

INTERACTIVE MODEL OF A DAIRY FARM: SHORT COMMUNICATION

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ABSTRACT

The objective of this paper is to introduce and illustrate the application EkonMOD milk, the decision support tool concept for dairy farm managements. The purpose of this simple web-based application is to assist dairy farms managers to better understand the dynamics of the dairy herd structure and to improve economically sensible decision-making abilities in Slovak conditions. The first module was developed to raise awareness about replacement heifer rearing costs and it can serve as a tool to evaluate specific economic and production parameters of a user specified dairy operation. The module Emissions from dairy farm was developed to allow individual dairy farm managers to calculate the GHG footprint of user-specified dairy operation. The EkonMOD milk tool introduced by the National Agricultural and Food Centre – Research Institute for Animal Production Nitra (NPPC – RIAP) continuously integrates applications previously developed in the sphere of dairy cow husbandry into one platform under the title "Interactive model of a dairy farm". The research and development team run this open access platform for relevant stakeholders to support the environmental and economic performance of dairy farms and to actively seek sound and smart solutions for the inevitable transition to circular economy and well-developed circular agro food systems in the future, with the key role of animal production.

Key words: decision; tool; dairy farm

INTRODUCTION

Integrated information tools will be a major contributor in the realization of a sustainable development, although they are receiving only limited attention in current research generally (Melville, 2010; Korte *et al.*, 2012), and especially in agriculture (Aubert *et al.*, 2012). Decision support systems (DSS) software packages have mainly been used by farm advisors and other specialists who work with farmers and policymakers (e.g. Nelson *et al.*, 2002; Fraise *et al.*, 2015). For farmers, and their advisers, software tools can facilitate effective farm management by recording data efficiently, analysing it, and generating a series of evidence-based recommendations (Rossi *et al.*, 2014). Agricultural production decision-making is becoming more complex, due in part to increased

competition caused by the globalization of agriculture and the need to adopt more sustainable farming practices (Rogers *et al.*, 2004). Keen and Morton (1978) defined decision support systems as computer systems that collect resources and use the ability of a computer to increase quality of decisions by focusing on semi structured problems. The decision support tools typically provide quantitative output and place emphasis on the end user for final problem solving and decision making (Newman *et al.*, 2000). Arnott and Pervan (2005) defined DSS as the area of the information systems' discipline that is focused on supporting and improving managerial decision-making. They are designed to help users make more effective decisions by leading them through clear decision stages and presenting the likelihood of various outcomes resulting from different options (Dicks *et al.*, 2014;

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Parker, 2004). Sheng and Zhang (2009) defined DSS as human-computer systems that collect information, process information and provide information based on computer systems. Furthermore, a decision support tools can support the decision-makers in an on-going decision situation or it can prepare them to perform better in the future through decision training (Alenljung, 2008). The development of future sustainable agriculture requires acquisition, application and adaptation of knowledge, with the support of appropriate set of IT (Lindblom *et al.*, 2014). However, decision makers often argue that there is no easy way to absorb the information available from the scientific research results, so many of the decisions are limited by inadequate or incomplete datasets (Elhag and Walker, 2011). In addition, the farmer needs to develop planning strategies that achieve maximum socio-economic benefits and eco-environmental quality on a macro scale through the optimisation of synthetic systems at the country level (Booty *et al.*, 2009). To bridge the gap and to tackle the challenges and complexity of a sustainable development of modern agri production, the farmers need DSS that not only provide current and relevant knowledge, but are also tailored to the farmers' specific needs and plans (Leeuwis, 2004). However, despite their apparent value the uptake of DSS by farmers and advisers in many countries has been limited (Alvarez and Nuthall, 2006; Gent *et al.*, 2013; Parker *et al.*, 1997). Furthermore, the uptake and levels of acceptance of are low, because scientists do fail to capture the actual needs of the farmers in practice, preferring their own attitude and position on given on-farm issues (e.g. McCown, 2002; 2005; Parker & Sinclair, 2001; Öhlmér, 2001; Öhlmér *et al.*, 1998). Additional failure factors are lack of confidence, validity, poor user interface design, low adaptability, and the fear of replacing advisors (e.g. McCown, 2002; Parker & Sinclair, 2001). Following this outcomes, Parker & Sinclair (2001) point out that the single unifying predictor of success or failure of a DSS is the extent to which users are involved and participate in design and development processes.

User involvement is showing to be a critical factor also in the study of Harris & Weistroffer (2009). The importance of involving stakeholders as active participants throughout the whole development process was also highlighted in studies by Jakku

and Thorburn, Stewart, *et al.*, Valls-Donderis *et al.* and Volk *et al.* One of the identified reason for the failure in implementation is the lack of effective communication between users and developers (Hartwick & Barki, 2001). Van Meensel *et al.* (2012) identified reasons for the low adaption rate arguing that some DSS are too complex, terminology and functions are not adapted and irrelevant to the intended users and their activities, and the often mentioned gap between science and practice within agriculture (Van Meensel *et al.*, 2012). The literature review of various DSS analyses emphasised the importance of user-friendliness (McIntosh *et al.*, 2008; Nguyen *et al.*, 2006; Robinson, 2004; Freebairn, 2002). McIntosh *et al.* (2011) also suggested that the DSS should be designed with "user-friendly interfaces based on elucidating the user's needs and capabilities" and be "adaptable to different types of users, based on their knowledge/expertise". The limited use of scientific results in environmentally driven decisions has been partially sourced in low accessibility to relevant scientific literature (Bayliss *et al.*, 2012; Matzek *et al.*, 2013; Graham *et al.*, 2011; Pullin and Knight, 2015; Young and Van Aarde, 2011).

Number of tools, which assist in the decision process for famers, are already available (Andrew *et al.*, 2013; Tamayo *et al.*, 2010; Zhong-xiao & Yimit, 2008). In general, dairy farms are deficient in the use of advanced projection frameworks such as simulation and optimization (Bewley *et al.*, 2010). An efficient DSS ion support system framework is critical for dairy farming management and decision-making (Meadows *et al.*, 2005; Cabrera *et al.*, 2006). A basic approach to reduce costs is to shorten the non-productive period of dairy heifers, which can be accomplished by breeding heifers earlier to reduce the age at first calving (AFC); Abeni *et al.*, 2000; Daniels, 2010). According to the Result of dairy herd milk recording in Slovak republic, which are annually conducted by the Breeding services of Slovak Republic, the optimal AFC for national conditions supports the previous foreign studies and research papers conclusions. Based on these outcomes it can be stated that reducing AFC in a Slovak Holstein herd had improved the length of productive life. The development of these performance indicators for the period since 2010 till 2017 can be found in Table 1.

Table 1. Development of the length of productive life and lifetime yield of Slovak Holstein cows

year	Age at first calving (days)	Length of productive life (days)
2010	829	827
2011	823	862
2012	815	907
2013	815	908
2014	808	910
2015	799	931
2016	796	930
2017	779	960

Source: Breeding Services of Slovak Republic, state enterprise BS SR, Results of cattle performance recording in Slovakia, (2010-2017)

Furthermore, the recent studies by Zahradnik and Huba (2018) and Zahradnik *et al.* (2018) support these results for Slovak Holstein dairy herds in 2017. The Holstein heifers which first calved at 22 months of age were confirmed to have the highest milk yield per lactation as well as lifetime milk yield per day. However, the highest value of lifetime milk yield was reached by Holstein heifers first calving at 24 months of age. The detailed overview can be seen in Table 2.

Development of the EkonMOD milk tool

This chapter draws heavily on previous works by Zahradnik (2017a, 2017b) and studies by Záhradník and Pokrivčák (2016a, 2016b), Zahradnik *et al.* (2018) describing the rationale of the tool and reflecting on our experiences in developing and delivering the DSS for dairy farmer management in Slovak conditions. Generally, each of the applications under the umbrella of the EkonMOD milk platform is used to evaluate the economic consequences of different on-farm strategies. The introductory

module – Number of heifers needed for replacement was based on several herd specific metrics: culling rate indicator for first lactation cows and for remaining stages of lactations in specified herd, stillbirths rate, dairy cow natality, mortality of calves, selection of calves indicator, ratio of heifers born, heifer selection indicator, culled cows that die before disposal, average age at first calving, Selling price of surplus heifers and culled cows and Cost to raise (purchase deficit) heifers. The application offers a graphical interpretation of these formulas and allows to change input variables in the terms of possible or planned on-farm scenarios. This module was developed to raise awareness about replacement heifer rearing costs and it can serve as a tool to evaluate specific economic and production parameters of a user specified dairy operation.

EkonMOD milk tool platform also includes a farm-focused calculator for greenhouse gases (GHG) emissions from a user-specified dairy farm, using following herd specific metrics: annual milk

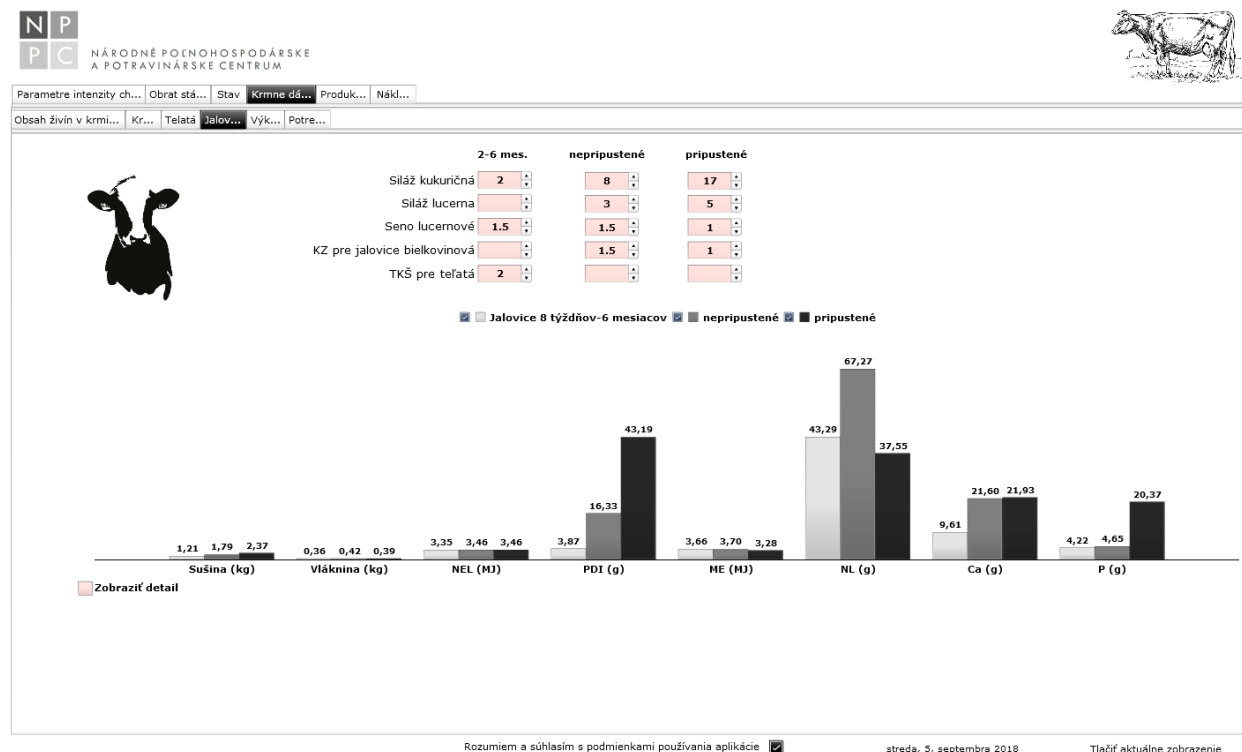
Table 2. Relation between age at first calving and lifetime yield in Slovak Holstein dairy herds

Age at first calving (days)	Number of lactations	Lifetime yield (kg)	Yield per lactation (kg)	Lifetime yield per day (kg)
22	2,32	21 706	9605	14,46
23	2,44	21 973	9318	13,90
24	2,51	22 514	9064	13,50
26	2,56	22 388	8820	12,66
27	2,59	20 726	8693	11,35
28	2,58	20 863	8534	11,51

yield, number of dairy cows, cow's liveweight (kg), milk fat (%), calving interval, number of cows on pasture, days on pasture, animal waste management system and others. The yields of methane (CH₄), ammonia (NH₃) and nitrous oxide (N₂O) of dairy cows, heifers, calves and fattened bulls, if present on dairy farm. The module Emissions from dairy farm was developed to allow individual dairy farm managers to calculate the GHG footprint of user-specified dairy operation. In addition, the application further determines the emission factors and yields of methane (CH₄), ammonia (NH₃) and nitrous oxide (N₂O) of dairy cows, heifers, calves and fattened bulls, if present on dairy farm.

The NPPC-RIAP research and development team continuously integrates applications developed in the sphere of dairy cow husbandry into one platform under the title "Interactive model of a dairy farm". The application can be found at the address: http://madobis-sk.cvzv.sk/hd/?menu=int_farma. The complex application analyses the input parameters of the breeding intensity, including specified parameters of reproduction and

performance, and determines a detailed herd turnover and status of the animals for each category within the given farm. Included in the model is also the determination of the nutritional requirements in feed doses for all categories of animals at the dairy farm. Balancing of the nutritional requirements and the nutritional content of the feed, which the breeder submitted into the model, is done automatically. Following that, the total requirements for feed as well as the storage space and litter requirements. The analysis of total production of marketable products is then, in the context of the particular farm and its characteristics, supplemented by complex evaluation of the milk production costs. The idea behind the application is to not only evaluate the existing state but to provide also an analysis of possible changes, which the farmer is considering or forced to implement. The accuracy, independence and timeliness of business analyses is always based on the relevancy of input parameters, but also on their character, which is that of a business plan. In communicating the idea of individual farm economy evaluation,



Source: Source: EkonMOD milk – Interactive model of a dairy farm screenshot (2018)

Figure 1. Balance between the nutritional and energy content of the feed and heifers requirements

the authors of the application consider this fact to be a decisive influence and therefore neither data nor any other information are archived or otherwise processed. For calculation, the application uses the reproduction and performance parameters input by the user and from this data, it determines herd turnover, status of the animals and nutritional requirements. The user inputs also the feed he plans to feed to the animals and the nutritional content of those. Nutritional requirements per animal category are generated by the application. User defines the portion of each feed in the feed ration and the application determines the difference in nutrient content in the feed ration and the nutritional needs of the animals. By combining the feeds, it is necessary to compose a feed ration in a way that minimises the differences (particularly in dry matter, fibre, Net Energy Lactation (NEL) and Protein Digestible in the Intestine (PDI)). An illustrative example of how the application works with a partially unbalanced feeding doses of the considered breeding system is shown on the enclosed screenshot of the application in Figure 1.

We consider perhaps the most important aspect, worth reiterating, to be the application's character of an open platform, which welcomes active participation in the form of feedback and suggestions for further development.

CONCLUSION

Interactive decision support platforms have the potential to address societal concerns related to economic resilient livestock farming system respecting animal welfare standards, lower the environmental burden of production and make resource use more efficient. This paper focused on the development of a range of easy to use tools that promote the implementation of region specific research results with a focus on feeding, reproduction and production of dairy cows. An early warning support system based on farm specific data, primarily derived from user unique inputs, pro-actively alerts the farmer on any economic and production impact of different scenario suggested. The future role of an integrated model of a dairy farm will be to facilitate and connect science and research by delivering more insight into

the dynamics of the herd structure and improving the decision making process on the farm level, respecting the needs from practice. The EkonMOD milk tool introduced by the NPPC – RIAP continuously integrates applications previously developed in the sphere of dairy cow husbandry into one platform under the title "Interactive model of a dairy farm". The research and development team run this open access platform for relevant stakeholders to support the environmental and economic performance of dairy farms and to actively seek sound and smart solutions for the inevitable transition to circular economy and well-developed circular agro food systems in the future, with the key role of animal production.

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