HUNGARIAN AGRICULTURAL ENGINEERING
No 41/2022 66-71
Published online: http://hae-journals.org/
HU ISSN 0864-7410 (Print)
HU ISSN 2415-9751(Online)
DOI: 10.17676/HAE.2022.41.66
Received: 01.06.2022 - Accepted: 25.06.2022

PERIODICAL
OF THE COMMITTEE OF AGRICULTURAL AND BIOSYSTEM ENGINEERING OF THE HUNGARIAN ACADEMY OF SCIENCES
and
HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES INSTITUTE OF TECHNOLOGY

HUNGARIAN UNIVERSITY OF AGRICULTURE AND LIFE SCIENCES
Institute of Technology

ANALYSIS OF LOGISTICAL AND MACHINE WORK COSTS OF THE CULTIVATION OF SWEET SORGHUM AS RAW MATERIAL FOR RENEWABLE ENERGY PRODUCTION

Author(s):
L. Magó[1]

Affiliation:
[1] Institute of Technology – Hungarian University of Agriculture and Life Sciences, 2100 Gödöllő, Páter Károly u. 1., Hungary;

Email address:
Mago.Laszlo@uni-mate.hu

Abstract: This work is a comprehensive examination that analyses the machine fleet formation and machine use of plant production farms that grow sweet sorghum too by using computer aided modelling. It considers the characteristics of machines used at the production technologies of different plants and it especially focuses on the appliance of machines with the convenient capacity and level from the side of costs at different farm sizes. The survey was based on the work tasks of a "classical" crop production farm. By the technical-economical analysis of the production-technology of sweet sorghum it has been determined that the total production cost of this plant per hectare in case of small-scale farm size is minimum 965 EUR. Examining the large-scale production, the costs are decreasing, but they cannot be reduced under the 860 EUR/hectare level.

Keywords: plant production, farm size, machine fleet planning, machine utilisation, low-cost machine fleet

1. Introduction

The goal of the research is the technical-economical analysis of the production-technology system of the sweet sorghum that is known as energy plant and nowadays as a promising base material of biotechnological industries [1].

Work done *by an efficiently developed machine system* is a significant condition of the fruitfulness of farming [2]. 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 [3].

We have accomplished the examinations by taking power-machines from different quality and cost levels as base. Through this we have showed that not only the size of the farms effects the amount of the operational costs, but the standard of mechanization too [4].

2. Materials and Method

2.1 The sweet sorghum (Sorghum vulgare saccharatum)

The sweet sorghum is one of Hungary's plants that is capable to produce the greatest amount of biomass and it's production can be fitted in the conventional alternation of the cereals and industrial plants and the outstanding yields can be ensured at lower costs than other cultures. From the point of view of energetic use, the component of the sweet sorghum that is classed as secondary product, the high sugar content solution that can be pressed from the spears, that is a suitable base material for bioconversion methods. The amount of the productable sugar reaches or exceeds the amount of the glucose that can be produced from cereals

grown on a land with the same size. The complex use of the components that can be obtained from the sweet sorghum can significantly increase the reachable profitableness of agriculture [5].

The plant is subtropical, needs hot weather and takes drought significantly. It is also called durra or sweet-cane. It was grown in a higher amount between the two world wars. After the II. World War, until the start of the sugar production, the sugar containing syrup pressed and condensed from the plant was used instead of sugar. Nowadays it is mainly used to produce silage fodder, planted with silage corn. The growing conditions are very advantageous, because the sweet sorghum gives a stable yield even in case of poor water supply (60-70 tonns/hectare) [6].

2.2 The surveyed crops

The surveys can be conducted by *modelling* the machine working processes of agricultural production. On the base of field crop production, a crop plan including cereal plants for human consumption, *sweet sorghum* 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. Depending on venture size the proportion of the crop area of the individual plants has been stipulated in view of the agronomical and production technological conditions.

2.3 The significance of machine utilization, the machine families applied, the parameters of model calculations

In the utilization costs of the more and more up-to-date and expensive power machines the proportion of *fixed costs*, especially amortization and maintenance is very high [7]. This expense can be decreased by increasing *utilization*. If the applied means are coupled to the individual field work operations at their effective operation cost – i.e. taking the rate of utilization into account – the effect of *working-hour performance* on costs will become measurable [8].

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 [9, 10].

The basic figures of machine utilization have been determined with the help of the data base of the Hungarian Institute of Agricultural Engineering [11, 12].

The *model-calculations* have affected the farm size points of machine stock development in a farm size of 30 and 1000 ha. 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 [13].

3. Results

3.1 The constitution of the machine system in case of the examined operating sizes

The power-machine system that can be ordered to serve the examined operating size of 30 hectares to finish the soil preparation in a good quality consists of the minimal 40 kW output piece and the attachable soil tilling, nutritive spreading and insecticide process machines. In case of the 1000 hectare farm size that is the base of the large-scale examination, the minimum is the tractors with 60-120 kW of output that can be the base of the machine works. The different output-categories are represented by two power-machines in each case. The easier nutritive supply and insecticide tasks are done by the machines with smaller output and the heavier tasks are done by the machines with higher output. The *materials handling to the depot* can also be done by these tractors by using tow-cars to increase the exploitage of the machines.

In case of farm size of 30 hectares, the finishing of the harvesting works as wagework is the most efficient. According to the calculations, on a 1000 hectare sized farm, to reach the acceptable capacity-utilization, one *cereal combine-harvester machine* can be operated as the property of the farm. The appliance of the self-propelled silo harvester that does the gathering of the sorghum as a property, highly increases the machine costs of the farm, therefore it can be seen in the chapter *results* in details that it is more advantage out to use a self-propelled silo harvester for commission work.

3.2 The number of the executed working-hours in function of the power-machine category, the mechanical level and the farm size

The number of the executable working-hours of the power-machines in case of different farm sizes determines the composition to each category of the power-machine system;

In case of the examined *smaller sized farm* (30 hectares) based on our calculations *low exploitage* can be reached to the tractors: maximum 435 working-hours/year.

In case of large estate sizes (1000 hectares) the executed machine working-hours of the farms power-machine fleet, based on our model calculations is 6650 working-hours, from which the tractors represent a major (1100 working-hours/year (power-machine with 60 kW output) and 1700 working-hours/year (power-machine with 120 kW output)) part.

With a clever-chosen cereal harvesting machine at *one thousand hectare* farm size executing about 450-500 working-hours it reaches *significant* exploitage, that results in *acceptable* operational cost. The annual capacity exploitage of the self-propelled silo combine in case of own property is only 150 working-hours, that makes the idea of purchasing the machine as property to think it over.

In case of a 30 hectare sized farm the machine work demand of sweet sorghum that's production is fitted in the rotation of crops is 120 working-hours, that is 14,8 working-hours/hectare. This value is slightly higher than the economic average. In case of a 1000 hectare sized farm the machine work demand of sweet sorghum that's production is fitted in the rotation of crops is 1675 working-hours, that is 6,7 working-hours/hectare. This marks well that the production of sweet sorghum is a labour-intensive activity, because this value is also higher than the value that is specific to the whole farm. By using *modern machines*, the shown working-hour execution parameters will decrease with 4-5 % [14, 15].

In case of small-scale production, the significant number of shift-hours increases the living work outlay, thereby *increases the employment*. In the farms with this size the use of small output machines is reasonable. However, the proper usage of the small capacity machines is not ensured either, so the significant constant costs induce *higher operational costs* [16].

3.3 The analysis of the machine usage costs

Applying *low-level* power-machine fleet, the annual machine use cost of a 30 hectare farm that produces sweet sorghum too is 11.785 EUR, that is 393 EUR per hectare. The specific machine cost of the produced crops is the following: wheat 365 EUR/hectare, sunflower 375 EUR/hectare, rape 395 EUR/hectare, sweet sorghum 440 EUR/hectare. In the sowing plan the ratio of the plants is the following: wheat 40%, sunflower 25%, sweet sorghum 25%, rape 10%.

Applying *modern power-machines* the annual machine use cost is 14.645 EUR, that is 491 EUR per hectare. In case of the produced plants the machine costs are the following: wheat 460 EUR/hectare, sunflower 475 EUR/hectare, rape 500 EUR/hectare, sweet sorghum 540 EUR/hectare.

Those who work on small sized farm can count with low power-machine utilization, that also has effects on the use costs per working-hour of the tractors. This value is 19 EUR/working-hours in case of the 40 kW tractors that are usually used in small works. At this production size, the calculated cost of the borrowed used cereal harvester and self-propelled silo combine is 52,5 EUR/working-hours and 72,7 EUR/working-hours. In case of *modern machines*, the specific cost of the mentioned tractor to a time unit is 24 EUR. The cost of the cereal combine is 73,6 EUR/working-hours. In case of an ensilage cutter, we can also count with the given values, because in the database that we used for the calculations we haven't found two different technical levels from the harvesting machines with these functions.

Considering a 1000 hectare sized farm in case of *low level* mechanization, taking the above mentioned sowing plan ratios the annual use cost of the machines is 303,5 thousand EUR, that is 303,5 EUR/hectare. The machine cultivation cost per hectare to each of the plants: wheat: 240 EUR, sunflower 270 EUR, rape 245 EUR, sweet sorghum 465 EUR.

If the use of the self-propelled ensilage cutter machine is not as an own property, than it is *leased work*, the machine use cost of the whole farm is 267,8 thousand EUR. The specific value for a hectare is 267,8 EUR. And the specific machine cost of the sweet sorghum production is the advantageous level of *320 EUR/hectare*.

With the appliance of *high-level* power-machines the annual machine use cost projected to the whole farm is 339 thousand EUR, specifically 339 EUR/hectare. In case of wheat it is 275 EUR/hectare, sunflower 305 EUR/hectare, rape 275 EUR/hectare and sweet sorghum 505 EUR.

It can be observed that the machine cost of sweet sorghum is the highest in every case, compared to the other plant cultures. This is mostly because great volume of the harvesting and crop transporting tasks: at least 60-80 t/hectare of crop has to be harvested and transported to the processing plant.

If the ensilage cutter machine does it's tasks as *leased work*, the costs decrease. As a result of the calculations, the total machine use cost of the whole farm is 303,5 thousand EUR. Specifically it is 303,5 EUR/hectare. The machine work cost of the sweet sorghum production is *365 EUR/hectare*.

The Figure 1 also shows the previously introduced things, where the upper and lower limit of the machine use costs are shown in function of the farm size, that are determined considering the use of low-level power-machines and implements and the expensive power-machines that represent the modern machine technologies.

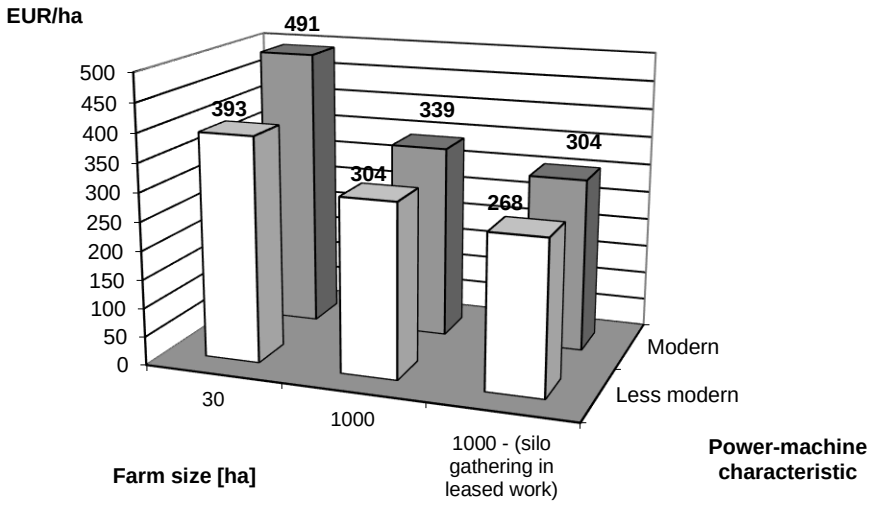

Figure 1. The specific machine utilisation costs in case of different mechanization levels at farms with the investigated sizes

In large-scale production the exploitage of the power-machines is more advantageous. The tractor with 60 kW output works 1100 working-hours and the medium sized universal power-machine with 120 kW output works 1750 working-hours annually. The use cost of them to one working-hour is 15,7 EUR, and 27,3 EUR. According to our calculations the use cost of the cereal harvester and self-propelled silo combine as own property is 83 EUR/working-hour, and 243,2 EUR/working-hour. If we borrow the ensilage cutter for work, the cost reduces significantly to 97,4 EUR/working-hour. In case of *modern power-machines* the specific cost of the mentioned tractors to a time unit are 19,7 EUR and 31,4 EUR. The cost of the cereal combine is 93,4 EUR/working-hours. In case of an ensilage cutter as we have mentioned, we can calculate with the above given values.

The operational costs of the work processes of the sweet sorghum production calculated after the computer modelling can be seen on Table 1.

The marked costs in the chart show the direct costs of the machine operation, plus the accessory costs (farm level costs) that increase the discussed values with almost 20%.

The difference between the costs of the small and the large-scale farm size is well-marked. This all can be explained with the efficiency of the machine exploitage. In the field of costs there is also a difference between the use of modern and less modern machines. In case of small-scale farm size, with using less modern power-machines a more advantageous cost level can be reached, although the quality of the work and the circumstances of the working must be considered. In case of large-scale farm size the difference between the operational costs of the less modern and modern machines decrease significantly, because the operation of

the less modern machines is more expensive at larger strain and the high level constant costs of the modern machines significantly decrease, according to their better exploitage, considering one unit of work.

The values in brackets show the first-cost of the leased work.

Table 1. The direct machine operation costs of the work processes of the sweet sorghum production

	In case of using low-cost power-machine		**In case of applying modern power-machines**	
Farm size	**30 ha**	**1000 ha**	**30 ha**	**1000 ha**
Dimensional unit	EUR/ha	EUR /ha	EUR /ha	EUR /ha
Stubble ploughing	23	15,4	28,6	17,6
Fertilizer distribution	11,8	8	14,8	8,3
Muck-spreading		34,9		39,8
Stubble care	23	15,4	28,6	17,6
Deep ploughing	69,4	33,8	78,9	37,5
Plough levelling	23	15,4	28,6	17,6
Herbicide spraying	10,9	7	13,4	7,8
Chemical pouring	15,5	10,6	19,2	12,1
Preparation of seedbed	15,5	10,6	19,2	12,1
Sowing	22,3	18	25,9	19,8
Chemical plant protection	10,9	7,0	13,4	7,8
Within-the-row cultivation	19,6	7,7	23,8	9
Harvesting	*(65,2)*	171 *(64,1)*	*(65,2)*	171 *(64,1)*
Crop transportation to depot	*(57,1)*	32,9	*(65,3)*	38,5

4. Conclusions

Besides the introduced machine costs we must count with the prices of the input materials of the sweet sorghum production to know the whole cost of the production of the plant. Adding all the cost of the nutrient supply, the seeds and the cost of the pesticide, we face that a minimal input material cost is 500 EUR/hectare. Beside this we must not forget about the cost of the insurance and other supplemental expenses that is connected to the production.

Adding everything, the total production cost of the studied plant per hectare in case of small-scale farm size is minimum 965 EUR. Examining the large-scale industrial production the costs reduce, but they can not be reduced under the 860 EUR/hectare level.

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

References

[1]. **Erdeiné Késmárki-Gally Sz., Szabó I.**: (2012) A magyarországi cukortartalmú növények (termesztésének) gazdasági elemzése - Beszámoló Jelentés", VM Mezőgazdasági Gépesítési Intézet, Költségvetési kutatási téma. 12. p.

[2]. **Magó L.**: (2020) Smart Control on Agricultural Machines, Hungarian Agricultural Engineering, Periodical of the Committee of Agricultural and Biosystem Engineering of the Hungarian Academy of Sciences, Vol. 37/2020. p. 41 - 47. DOI: 10.17676/HAE.2020.37.41

[3]. **Husti I., Kovács I.**: (2009) Adaptation of Integrated Enterprise Management Systems for Farm Machinery Management, Abstracts of the International Conference "Synergy and Technical Development in the Agricultural Engineering", Gödöllő, Hungary, 31. August - 3. September 2009. p. 101.

[4]. **Magó L.**: (2008a) The Comparison of the Technical-economical Parameters of Machine Utilization under Different Level of Mechanization Subject to Farm Size, Agricultural Engineering Research – Bulletin of the Hungarian Institute of Agricultural Engineering, Gödöllő, 39 p.

[5]. **Erdeiné Késmárki-Gally Sz., Barabás N.**: (2012) „A cukorcirok termesztési vizsgálata Halmajon "Mezőgazdasági Technika, tudományos, műszaki fejlesztési és kereskedelmi folyóirat, Vol. LIII, No 12., p. 34-36.

[6]. **Kocsis L.**: (2009) A cukorcirok betakarításának lehetőségei a feldolgozási folyamat gazdaságosságának figyelembevételével. Mezőgazdasági Technika. Vol. L., No. 7. p. 12-14.

[7]. **Daróczi M.**: (2007) Basic Tasks of the Agricultural Investment Process, Hungarian Agricultural Engineering. No. 20., p. 65-66.

[8]. **Magó L.**: (2008b) Improving the Efficiency of Machine Utilization by Rationalization of Shift-hour Performance of Power Machines Considering the Farm Size, Towards Environmental Technologies, International Conference on Agricultural Engineering, AgEng2010, Clermont-Ferrand - France, 6-8 September 2010. Book of Abstracts p. 268. Full paper in CD issue.

[9]. **Magó L.**: (2007) Low Cost Mechanisation Solutions for Effective Farming on Small and Middle-sized Arable Farms, Hungarian Agricultural Engineering, Periodical of the Committee of Agricultural Engineering of the Hungarian Academy of Sciences, Vol. 20/2007. p. 61-64.

[10]. **Fenyvesi L., Gockler L., Hajdú J., Husti I.**: (2003) A mezőgazdaság műszaki fejlesztésének lehetséges megoldásai. Gazdálkodás, No. 5. 1-15 p.

[11]. **Gockler L.**: (2015) Mezőgazdasági gépi munkák költsége 2015-ben., NAIK MGI. Gödöllő. 32 p.

[12]. **Erdeiné Késmárki-Gally Sz., Rák R.:** (2020): Mezőgazdasági gépi munkák költsége 2020-ban. NAIK MGI. 32 p.

[13]. **Bártfai Z., Lágymányosi A, Szabó I., Tímár T.**: (2019a) Development of a Digital Database for Supporting Precision Technologies, Mechanical Engineering Letters, Vol. 19. p. 195. - 201.

[14]. **Magó L., Cvetanovski A.**: (2019) Smart Attached Working Equipment in Precision Agriculture, Hungarian Agricultural Engineering, Periodical of the Committee of Agricultural and Biosystem Engineering of the Hungarian Academy of Sciences, Vol. 35/2019. p. 5-12., DOI: 10.17676/HAE.2019.35.5,

[15]. **Bártfai Z., Blahunka Z., Kátai L., Szabó I.**: (2019b) Synergy of Robotics and ICT in the Smart Farming, Hungarian Agricultural Engineering, Periodical of the Committee of Agricultural and Biosystem Engineering of the Hungarian Academy of Sciences, Vol. 36/2019. p. 22. - 28., DOI: 10.17676/HAE.2019.36.22,

[16]. **Takács I., Baranyai Zs., Takács E., Takács-György K.**: (2008) Change of Labour Productivity on Field Crop Farms in the EU Countries from 1989 to 2005, Cereal Research Communications, Akadémiai Kiadó, Vol. 36: p. 51-54.