Optimisation of dairy farming in Ukraine: Integrating modern information technologies for genetic improvement and sustainable herd management

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Abstract. The dynamic nature of the Ukrainian dairy sector requires the integration of modern information technology solutions for the judicious selection of economically viable animals, with a focus on genetic improvement through a comprehensive breeding index. However, the absence of a centralized data repository makes it impossible to calculate the breeding value of animals, does not contribute to making appropriate management decisions and thus does not help to improve the economic well-being of the farm. Farm software plays a key role in filling such a database. In Ukraine, there is a large number of software programs of various producers, including Ukrainian ones, which allow farms to organize correct recording and ensure the filling of the database. However, this diversity is often accompanied by the incompatibility of programs and the inability to combine the data registered by different programs. The study underlines the need for comprehensive improvements in the system of cow breeding using data from dairy farm software, especially in response to the growing trend towards automation.

Key words: breeding stock, dairy farm software, dairy farming, data analysis, precision agriculture.

INTRODUCTION

The application of modern information technology is a transformative catalyst for optimising agricultural practices. This comprehensive strategy includes methods for improvement and sustainable agricultural practices, paving the way for greater sustainability and productivity in agriculture. By harnessing advances in data analytics,

data science and precision farming, Ukrainian agricultural practices hold the promise of achieving unprecedented levels of efficiency, ensuring superior animal welfare and raising environmental management standards. A key focus of technology integration is precision farming, where technologies such as GPS, sensors and drones are instrumental in optimising crop management at the field level (Peleshko et al., 2016). The integration of the Internet of Things in agriculture, characterised by the use of connected devices and sensors to monitor and control farm operations, is emerging as another key area (Kolesnik et al., 2019; Tao et al., 2021; Davydenko et al., 2023). The integration of robotic systems is of paramount importance, with the potential to significantly reduce labour requirements and increase overall efficiency (Kumar & Aju, 2020; Shetty et al., 2021; Berezhnytska et al., 2022; Fedota et al., 2022). In addition, the use of sophisticated analytical tools to sift through vast amounts of data provides farmers with the insights they need to make sound and well-informed decisions (Kobets & Novak, 2021; Stender et al., 2024; Shergaziev et al., 2024). This multi-dimensional approach underscores the central role of modern technology in shaping the future landscape of Ukrainian agriculture.

Contemporary dairy farming in Ukraine is characterised by a changing quantitative and qualitative composition of the herd, which requires the use of modern evaluation methods to select and subsequently breed profitable animals (Stavetska et al., 2022). The genetic improvement of cows, covering a spectrum of traits, remains crucial for the financial success of farms (Cole et al., 2021; Ruban et al., 2023). Integrating these traits into a selection index that incorporates information on both the genetic and economic value of traits facilitates a comprehensive evaluation of animals (Cervo et al., 2017; Matvieiev et al., 2023a).

However, the organisational structure of livestock breeding in Ukraine does not fully meet international standards. While individual farms use modern technological solutions to record animal productivity and behaviour, there is a notable lack of a central data repository to aggregate information from different farms. This deficiency hinders the reliable calculation of breeding values of animals, which in turn hinders effective decision making on breeding practices. Even with the potential use of powerful processors and artificial intelligence, the lack of such a repository poses a challenge to efficient animal valuation.

This situation has resulted in a lack of control by the scientific community and relevant associations over the genetic composition of available livestock in Ukraine. As a result, the state is not fulfilling its responsibility to preserve local breeds and biodiversity, and scientists are excluded from the breeding process, hindering their integration into the global scientific environment for genetic resources management.

Currently, about the half of the breeding stock on the Ukrainian market is of uncontrolled imported origin, reaching for certain species the vast majority of population. The importance of this issue was highlighted during the war with Russian Federation, as disruptions to traditional breeding stock supply chains could have a negative impact on the efficiency of livestock production.

An integral part of the modern breeding system is the availability of an information and analysis system for collecting, storing and analysing primary breeding data, particularly in relation to productivity. This is in line with the functions of modern herd management systems within the Smart Farm and Precision Agriculture concepts. By

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consolidating information from technologically advanced farms, a primary database could be created to support selection decisions at the population level.

Although there is a wide range of software and associated hardware currently used in livestock production, their suitability for the outlined tasks varies. The aim of this paper is to analyse Ukrainian and international experiences with different herd management software and to propose possible solutions to the existing challenges in the breeding sector.

MATERIALS AND METHODS

This study uses a mixed methods approach, integrating data analysis from publicly available sources and direct communication with farm professionals over the period 2020–2024. The primary objective is to investigate the use of different software solutions in contemporary farm management practices. We have analysed 375 farms from all over Ukraine, where different types of software are used.

In terms of data collection, extensive information was gathered from various open sources, including research papers, reports and official documents. These sources contribute to a global understanding of digital technologies in agriculture, highlighting trends, challenges and progress. In addition, direct interactions with agricultural professionals between 2020 and 2024 serve as a valuable qualitative component of this study. Insights from practitioners actively using various software applications provide a real-world perspective on the adoption and impact of digital tools in farm management.

The study focuses on several key areas. First, it explores the transition from traditional paper-based record keeping to electronic data management in farm practices, with a focus on the adoption of specialised software for herd management and breeding. The impact of technological innovations was analysed, in particular devices that record a range of parameters relevant to effective farm management, with a focus on health and behavioural indicators.

In terms of perspective, the research includes a global overview of widely used software programmes, complemented by a regional focus on specific areas such as Finland, Canada, the UK and Ukraine. This dual perspective ensures a comprehensive understanding of both overarching trends and localised applications.

This methodology provides a robust framework for systematically exploring the adoption and impact of digital technologies in contemporary farm management practices, offering a nuanced understanding from both global and local perspectives.

RESULTS AND DISCUSSION

Farm management decisions should be based on objective information, achieved through comprehensive processing of maximum available data (Wolfová et al., 2007). The ubiquity of information technology in various fields (Nehrey et al., 2023a) has introduced new business conditions and concepts, especially in the agricultural sector (Arivazhagan et al., 2023).

Traditionally, accounting information has been captured through various paper-based reports. However, this method proved to be inconvenient due to limited information capacity, and the conversion of the entire data set into a digital format complicated statistical data processing. Over time, the livestock sector, particularly

cattle farming, moved towards electronic document management, which eventually became standard practice (Haldar et al., 2022). This shift encouraged the adoption of specialised programmes, particularly for herd management and breeding purposes (Bauer et al., 2016).

At the same time, technological innovations have led to the development of numerous devices capable of recording a wide range of parameters. The analysis of such parameters has provided additional data that is crucial for effective farm management, including health and behavioural indicators (Kleen & Guatteo, 2023).

Modern herd management systems harmonise the efforts of recorders/sensors populating a data warehouse with software designed to process this data to facilitate optimal decision making.

According to the study (Belanche et al., 2019), implementing Eskardillo software allowed faster genetic progress in milk yield on Spanish goat farms. In addition, Austrian and Turkish farmers believe that dairy cow breeding associations can provide farmer training courses on a wide range of cattle breeding issues because they have integrated information databases (Kuyululu et al., 2013; Weissensteiner et al., 2018).

Currently, widely used software programs such as Dairyplan C21, Afifarm, Alpro and Uniform-agri offer comprehensive computerised management for modern dairy farms. The use of such tools increases administrative efficiency, enables task delineation for farm personnel, monitors key indicators of animal productivity, reproduction and health, facilitates timely generation of reports for desired characteristics over any period of time, and reduces unnecessary costs and disease incidence (Bauer et al., 2016). These programes are widely used on farms in North America, Europe and Israel.

At the same time, alternative programes are available on the market, including Ammu & Elmer, Pihvi, MOOML, AG PANTHEON Farming, MISTRO, EASY DAIRY, Agridata, Myhealthyherd, Farm Matters, Farmplan, Kingswood Herd Management Software and others.

In Finland, the herd book is an integral part of the breeding database maintained by the Finnish Animal Breeding Association, with ProAgria Maatalouden Laskentakeskus as a partner company. Specialists from ProAgria Maatalouden Laskentakeskus collect accounting data from farms and develop software solutions for both farmers and consultants (ProAgria, 2018). The Finnish National Dairy Disease Register, which has been in operation since 1982, is a special feature of the country's comprehensive animal database, documenting individual information on animals (Rintakoski et al., 2012).

ProAgria has developed the Ammu & Elmer and Pihvi programmes specifically for livestock farms. These programmes include functions for monitoring productivity, maintaining cow registers, registering animals, contacting veterinarians and planning farm activities (milking, health, reproduction, weighing). The inclusion of mobile applications enhances the usability of these programmes (ProAgria, 2018).

Schaumann introduces an online herd management and analysis system called MOOML, which is compatible with PCs, smartphones and tablets across different operating systems. MOOML consolidates data from different sources on dairy and beef farms and synchronises with milking parlour programmes (Afifarm, Boumatic, De-Laval, Fullwod, Lely, Westfalia). The collected data is automatically transferred to a central database. The CRV module within the MOOML software allows the generation of reports on productivity, reproduction, insemination and automated pedigree generation (Mooml, 2020).

PANTHEON Farming, developed by the Swiss company Datalab Agro AG, serves as a robust and informative livestock management system, providing online tools for managing farm operations and finances (AAC Export Catalogue, 2020). This programme facilitates the maintenance of individual and group livestock records based on productivity metrics such as live weight gain and milking control indicators. It allows feed tracking, ration development, veterinary records, registration of reproductive parameters and control of animal movements. The Cattle module includes all the information needed to manage a dairy farm, breeding and fattening. In particular, this herd management system is used by the Austrian Federal Breeders' Association (ZAR, 2020).

For animal registration with the Holstein Association of Australia (Holstein Australia, 2019), farmers use MISTRO or EASY DAIRY software, both of which are user-friendly and offer extensive functionality for recording a wide range of data. While both software products were developed in Australia, MISTRO is also used in New Zealand and Brazil (Easy Dairy Herd Management Software, 2020; Mistro, 2021).

In Canada, Lactanet is responsible for recording milk productivity and analysing milk quality (Lactanet, 2023). Using Lac-T software, Lactanet specialists are involved in viewing scheduled events, planning veterinary treatments and interventions, creating reproduction and treatment protocols, scheduling bull imports and overall herd management. Lac-T facilitates the exchange of information with veterinary services and certain feed suppliers. This software platform allows herd animals to be registered in multiple breed associations while maintaining a comprehensive record of qualitative and quantitative traits related to milk production (Lac-T, 2021).

In the UK, a variety of programmes are used for herd management, with Agridata, Myhealthyherd, Farm Matters, Farmplan and Kingswood Herd Management Software being popular choices (Agricultural, Farm Business and Cattle Management Software Companies, 2021). Agridata, a computer programme designed for comprehensive livestock record keeping, is used on all beef, dairy and sheep farms, regardless of farm size (Agridata, 2021). This software allows for the registration of all livestock movements, maintaining records of animals from birth to slaughter, cross-referencing with the British Cattle Movement Service (BCMS) database and monitoring the circulation of medicines. Agridata provides robust management information capabilities, enabling the generation of over 60 reports on the company's business activities.

The BCMS is responsible for registering and recording the productivity of dairy and beef cattle throughout the UK, excluding Northern Ireland (Gates, 2013).

Myhealthyherd serves as a specialised application for veterinarians, facilitating strategic planning of various medical procedures within a herd and effective management of animal health (Myhealthyherd, 2019).

Afimilk, based in Israel, presents the AfiFarm herd management programme (Afimilk, 2018), a comprehensive system that collects and analyses data from a network of sensors. The AfiMilk MPC milk meter, certified by ICAR, measures milk yield and conductivity. AfiLab provides real-time insight into the qualitative composition of milk, including fat, protein, lactose and blood content, enabling the identification of metabolic and health problems, as well as tracking qualitative changes in feed. AfiAct II acts as an animal identification tool, recording motor activity, resting time during the day, detecting estrus, warning four hours before calving and identifying calving challenges such as twins. The AfiFeed individual feeding system accurately determines the

concentrated feed intake of each animal (Afimilk, 2023). The AfiFarm app allows users to monitor the progress of their animals online via mobile applications.

Future applications of precision dairy farming are expected to rely heavily on computer vision systems complemented by deep learning algorithms. These technologies offer precision, result generalisation, low computational cost and customisation to specific customer requirements (Mahony, 2019).

Herd management systems are actively used in Ukraine and include both well-known programs from leading global vendors, such as Uniform-agri, and purely Ukrainian developments, such as Intesel Orsek and PlemOffice. Each programme has unique features and serves specific purposes (Ladyka et al., 2016). Intesel Orsek and PlemOffice, as Ukraine-made breeding programmes, focus on breeding activities. Uniform-Agri, on the other hand, is mainly used for herd management and information accumulation and lacks features for assessing the breeding value of animals, breeding selection and other related activities.

Farmers use Uniform-Agri to accumulate information about animals, such as calving (date, calf weight, calving difficulty, calf identification number), insemination (date, bull name, artificial insemination technician name, synchronization scheme used for insemination), weighing, measurements, animal identification, disease cases, prescribed and administered animal treatments, synchronization schemes, fertility examinations, and reproductive organ pathologies. Additionally, they input preventive measures (dehorning, tail docking, castration, vaccination), data on control milkings, data on culling and transfers of animals between groups and farms, and reasons for culling animals from the farm. Uniform-Agri generates reports based on the collected information regarding reproduction, productivity, youngstock development, animal culling, disease prevalence dynamics, and users can also manually create reports using a variety of filters.

Users also find it convenient to set up an event planner and work on a weekly schedule with animals, ensuring no animal or necessary procedure is missed and their work is done in a timely manner.

Consultants from breeding companies, who are involved in selecting breeding bulls, use data from Uniform-Agri as a basis for checking pedigrees to prevent inbreeding on the farm. This software effectively fulfils this function.

The programmes analysed generally consist of similar functional blocks, including a cow card for basic cow information, reproduction, insemination, calving and young animal (automatic generation of pedigrees), transfer for moving animals between groups, a calendar events block for scheduling and a health block (Ladyka et al., 2016).

It is noteworthy that the most informative block in the Uniform-agri programme is the 'Economy' block, which allows the generation of comprehensive economic reports. In particular, the 'external' and 'selection or breeding' blocks are exclusive to the 'Intesel Orsek' and 'PlemOffice' programmes and are missing in the 'Uniform-agri' software. The 'Economy' block, developed by Dutch representatives, provides a comprehensive overview for comparing the operations of farms in Ukraine and worldwide. This comparison is based on the use of similar software and up-to-date information from farms, which provide their indicators for business analysis. An interesting feature of this functionality is its ability to compare farms of average performance, particularly those using the same milking parlour equipment or similar

housing methods. In programmes developed in Ukraine, this block has a different name and covers less extensive functionality.

The Cattle.Center online resource, specifically the Centre for Digital Monitoring of Welfare in Cattle, Sheep and Goat Breeding, is notable for its ability to create a database of animals on participating farms (Valchuk et al., 2017). This process automatically categorises the herd into technological groups.

The Obstetric and Gynaecological Examination module of the Cattle.Center software facilitates easy monitoring of reproductive function (Valchuk, 2015). It allows the evaluation of animals based on specific characteristics such as weight and weight gain as well as milk production. In addition, this module automates the recording of milk sales to dairies, establishes a uniform animal classification system and provides information to users at different levels based on access rights. It also includes the ability to automatically generate and store reporting forms for daily farm operations.

Recently, voluntary milking systems (Piwczyński et al., 2020; Cogato et al., 2021; Gaworski, 2023), including those from Delaval and Lely GEA, equipped with DelPro herd management software, T4C and DairyPlan C21, have gained popularity in Ukraine. Each system has its own interface and specific characteristics. While these robotic sensors are capable of collecting significant amounts of data, scientists have identified challenges associated with their use. The predominant issue is the closed nature of most sensor ecosystems, which include the sensor, databases, computer programs and specific reporting tools, including dedicated computer terminals. This closed model has contributed to occasional challenges in system integration and performance optimisation (Gengler, 2019).

In the Table 1 you can see the results of comparison of 2 most common international and 2 most popular Ukrainian types of dairy farm management software.

Table 1. Comparison of dairy farm management software functionalities

Indicator	Software			
	DairyPlan C21 (Shergaziev et al., 2024)	Uniform-Agri (Shergaziev et al., 2024)	Intesel Orsek	Cattle.Center
Productivity	Individual and overall assessment of milk production, mastitis control, animal sorting	Possibility to manage all groups of cattle (cows, bulls, young animals, analysing of records history). Daily monitoring of milk production. Unique Dutch method for calculating peak dairy performance - SPP Analysys	Individual control of milk production (fat and protein content)	Recording of milk yield and milk sales. Monitoring of animal weight and weight gain
Veterinary module	Determining the need for treatment of sick animals. Prescribing, conducting and monitoring of treatment	Monitoring of animal health (somatic cell count, use of drugs, registration of diseases and preventive measures)	Not available	Database of veterinary drugs

Table 1 (continued)

Reproduction	Heat detection by the evaluation of animal's activity	Storage of information on the use of sire semen. Monitoring reproductive performance with reports and analyses	Control of the days open	Original module of obstetric control and gynecological screening. Control of the reproductive function. Division of females of reproductive age into groups depending on obstetric and gynecological status
Feeding	Controlling of the consumption of concentrated feed	Ability to connect to a feed dispenser computer	Not available	Not available
Analytics	Calving forecast, prediction of dry period, list of veterinary drugs	Productivity. Health. Veterinary records. Economics	Lactation curves, animal growth curves, compilation of animal pedigrees, generation of various reports on animal productivity	Real-time display of up-to-date information on the farm. Display of data in the form of charts, tables, graphs, comparisons. Standardized reporting system
Mobile application	DPMobil 2	Uniform App	Not available	Mobile application available
Additional options	Determination of the weight of the animals during its movement. Quality control of cleaning of dairy equipment. Monitoring the temperature of milk in the tank. Control of calf feeding when using special feeders. Identification system with conveyors	Reproduction. Benchmarking. Cloud synchronisation. Communication with trackers. Work with different herds. Networking. Creation of personalised reports for any required indicators. Kalender - the programme reminds you what actions is to take and with which groups of animals	Selection of animals, assessment of exterior, calculation of breeding value of animals	Not available

The issue of obtaining data on individual dairy farm productivity is currently a pressing concern in Ukraine. In our country, with the support of the Canadian government, two state-of-the-art laboratories have been established: the Lviv Agricultural Advisory Service in Lviv and the Dairy Management System (DMS) in Dnipro. These

laboratories are designed to support the development of dairy farms as part of the Dairy Business Development in Ukraine project. Currently, these organisations carry out a significant number of milk analyses on farms in different regions of Ukraine. However, the main use of these data is to adjust cow rations rather than to meet breeding objectives.

The Agency for Animal Identification and Registration has developed a personal account for business entities to interact with the Unified State Register of Veterinary Documents. This platform allows users to create and submit applications for veterinary certificates, monitor payment status for administrative services and generate convenient reports. This product is seamlessly integrated with USREOU, the Unified State Register of Animals, and efforts are underway to integrate it with the National Database of Laboratory Tests (Bryl & Karpenko, 2020; Tvarynnytstvo siohodni, 2022).

However, the data set used in livestock breeding goes beyond milk production data. The list of traits continues to grow with the advent of new technological innovations, in particular various automated activity monitors such as pedometers, bolus sensors, accelerometers (Santos et al., 2022) and in-line milk analysis systems (Bruinjé & Ambrose, 2019). Consequently, it is imperative to continuously monitor the available options for collecting, efficiently storing and analysing the information received (Nehrey et al., 2023b; Matvieiev et al., 2023b; Trapanese et al., 2024).

Despite the obvious benefits of digital technologies, particularly herd management software, a number of challenges hinder their wider adoption. In particular, a lack of awareness of modern software in the agricultural sector has been highlighted by researchers (Arivazhagan et al., 2023).

CONCLUSIONS

To sum up, the prevailing dairy landscape in Ukraine presents a dynamic scenario characterised by fluctuating herd size and quality. The adoption of modern evaluation methods is imperative for the judicious selection and breeding of economically viable animals, highlighting the key role of genetic improvement in various traits in ensuring the financial viability of farms. The integration of these traits into a comprehensive breeding index, incorporating both genetic and economic considerations, outlines a holistic framework for animal evaluation.

However, the existing organisational framework within the Ukrainian livestock sector falls short of international benchmarks. Although individual farms have adopted modern technological solutions for documenting animal performance and behaviour, the lack of a centralised data repository poses a challenge to the efficient calculation of breeding values and hinders informed decision making in breeding practices. This deficiency not only threatens the conservation of indigenous breeds and biodiversity, but also prevents scientists from making meaningful contributions to global genetic resource management.

The reliance on unregulated imports of breeding stock further exacerbates the situation and poses risks to the operational efficiency of livestock production, particularly during disruptive events such as the war with Russia. The establishment of a centralised information and analysis system for the systematic collection, storage and analysis of primary breeding data emerges as imperative, in line with the principles of modern herd management systems within the paradigms of smart farming and precision agriculture.

The study meticulously examines various software and hardware applications used globally and regionally, highlighting the heterogeneous technological landscape in different countries. It reveals that Ukraine lacks a unified database of comprehensive animal information, which requires animals to be assessed at the individual farm level. Consequently, the use of computer software not only expands the range of traits that can be recorded, but also increases the frequency and reliability of data collection. Given the increasing trend towards automation and computerisation in Ukrainian dairy farming and the concomitant increase in the amount of information available for breeding purposes, there is a need for a comprehensive improvement of the cow breeding system based on the use of data encoded in dairy farm software.

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