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APPLICATION REPORTING YIELD FORECASTS OF THE SELECTED CROPS IN POLAND[1]

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ABSTRACT

Since 2005, in IUNG-PIB [Institute of Soil Science and Plant Cultivation – State Research Institute] work on the construction of the "Decision support system in plant production" (DSSPP) has been conducted. The purpose of the system is to generate information for agricultural producers, advisers, administration, etc. The DSSPP includes the yield forecast module (YFM), which implements in SQL language the yield forecast models of the selected crops developed at the Institute. As a supplement to the YFM, an application for generation of reports on yield forecasts was built with the use of the models. Reports in text and spreadsheet form are sent by e-mail to designated recipients. The application extends the YFM functionality adjusting information to the recipient's needs (selection of crops and localities). The tests conducted on the application showed conformity of the results generated by the reporting application and the yield forecast module.

Introduction

In 2005 at IUNG-PIB a research project aiming at the construction of the "Decision support system in plant production" (DSSPP) intended for generation of information for agricultural producers, advisers, administration etc. was undertaken (Zaliwski, 2009). One of the elements of the system is a module of forecasting maize, potato, winter wheat and triticale yield. The construction of the module of yield forecast assumes the application of long-term research achievements of the IUNG-PIB's Department of Agrometeorology within the scope of investigating relations between the crop yield and the weather. The beginnings of the research works carried out in this area by the Department (transformed in 2000 into the Department of Agrometeorology and Applied Informatics) date back to 1971-1975. At that time they focused on the recognition of climatic requirements of the selected cultivation plants and development of the methodology of assessment of the effectiveness of the climate with regard to the yield formation potential (Demidowicz et al., 2013). In the

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later period, the emphasis was placed on the climatic variability of plant yielding and the improvement of the methodology for determination of the relation of plant development and yielding to the weather. Construction (in the spreadsheet) of yield models of a number of cultivation plants followed, making it possible to build the Internet "System of agricultural recommendations related to the weather" (IPO) in 2005 (Kozyra et al., 2009). For the system needs the yield models were implemented in SQL language. The interface of the IPO system was rebuilt during the development of its second version (the first one is still available in the Internet). Moreover, many elements which enable remote administration, automatic supply of weather data from IUNG-PIB's agrometeorological stations and upload of decade data from synoptic stations of IMGW [Institute of Meteorology and Water Management] were added. The intention of the constructors of the IPO system was to make the implemented yield models available to a wider circle of users.
The objective of the article is to present the application for generation of reports on yield forecasts of the selected crops and sending them by e-mail to specific recipients, such one that enables personalization of information (selection of crops and localizations).

Structure and operation of the application

The reporting application was written in C#3.0 language for the ASP.NET 3.5 Framework environment as a console program (for running in DOS window). The application has two work modes: manual and automatic. Selection of the work mode depends on the value of a respective argument provided in the command line or on the value of the respective parameter in the configuration file (fig.1). In a similar manner (from the command line or the configuration file) the application reads out the remaining settings: addresses to which e-mails are to be sent, crops and localizations of station, for which forecasts must be calculated. Absence of one of these settings aborts processing.

Manual start of the application is used mainly for testing of its operation on the local machine. In the automatic operation mode, the application is started by the Task Schedule and performs consecutive stages of processing in a loop (fig. 1). Iteration of processing stages may finish after the first run or it may be multiple. In the second case the application resides in the RAM memory and repeats the attempt of e-mail creation in specific time intervals up to the moment of success. The repetitions constitute a security measure against faults, such as a temporary unavailability of the database server. A successful readout of the information on stations, generation of the forecasts and sending an e-mail according to the settings (fig. 1) means a successful run of the application and releases the RAM memory.

The application operation and possible errors are tracked and registered in two text files: the work-progress registration file and the error registration file. After achieving a particular size they are compressed in the specified catalogue and removed from the hard disc. The compression procedures are ensured with the library SharpZipLib.dll (IC#Code, 2012).

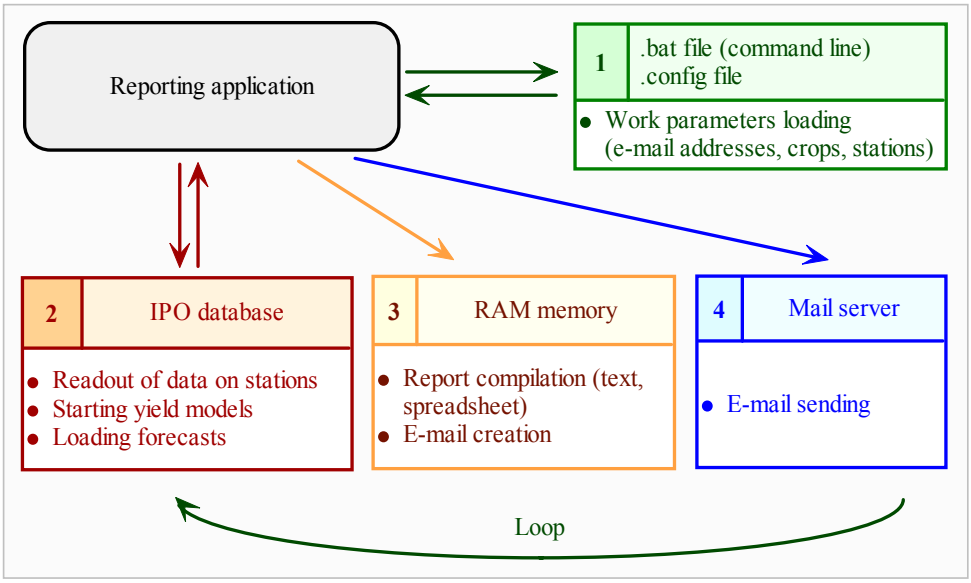

Figure 1. Task sequence of reporting application: 1 – work parameter loading, 2 – forecast loading, 3 – report and e-mail message creation, 4 – message sending

Implementation of yield models in SQL language

Yield models are started in the second stage of the application operation, which consists of three steps (fig.1):
– readout of data on synoptic stations from the IPO database,
– starting the yield models,
– loading yield forecasts for the crops and stations assigned.

Failure in the realization of one of these steps stops further operation of the application. In the automatic work mode it means repeating stages 2, 3 and 4 inside a loop (fig.1). When the yield models are started, the control switches to the database. The yield models were written as stored procedures in SQL language (Vieira, 2007) and are identical with the procedures used by the yield forecast module of the "System of agricultural recommendations related to the weather" (IPO, 2013; Kozyra et al., 2009).

The yield models (for winter wheat, winter triticale, maize and potato) were developed at the Department of Agrometeorology and Applied Informatics of the IUNG-PIB in Puławy. The author of the concept and methodology of their development and the author of three of them (winter wheat, maize and potato) is Tadeusz Górski (Górski et al., 1994, Górski et al., 1997). The model of winter triticale yield was constructed by Anna Nieróbca who drew on Górski's methodology. In order to make the use of the models in the yield forecast module of the IPO system they were adapted to the network database environment and rewritten as SQL stored procedures. Such a solution was dictated by an intensive communication of the models with the database (multiple data selection operations at subse-

quent calculation stages). Moreover, the implementation of models entirely in the database language makes them more universal (independent from the platform and the language used for application programming). In case of possible need to modify a model, there is only a necessity to change the stored procedure, provided that the interface remains unmodified (see fig. 2). Thus, an interference in the application code is averted. A confirmation of practical value of this solution would be probably particularly evident in the case of switching to a database of another manufacturer, different from the one in use with the YFM. Most probably it would require verification and revision of stored procedures, but the only modification necessary in the application *per se* would be a change of the database connection string in the configuration file.

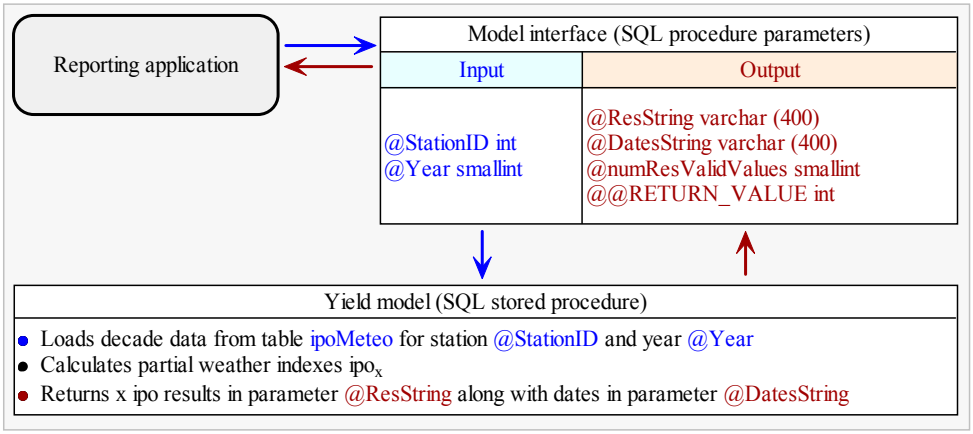

Figure 2. Interface of yield model (input and output parameters of SQL stored procedure)

Input parameters of the models (fig. 2) are: meterorological station index (@StationID) and the forecast year (@Year). The remaining parameters constitute the model output: they return the calculation results to the calling procedure. The essential results (values of weather indexes ipo_x and forecast dates) are transferred in the parameters @ResString and @DatesString of string type. Such a solution was adopted because of a variable number of results, wich depends on the forecast date and completeness of weather data. It allowed the use of one interface for all models. The year of the beginning of the yield calculation of winter crops (winter wheat and winter triticale) is the year preceding the year provided in the parameter @Year; in other words it is @Year-1. Particular dates and values of weather indexes placed in strings are separated with the sign ^. Their extraction from a string does not present a problem.

In the parameter @@RETURN_VALUE (fig. 2) a code is returned – an integer belonging to the code set, which helps to describe all stages of the model operation. Based on the interpretation of the return code value a decision on further proceeding is made. In the case of lack of any calculations, the procedure generates codes with negative values (different for errors and "no data") (fig. 3). Such a situation occurs before 1st November of the previous year, when in the database the dataset necessary for calculating the first forecast is not complete (calculation of the weather index ipo_1). Positive values of the code are used for

notification that the model carried out a calculation of one of fractional weather indexes (ipo_1-ipo_{10}). Code 0 (zero) means, on the other hand, the end of the procedure run with a complete dataset, resulting in the full number of weather forecasts ipo_1-ipo_{11} (fig.4).

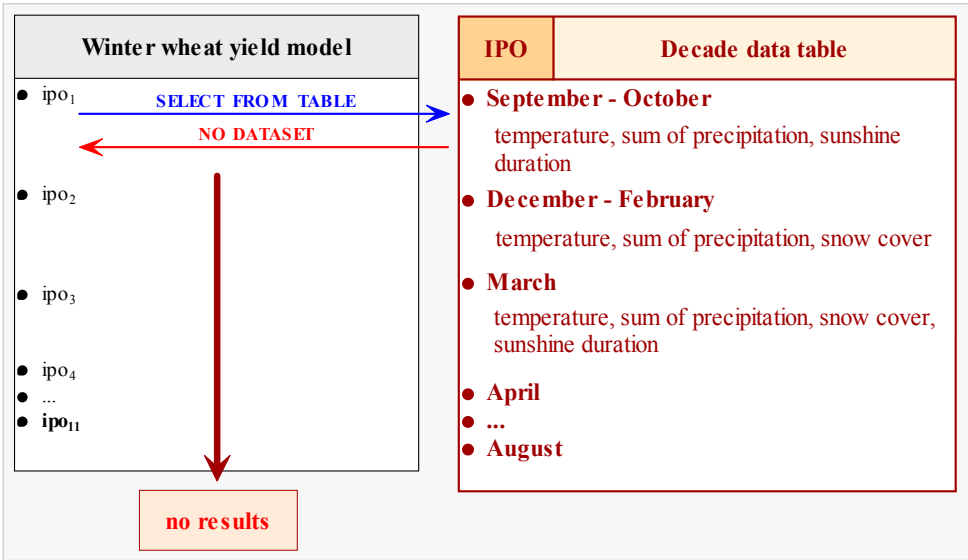

Figure 3. Yield model of winter wheat – no calculations. Markings: $ipo_{1\text{-}4\ ...}$ – partial weather indices, ipo_{11} – final weather index, NO DATASET – no weather data

Subsequent weather indexes constitute an yield assessment made on the basis of a series of the weather data from the consecutive periods; thus, the nearer the period draws to the cropping date, the more precise the approximation to the real values becomes. Consecutive indexes ($ipo_{2\text{-}11}$, except for ipo_1) are calculated acc. to the formula (1):

$$ipo_x = i_x + (ipo_{x-1} - 100) \quad (1)$$

where:

x – date of conducting a forecast,
ipo_x – fractional weather index for the date x, (%)
i_x – result of calculation of the weather index for date x, (%)
ipo_{x-1} – fractional weather index for the date preceding the date x, (%).

Each consecutive fractional weather index expresses then the impact on the yield of all the preceding indexes. Real values of yields may be obtained only after the harvest of winter wheat, which in Poland as a rule takes place not earlier than on 8th July and not later than 7th September (Cyfert et al., 2008; Najewski et al., 2012). These dates are of course approximate, because the date of harvest depends on the region and the weather in a given year.

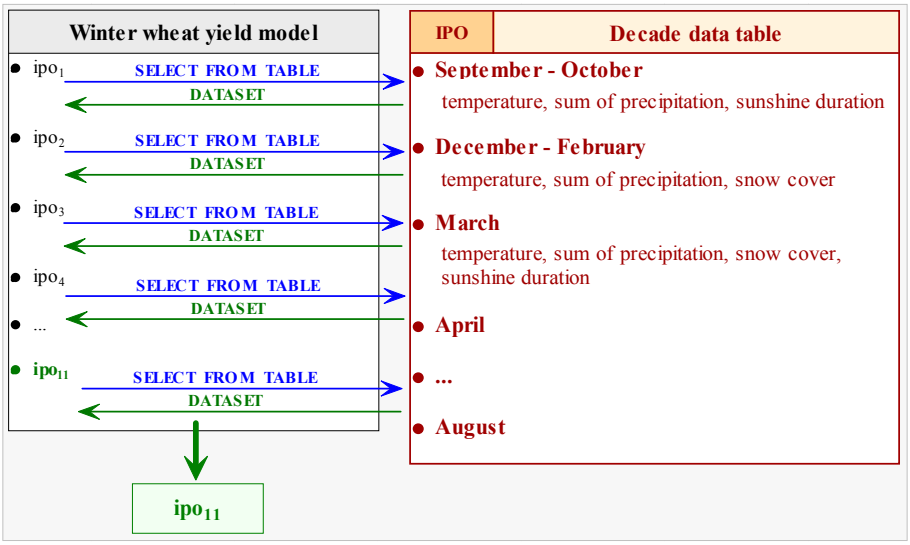

Figure 4. Yield model of winter wheat – calculation of final weather index. Markings: $ipo_{1\text{-}10}$ – partial weather indexes, ipo_{11} – final weather index, DATASET – query returns a dataset for calculations

Results of testing the reporting application

The reporting application was tested first on a local machine with a remote access to the database of the IPO system, and then on a remote server. The database was placed on the database server in IUNG-PIB. Tests were carried out for weather data in years 2011-2012 from 34 meteorological stations. The application allows sending messages about yields forecasts in text format and in a spreadsheet file attached as an enclosure to the e-mail. For creation and filling in the spreadsheet the application uses the library ExcelLibrary.dll (E-Infotainment, 2013) including classes that allow substituting the COM technology (COM, 2013). Thus, the installation of the Excel application is not required on the machine, on which the application is started.

Stacja Lublin Radawiec
Pszenica ozima, sezon wegetacyjny 2011-2012
2011.11.01 98,532
2012.03.01 97,826
2012.05.01 98,288
2012.06.01 89,23
2012.06.11 89,535
2012.06.21 88,502
2012.07.01 88,308
2012.07.11 85,683
2012.07.21 86,138
2012.08.01 88,621
2012.09.01 91,327
- prognoza OK: stosunek wyników prawidłowych/brakujących = (11/11)

Figure 5. Sample e-mail text message (fragment)

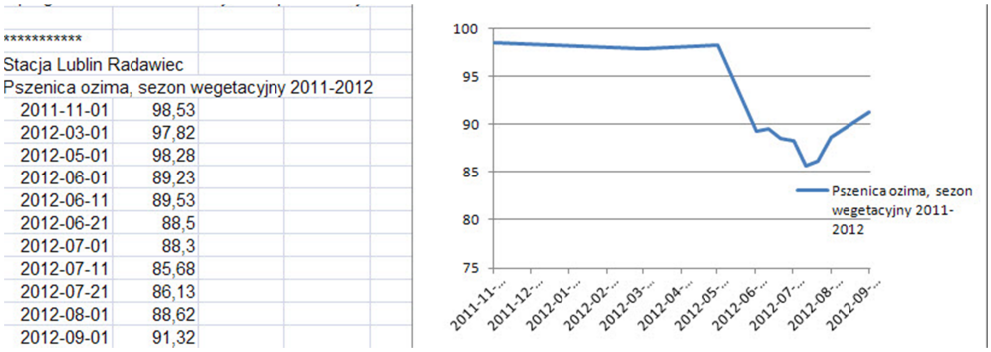

Figure 6. Sample message in spreadsheet attached to e-mail (fragment)

Fig. 5 presents a fragment of the text e-mail sent by the application and in the fig. 6 the corresponding fragment of the message in Excel file is shown. These are forecasts of the winter wheat yield for the locality of Lublin Radawiec in the vegetation season 2011-2012. Both mails include the same data. The format of the spreadsheet may be more suitable in case of further processing of the results. For instance, using the data placed in the sheet, it is easy to make a plot of the impact of weather conditions on yield. Such a plot (fig. 6) was made manually. It expresses considerably better than dry numbers (shown on the left side of the picture) a collapse of weather conditions, which took place from May 2012 to the first decade of July inclusively. The further course of the weather, up to the cropping, was favourable for the yield. Nonetheless, as one may conclude from the forecast results, the conditions were not sufficiently propitious as to make up for the losses.

A comparison of the forecasts generated by the reporting application with the forecasts made by the yield forecast module showed a full conformity of calculation results.

Conclusion

A possibility of automatic reporting of yield forecasts of the selected crops for a locality with the use of e-mail was verified in practice. A reporting application, created for this purpose, uses models of yields developed at IUNG-PIB and implemented in SQL language in the yield forecast module of the "System of agricultural recommendations related to the weather", supplied with decade weather data. The tests which were carried out proved a full conformity of results generated by the application and the YFM module.

Correctness of operation of the reporting application, as well as of the IPO system, depends on the timely update of the weather data. The application complements the system with a signalization function, transmitting information on forecasts to the recipients as soon as it becomes available.

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APLIKACJA RAPORTUJĄCA PROGNOZY PLONÓW WYBRANYCH UPRAW W POLSCE

Streszczenie. Od 2005 roku w IUNG-PIB prowadzone są prace nad budową "Systemu wspomagania decyzji w zakresie produkcji roślinnej" (SWDPR), przeznaczonego do generowania informacji dla producentów rolnych, doradców, administracji, itd. W skład SWDPR wchodzi moduł prognozowania plonów (MPP), implementujący w języku SQL modele plonowania wybranych roślin uprawnych opracowane w Instytucie. Jako uzupełnienie MPP zbudowano aplikację do generowania raportów o prognozach plonowania roślin uprawnych, wykorzystując modele pochodzące z MPP. Raporty w formie tekstowej i w arkuszu kalkulacyjnym są przesyłane drogą elektroniczną do określonych odbiorców. Aplikacja rozszerza funkcjonalność MPP umożliwiając dostosowanie informacji do potrzeb odbiorcy (wybór uprawy i miejscowości). Testowanie aplikacji pozwoliło stwierdzić zgodność wyników generowanych przez aplikację raportującą i moduł prognozowania plonów.

Słowa kluczowe: model plonowania, indeks pogodowy, implementacja modelu, SQL, aplikacja raportująca, e-mail