 HUF/ha (47%) and the cost of machinery work is 160 000 HUF/ha (50%). Personnel costs are 5,000 HUF/ha (2%), other direct costs are 5,000 HUF/ha (2 %), (Table 9). With a yield of 10 tons and a selling price of HUF 45,000/t, the sales revenue is HUF 450,000/ha, the gross margin is HUF 137,000/ha. The break-even yield is 7.6 t/ha, while the cost of production is HUF 34,400/t.

Table 9: Cost and revenue for the corn enterprise

corn		
Cost of input materials (HUF/ha)	143 000	47%
Cost of machinery work (HUF/ha)	160 000	50%
Personnel cost (HUF/ha)	5 000	2%
Other cost (HUF/ha)	5 000	2%
Direct cost (HUF/ha)	313 000	100%
Total cost (HUF/ha)	344 000	
Yield (t/ha)	10	
Sales price (HUF/t)	45 000	
Sales revenue (HUF/ha)	450 000	
Gross margin (HUF/ha)	137 000	
Break-even yield (t/ha)	7.6	
Average total cost (HUF/t)	34 400	

Source: Author's own construction

Table 10: Cost and revenue for the grain sorghum enterprise

sorghum		
Cost of input materials (HUF/ha)	122 000	45%
Cost of machinery work (HUF/ha)	130 000	52%
Personnel cost (HUF/ha)	5 000	2%
Other cost (HUF/ha)	5 000	2%
Direct cost (HUF/ha)	262 000	100%
Total cost (HUF/ha)	288 000	
Yield (t/ha)	8	
Sales price (HUF/t)	45 000	
Sales revenue (HUF/ha)	360 000	
Gross margin (HUF/ha)	98 000	
Break-even yield (t/ha)	6.4	
Average total cost (HUF/t)	36 000	

Source: Author's own construction

In the case of grain sorghum, the total direct costs are HUF 262,000/ha. The cost of input materials is HUF 121,500/ha (Table 10). The cost of machinery work is HUF 130,000/ha (52%), the personnel cost is HUF 5,000/ha (2%), other costs are HUF 5,000/ha (2%). Calculated with a yield of 8 tons and a sales price of HUF 45,000/t, the sales revenue is HUF 360,000/ha, the gross margin is HUF 98,000/ha, the break-even yield is 6.4 t/ha. The cost of production is HUF 36,000/t.

Table 11: Cost and revenue for cropping structure with no sorghum

item	Winter wheat	Rape	Sunflower	Corn	Total
arable land (ha)	700	350	350	700	2 100
Direct cost (thousand HUF)	155 400	94 500	77 350	219 100	546 350
Sales revenue (thousand HUF)	227 500	137 200	126 175	315 000	805 875
Gross margin (thousand HUF)	72 100	42 700	48 825	95 900	259 525

Source: Author's own construction

In the case of grain sorghum, the total direct costs are HUF 262,000/ha. The cost of input materials is HUF 121,500/ha (Table 10). The cost of machinery work is HUF 130,000/ha (52%), the personnel cost is HUF 5,000/ha (2%), other costs are HUF 5,000/ha (2%). Calculated with a yield of 8 tons and a sales price of HUF 45,000/t, the sales revenue is HUF 360,000/ha, the gross margin is HUF 98,000/ha, the break-even yield is 6.4 t/ha. The cost of production is HUF 36,000/t.

Table 12: Cost and revenue for cropping structure with sorghum

item	Winter wheat	Rape	Sunflower	Corn	Sorghum	Total
arable land (ha)	700	350	350	350	350	2100
Direct cost (thousand HUF)	155 400	94 500	77 350	109 550	91 700	528 500
Sales revenue (thousand HUF)	227 500	137 200	126 175	157 500	126 000	774 375
Gross margin (thousand HUF)	72 100	42 700	48 825	47 950	34 300	245 875

Source: Author's own construction

Summarizing the enterpise cost and revenue analyses, the direct costs for 350 hectares of sorghum, 350 hectares of corn, 350 hectares of rape, 350 hectares of sunflowers and 700 hectares of winter wheat amount to HUF 528,500 thousand (Table 11). The total sales revenue is 774,375 thousand HUF producing the gross margin that is 245,875 thousand HUF. Thus, in comparison with the cropping structure with no sorghum (Table 10), it is 17,850 thousand HUF, that is, 3% less direct costs are incurred. At the same time, it gives less sales revenue by 4% and a lower sum of gross margin by 5%.

CONCLUSIONS

Sorghum is suitable for replacing corn in the crop rotation in areas with unfavorable conditions, so a stably growing crop can be added to the crop rotation of autumn ears of corn, rape, and sunflower instead of corn. We compare this with the effects of responses to the challenges that arise during farming. Such is the fact that the machinery and equipment pool does not hinder modernization efforts either, since the precision tools and developments already started in the corn production can be used well, and does not require a special tool park. At the same time, in light of the increasingly frequent negative climatic effects, its integration into the plant production structure is encouraging, because we have to count on 3-4 drought years in a decade. The stability of sorghum, its content values, and its quality parameters are increasingly making it an alternative to corn. It is justified to increase the weight of sorghum in the sowing structure, whether it is produced as feed material or for sale, completed by further investigation of its positive effects on farming. Based on our analysis, the inclusion of sorghum in the crop structure does not significantly reduce the income, which is acceptable in the given economic environment. However, its stability can significantly contribute to improving the resilience of farming, especially in comparison with corn.

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