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Optimisation of the machinery park with the use of OTR-7 software in context of sustainable agriculture

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Abstract

The paper presents possibilities for the use of OTR-7 software (Organizer of Agricultural Technology) for optimization of the machinery park equipment in sustainable agriculture. The applied algorithms enable selection of the relevant technical equipment which enables performance of the planned field work. Due to the use of the specialised software, desired economic effects and competitive advantage can be obtained and the risk related to the purchase of expensive equipment can be minimized.

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Keywords: machinery park; sustainable agriculture; optimisation; agricultural technology; agricultural software.

1. Introduction

A correct selection of the machinery park is vital for correct functioning of a farm. It is particularly significant in sustainable agriculture, where agricultural production must be effective and should enable production of safe, high quality food in a manner that protects the condition of the natural environment, social and economic conditions of farmer's life, employees employed in a farm as well as local societies.

Agricultural machines that have been correctly chosen enable performance of the planned work on time and with

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maintenance of appropriate quality and care for the performed work. Meeting these requirements must be obligatory. However, it may be performed with the use of various sets of machines. Yet, the use of machines with incorrectly selected size and performance may generate too high costs, although it allows performance of fundamental agro-technical treatments. Such costs may considerably exceed those which may be incurred at the optimally selected set of machines. The increase of operating costs of machines may be reported both in case of machines which are too big (and expensive as well) and in case of machines, which are too small (their operation time is too long).

A farm is a complex body with a network of relations between its particular elements. These relations occur between particular branches of production, specific plants (crop rotation) and in the machinery park. When mechanization is designed, selection of suitable field work technologies enforces planning of machines, which perform these works. For example, planning of a no-till technology results in elimination of ploughs from a farm and replacing them with other machines. As a rule, introduction of modern, high-efficient machines enforces at the same time introduction of greater power tractors to a farm. As a consequence, the design of the machinery park must be complex and must cover practically the entire farm (or must reflect the existing one). In particular, field work technologies must be outlined, machines must be adjusted to the predicted amount of work, and tractors to machines which they cooperate with.

Farms are becoming better equipped with computer equipment, they have internet access and software operation skills are higher. As a result, farmers more often use computers to support functioning of their farms (Francik, 2010; Kapela, Borusiewicz, 2012).

2. Selected algorithms for design

Figure 1 presents a simplified algorithm for design with the use of OTR-7 software. Two parts were distinguished there, i.e. a part of the decision-making, where a man decides on the course of the project (introduces data) and a part of computational, where a computer processes data and shows results. In case of non-satisfactory results, users return to a decision-making part, where they change input data and check how it influences the farm balance. From the point of view of selection of the machinery park, the most vital are: production technology changes and replacement of machines and tractors with ones that better suit farmer's needs. Division into two parts (a decision-making and computational) is reflected in the OTR -7 interface, whose main window is divided into two parts: the upper - decision-making, designed for introduction of data and the lower - computational, where computation results are presented.

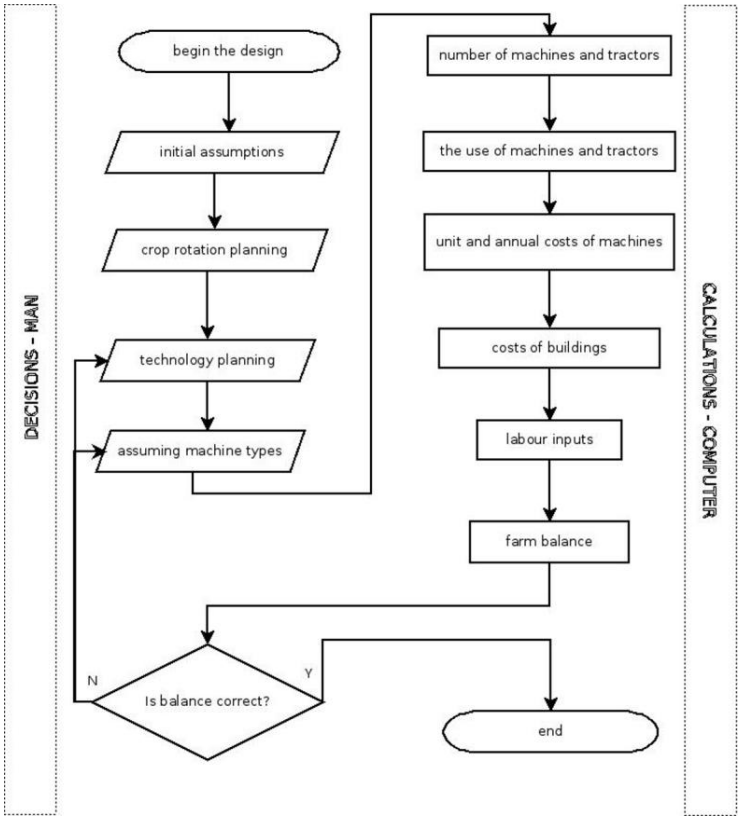

Fig.1. Simplified algorithm for design

Selection of the machinery park consists in planning a relevant type of a machine and then counting a minimum number of machines, which enable performance of the planned works on time. Then, the annual use of a machine and consequently unit (per hour) and annual costs are calculated. This, on the other hand, is a foundation for further calculations and mainly for determination of technology costs and a farm balance. A simplified algorithm for the machine selection has been presented in fig. 2. It shows a procedure optimisation of machine selection for the planned technology. A consequence of choosing a specific machine is assuming appropriate calculation parameters, such as operating efficiency and data indispensable for determination of its operating costs. As a result of assuming a relevant efficiency, a number of required machines of a given type, the annual and unit use as well as annual costs, are calculated. In case the hour costs are too high, a change of the machine type and new calculations are necessary. These actions are undertaken until satisfactory results are obtained (an optimal machine in given conditions).

Too high operating costs may be caused by the fact that the assumed machine is too big and expensive (too high performance) or too small (too low performance). A machine with efficiency that considerably exceeds the needs, due to its high price and low use generates high costs. On the other hand, accepting a machine which is too small, means that a few machines will have to be purchased, its operation time will be long and additionally a few tractors will have to be used for its drive (whose operation time is longer than in case of a suitable machine).

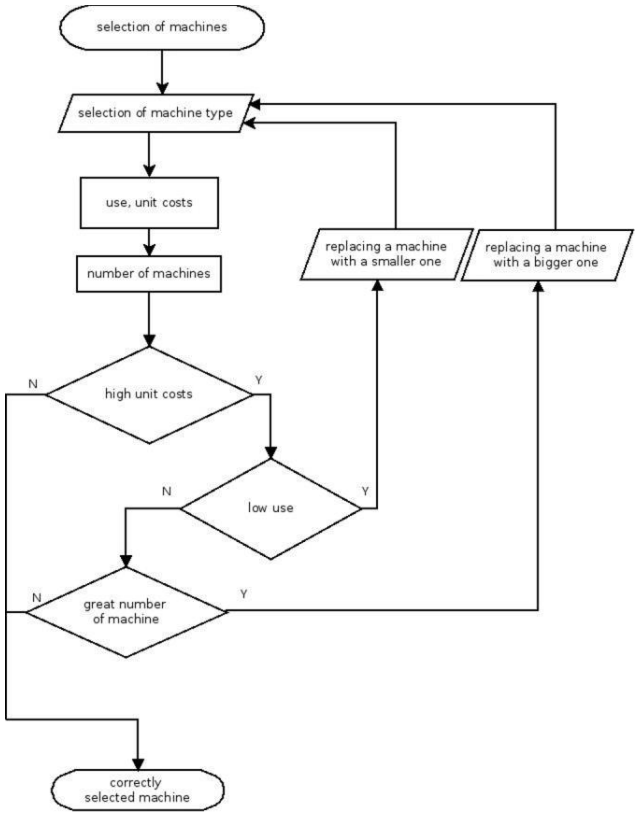

Fig.2. Simplified algorithm for selection of a machine

Machine types are replaced until optimal, in a given situation, rates are achieved. Taking into account the entire farm, where many activities are undertaken, having many machines is necessary. As a result, a designer must analyse many combinations, taking into account that introduction of various machines influences also the costs of use and operation of tractors.

3. Application of OTR-7 software for optimisation of machine selection

The OTR-7 software represents a small group of programs for design in agriculture. Its main function is to support selection of the machinery park for a farm so that technical equipment is relevantly selected on account of quality and quantity. The main criterion of optimisation is minimization of operating costs of machines and assumption of a correct and timely performance of field work. An exemplary screenshot of OTR-7 software has been presented in fig. 3.

The use of the application requires from a user appropriate professional knowledge i.e. knowledge of agrotechnology principles, field work technology, principles of farm machines exploitation etc. When data have been introduced (upper part of the program window), the program calculates data and shows present results (in the lower part of the program window). Further bookmarks in the window, where data are introduced enable design of plant, animal production, additional activity of a farmer and mechanization services both within the scope of their rendering as well as their usage. In the next step, data concerning machines and farm tractors, information on activities undertaken in a farm, farm products, buildings and structures etc. are introduced.

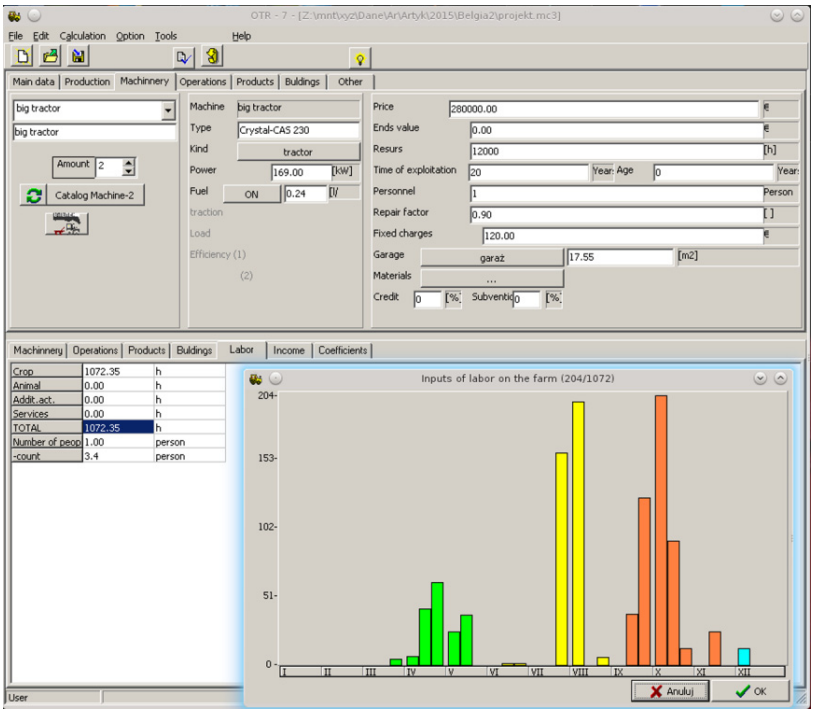

Fig.3. Exemplary screenshot of OTR programme

OTR-7 programme enables calculation of the selected rates for agricultural machines, such as the use and operating costs with division into their particular elements. Detailed analyses concern the farm balance, profitability of particular branches of production, costs and production of particular plants, labour inputs, buildings and calculation of costs of particular agrotechnical treatments. The use of machines and labour inputs in decades may be presented in the form of clear plots, which facilitate analysis and searching for elements of a farm which negatively influence the farm efficiency.

The programme may be used in agricultural didactics and practice enabling design and optimisation of farms with the area from a few hectares to a few thousand hectares. The design process may concern the existing and new-formed farms with a varied production structure. It should be mentioned that optimisation of the existing objects is more difficult. In such case, firstly it is necessary to make a real model of a farm and the best possible reflection of real elements in the program. Further work on optimisation of the model consists in simulation of various changes in the real object and checking their impact on the final financial result. Such simulations must take place with the farm producer's cooperation. It aims at elimination of such suggestions of changes, which theoretically bring beneficial effects, but are unacceptable for a farm owner. It should be mentioned here that e.g. replacement of many machines, although it could be beneficial, as a rule cannot be carried out due to a high value of investment (no funds for its realization).

Sustainable farming, for realization of its fundamental aims, requires a proper selection of the machinery park, which due to a high value, has a vital impact on the financial results, which an agricultural producer obtains. Agricultural machines and tractors are fixed assets, whose lifetime of the machine in the existing farms often exceeds 20 years, so purchase of each machine should be well considered. Farmers, when taking up a decision on the purchase of a machine, take many factors into consideration. However, these are not diligent calculations. It causes that agricultural producers often have an over-invested machinery park, whose work potential considerably exceeds the farmer's needs (Lorencowicz, Cupiał, 2013). Farms, which use software, represented by OTR-7, which enable calculation and simulation of introduction of new machines and cultivation technologies, increase their competitiveness. Moreover, a risk related to incorrect decisions on the modernization of a machinery park is reduced.

4. Summary and conclusion

Contemporary agricultural producers even more frequently reach for computer programmes to back up their activity (Mobli, Rafiee, Madadlou, 2012; Favier, Dodd 2003). The most frequently used software consists of applications which assist current activity, such as financial and reporting programmes, which enable recording of the performed treatments, purchased production means and obtained production. Software for planning and designing the production are less used. It mainly results from the fact that there are more reporting and balance programmes than the planning ones (Cupiał, Szeląg-Sikora, 2014; Jensen, Boll, Thysen, Pathak, 2008). However, the use of applications which belong to the second group may give a farmer a considerable competitive advantage and helps him to avoid mistakes in the process of decision-taking (Recio, Rubio, Criado, 2003). OTR programme, whose basic function is to optimally select the machinery park equipment, gives an opportunity to carry out such simulations and allows checking the results of the decisions, which are undertaken.

Correct planning of the machine set is particularly important in case of the sustainable agriculture. Although, its basic objectives are: compliance with a correct selection and crop rotation, developing a fertilization plan, not using sewage sediments, correct fertilization, livestock density; realization of these objectives and maintaining appropriate production profitability is possible only with suitably selected machines. Taking the above into consideration, it should be assumed that in the near future, significance of programs designed for planning and design in agriculture will increase and farmers even more often will use such type of applications in their farms.

References

Cupiał M., Szeląg-Sikora A. 2014. Komputerowe wspomaganie zarządzania w gospodarstwach ekologicznych. Kraków, ISBN 978-83-64377-11-2.

Favier J.F., Dodd V.A. 2003. The development of a prototype computerised management information system for a mixed enterprise farm. Agricultural Systems. Volume 35, Issue 3, 287-311.

Francik, S. 2010. Analiza wykorzystania przez rolników programów komputerowych do wspomagania decyzji. Inżynieria Rolnicza, 7(125), 47-54.

Jensen A. L., Boll P. S., Thysen I., Pathak B.K. 2000. Pl@nteInfo - a web-based system for personalised decision support in crop management. Computers and Electronics in Agriculture, Volume 25, Issue 3, February 2000, 271-293.

Konstankiewicz, K.; Pukos, A. 2012. Wykorzystanie technologii informacyjno-telekomunikacyjnych (ICT) w wybranych gospodarstwach rolnych województwa podlaskiego. Inżynieria Rolnicza, 2(136), 121-128.

Lorencowicz E., Cupiał M. 2013. Assessment of investing activity of farmers using the EU funds on the example of lubelskie voivodeship. Acta Scientarium Polonorum, Oeconomia 12 (1) 2013, 17–26.

Mobli H., Rafiee S., Madadlou A. 2012. The use of artificial neural network to predict exergetic performance of spray drying process: A preliminary study. Computers and Electronics in Agriculture, Volume 88, October 2012, 32-43.

Recio B., Rubio F., Criado J.A. 2003. A decision support system for farm planning using AgriSupport II. Decision Support Systems. Volume 36, Issue 2, 189-203.