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Original article

SOFTWARE FOR MONITORING THE PRODUCTION PROCESS OF RICE AGROCENOSIS BASED ON A DATABASE

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Abstract

Background. The results of the study of the production process of intensive and extensive rice varieties are summarized in a single database (DB) registered in Rospatent No. 202462462. It includes two main parts: descriptions of the object of study and tabular data having a structure and interrelations according to the logical scheme, which was created in the Microsoft Access program. The latter manages the database (DBMS) of biological features that form the rice yield. The database contains data for identifying the interaction of biological features of plants with their optical characteristics in the formation of the yield of rice agrophytocenoses and the introduction of scientifically sound methods for monitoring the physiological state of crops and forecasting the yield. In vegetation and microfield experiments, the patterns of growth and formation of productivity of different types of rice varieties are considered. Particular attention is paid to the characteristics of donor-acceptor relationships in plants and crops as the main stage of the production process, determining the economic productivity of genotypes.

Purpose. The aim of the research is to study the production process of intensive and extensive rice varieties.

Materials and methods. The research was carried out in two experiments: a vegetation-microfield experiment and a field experiment (2017-2024).

Results. The developed database contains a set of data reflecting information on the biological characteristics of plants that determine rice yield. Research on monitoring rice crops was conducted in the physiology laboratory of the Federal State Budgetary Scientific Institution “Federal Scientific Center of Rice”. The developed database is necessary to identify the interaction of biological characteristics of plants with their optical characteristics. In this version of the program, five basic forms are used to enter the initial data, with the help of which data is entered, edited and viewed: information on the yield and its structure (productivity); optical characteristics of the object (optical indicators); information on the research material (research material); information on climatic conditions (climatic data); Variety passport (characteristics of the variety under study).

Conclusion. The structure of the DB of morphophysiological features of rice plants is presented. Information support for monitoring rice agrophytocenoses is carried out based on the entered data on biological features that form rice yield. Specialists of rice-growing farms to monitor the state of rice crops, adjust nitrogen fertilization and forecast the yield use the presented DB.

Keywords: rice; production processes; information support for monitoring; database

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Научная статья

ПРОГРАММНОЕ ОБЕСПЕЧЕНИЕ ДЛЯ МОНИТОРИНГА ПРОЦЕССА ПРОИЗВОДСТВА АГРОЦЕНОЗА РИСА НА ОСНОВЕ БАЗЫ ДАННЫХ

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Аннотация

Обоснование. Результаты изучения производственного процесса интенсивных и экстенсивных сортов риса обобщены в единой базе данных (БД), зарегистрированной в Роспатенте № 202462462. Она включает две основные части: описание объекта исследования и табличные данные, имеющие структуру и взаимосвязи в соответствии с логической схемой, которая была создана в программе Microsoft Access. Последняя управляет базой данных (БД) биологических признаков, формирующих урожайность риса. База данных содержит сведения для выявления взаимодействия биологических признаков растений с их оптическими характеристиками в формировании урожайности рисовых агрофитоценозов и внедрения научно обоснованных методов мониторинга физиологического состояния посевов и прогнозирования урожайности. В вегетационных и микрополевых опытах рассмотрены закономерности роста и формирования продуктивности различных видов сортов риса. Особое внимание уделено особенностям донорно-акцепторных отношений в растениях и посевах как основного этапа продукционного процесса, определяющего хозяйственную продуктивность генотипов.

Цель. Целью исследования является изучения производственного процесса интенсивных и экстенсивных сортов риса.

Материалы и методы. Исследования проводились в двух экспериментах: вегетационно-микрополевом и полевом (2017-2024 гг.).

Результаты. Разработанная база данных содержит набор данных, отражающих информацию о биологических особенностях растений, определяющих урожайность риса. Исследования по мониторингу посевов риса проводились в лаборатории физиологии Федерального государственного бюджетного научного учреждения «Федеральный научный центр риса». Разработанная база данных необходима для выявления взаимодействия биологических характеристик растений с их оптическими характеристиками. В данной версии программы для ввода исходных данных используются пять основных форм, с помощью которых осуществляется ввод, редактирование и просмотр данных: информация об урожае и его структуре (продуктивность); оптические характеристики объекта (оптические показатели); информация о материале исследования (материал исследования); информация о климатических условиях (климатические данные); паспорт сорта (характеристика изучаемого сорта).

Заключение. Представлена структура БД морфофизиологических признаков растений риса. На основе введенных данных о биологических признаках, формирующих урожайность риса, осуществляется информационное обеспечение мониторинга рисовых агрофитоценозов. Специалисты рисоводческих хозяйств для мониторинга состояния посевов риса, корректировки азотных удобрений и прогнозирования урожайности используют представленную БД.

Ключевые слова: рис; производственные процессы; информационное обеспечение мониторинга; база данных

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Introduction

Until recently, remote sensing was used to inventory agricultural areas, identify areas of salinization, erosion, waterlogging and entanglement. Recently, there has been a need to forecast crop yields based on remote sensing data [1-4]. This has led to the need to conduct research and establish a relationship between plant productivity and remote sensing data in various soil and climatic conditions [5].

In plants, the production process includes all stages of their development. This includes the formation of shoots, tillering, nutrition, respiration, photosynthetic activity with the formation of metabolites, their transport and distribution among organs and storage, and the growth of fruit-bearing organs [6]. Shoot formation has a great influence on the crop yield. The number of productive shoots per unit area depends not only on the intensity of plant tillering, but also on the sowing qualities of seeds (their growth force), the density of seedlings (seeding rate), and the safety of lateral shoots [5; 7]. The productivity of rice varieties is greatly influenced by the water regime and optimal mineral nutrition. The water regime creates conditions for restorative processes that convert nitrogen from the soil and fertilizers into ammonium, and potassium and phosphorus into more accessible forms that are better absorbed by plants [8; 9].

In a similar way, phosphorus and potassium from mineral fertilizers and from natural soil reserves after restored processes in flooded conditions increase their availability for rice plants. Therefore, to enhance the production process in plants when applying phosphorus and potassium fertilizers, it is necessary to take into account their content in the soil [8].

The physiological state of agricultural crops is assessed not only by the area of their photosynthetic surface and the concentration of chlorophyll in the leaves, but also by the size of the vegetation index, which is an optical-biological characteristic of plants [10-13]. Establishing the mechanism of the relationship between these features will allow us to better study the physiology of growth and the production process of cereal crops. This is possible using not only experimental ground-based data, but also the results of remote sensing of the Earth. According to many scientists, the increase in the productivity of grain crops occurs not due to an increase in the intensity of the photosynthetic apparatus of plants, but due to an improvement in the donor-acceptor relationships of plants, as a result of which the influx of assimilates to the generative organs increases. At the same time, the mass of grain in the panicle and, accordingly, the yield increase [5; 14-17].

The above was confirmed in our works. The productivity of the studied varieties increased as a result of the increased influx of formed metabolites to the panicle, which increased the grain weight in it [18-21]. In addition, for the same reason, the coefficient of economic efficiency of photosynthesis also increased in these highly productive varieties [17; 22; 23]. But these varieties experienced a decrease in the weight of 1000 seeds, since it has a negative relationship with the grain weight from the panicle, plant and unit area of crops, and, consequently, with the yield of these varieties. The conducted research work made it possible to create a number of morphophysiological indicators for a qualitative assessment of the most adaptive and productive rice varieties. They should be used to assess the condition of crops and forecast yields in Kuban. It is combined into a single database (DB) and registered in Rospatent No. 20224624627 [24]. The aim of the study is to identify the relationship between the morphophysiological characteristics of rice crops and their optical characteristics using a database.

Purpose.

To systematize biological characteristics of rice plants with their optical parameters for analysis in a database.

Materials and methods

The experiments were carried out in vegetation micro-checks and field trials (2017-2024). In the first experiment, the following varieties were studied: Rapan (st), Vizit, Flagman (intensive), Stanichny, Sonata, Atlant (extensive) in concrete tanks with an area of 3.6 m^2. Meadow-chernozem soil for them was taken from rice fields. Fertilizers were applied according to the following scheme: 1 - control (without fertilizers); 2 - $N_{12}P_6K_6$ (medium background); 3 - $N_{24}P_{12}K_{12}$ (optimal background); 4 - $N_{36}P_{18}K_{18}$ (high background), g of active substance per 1 m^2 [25]. The plant density in the crop was 300 pcs./m^2. During the vegetation period of plants in all growth phases, their raw and dry biomass, total nitrogen were determined on the UDC 127 device, leaf surface area was measured, and the NDVI vegetation index was measured with a GreenSeeker Handheld Crop Sensor spectrometer [27]. Using the N-tester device, leaf diagnostics were performed to determine the nitrogen content in rice plants. Similar determinations of biological and optical characteristics of rice crops were carried out in a field experiment on the production crops of the “FNC Rice”.

Results

The created database contains a set of information about the biological features and optical characteristics of plants that affect productivity. The determination of the state of rice crops was carried out in the Laboratory of Physiology of the Federal Rice Research Center. The database allows us to identify the relationship between the biological and optical characteristics of rice plants.

Data is entered into the program using five main forms, in which editing and viewing of information is carried out: information on the structure of the crop and its (productivity); optical parameters of the object (optical indicators); initial values of the material being studied (research material); indications of meteorological conditions (climatic data); variety passport (data on the variety), which is accessed through the menu shown in Fig. 1. Fig. 2 shows the logical structure of the database.

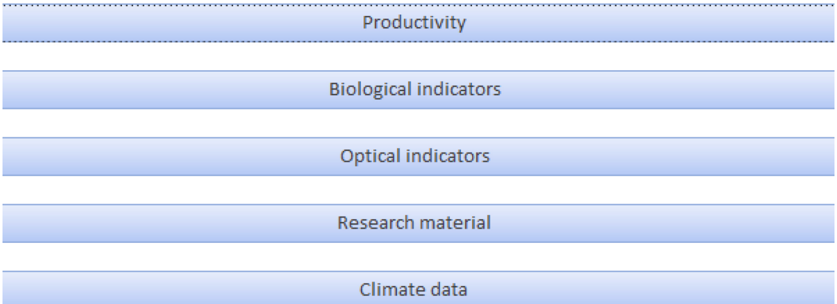


Fig. 1. Start panel for selecting the data entry form

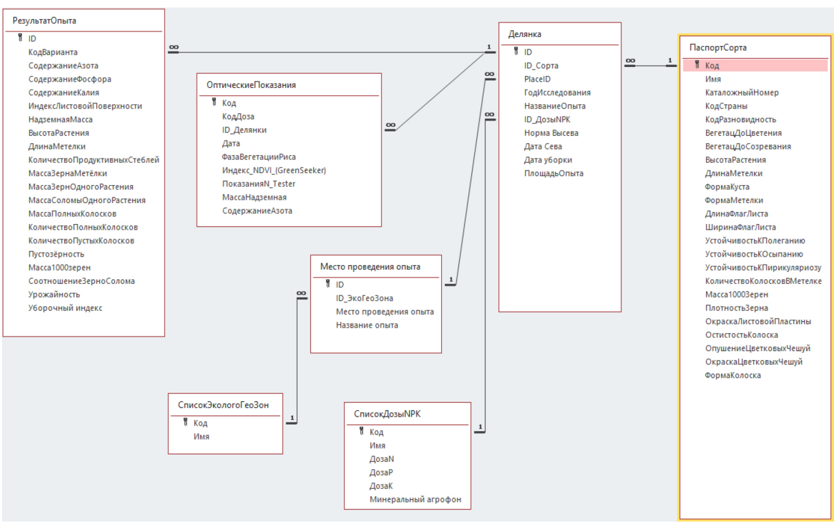
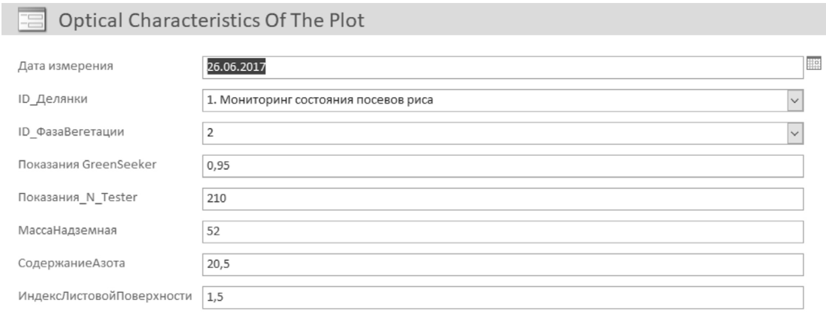


Fig. 2. Logical structure of the database

Fig. 3 shows the optical parameters of plants that are entered into the database. It includes the leaf area index, the above-ground mass of rice plants, the nitrogen content, the NDVI vegetation index and the N-tester values,

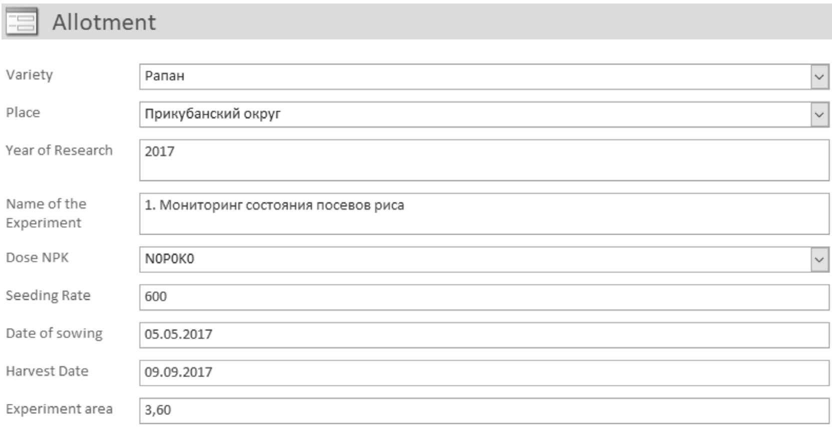

Optical Characteristics Of The Plot

Дата измерения	26.06.2017
ID_Делянки	1. Мониторинг состояния посевов риса
ID_ФазаВегетации	2
Показания GreenSeeker	0,95
Показания_N_Tester	210
МассаНадземная	52
СодержаниеАзота	20,5
ИндексЛистовойПоверхности	1,5

Fig. 3. Optical characteristics of plants

The task of achieving ever-higher levels of rice crop yield determines the optimal supply of nitrogen. In the $N_{24}P_{12}K_{12}$ variant, its concentration corresponds to the optimum [15]. The data are consistent with the readings of the N-tester, which characterizes the color of plant leaves in any phase of vegetation, which are associated with the ILP values and phytomass. Rice plants have different spectral reflectivity, which allows using remote sensing data to assess their condition. Precision agriculture uses indices that express the dynamics of these changes. The NDVI vegetation index we measured is an indicator of the ability of plants to reflect and absorb light waves. Chlorophyll, which is part of plant cells, reflects green waves of the light spectrum. The higher the values of the vegetation index, the higher the amount of green phytomass. NDIVI - analysis is relevant at any phase of plant development, while it is necessary to pay attention to the patterns of its values. At the beginning of the growing season and formation of the stem stand, it increases, and stops during the flowering and grain filling phase. It decreases during the full ripeness phase. In the middle of the growing season, the NDIVI index can be 0.5-0.8, which indicates good crop biomass. In our experiments, the vegetation index values varied from 0.21 to 0.79 depending on the level of mineral nutrition and is closely related to the nitrogen status. Its optimal value is in the range of 0.72-0.78 and corresponds to nitrogen values of 4.06-4.46% in the aboveground mass. These values relate to the beginning of the tillering phase and are used in diagnostics of the nitrogen status of plants.

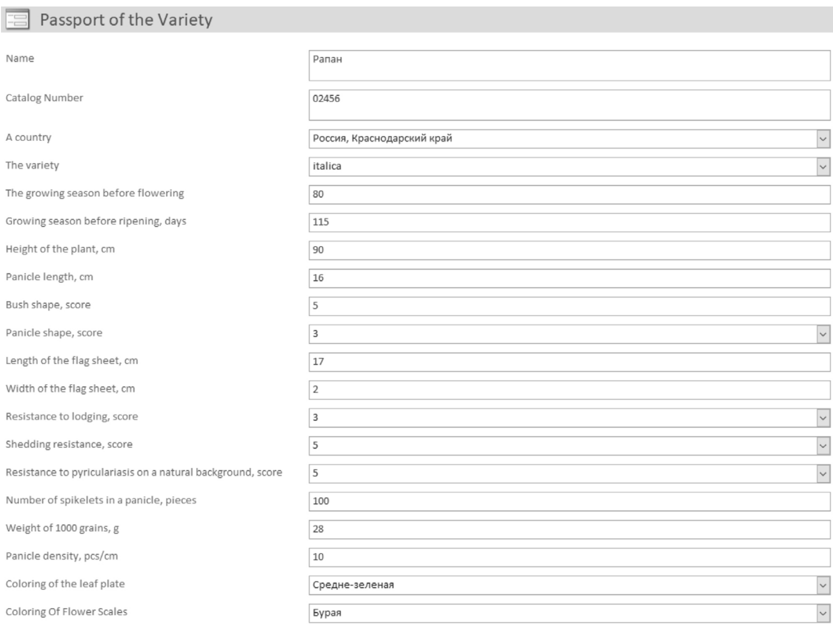
Fig. 4 shows a form about the research object. It contains fields where the main information about the research is entered: the location of the experiment, its name, variety, sowing date, sowing rate, area of the experiment, dose of mineral fertilizers.



Allotment

Variety	Рапан
Place	Прикубанский округ
Year of Research	2017
Name of the Experiment	1. Мониторинг состояния посевов риса
Dose NPK	N0P0K0
Seeding Rate	600
Date of sowing	05.05.2017
Harvest Date	09.09.2017
Experiment area	3,60

Fig. 4. Information about the research material



Passport of the Variety

Name	Рапан
Catalog Number	02456
A country	Россия, Краснодарский край
The variety	italica
The growing season before flowering	80
Growing season before ripening, days	115
Height of the plant, cm	90
Panicle length, cm	16
Bush shape, score	5
Panicle shape, score	3
Length of the flag sheet, cm	17
Width of the flag sheet, cm	2
Resistance to lodging, score	3
Shedding resistance, score	5
Resistance to pyriculariasis on a natural background, score	5
Number of spikelets in a panicle, pieces	100
Weight of 1000 grains, g	28
Panicle density, pcs/cm	10
Coloring of the leaf plate	Средне-зеленая
Coloring Of Flower Scales	Бурая

Fig. 5. Variety passport

Fig. 5 shows the form in which information on the biological characteristics of rice varieties is entered. It is of a reference nature, which allows characterizing the studied varieties by individual characteristics.

The reporting form of the database contains summary information on biological characteristics and results of monitoring the state of rice crops, presented in the form of a table. The report presents data that allow creating a mathematical model of crop productivity and developing an algorithm for providing plants with nitrogen to increase the yield of rice agrophytocenoses (Fig. 6).

Report 1

Variety	Dose NPK	NDVI	N-Tester	Plant weight	Nitrogen	LAI	Productivity	Harvesting Index
Рапан	N0P0K0	0,25	210	52	2,1	1,6	0,559	54,4
Рапан	N12P6K6	0,62	457	168	3,35	1,99	0,747	49,6
Рапан	N24P12K12	0,8	517	207	4,02	2,67	1,25	48,6
Рапан	N36P18K18	0,81	520	297	4,39	3,61	1,256	46
Визит	N0P0K0	0,24	220	58	2	1,48	0,57	52,4
Визит	N12P6K6	0,61	420	198	3,37	2,43	0,752	49,7
Визит	N24P12K12	0,79	513	195	3,88	2,73	0,999	46,3
Визит	N36P18K18	0,81	519	231	4,5	3,32	1,149	42,2
Флагман	N0P0K0	0,23	215	46	2,2	1,75	0,521	52
Флагман	N12P6K6	0,58	469	207	3,13	2,43	0,803	46,4
Флагман	N24P12K12	0,77	505	285	4,26	3,89	1,115	41,1
Флагман	N36P18K18	0,8	516	393	4,41	4,66	1,256	44,1

Note: NDVI, units; N-tester, units; plant weight, g/m^2; nitrogen content, %; LAI, m^2/m^2; yield, kg/m^2; harvesting index, %.

Fig. 6. Rice crop monitoring report

Discussion

The developed database will allow structuring large volumes of information required for analytical processing in research works. The database allows developing algorithms and identifying patterns of regulation of plant nutrition regime. Regulates the formation of productive sprouts and promotes the creation of highly productive agricultural crops. Based on the morphophysiological and optical characteristics of rice crops, based on the presented database, it is possible to determine the nitrogen supply in the tillering phase and develop an effective scheme for its application.

Conclusion

The biological and economic productivity of rice crops is largely determined by the morphophysiological characteristics of plants and is closely related to their optical characteristics formed the basis of the presented database. It is aimed at monitoring the state of rice crops and planning the harvest of future years.

Sponsorship information. The work was carried out within the framework of the activities of the world-class scientific and educational center "Center for Modern Breeding of Agricultural Plants", which carries out research and development in priority areas of scientific and technological development (Agreement No. 075-15-2025-574).

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