// Solar Energy. - Vol. 66. - No. 5. - Aug. 1999. - PP. 349–354. - doi: 10.1016/S0038-092X (99)00032-8.

3. Harmim A., Merzouk M., Boukar M., Amar M. Design and experimental testing of an innovative building-integrated box type solar cooker // Solar Energy. - Vol. 98. - No. PC. - Dec. 2013. - PP. 422–433. - doi: 10.1016/J.SOLENER.2013.09.019.

4. Panwar N.L, Kaushik S.C., Surendra Kothari. State of the art of solar cooking: An overview // Elsevier. - Vol. 16. – 2012. - PP. 3776–3785. - doi: 10.1016/j.rser.2012.03.026.

5. Yettou F., Azoui B., Malek A., Gama A., Panwar N.L. Solar cooker realizations in actual use: An overview // Renewable and Sustainable Energy Reviews. - Vol. 37. - Sep. 2014. - PP. 288–306. - doi: 10.1016/J.RSER.2014.05.018.

6. Kumaresan G., Santosh R., Raju G., Velraj R. Experimental and numerical investigation of solar flat plate cooking unit for domestic applications // Energy. - Vol. 157. - 2018. - PP. 436–447.

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THE CURRENT STATE OF IoT SYSTEMS IN CROP PRODUCTION

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Abstract: *Analyzed the main trends in the development of Internet of Things technologies and Decision Support Systems (DSS) in agriculture for further implementation in science and crop production.*

Keywords: *IoT technology, DSS, agriculture, climate change, crop production*

The main tasks identified for IoT in modern agriculture can be attributed to the problem of implementing climate-optimized agriculture and are usually reduced to solving specific tasks- maintaining a microclimate to create ideal plant growth conditions, improving irrigation and fertilizer practices, monitoring and prevention infections and increased safety of production [1]. The safety of agricultural production can be achieved by using infrared cameras, unmanned aerial vehicles/systems for remote monitoring, optical monitors, infrared and thermal sensors for detecting pests [2].

The classical architecture of measurement networks in the field of agriculture, forestry and ecology based on the Internet of Things technology consists of four basic levels [3]

1. Sensors distributed over the research object, that collect information from the environment

2. Internet of Things gateways and systems-collection from hub devices that collect data directly from sensors and transmit it directly to the Internet.

3. The server layer. Data collected from gateways and hubs is processed, combined into databases, and post-processed for easy storage and transfer to end-user devices.

4. End-user access applications - can be represented by both web and mobile and desktop applications that provide convenient representation and access of end users to processed raw data.

Despite the huge variety of sensors available on the market, any developer faces a choice problem, which is determined by a combination of factors such as cost, accuracy, power consumption, the ability to work at extreme humidity temperatures, withstand freezing, the ability to integrate with existing systems, data transfer formats and API availability [4].

One of the most urgent and widespread tasks assigned to IoT monitoring systems is the management of water resources in agriculture in all their diversity. In the works of Bonfante (2019) [5] shows that efficient use of water is critical for obtaining a yield and for its successful solution, the authors suggest using irrigation consulting services (IAS) and decision support systems (DSS), which are provided by distributed sensor networks based on the Internet of Things technology.

The Intergovernmental Panel on Climate Change predicts that agricultural prices will increase by 1-29% by 2050 [4]. The challenges associated with climate change in agriculture can be partially offset by a shift to producing more products under controlled conditions, which means a further increase in the adoption of IoT technologies [5]. Thus, as of 2021, the spread of greenhouses in the Mediterranean region is actively shifting to areas that are significantly affected by climate change and global warming [5].

Modern publications on IoT technology in crop production most often devoted to its application in precision farming, especially in arid climates, as its main task becomes management or recommendations for irrigation, or on the nuances of commercial applications in the optimization of the microclimate of greenhouses, almost no ideas for the introduction of technology in small farms because of the high cost of technology for small farms

One of the main technological challenges facing the implementation of IoT on a particular farm for precision farming in open ground conditions remains costly of deploying IoT infrastructure [6].

It is important to note that at the moment there are a large number of wireless communication standards actively used in IoT, among the most widely used protocols are Zigbee [7], Bluetooth Low Energy (BLE), Sigfox low-power wide-area network (LPWAN), 6LoWPAN, LoRaWAN, NB-IoT. Each of them has dozens of parameters and it can be very difficult for a non-professional in this field to decision the right choice, since the wrong choice of network type can lead to multi-million losses. For example, the use of NB-IoT requires the deployment of LTE networks, which is beyond the power of even large farms and means that the user must use already deployed networks of mobile operators, and the BLE, and ZigBee protocols provide communication at a distance of no more than 10 meters and are not suitable for use in the fields. In this connection, there is still a discussion in the scientific literature whether the benefits even in the long term exceed the benefits of deploying IoT infrastructure for its implementation. In addition to wireless protocols, which are becoming the de facto standard for outdoor projects, a number of indoor projects are quite feasible using a network of sensors, using a wired connection.

One of the most notable initiatives to increase the implementation of IoT in general and adapt the technology to implementation in small agricultural enterprises is the FIWARE foundation and the Agricolus platform, which is developing on its basis, including the DSS [25]. FIWARE is an open standard platform, owned by the Future Internet Private Public Partnership (FI-PPP) program. This program is aimed at increasing the competitiveness of the European Union in the field of digital technologies, and in particular, at supporting the new European Cloud platform. FIWARE is represented in many industries in Europe, such as healthcare, telecommunications, and more recently, agriculture. A key feature of FIWARE is the open architecture and reference implementation of the service infrastructure, based on common and reusable components available through the API, called Generic Enablers (GE). A sophisticated architecture and open APIs allow you to develop new applications for integrating the IoT sensor system. Examples of such applications may include:

1. Agri-IoT is a project to provide a semantic framework for intelligent agricultural applications based on IoT, with support for real-time analysis of various heterogeneous sensor data streams [6].

2. Cropinfra – is a comprehensive network infrastructure system for crop production that helps farmers increase their work efficiency using the best available technologies [7].

3. SME Widhoc is an application designed to reduce water consumption in irrigation and arid zones in southern Spain.

Decision support systems in connection with the transition to Agriculture 4.0 are subject to the following set of requirements [4]:

1. Increased productivity: the simultaneous increase in population growth and quality of life leads to an increase in demand for agricultural products, especially livestock products.

2. Reasonable resource allocation: improper use of agricultural practices leads to degradation of agricultural land, excessive use of water resources and excessive consumption of energy and resources for inefficient actions.

3. Climate change adaptation: Agricultural producers are particularly vulnerable to the effects of climate change and contribute significantly to greenhouse gas emissions, which means not only adapting to a changing climate, but also switching to low -carbon farming.

The most complexe systems, that include a sufficient number of sensors can apply self-learning algorithms when machine learning algorithms draw conclusions based on a large amount of accumulated empirical data [7]. A large number of nuances of applying the Big Data approach in precision farming are discussed in detail in this paper Bhata et al. Big data requires extraordinary techniques to efficiently process vast amounts of data with infinite execution time. The classical statistical approach based on hypotheses and machine learning are currently the two main paradigms in research and data.

Agriculture data are better analyzed by statistical methods, since we already have repeatedly verified assumptions about the relationship of individual variables, while machine learning methods do not take into account any pre-established relationships between variables and proceed from the data itself to search for potential relationships between variables. Large data obtained from farms exhibit spatiotemporal autocorrelation, have heterogeneity and high dimensionality, are non-stationary, and, as a rule, must be processed in a constant way. In addition, taking into account the high computational capacity of machine learning methods, the use of more classical methods, such as the support vector method, can reduce the calculation time and costs of their implementation.

References

1. Ratnaparkhi, S., Khan, S., Arya, C., Khapre, S., Singh, P., Diwakar, M., & Shankar, A. Smart agriculture sensors in IOT: A review // Materials Today: Proceedings. – 2020. – (https://doi.org/10.1016/j.matpr.2020.11.138)

2. Conover, M. R., Butikofer, E., & Decker, D. J. (2018). Wildlife damage to crops: Perceptions of agricultural and wildlife leaders in 1957, 1987, and 2017 // *Wildlife Society Bulletin* - *42*(4). – P. 551–558. – (https://doi.org/10.1002/wsb.930)

3. Lova Raju, K., & Vijayaraghavan, V. (2020). IoT Technologies in Agricultural Environment: A Survey // Wireless Personal Communications. – 2020. – Vol. 113. - Issue 4. – (https://doi.org/10.1007/s11277-020-07334-x)

4. Mtz-Enriquez, A. I., Padmasree, K. P., Oliva, A. I., Gomez-Solis, C., Coutino-Gonzalez, E., Garcia, C. R., Esparza, D., & Oliva, J. Tailoring the detection sensitivity of graphene based flexible smoke sensors by decorating with ceramic microparticles // Sensors and Actuators, B: Chemical. – 2020. – (https://doi.org/10.1016/j.snb.2019.127466)

5. A. Bonfante, E. Monaco, P. Manna, R. De Mascellis, A. Basile, M. Buonanno, G. Cantilena, A. Esposito, A. Tedeschi, C. De Michele, O. Belfiore, I. Catapano, G. Ludeno, K. Salinas, A. Brook, LCIS DSS—An irrigation supporting system for water use efficiency improvement in precision agriculture: A maize case study // Agricultural Systems. – 2019. – Volume 176. – (https://doi.org/10.1016/j.agsy.2019.102646)

6. Mbow, C., C. Rosenzweig, L.G. Barioni, T.G. Benton, M. Herrero, M. Krishnapillai, E. Liwenga, P. Pradhan, M.G. Rivera-Ferre, T. Sapkota, F.N. Tubiello, Y. Xu. Food Security // Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems. – 2019. [P.R. Shukla, J. Skea, E. Calvo Buendia, V. Masson-Delmotte, H.-O. Pörtner, D.C. Roberts, P. Zhai, R. Slade, S. Connors, R. van Diemen, M. Ferrat, E. Haughey, S. Luz, S. Neogi, M. Pathak, J. Petzold, J. Portugal Pereira, P. Vyas, E. Huntley, K. Kissick, M. Belkacemi, J. Malley, (eds.)].

7. Kavga, A., Thomopoulos, V., Barouchas, P., Stefanakis, N., & Liopa-Tsakalidi, A. Research on innovative training on smart greenhouse technologies for

economic and environmental sustainability // Sustainability. – 2021. – 13(19). – (https://doi.org/10.3390/su131910536)

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DEVELOPMENT OF ALLOPLASMIC MALE-STERILE LINES OF CARROT BY PROTOPLAST FUSION

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Abstract: *The main method used in carrot breeding is F1-hybrid based on the application of cytoplasmic male sterility CMS. Cytoplasmic male sterility (CMS) is commercially utilized for hybrid seed production. Alloplasmics are created when the cytoplasm of one species is replaced by that of another species through backcrossing or bio techniques such as somatic hybridization.* [4]

Keywords: *Daucus carota, protoplast fusion, hybrid, cytoplasmic male sterility CMS, Aloplasmics*

Carrot is among the top-ten most economically important vegetable crops all over the world, in terms of both areas of production and market value.

Cytoplasmic male sterility (CMS) in carrot takes two basic forms: “brown anther” and “petaloid”. The plant trait cytoplasmic male sterility (CMS) is determined by the mitochondrial genome and is associated with a pollen sterility phenotype that can be suppressed or counteracted by nuclear genes known as restorer-of-fertility genes. [1]

CMS, caused by mutations in the mitochondrial genome, is found in higher plants and increases heterosis and improve genetic resources. Mitochondrial markers can be used to differentiate between the various types of CMS sources. Molecular markers that can predict the CMS status at an early developmental stage will be valuable tools in carrot breeding and seed production programs, as well as for basic studies of male sterility [2].

In carrot, F1 hybrids are valuable due to uniform maturity, high early and total yield, better curd quality with respect to curd compression and color as well as for resistance to insect pests, diseases and adverse weather conditions an efficient, reliable and established method of F1 seed production without infectivity by self-fertilized seeds from each parent is vital. Manual emasculation and pollination method in carrot is not useful at commercial level due to incompatible flower size and structure. So far hybrids in carrot have been developed using self-incompatibility (SI) system. In recent years, important heterosis has also been reported in hybrids developed using CMS system for yield, yield linked and quality traits [3].

Preparation of plant material: