International Journal of Engineering Research and Technology. ISSN 0974-3154, Volume 12, Number 12 (2019), pp. 2465-2472

The Role of the Irrigation Management Software in Kazakhstan

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Abstract:

The article analyzes methods for the determination of water consumption of crops. An algorithm for calculating sustainable water supply, which allows achieving high yielding capacity. On the basis of bioclimatic model of determining crops water consumption, the model of agriculturally used areas water consumption rationing is proposed, including the basic principles of land reclamation, improving of biological and preventing of geological circulation of water and chemicals. Developed algorithm for determining the rules of water consumption with the usage of meteorological data allows developing irrigation management software. The algorithm is very flexible, so it can be adapted to the specific features of the territory on which it is going to be used. This methodology can be applied in countries with arid climate. The proposed model would help to solve the problem of sustainable water consumption and irrigation of areas with inadequate water supply.

Keywords - Arid Climate, Database, Database Management System, Information, Irrigation, Programs, Software, Underground Water Table, Water Supply.

I. INTRODUCTION

In recent years, the interest of agricultural producers to restore and reconstruct irrigation systems has increased, and, consequently, in the insurance of their effective operation, which largely determines the rational use of reclaimed land. Systemic consideration and analysis of the main ways to improve the efficiency of irrigated land use allows us to conclude that it is necessary to create new irrigation management systems and modernize the existing ones.

Practical implementation of such systems will ensure rational distribution of irrigation water by fields and crops and specify irrigation schedules for crops, depending on the needs of the plants, taking into account technical capabilities of the irrigation network, and etc.

Irrigation management systems are based on the solution of a set of interrelated planning tasks and subsequent water distribution, including by agreeing the timing and volumes of water supply with the operation of irrigation equipment. Operative management of irrigation on large irrigation systems can be divided into two stages: irrigation scheduling according to climatic parameters and their subsequent organizational and technological implementation. Providing favorable conditions for crop production the operational management plays an important role in effective use of water, technical, energy and labor resources. The development of information systems for the operational management of the production of agricultural crops irrigation aimed at the effective use of technical means of the irrigation and drainage system, rational use of land, water and labor resources is an urgent task.

Software includes a set of programs that implement the functions and tasks of the information system and ensure stable operation of technical equipment complexes. The software includes system-wide and special programs, as well as instructional and methodological materials on the use of software tools and the personnel involved in its development and maintenance for the entire life-cycle of the information technology.

The system-wide software includes programs designed for a wide range of users and designed to organize the computational process and perform frequently occurring information processing options. They allow expanding the functionality of the computer, automating the scheduling of the order of computational work and automating the work of programmers. Special software is a set of programs developed for the purpose of creating information technology for a specific functional use. It includes packages of application programs that organize and process the data when solving functional tasks of the information systems.

The software "Norms of water demand for agricultural crops" implements the interactive principle of information input and setting the directives.

In developing the scenario of a dialogue, the developers were guided by the following main provisions:

- specialists and workers of water and agriculture can work with personal computers without having special training in computing, but only having get a general idea of it;

- instructions should contain a minimum number of service terms;

- input programs must not pass erroneous information to the output, that is, calculations must be automatically interrupted until the correct data is entered;

- the contact of a person with a computer should be understandable "friendly" in nature, for which he must receive all kinds of "tips" from the computer.

The dialogue should be as simple and understandable as possible for the specialist, in this case - for the ameliorator or agronomist, in his subject area.

II. MATERIAL AND METHODS

II.I General Part

The general trend of modern development of nature management and environmental management in the world is to create conditions for a stable management of biological and geological cycles of water and chemicals in the natural system under human anthropogenic activity.

There are various methods for establishing irrigation regimes for crops, from which two main groups can be distinguished:

- determination of irrigation regimes for crops based on special field experiments (deterministic methods);

- determination of total water consumption and irrigation regimes by indirect (calculated) methods using the main indices of the plant's life environment.

From these groups of methods, the most reliable and objective way to justify and determine irrigation regimes for crops are the methods based on determination of special field experiments. The criterion for assessing the final results is yield and technical and economic indicators.

Applying deterministic methods, the optimal parameters of irrigation regimes are determined by studying and comparing various options for watering purposes by the deficiency of water balance of soils, physiological indicators of plants, hydrological and meteorological indicators, and etc. These methods are widely used in establishing irrigation regimes and studying irrigation efficiency in unexplored areas or cultivating new varieties of crops. At the same time, the received indicators basically correspond only to the given or identical by conditions object. And adopting and transferring necessary indicators in other conditions not always reach positive results. In addition, the research management using these methods requires considerable time, labor and resources.

At present, along with deterministic methods of research, computational methods for determining evapotranspiration and irrigation regimes have been widely used. They are based on the application of qualitative indicators of the relationship between gross water consumption of plants and climatic conditions. The form of the connection between water consumption by plants and stochastic climate indices in different calculation methods is expressed in different ways. It is quite natural, since regional features have an individual effect on these relationships. For calculating water consumption of plants some researchers recommend to use the sum of air humidity deficiencies, and others - the radiation balance.

The works by N.A. Kostyakov [1], N.A. Sharov [3], Kh.L. Pennman [2], H.T. Blaney and V.D. Kridd [4], S.V. Thornthwaite [6], L. Türk [5], D. I. Shashko [7], V.S. Mezentsev [8], A.M. and S.M. Alpatyev [9;10] and others are well-known in this field.

The analysis of the recommendations and methodological basis of the group of calculation methods for defining irrigation regimes for agricultural crops shows that they comprehensively enough take into account the factor of moisture availability of the plant with a change in climatic parameters in time and to a small extent or indirectly reflect the relationship in the plant-soil system. Irrigation regime parameter data are always required for calculation methods; therefore, it is necessary to create a database of irrigation parameters for the system automation [1-15].

II.II Database

Database (DB) is an ordered set of data about a specific object, stored in the external memory and organized in a certain way. Or you can say that this is an organized set of data, designed for a long-term storage in the external memory of a computer and their constant use. There are several models (schemes) of the database. As a rule, the DBMS is included in the concept of databases as an element of a complex hierarchical system. We distinguish hierarchical, relational, network databases, distributed and centralized databases, and etc.

III. RESULTS

III.I Classification of databases

There are such kinds of database classification:

- by the nature of the stored information: factographic and documentary;

- by the method of data storage: centralized and distributed;

- by the structure of data organization: relational (tabular databases), hierarchical and network databases.

The main function of the database is to store large amounts of data that can be manipulated using the built-in features of the software environment, such as editing data, selecting data by condition and creating reports of various forms. The database can be displayed on the screen in the form of a table and as a file cabinet, regardless of the type of the format used.

Most databases use a tabular format as their main information structure. A relational database is a set of interrelated tables, each containing the information about objects of a certain type. The table has rows and columns, which are called a record and a record field, respectively. Fields determine the structure of the database.

Fields are different characteristics (sometimes they are called attributes) of an object.

For example: Let us consider the object of the irrigation regime of crops. The main properties of the object interesting for the consumer will be climate conditions of Kazakhstan. The selected attributes will serve as the fields of the created database. Each record field contains one characteristic of the object and has a strictly defined data type (for example, a character string, a number, a date, etc.). All entries have the same fields, but they contain different attribute values.

Access to the database and database management is carried out using the Database Management System (DBMS). The main functions of the DBMS are data definition (description of the data structure), data processing and data management.

International Journal of Engineering Research and Technology. ISSN 0974-3154, Volume 12, Number 12 (2019), pp. 2465-2472
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As a rule, Database management systems include the following elements:

1. Interface - the user's environment for working with the help of the menu.
2. Interpreter - an algorithmic programming language.
3. Compiler – a converter of programs into offline executable files.
4. Utilities - tools for programming the routine operations.

Any DBMS allows you to perform four simple operations with data:

- add one or more records to the table;

- delete one or more records from the table;

- update the values of several fields in one or more records;

- find one or more records that satisfy the given condition.

The request mechanism is used to perform these operations. The result of the request execution is either a set of records selected by certain criteria, or changes in the tables. Requests to the database are generated in a specially created language. And the most important function of a DBMS is data management. Data management is usually understood as the protection of data from unauthorized access, support for multi-user data mode and ensuring data integrity and consistency.

The functions of the DBMS are unnoticed for a user, since the system is maximally adapted to the needs of the individual. It makes possible to master the work with the database with minimal knowledge. Let us consider the steps for creating a database:

- database design (the object definition and allocation of the object attributes as database fields);

- setting the structure of the database (single-table database or a database consisting of several linked tables);

- input of a data structure with the description of the types of data entered in the fields of the table;

- direct input of data into the database;

- editing of data;

- manipulation of data (sorting, sampling data using filtering and / or queries).

In Microsoft Office Access 2007, the data are organized in tables for crops irrigation regime parameters. A simple database can consist of only one table. Most databases include several tables. For example, one table can store the information about agro zones, the second stores the information on the average monthly air temperature in Kazakhstan, and the third contains the information about the meteorological stations of the region, etc. Ten tables are organized in our database (Fig. 1).

Fig. 1. Database tables

III.II Principles of databases building

To the modern databases, and, consequently, to the DBMS on which they are built, the following basic requirements are imposed.

1. High speed (short response time to the request).

The response time is the time interval from the moment of the query to the database until the time when the actual data are received. A similar term is the access time. It is the time interval between the issuance of a write non-memory-reference (reading) and the actual receipt of data. Access is understood as the operation of searching, reading or writing the data. The operation of writing, deleting and modifying data is often called an update operation.

2. Simplicity of data updating.

3. Independence of data.

4. Sharing of data by many users.

5. Safety of data - protection of data from deliberate or unintentional violation of secrecy, distortion or destruction.

6. Standardization of database construction and operation (actually DBMS).

7. Adequacy of mapping the data of the relevant subject area.

8. User-friendly interface.

The most important requirements are the first two contradictory requirements: increasing the high speed response requires simplification of the database structure, which, in turn, complicates the procedure for updating data, increases their redundancy.

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At present, the development of agriculture and melioration in Kazakhstan takes place in difficult economic, environmental and social conditions. However, ensuring the country's food security is impossible without land reclamation and the development of irrigated agriculture, since the largest part of agricultural land is located in arid regions related to zones of unsustainable farming.

The aim of the work is to develop methodological justification and create database of parameters for irrigation regime of agricultural crops for the entire region of Kazakhstan, meeting the requirements of resource saving and environmental sustainability of agrolandscapes. Entering data by regions can be organized by the form of the object (Fig. 2).

Independence of data is the ability to change the logical and physical structure of the database without changing the views of users.

Data independence implies invariance to the nature of data storage, software and hardware. It provides minimal changes in the structure of the database when changing the strategy for accessing the data and the structure of the original data themselves. This is achieved by "shifting" all changes to the stages of conceptual and logical design with minimal changes at the stage of physical design.

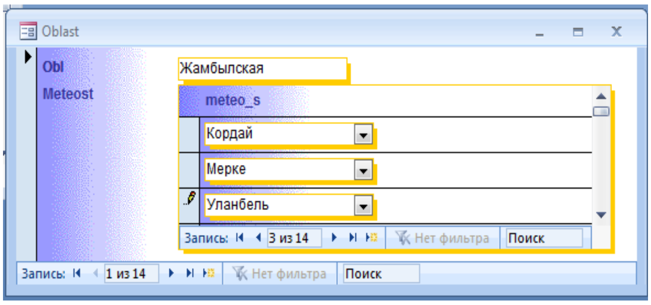

Fig. 2. Entering data by region

The temperature index for the regions of Kazakhstan for any season can be entered into the database using the following form (Fig. 3).

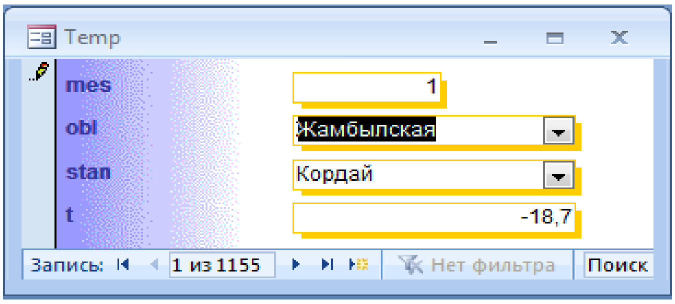

Fig. 3. Entering the temperature index by Kazakhstan regions

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The temperature index for the regions of Kazakhstan for any season can be entered into the database using the following form (Fig. 3).

Data security includes their integrity and protection.

Data integrity is the stability of stored data to failure and destruction associated with hardware malfunctions, system errors and erroneous user actions. It supposes:

- absence of inaccurately entered data or two identical records about the same fact;

- protection from errors when updating the database;

- impossibility of deleting (or cascading deleting) of related data from different tables;

- non-distortion of the data when working in multi-user mode and in distributed databases;

- data integrity in case of hardware failure (data recovery).

The integrity is provided by integrity triggers - special application programs that work under certain conditions. Data protection from unauthorized access involves limited access to the confidential data and can be achieved by:

- the introduction of a password system;

- obtaining permissions from the database administrator (DBA);

- prohibition for access to data from DBA;

- formation of types - tables derived from the source ones and intended for specific users.

The last three procedures are easily performed within the Structured Query Language - SQL, often called SQL2. Standardization provides continuity of generations of DBMS, simplifies the interaction of databases of the same generation with the same and different data models.

A relational database is a collection of tables that are wired (linked) by primary and foreign keys. The relational data model includes a set of rules that help you create the right relationships between tables. These rules are called "normal forms". In a relational database, connections make possible to avoid data redundancy. The types of relationships between the tables are done by comparing the data in the key columns; these are usually columns that have the same name in both tables. In most cases, the primary key of one table, which contains a unique identifier for each of the lines is compared with a foreign key of another table.

A “one-to-many” relationship is created when only one of the linked columns is constrained to uniqueness or it is the primary key.

When you establish a many-to-many relationship, each row in Table A can correspond to multiple rows of Table B and vice versa. This relationship is created using the third table, called a connection table. Its primary key consists of foreign keys associated with tables A and B.

When establishing “one-to-one relationship”, only one row of table B can correspond to each row of table A and vice versa. “One-to-one relationship” is created when both related columns are primary keys or uniqueness constraints are imposed on them.

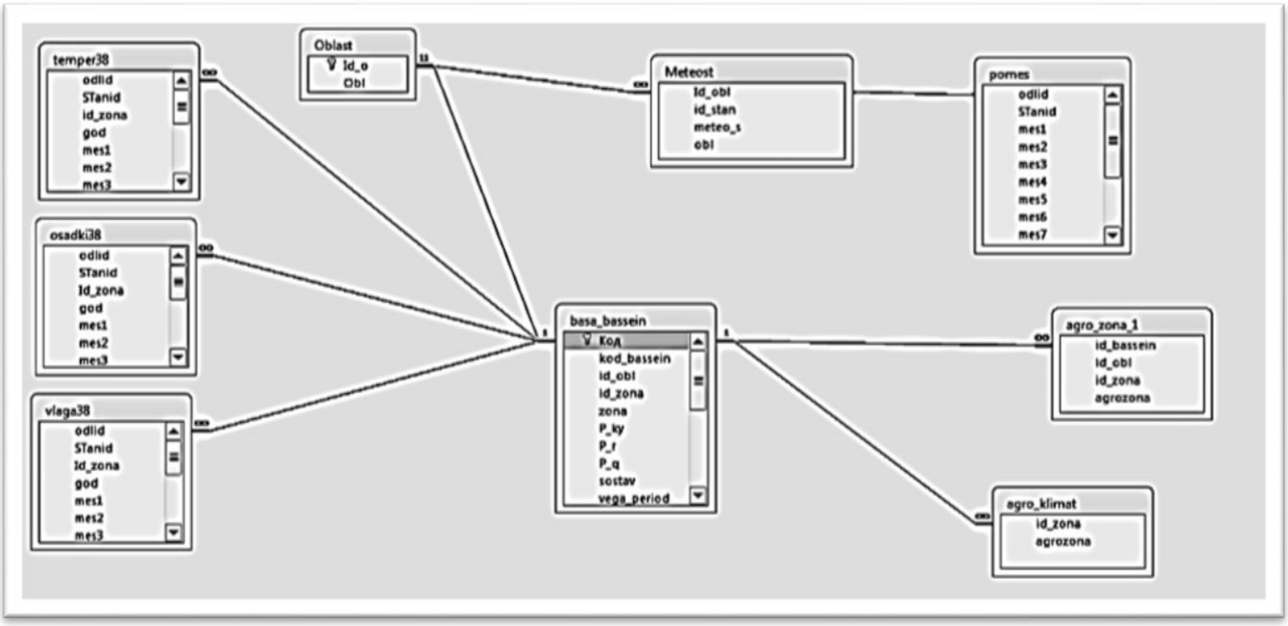

Fig. 4. Database links diagram

Thus, the created database makes possible to organize an automated system for calculating the parameters of the crop regime.

The program "Model of linear stochastic programming" includes the most detailed presentation of the information-advisory system of operational planning of the norms of water consumption of agricultural crops (Figure 14).

The program menu consists of the following main sections:

- Scheme;

- Conditions;

- Function;

- Calculation;

International Journal of Engineering Research and Technology. ISSN 0974-3154, Volume 12, Number 12 (2019), pp. 2465-2472

- Model of optimization;
- Calculation of biological coefficients;
- Database;
- Exit.

Fig. 5. Main Menu

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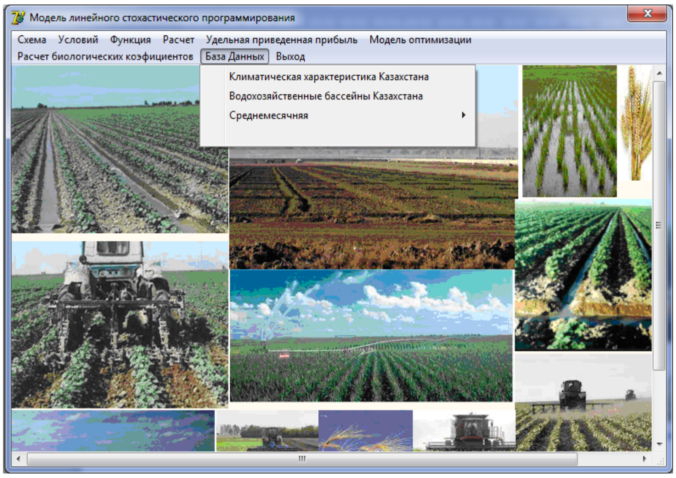

Fig. 6. "Database"

The block "Water basins of Kazakhstan" contains the information on the administrative areas and natural areas of Kazakhstan (Table 1).

Table 1. Administrative-territorial division of the territory of Kazakhstan

Water-based basin	Region	Agroclimatic zone
1	2	3
Yertys'kyi	East Kazakhstan	Mountain steppes (MS)
		Piedmont Steps (PS)
		Semi-desert (SD)
	Pavlodar	The arid steppe (AS)
		Dry steppe (DS)
		Semi-desert (SD)
Balkhash-Alakol	Almaty	Piedmont steppe (PS)
		Piedmont semidesert (PS)
		The Southern Desert (SD)
	Zhambyl	The Southern Desert (SD)
	Karaganda	The Northern Desert (ND)
	East Kazakhstan	The Northern Desert (ND)
Shu-Talas	Zhambyl	Piedmont steppe (PS)
		Piedmont semidesert (FDP)
		The Southern Desert (PJ)
	South Kazakhstan	The Southern Desert (PJ)
Aral-Syrdarya	South Kazakhstan	Piedmont semidesert (PS)
		The Southern Desert (SD)
	Kyzylorda	The Southern Desert (SD)
Zhayik-Kaspiyskaya	West Kazakhstan	Dry steppe (DS)
		Semi-desert (SD)
		The Northern Desert (ND)
	Atyrau	The Northern Desert (ND)
	Mangistau	The Southern Desert (SD)
	Aktobe	Dry steppe (DS)
		Semi-desert (SP)
		The Northern Desert (ND)
Nura-Sarysu	Karaganda	The arid steppe (AS)
		Dry steppe (DS)
		Semi-desert (SP)
		The Northern Desert (ND)
Yesilskaya	North-Kazakhstan	Forest steppe (FS)
		The arid steppe (AS)
	Akmola	Forest steppe (FS)
		The arid steppe (AS)
		Dry steppe (DS)
Tobol-Turgai	Kostanay	The arid steppe (AS)
		Dry steppe (DS)
		Semi-desert (SD)
		The Northern Desert (ND)

Within the water basins there are regions and natural zones that allow determining the areas and the natural areas where the research objects are located.

The menu "Agroclimatic zone" in parallel reflects the information of climatic zones and their meteorological stations (Fig. 7).

The block "Climatic conditions of Kazakhstan" contains information on the climatic characteristics of Kazakhstan. When choosing the name of a region, for example, “Zhambyl Region”, a list of meteorological stations located on the territory of Zhambyl Region appears (Fig. 7).

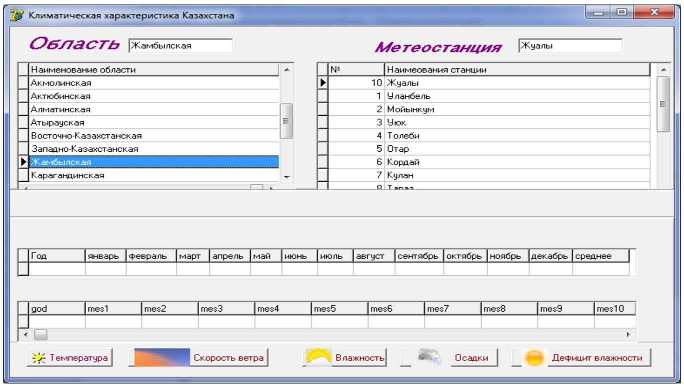

Fig. 7. The " Agroclimatic zone" menu

When selecting the names of areas and weather stations, the selected "Area" and "Meteorological station" are displayed accordingly, as well as the control buttons at the bottom of the window: "Temperature", "Wind speed", "Humidity", "Precipitation", "Moisture deficit". Hence it is necessary to select the targeted names of the regions and meteorological stations that characterize the climatic conditions of the proposed irrigated massifs (Fig. 8).

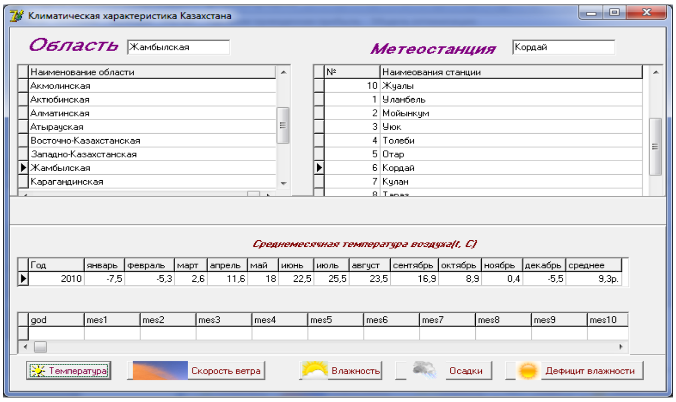

Fig. 8. “Weather Station” menu

As a rule, when selecting the appropriate icons, the result of calculating the monthly average values of air temperature, wind speed, humidity, precipitation and moisture deficit is displayed, which are necessary to determine the monthly average values of evaporation. Accordingly, the data on average monthly air temperature (°C) appear in the “average monthly temperatures” window. By clicking the “wind speed” button you can get wind speed information for meteorological stations of interest (Fig. 9).

To calculate the average monthly evaporation during the growing season, data on the average monthly relative humidity of the air are still needed. They are determined by pressing the cursor once on the “humidity” and “precipitation” buttons (Figs. 11-13).

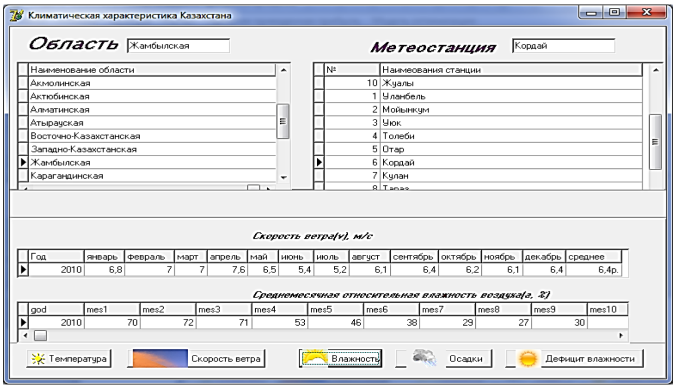

Fig. 9. “Weather Station” menu - “wind speed”

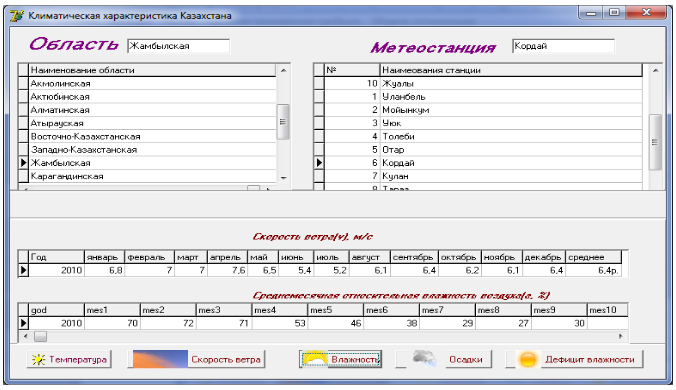

Fig. 10. Weather Station” menu - “average monthly relative humidity of air”

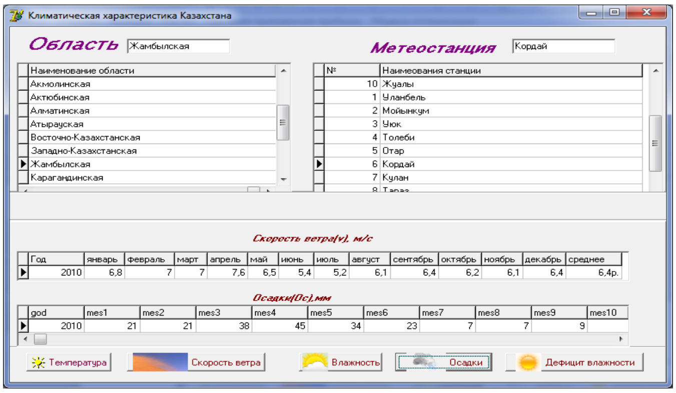

Fig. 11. “Weather Station” menu - “precipitation”

To perform the calculation on determining the average monthly evaporation, it is necessary to select crops, which are determined by the water demand rate and their duration, that is, the beginning and end of the growing season.

The length of the growing season for specific crops and natural areas can be determined from the table.

IV. CONCLUSIONS

The main task of the information management software for operational irrigation management under conditions of insufficient moisture in Kazakhstan is to create models and algorithms for solving functional problems in the field of irrigated agriculture on the basis of the systematization and analysis of information and software.

2. The software of information and advisory operational irrigation management systems, including a set of programs that implement the functions and tasks of the information system and ensure the stable operation of complexes of technical means, provides a qualitative assessment of the crop irrigation regime.

3. The developed software of information and advisory systems for operational irrigation management will significantly expand the capabilities of water management services in predicting the crop irrigation regime and will provide qualitative and quantitative information for decision-making.

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