

PROJECT OF AN OPEN INFORMATION TECHNOLOGY SYSTEM SUPPORTING FARM MANAGEMENT

Summary

This paper presents an original information system supporting the management of an agricultural holding codenamed AGMS (Agro-Management System). This system was created in C# language, using ASP. NET MVC programming technology. The application database layer was supported by SQL Server and Entity Framework technology. The creation of the program's views enabled such languages as HTML 5, CSS3 along with Bootstrap library and Javascript with dedicated Knockout.js library. The development of the system was preceded by an analysis of requirements, in accordance with software engineering procedures. The documentation created at this stage in the form of UML diagrams was prepared in Microsoft Visio. The AGMS program presented in this article is a developmental version, so all its functionalities are not yet fully implemented. The user can use the current version of the software to map fields, manage events related to individual fields and, among other things, obtain information on pests and weeds. The article also describes the concept of the final version of the program, which should include modules implementing simple methods of artificial intelligence in the field of image recognition and decision support.

Key words: farm management, IT in agriculture, Internet application, .NET Framework

PROJEKT OTWARTEGO SYSTEMU INFORMATYCZNEGO WSPOMAGAJĄCEGO ZARZĄDZANIE GOSPODARSTWEM ROLNYM

Streszczenie

Zaprezentowano autorski system informatyczny wspomagający zarządzanie gospodarstwem rolnym o nazwie kodowej AGMS (Agro-Management System). System ten został wytworzony w języku C#, w technologii programistycznej ASP.NET MVC. Warstwa bazodanowa aplikacji została obsługiwana przez SQL Server oraz technologię Entity Framework. Wytworzenie widoków programu umożliwiły takie języki jak HTML5, CSS3 wraz z biblioteką Bootstrap a także Javascript z dedykowaną biblioteką Knockout.js. Opracowanie systemu zostało poprzedzone analizą wymagań, zgodnie z procedurami inżynierii oprogramowania. Powstała na tym etapie dokumentacja w postaci diagramów UML została przygotowana w programie Microsoft Visio. Program AGMS prezentowany w niniejszym artykule jest wersją rozwojową, a zatem jego wszystkie jego funkcjonalności nie są jeszcze w pełni zaimplementowane. Użytkownik korzystając z aktualnej wersji oprogramowania ma możliwość mapowania pola, zarządzania zdarzeniami dotyczącymi poszczególnych pól, a także m.in. może zasięgać informacji o szkodnikach czy chwastach. W pracy opisano także koncepcję finalnej wersji programu, w której powinny znaleźć się moduły implementujące proste metody sztucznej inteligencji w zakresie rozpoznawania obrazów i wspomaganie podejmowania decyzji.

Słowa kluczowe: zarządzanie gospodarstwem rolnym, IT w rolnictwie, aplikacja internetowa, .NET Framework

1. Introduction

Managing an agricultural holding, especially when its area exceeds several dozen or hundreds hectares often becomes a very difficult task. It may be particularly difficult to establish an order in the documentation if it is kept in obsolete programmes or in paper form [1]. Issues related to the management of agricultural machinery are also problematic, as well as the profitability of their purchase, or even the calculation of the cost of its operation.

The applications produced so far for farmers are largely stand-alone applications, so that their use is usually limited to a single computer on which the licence is implemented. Naturally, in recent years, due to the prevailing standards, there have also been many applications offering the service of keeping records, farm management via the Internet. Data are stored in the cloud, while access to the application itself is possible both from a computer and a smartphone, which have become an integral part of every entrepreneur (also a farmer). Also access to mobile networks is practically unlimited, and the range of high-speed Internet frequency bands covers almost the entire Poland [2]. This state of af-

fairs therefore allows access to farm data from anywhere in the world.

It is also worth mentioning the change in the pricing model of this type of application. It is largely based on modular access in the form of monthly subscriptions and not, as in the past, on the purchase of a single licence [3,4]. Therefore, in order to make full use of farm management systems, additional monthly expenditure should be planned. Given the fact that the average age of farm owners in Poland is decreasing [5], this form of access seems justified. However, we should not forget the farms belonging to farmers who do not cope well with information technology. In this case, using the form of free apps, but with the advertisements displayed, may bring a larger range of the program.

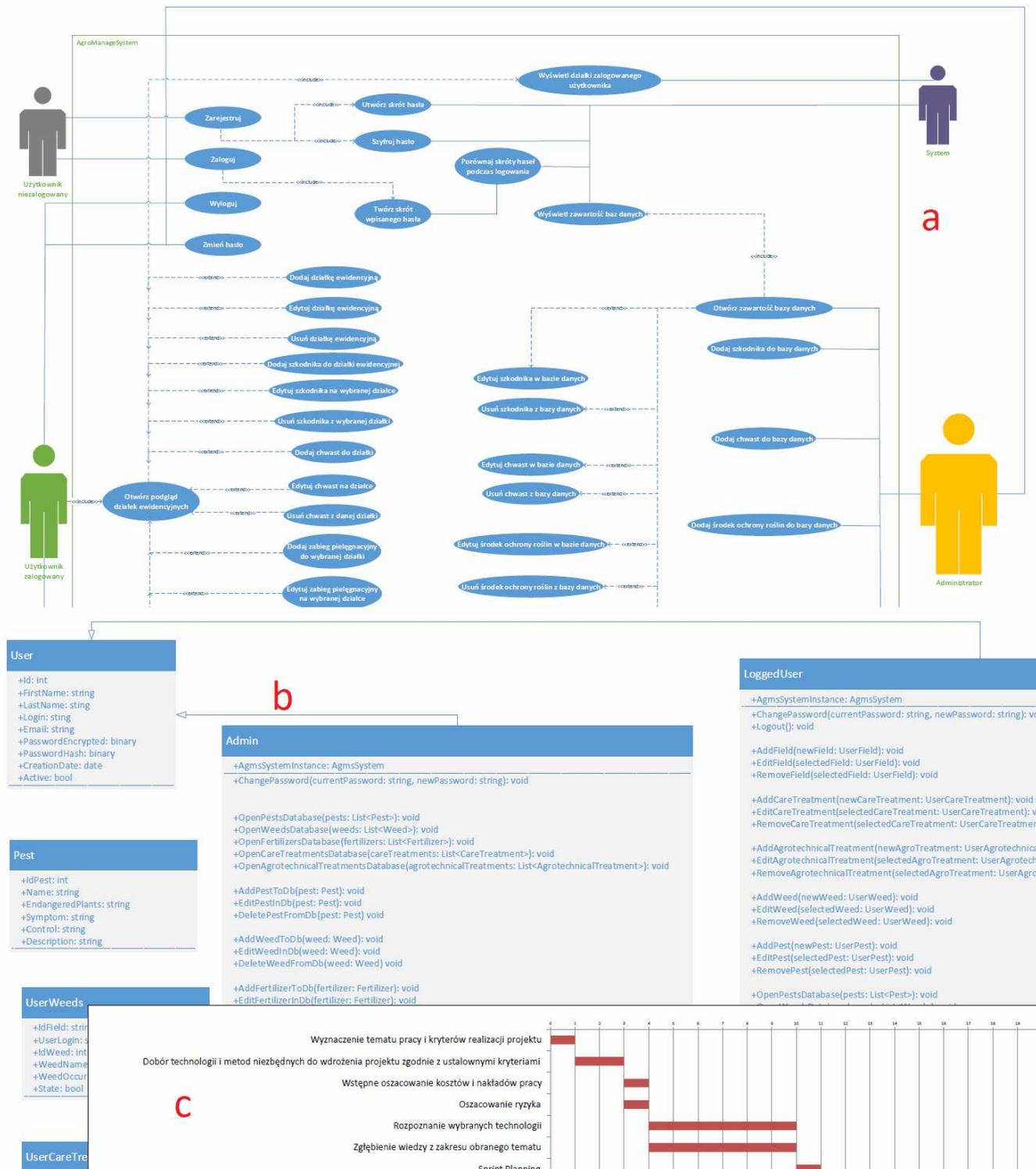
This paper will discuss the system, whose aim is to integrate many modules facilitating farm management, as well as making decisions concerning the purchase of machinery and tools, renting out agricultural services and the use of fertilising and spraying preparations. It was manufactured using ASP. NET MVC technology [6], i.e. one of the most modern programming technologies in the field of designing and manufacturing Internet applications. Databases

were developed using *SQL Server Management Studio* database environment, and *Entity Framework* technology was used to connect the program with the database.

2. Aim of the work

The aim of the study was to create an Internet application, which comprehensively covers the issues related to farm management. The aim of the project was also to integrate advisory applications designed and developed so far

by the Institute of Biosystem Engineering, mainly concerning the calculation of costs of operation of agricultural machinery. The industry information has clearly shown that farmers have insufficient knowledge of the choice of equipment, services or appropriate spraying or fertilisation products. The secondary objective was therefore to adapt the application to the needs of small farm owners, who very often do not want to spend money on expensive documentation management programs.



Source: own work / Źródło: opracowanie własne

Fig. 1. Documents prepared to facilitate work during the implementation of the application. Fragments of: a) use case diagram; b) class diagram; c) a chart of the sequence and duration of the different tasks

Rys. 1. Dokumenty sporządzone w celu ułatwienia pracy podczas implementacji aplikacji. Fragmenty: a) diagramu przypadków użycia; b) diagramu klas; c) schematu kolejności i czasu trwania poszczególnych zadań

3. Methodology

The *AGMS (Agro-Management System)* IT system has been designed in accordance with the principles of software engineering. Its components and mechanisms of operation were created during the system design phase, so the next programming process was based on technical documentation. Of course, in a project of this size, it is not necessary to produce documentation, but in any project such documentation is a very helpful tool. In this work, the concept of system operation was described using *UML* diagrams, i.e. diagrams showing system components, waveforms and operation sequences. The first design phase involved the creation of a task scheduler that controlled the entire process. Each task necessary for its completion is specified, as well as a maximum duration. The next step was to generate the already mentioned *UML* diagrams (Fig. 1).

On the basis of such documentation, work started on system implementation. The *Visual Studio 2015* development environment has been used for this purpose, and the application was developed using *ASP.NET MVC* technology in *C#* language [7]. This technology is a web application platform developed by Microsoft that implements the Model-View-Controller (MVC) design template. This allows you to separate the logic from the presentation layer in a more transparent way, making it easier for more developers to work on the project. The application view layer has been developed using *HTML5*, *CSS3* and *Javascript* with a dedicated *Knockout.js* library. The software databases were generated in *Microsoft SQL Server Management Studio* database environment and their implementation on the application side was possible thanks to *Entity Framework* technology. The testing phase of individual application components was carried out using the *Azure* platform, which made it possible to publish subsequent versions of the system on the Internet without any cost, so that it would be accessible to selected testers.

4. Application description

The *AGMS* IT system is equipped with login and registration functions. In order to use all functionalities of the application, it is necessary to log in. After creating an account, the user will receive information in the form of an electronic message containing the operating instructions with the program. Logging in is done by entering the login and password. As shown in Fig. 2, the passwords and any other confidential information stored in the database are encrypted. This means that any attempt to break into the application servers would result in the inability to steal data. The application interface starting with the registration and login screens is clear and the fonts are as large as possible.

After logging in, the user receives access to all system modules. The window that is displayed after logging in contains a large button for adding new fields located in the central part of the window. The top navigation bar contains the following buttons:

- *Management* - a link that moves the user to the start page, which is also a list of all fields entered by the user.
- *Map* - A link that moves the user to the map module, where all user fields are drawn.
- *Knowledge base* - a development list with links to individual databases containing information on pests, fertilisers and weeds
- *User name* - pressing it opens a drop-down list with links to the control panel, instructions and frequently asked questions.
- *Log out* - the system's logout function that removes the currently stored *AGMS* application cookie from the operating system.

The side folding bar provides access to features such as

- *Pest addition* - a function that allows an event to be added in a specific field that relates to the sighting or control of a pest

The image shows two screenshots of the application interface. The left screenshot displays the registration form with input fields for email, login, password, name, and surname, along with a 'Zarejestruj' button and an optional checkbox. The right screenshot shows the login form with input fields for the username 'adam fojud' and a masked password, a 'Zaloguj' button, and a link for users without an account. Below the screenshots is a table of database records showing encrypted passwords.

	Password_encrypted	Password_hash
1	b Bd fR3z2fg W9HN nl5W04lnGtuR6nanOmWp9A1ba+ TV3Rds...	100000uB9+uh6GV53TtHExPXR7EzGkhH5oN+YpuTRaJro1hEP...
2	DS+Y6Lkz80o+MTC W9IU lHmJbYMPV YU nfjs578eSGlxVNS...	100000puGQ3wGBNBP BIOYcC6VbZ54eG2Rcke5VD6G4Rnun...
3	bHINZByMfmmAx29PK552JG32BP+505JzswKPhrUgKlvkVemlEx...	100000Yx O WjdoJMDwVfrM YoiCkC3C4kfeYXHyJyD8PAdguntjg==
4	dCmYm2ak+ZB4V LwD VkjNqDBMkSz7kC MGXnZkGzucfn71M...	1000001e8qa/8z2F+Lq VoqS0 U Wk+zu1lv80n+0FGAO.Zu5gnQ==
5	hQB05u vfe3dRZbgECsUQXa4 UybsfjHutKGG5EG07odnsUGdu...	100000rw7FV5Prz H3b9LMTjg3J Woj4E8BS WXZEHU60Cymh...
6	TCvJ58RMyMEy25nMgN8BG5bP8y+L.AmeYSHlpr/ bMesVbXn...	100000Rld7c4dR9F 0xTlMnq/N5eTKCR4FFckq2hpiDDdmvuyg==

Source: own work / Źródło: opracowanie własne

Fig. 2. Registration and login forms with exemplary database records containing encrypted passwords
Rys. 2. Formularze rejestracji oraz logowania wraz z przykładowymi rekordami bazy danych zawierającymi zaszyfrowane hasła

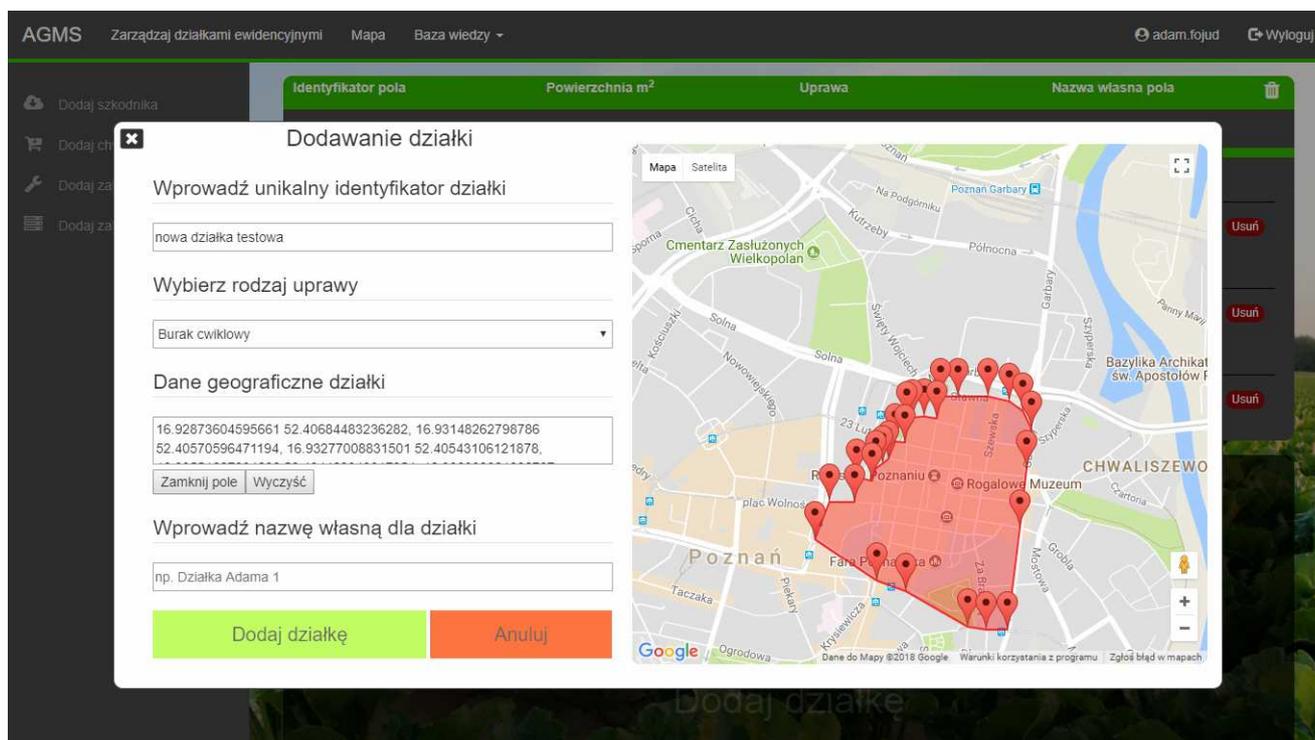
- *Weed addition* - a function that allows the addition of an event in a specific field that relates to the observation or eradication of weeds.
- *Adding an agrotechnical treatment* - this function allows to add an event in a specific field related to the implementation of an agrotechnical treatment
- *Adding a care-treatment* - this function allows to add an event in a specific field related to the application of a skin-care treatment.

The first module, which is in fact the most important module in the whole system, is the field mapping module. Its launch is possible both from the level of the register plots management tab and from the level of the map module. The operation of the field mapping algorithm is shown in Fig. 3. How it can be noticed, user is asked to enter information about the unique parcel identifier. In addition to the parcel name, this will be a basic information allowing the user to search for the entered field. The next step is to introduce the type of cultivation. It is worth mentioning here the phase in which the project is currently located. This is a development phase and in this case it means that the system has a well-developed backbone of functionality and graphic layout, but it does not have all the necessary information in the knowledge base. Therefore, in the field concerning the selection of crops, there are only two plants at times: beetroot and potato. The most important action during operation with the field mapping module is to select the field borders. The user can select the characteristic points of a given field by right-clicking on the map. After selecting all necessary points to map, user can select the *Close Field* button to close the field contour, or the *Clear* button to clear it. After entering all data and selecting field, the user can add a plot by selecting the appropriate button. At this point the program algorithm will process the data and display the main screen with the plot already added.

The field added by the user will also be visible in the map module. In the left part of the map module window, the parcel identifiers and their own names assigned by the user will be displayed. When user clicks on a selected plot, it will be searched on the map and the map position will be changed. Fig. 4 shows an example of a field contour that covered the surface of Lake Malta in Poznań. This example illustrates well the capabilities of the algorithm used in the system, which, despite the use of many characteristic points, is able to cope well with calculating the area of a given field.

Information about fields added by the user also appears in the main window of the system. Fields are shown there as bookmarks in which detailed information about a given field is specified. A single tab contains field identifier, field area, cultivated plant and field name. Below you will find the place where the information about individual events in the field will be displayed. As shown in Fig. 5, data are displayed there, e. g. on the treatment procedure, the fertiliser applied and the date of the treatment. Any item that describes an event or a single plot can be deleted by selecting the *Delete* button or the bin icon. Such action is always preceded by a question about the certainty of performing functions.

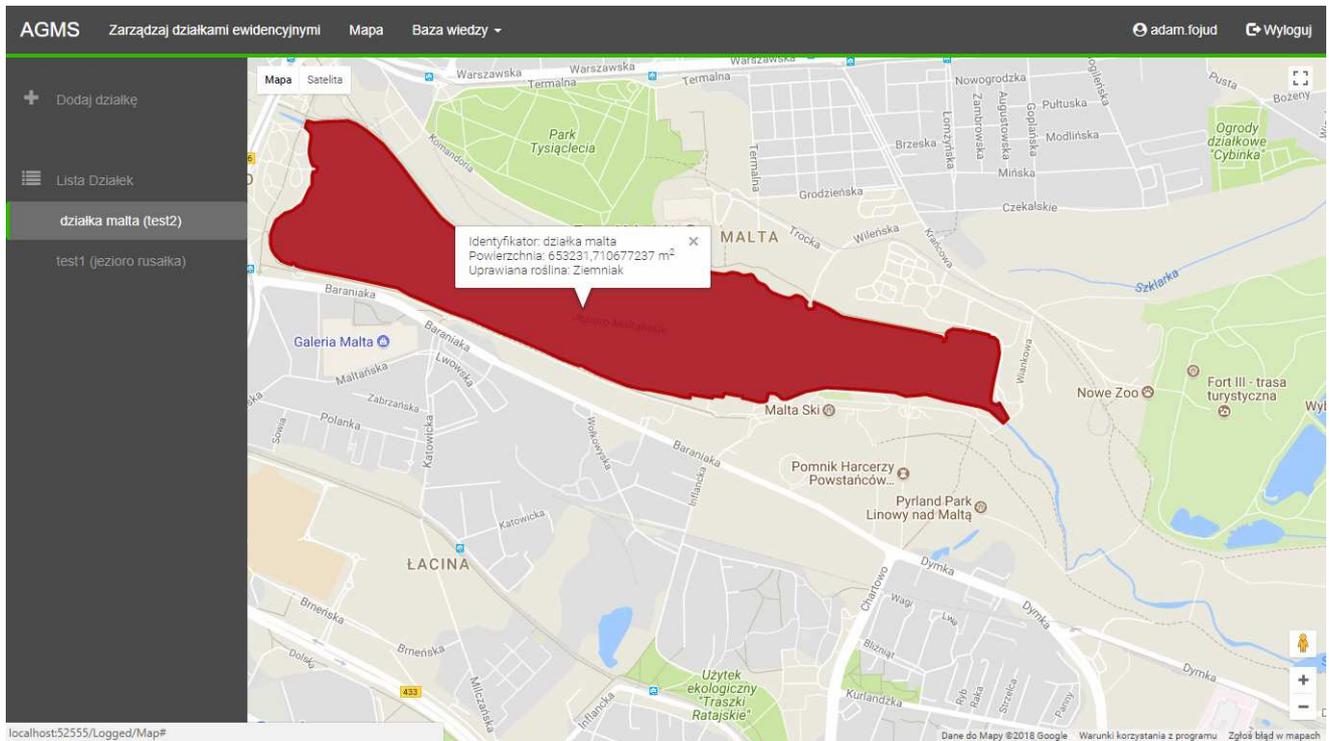
As mentioned above, it is possible to add events in individual fields. These events describe, among other things, the observance of a pest or weed in a field, the implementation of an agrotechnical or agronomic treatment. All of these functions work similarly. Fig. 6 shows a window that allows user to add a single event. The event shown in Fig. 6 is about adding the date of pest occurrence in the field. When working with the function of adding individual events, the user is asked to select the parcel to be affected by the event. Depending on the selected plot of land and, more precisely, on the plant cultivated on it, the possibility of selecting the pest will depend on the selection.



Source: own work / Źródło: opracowanie własne

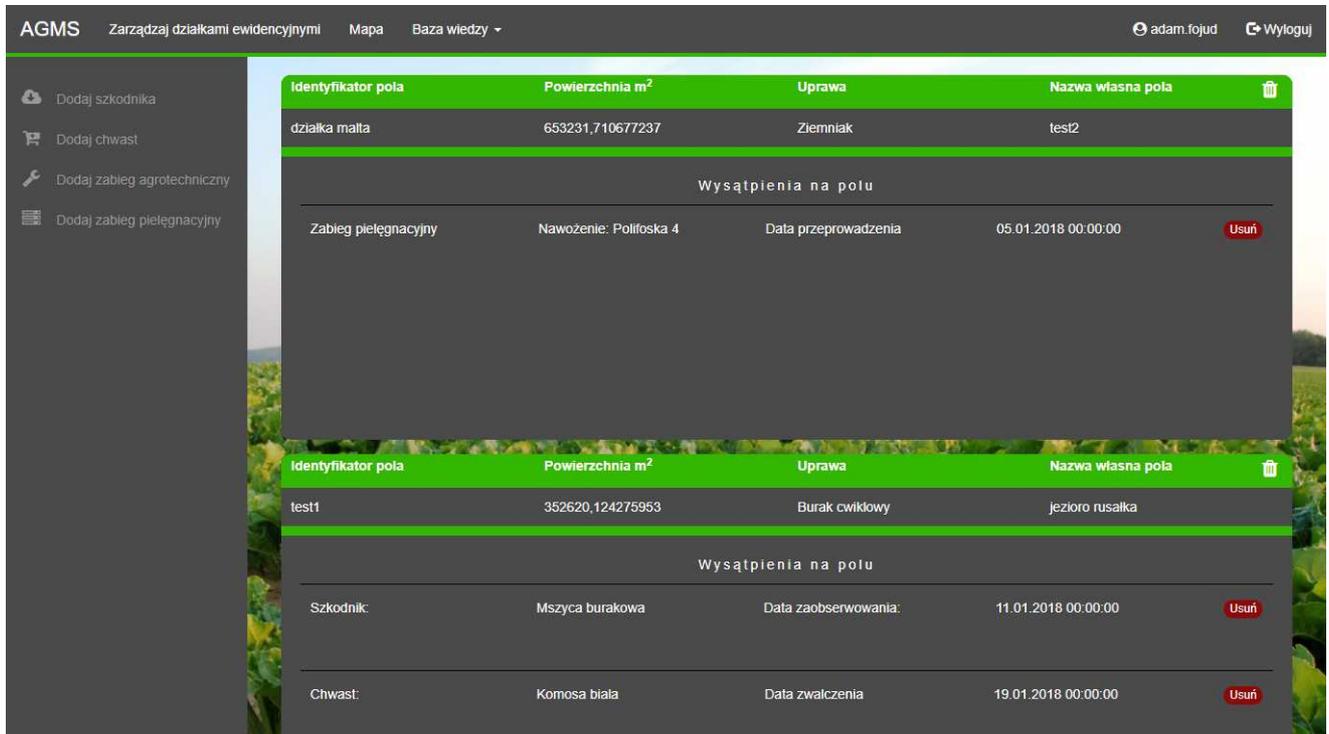
Fig. 3. Parcel addition module with shown field mapping mechanism

Rys. 3. Moduł dodawania działki wraz z ukazaniem mapowania pól



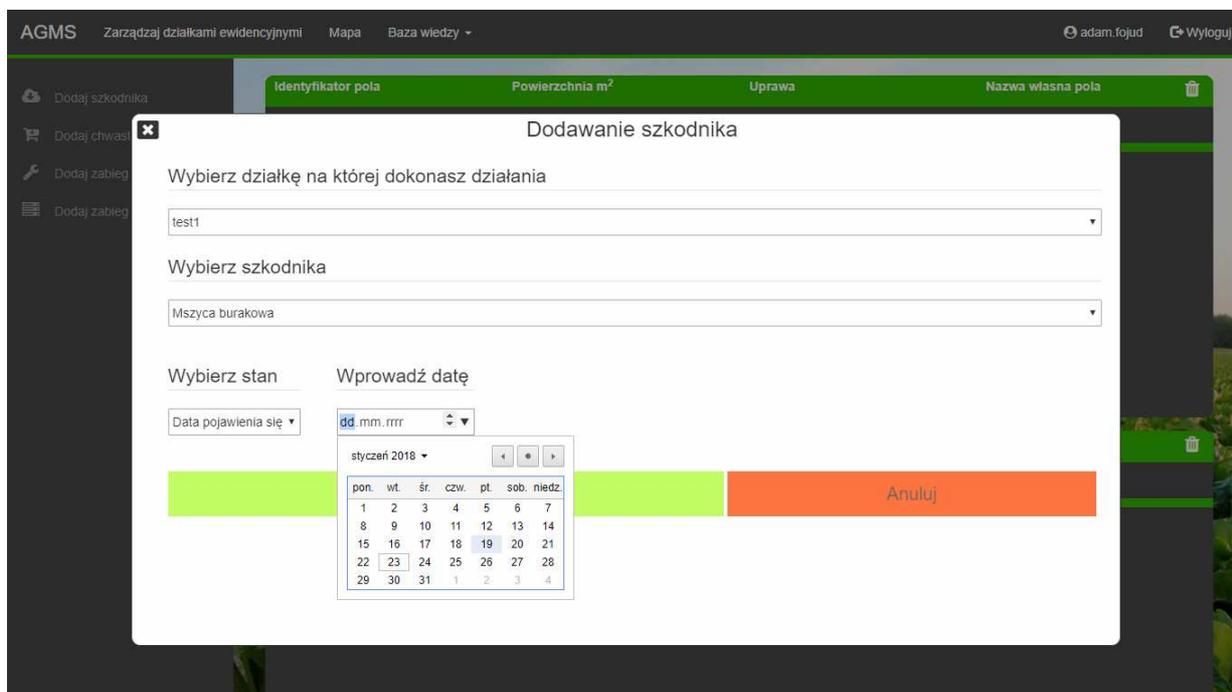
Source: own work / Źródło: opracowanie własne

Fig. 4. Map module view with selected area. Example showing the function of surface calculation
 Rys. 4. Widok modułu map z zaznaczoną działką. Przykład na którym ukazano funkcję obliczania powierzchni



Source: own work / Źródło: opracowanie własne

Fig. 5. View of the part of the management module with added elements such as field and events occurring on it
 Rys. 5. Widok modułu zarządzania działkami z dodanymi elementami takimi jak pole oraz zdarzenia na nim występujące



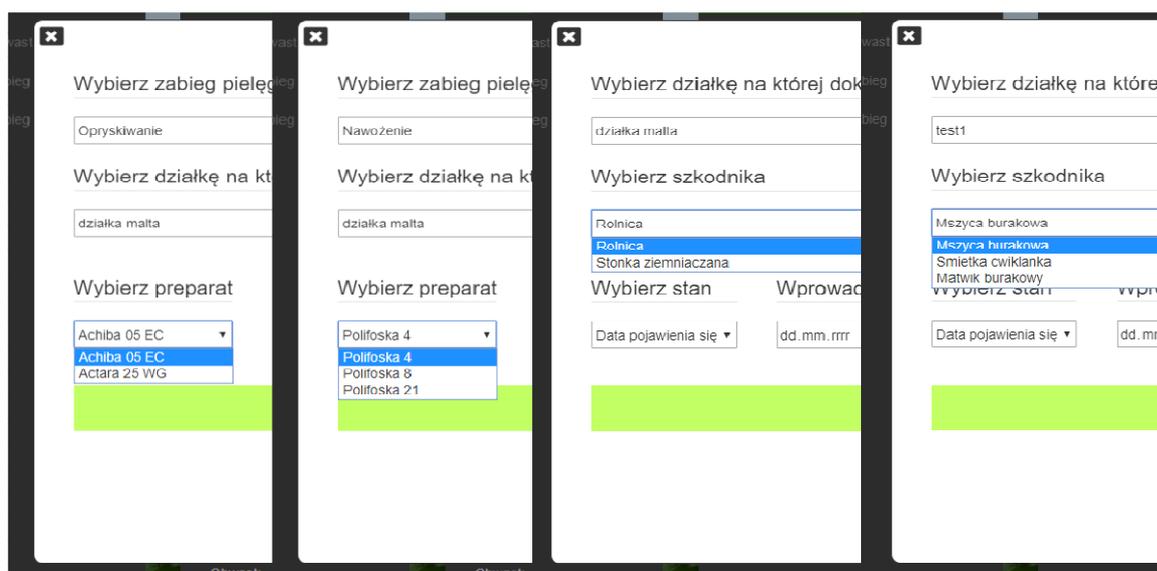
Source: own work / Źródło: opracowanie własne

Fig. 6. View of the pest addition presentation window
Rys. 6. Widok okna prezentującego dodawanie szkodnika

In the following cases, Fig. 7 shows how the dependencies of the choices are presented. If a care treatment event added on a field where potatoes are grown, the choice of treatment will determine whether to choose a preparation for spraying or fertiliser. The same applies to the addition of pests. In the field where beetroots are grown, the possible pests to choose are limited to those that can be found on the beetroot plantations. Similarly, in the case of a field on which potatoes are grown - pests that the user can choose are e. g. Colorado potato beetle.

Expansion of the system in the future will make it possible to offer the users an extensive advisory system, whose verification mechanism is based on a decision-making tree.

The AGMS also implements a knowledge base module. It contains information about pests or weeds and is intended to inform the user if he is not sure what he has observed in the field. Only descriptive information is available at a moment in the system (Fig. 8), but it is planned to add graphic information in the future. Moreover, the system concept provides for the implementation of an image analysis module. This would allow the user to enter the image into the system via a graphical file, and the task of the analysis algorithm would be to recognize the object in the field. Such an algorithm should be based on a neural model which, when the input signal is received in the form of image information, would inform the user about the type of weed or pest [8].



Source: own work / Źródło: opracowanie własne

Fig. 7. Examples of the addition of treatment and pest events. Demonstration of the event-field dependency mechanism
Rys. 7. Przykłady dodawania zdarzeń zabiegu pielęgnacyjnego oraz szkodnika. Ukazanie mechanizmu zależności zdarzenia od uprawy na polu

Nazwa szkodnika	Zagrożona roślina	Objawy	Zwalczanie	Opis szkodnika
Mszyca burakowa	Burak chwilkowy	Występowanie na liściu	Plantacja zdala od kaliny, trzmieliny i jasmionowca	Mszyce barwy czarnej, długość 2mm
Smietka chwilkanka	Burak chwilkowy	Występowanie na liściu	Wczesny wysiew, właściwa agrotechnika, oprysk 2-3 razy Bioczosem	Osobnik szaro-zielony, 7 mm długości
Matwik burakowy	Burak chwilkowy	Występowanie na korzeniu	Stosowanie conajmniej 4 letniej przerwy w uprawie buraka, roślin kapustnych i rzepaku na tym samym polu	Dorosłe samice od 0,5 do 1,1 mm, białe
Rolnica	Ziemniak	Wiedniecie rośliny, obgryzione pędy, korzenie i liście		
Stonka ziemniaczana	Ziemniak	Od roślin rosnących na obrzeżach	Oprysk w momencie pojawienia się, termin po wyługu larw	Dorosłe chrząszcze długości 10mm, barwa żółta, 10 czarnych pasków

Source: own work / Źródło: opracowanie własne

Fig. 8. View showing the contents of the pest knowledge database

Rys. 8. Widok przedstawiający zawartość bazy wiedzy dotyczącej szkodników

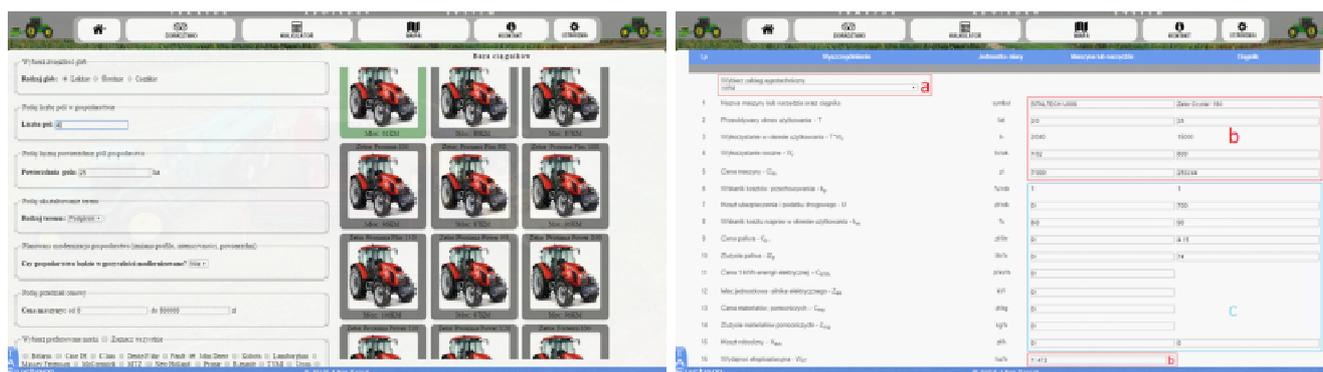


Fig. 9. TAS application. Operation of advisory modules for tractor selection and selection of agricultural machinery [9]

Rys. 9. Aplikacja TAS. Działanie modułów doradczych w zakresie doboru ciągnika oraz doboru maszyn rolniczych [9]

An additional concept for this system is to integrate it with the existing agricultural advisory solutions developed at the Institute of Biosystem Engineering. This is mainly about software to support decision making in the selection of tools and agricultural machinery (Fig. 9) [9]. The integration of such software would allow the creation of a comprehensive IT system for both small and large farms. One place would be occupied by such functionalities as the following ones:

- possibility of fields mapping,
- keeping documentation describing events in a given field,
- maintaining documentation on the machine park, their service and operation,
- correctness verification of the evaluation of observed weeds or pests,
- correctness verification of the selection of tractors and agricultural machinery.

5. Summary

Designing and creating an open application supporting farm management enables such programmes to reach farmers of small farms, who so far have used the little-advanced solutions, or have not kept the required documentation at all. What is more, the system concept includes the implementation of many open modules which facilitate work and decision-making. In the future, the AGMS system may prove to be a good alternative to the currently used solutions, most of which are based on the subscription model.

An open and free system supporting farm management, especially in Poland, may achieve market success.

6. References

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