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11th International Conference on Renewable Electrical Power Sources

PROCEEDINGS

Editor Dr Milica Vlahović

Belgrade, November 02-03, 2023

P R O C E E D I N G S

11th International Conference on Renewable Electrical Power Sources

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FOREWORD

The conditions created by the development of technologies in which modern man lives have led to a complex and paradoxical effect: that by removing obstacles on the way to a more comfortable, simpler, faster and more efficient life and way of working, man also generates numerous misfortunes, attracting dark clouds of threats to the survival of the planet and humanity. The question that concerns and affects all of us - all people, all living beings, systems in which life takes place, large and small, strong and weak - boils down to the problem of the negative impact of man on the environment; this issue invites us to an urgent solution by looking at the causes, proposing solutions, evaluating them, changing approaches and ways of thinking, as well as drawing correct conclusions. Simply put, by adapting nature to one's own needs, man threatens and damages it. That is why, with the joint efforts of all of us, individuals, organizations and states, it is necessary to take all possible measures to immediately prevent the negative effects that are ahead of us.

The importance of renewable sources of electricity, which this international conference focuses on, is noticeable from two angles: the first - it is certain that fossil fuels as a resource will disappear and it is necessary to find alternative sources, the second - the use of renewable energy sources by its essence implies "clean" technology that significantly contributes to reducing CO_2 *emissions and thus mitigating climate change and reducing pollution, while encouraging social and economic development in all spheres of life.*

The 11th International Conference on Renewable Electrical Power Sources is organized by the Society for Renewable Electrical Power Sources (DOIEE) at SMEITS, with co-organizers: The Institute of Architecture and Urban & Spatial Planning of Serbia (IAUS) and the Chamber of Commerce and Industry of Serbia, with the support of the Ministry of Science, Technological Development and Innovation of the Republic of Serbia.

The registered participants designed their papers according to the given conference topics:
- Energy sources and energy storage;
- Energy efficiency in the context of use of renewable energy sources (RES);
- Environment, sustainability and policy;
- Applications and services.

Eminent authors - scientists, teachers, experts in this field from fifteen different countries: Algeria, Belgium, Bosnia and Herzegovina, China, Croatia, Greece, Hungary, India, Portugal, Saudi Arabia, Serbia, Slovenia, Spain, the United Arab Emirates, and Ukraine, contributed to the conference through sixty-nine papers that were reviewed by the Scientific Committee of the Conference, and after the review process were accepted for presentation at the conference and for publication in the proceedings.

At the end of this short message and at the beginning of the proceedings I believe that it can be proudly said that scientists, researchers, policy makers and industry experts gathered in one place, in order to exchange experiences and knowledge with the aim of promoting scientific and professional ideas and results of research, technology improvement for the use of RES, promoting the rational use of electricity, affirming and proposing inventive solutions in the field of sustainable sources of electricity.

Belgrade, *Milica Vlahović*
November 2023

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TEHNOLOGIJE ZA PRAĆENJE POLJOPRIVREDNIH ZASADA POMOĆU BESPILOTNIH LETILICA

TECHNOLOGIES FOR MONITORING AGRICULTURAL CROPS USING UAV

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Apstrakt

Povećana potreba za poljoprivrednim proizvodima neprestano utiče na fundamentalna i inovativna istraživanja, kao i predstavljanje novih rešenja u energetskoj uštedi izvora energije. Osim energetskih izvora koji se dobijaju iz svetlosti, vetra i biomase, učešće tehnologije nadgledanja sa distance može biti važan za agrarni asortiman uređenog poljoprivrednog gazdinstva. U ovom radu se predlažu određene ideje o primeni bespilotnih letilica (UAV) ili dronova, koje sa distance u različitim vremenskim prilikama, omogućavaju operatorima da racionalno koriste agrarne resurse i doprinesu efikasnom upravljanju od sadnje, preko tretiranja đubrivima, vodom do određivanja perioda prihvatanja plodova.

Ključne reči: *tehnologija; poljoprivreda; dronovi; obnovljivi izvori energije*

Abstract

The increased need for agricultural products constantly affects fundamental and innovative research, as well as the presentation of new solutions in energy saving energy sources. In addition to the energy sources obtained from light, wind and biomass, the participation of remote monitoring technology can be important for the agricultural range of an organized agricultural farm. This paper proposes certain ideas on the application of Unmanned Aerial Vehicles (UAV) that, from a distance in different weather conditions, enable operators to rationally use agricultural resources and contribute to efficient management from planting, through treatment with fertilizers, water to determining the period of acceptance of fruits.

Key words: *technologies; agriculture; Unmanned Aerial Vehicles; renewable energy sources*

1 Introduction

Agriculture in the 21st century is very different from what it was until 50 years ago, and apart from agroengineering with advanced machines, the role of biodiversity has increased under the influence of bioengineering of different strains of crops, modifications that do not affect the genetic structure, but only the resistance to insects . and diseases. The Unmanned Aerial Systems Association International (2016) reported annual growth of 85-92% each year mainly in the growing agricultural market [1].

DRONE (**D**ynamic **R**emotely **O**perated **N**avigation **E**quipment), also known as UAV or Remotely Piloted Aircraft (RPA), is an aircraft that can go automatically, with GPS control, without a pilot [2,3].

With artificial intelligence (AI), drones will rank as the third revolution in military technology, after the invention of gunpowder and nuclear weapons. The first unmanned aerial vehicles were balloons with attached bombs, which were used during the Austrian siege of Venice in 1849. The first experiments with radio-controlled aircraft were carried out during World War I in the USA and the UK. In World War II, Germany built the notorious V-1 jet-powered aircraft, while American drones were used in Vietnam, and then in Afghanistan, Iraq and the former FRY. Military drones can be very tiny for peeking around corners, but also large jet-powered ones that serve as reconnaissance aircraft, for tactical support or direct attack.

The special importance of agrarian changes is driven by the greater use of technological solutions in the field of electronics, informatics, robotics, and mechatronics. The year of 2015 was declared as the year of increased use of different types of drones in all areas, especially in agriculture and forestry with 75% use [4].

Some of the applications applied in agriculture, based on the processing of images obtained using drones, include: application for monitoring and mapping the condition of the soil, classification of plants on production areas, monitoring the occurrence of diseases and pests, stress detection in plants caused by excess water, detection of water deficiency in soil, analysis of plant leaflets on pesticide content, assessment of the state of biomass of plants, as well as monitoring of the number of weed plants on production areas [5].

The examination of agricultural crops is not conditioned only by investment in seeds, irrigation and harvesting of fruits. The major role is played by the research of energy inputs, consumption of available energy sources, renewable energy sources. First of all, the focus is on the technological development and elements of the improvement of drones.

1.1 Regulation of the use of unmanned aerial vehicles

Improper use of drones can lead to safety risks such as endangering life, health and property of people on the ground, as well as endangering air traffic. In the Republic of Serbia, the use of drones is regulated by the Law on Aviation [6], as well as the Rulebook on Unmanned Aircraft [7], which entered into force in February 2020. If unmanned aircraft were to fly over the state border contrary to the rules, this would constitute a violation airspace of the Republic of Serbia. According to the Rulebook on Unmanned Aircraft, drones can fly into Serbian airspace with a special permit issued by the Directorate of Civil Aviation, with the consent of the Ministry of Defense.

It is expected that the European Union will promote the development of urban mobility through the operation of unmanned aircraft by 2050. This will be harmonized with the regulations through the EU, and then into the legal system of Serbia. In Serbia, according to the regulations of the Directorate of Civil Aviation [8], the use of unmanned aircraft is prohibited less than 500 meters from the National Assembly, government and presidency buildings, republican, provincial and local self-government bodies, military facilities, courts, public prosecutor's offices and foreign diplomatic missions. The ban also applies in the vicinity of important infrastructure facilities in the field of energy, traffic, telecommunications and water supply, unless the flight has been approved by the owner or user of the facility.

For flying in the vicinity of the airport and at heights higher than 100 meters above ground level, in addition to obtaining the approval of the Directorate of Civil Aviation, it is necessary to make an airspace allocation at Air Traffic Control. Any person who has received a permit from the Directorate of Civil Aviation has the right to operate a drone. In order to obtain a permit that lasts indefinitely, it is necessary to undergo a medical examination and to complete a knowledge test. For agricultural and scientific research purposes, the use of drones belongs to general air traffic, which is regulated by the International Civil Aviation Organization (ICAO).

Unmanned aircraft are defined under the Air Traffic Act as aircraft that do not have a crew and are controlled remotely. According to the Regulation on unmanned aircraft, the aircraft are divided depending on the weight into four groups, which are shown in Figure 1.

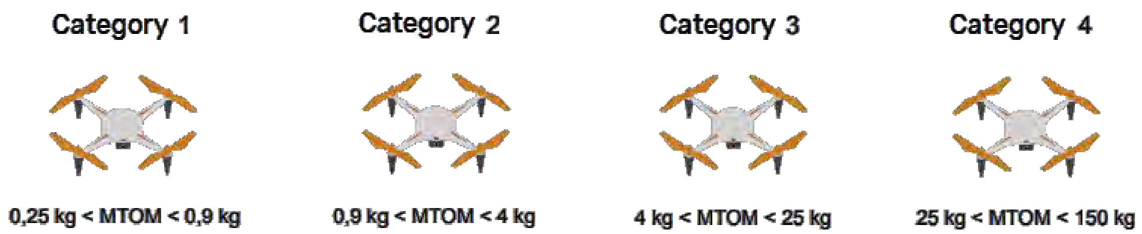

Figure 1. Categories of drones [8]

Drones weighing more than four kilograms must be registered in the Aircraft Registry, as well as aircraft of less than that weight that fly near airports, people and in areas where there is limited flight time.

2 Development and construction of drones

Drones originated in a research center for military purposes, but today its theoretical nature of use has increased so much that it is practically unlimited. With the help of special sensors for recognizing people, reacting to objects in front and a greater level of flight autonomy, the new drones could be at the center of a social, technical and scientific revolution. With optical sensors and a camera, it is possible to create a map of the environment and thus prevent collisions and damage to drones.

In 2015, the terms "fourth agricultural revolution" [9] or "agriculture 4.0" (Carl-Albrecht Bartmer, speech at Agritechnica) were proposed. These terms referred to the impact of sensors, satellites, digital technology, and robotics, not least in terms of paving the way for precision farming [10]. One part of this revolution is unmanned aircraft vehicles (UAV) or, when including the whole system, unmanned aircraft systems (UAS); and remotely piloted aircraft (systems) as RPAS from distant pilot active; and aerial robotics or airborne robotics.

The main goal of the aerodynamic design and optimization of the aircraft is to ensure maximum aerodynamic efficiency, the ability to successfully perform assigned tasks and safety. The aircraft's mission is divided into five flight phases (vertical take-off, transition, cruise and maneuvers, transition period for landing and landing). The control depends on the quality of the sensors used by the autopilot, calibration factors, propulsion. Also on the aerodynamics in terms of the geometric and lift characteristics of the aircraft, which determine the speed stall. The technology in drones enables the collection of accurate information, which is processed by software and algorithmic delivered in an easy-to-read format.

2.1 UAV elements and types

The most common form of drones is a four-armed aircraft with a motor on all four wheels. Propeller engines are placed in the same bay and are oriented vertically. As a constructed quad copter, the problems of coordinated motor control were not easily solved. With the development of micro controllers and efficiency increases, the areas of application are expanded with more sensors.

Drones, depending on their complexity, may have all or some of the following elements: 1. drone body (frame), 2. motors, 3. propellers - propellers and guards, 4. motor controllers, 5. distribution board for power supply, 6. flight controller, 7. batteries, 8. bluetooth receiver, 9. camera, 10. video transmitter, 11. sensors (positioning system, navigation, accelerometer, etc.), 12. on/off button, 13. solar cells, 14. Antennae.

The control unit uses sensors such as magnetometer, accelerometer, gyroscope for orientation in space. In order for an UAV to generate the thrust necessary for entry and movement, it must have rotors to move in all directions and to maintain system stability. A real or virtual pilot must follow the drone's surroundings, which he achieves with a camera. Advanced batteries should provide enough power to start, accelerate, take off and long-term flight of the drone. Complete independence of the drone is installation of solar cells on the top of the drone to accumulate energy in the batteries.

Important parameters for drone design are wingspan, drone weight, wing load, range, maximum flight height, speed, endurance, types of drive motors, production costs and based on that they can be selected for agricultural applications.

Types of drones [11] can be:

1. UAV type drones are different from other small unmanned aerial vehicles, because they have special materials that are used due to their complexity and purpose, as well as the way they land and take off from and on surfaces.
2. A μUAV (micro UAV) drone is an unmanned aerial vehicle that can be carried and launched by a single operator.

3. The MAV type of unmanned aerial vehicles has a length of up to 100 cm and is lighter than 2 kilograms.
4. NAV type drones are extremely small and light, with a wing length of up to 15 cm and a weight of up to 50 grams. They have a flight range of up to 1 kilometer with the highest point of flight about 100 meters.
5. The PAV type of drone is a tiny insect-shaped aircraft with mini wings and is called a pico aircraft.

3 Application possibilities and advantages of using drones

Unmanned aerial vehicles have unlimited possibilities of application regardless of the type of payload, industry or position of work. With computer tracking and data collection, there is the possibility of autonomous flight at a lower altitude, so that it is controlled according to a predefined path or remotely in relation to changes.

The possible applications of drone technology [1] are listed below:

1. Efficient water management,
2. Assessment of temporal land use land cover changes,
3. Crop monitoring and diagnosis of abiotic and biotic stresses,
4. Judicious and precise application of agro-chemicals,
5. Crop and weed species distribution mapping,
6. Monitoring of crop growth and development,
7. Geo-fencing with thermal cameras mounted for detecting animals,
8. Livestock management with detecting a sick animal and take action,
9. Fisheries management for improving resource monitoring,
10. Agro-forestry management, with predictive planning and analysis,
11. Horticulture and plantation crop management with impact of weather conditions,
12. Water body and makhana surveillance.

In sparsely populated places that are inaccessible, drones will deliver mail, goods, damage assessment in affected areas will be accelerated. The great advantage of drones is that food, medicine or fresh flowers can be delivered instantly. That means a larger profitability of drones in special and urgent needs, but also for monitoring construction sites or checking the stability of bridges.

Drones for observing terrain that have been cut off by floods, landslides, and fires must be resistant to strong winds and waterproof. In the case of nuclear pollution and the isolation of the population, it is possible to deliver aid packages or notifications by drones.

The negative sides of drones are that they can crash in populated areas and cause a lot of damage, and also concerns about the privacy of the population and spying, because the aircraft are equipped with cameras. It is also considered that in urban areas the infrastructure of traffic and distribution of goods and mail has already been developed, so the use of drones is unnecessary and burdensome. In populated areas, delivery is more efficient with trucks carrying more goods, while autonomous vehicles are expected to be used soon, reducing the number of workers. The need for learning to drive cars is also decreasing, and the need for drone control training is increasing.

4 Drones as a technological revolution in agriculture

Adaptation to environmental conditions in agriculture can lead to differences in the success of agricultural activity, so that increasing yields, reducing costs, and saving time are achieved with new technologies. It is very difficult or impossible to influence the weather conditions, temperatures, air humidity, soil conditions, hail, rains, droughts or floods. Using the technology to monitor and control the events on the plantations there are spreading a field of adoption drones. It is very important for the farmer to be able to adapt to external factors and receive information about crop rotation, ripening, moisture level of the fruit or damage.

After the construction industry for mapping of plots and the monitoring of construction works, the agriculture ranks second in the adoption of unmanned aerial vehicles. Agricultural production with drone technology will ensure large-scale production of crops, treatment, irrigation, picking, spraying, painting, pruning, and leading livestock to pasture, herding livestock, all with timely decision-making, precision, economy and efficiency.

The use of drones in agriculture facilitates work in the field, processing data and responding to crisis situations. None of this can be done without a high-quality Internet connection that will transmit data without delay and with the desired image quality. The generation of mobile technology that implies high speeds of 5G technology. It can meet the huge growth in demand for data download and upload, for remote management, suitable speed and stability. The 5G network can achieve high-quality video data collection and fast transmission to users who are far from large estates and farms. It is possible with the automatic transmission of HD videos, images and audio recordings to identify weeds in the field, pests or theft. Smart technologies in agriculture will attract new producers, who will not direct spray herbicides.

4.1 Energy sources for drones

There are four sources of energy for drones: traditional jet fuel, batteries, fuel cells and solar energy. Jet fuel (kerosene) is primarily used for large fixed-wing drones. Battery-powered drones have a shorter flight time and range, but are practical because of the battery and are often used for recreation. A fuel cell is an electromechanical device that converts the chemical energy of fuel into electrical energy, without conversion into thermal and mechanical energy. The advantage of using cells is that drones can fly longer compared to batteries. Drones with solar cells (Figure 4) are rare, due to low efficiency, and the cells are suitable for multirotor drones.

Figure 2. Drone with solar panel

4.2 Precision agriculture

Precision agriculture (or farming) became the foremost application area for unmanned aircrafts in agriculture [12]. This concept is action and timing adjust to different spots in each field, since the fields are heterogenous regarding many aspects. Field maps containing different information are therefore central. It is very important as information for variable rate technology, which enables machines to act upon detailed field segment information. Precision field data can be collected by use of sensors mounted on a tractor or other ground vehicle or by handheld instruments. UAS became an efficient new method for gathering data, as it is cheap, reliable, and avoids negative soil compaction.

In precision agriculture, the core application is to collect, process, and use data about the fields. In Fig. 2, the symbol (a) represents a sensor kit with RGB camera for a multispectral and a light sensor, LIDAR (laser), thermal infrared and hyper spectral sensors. A gimbal with gyro for stabilization (b) is used for sharper images. The aircraft (c) can be fixed wing or a helicopter and the system includes automatic flight control and planning software, computer GPS location memory. Precision maps (d) are at the heart of the system, and advanced farmers also use big data processing services (e), which combine many data sources and use data algorithms and geostatistics tools.

The farm's decision maker, with or without agronomic advisers (f), both analyze and prescribe actions, partly by help of mobile devices. One action tool is prescription files to machines (g) that can receive and respond to these files. The farmer sometimes also integrate data from satellites, weather stations, soil sensors, or other sources (h) and these data may feed the big data processing.

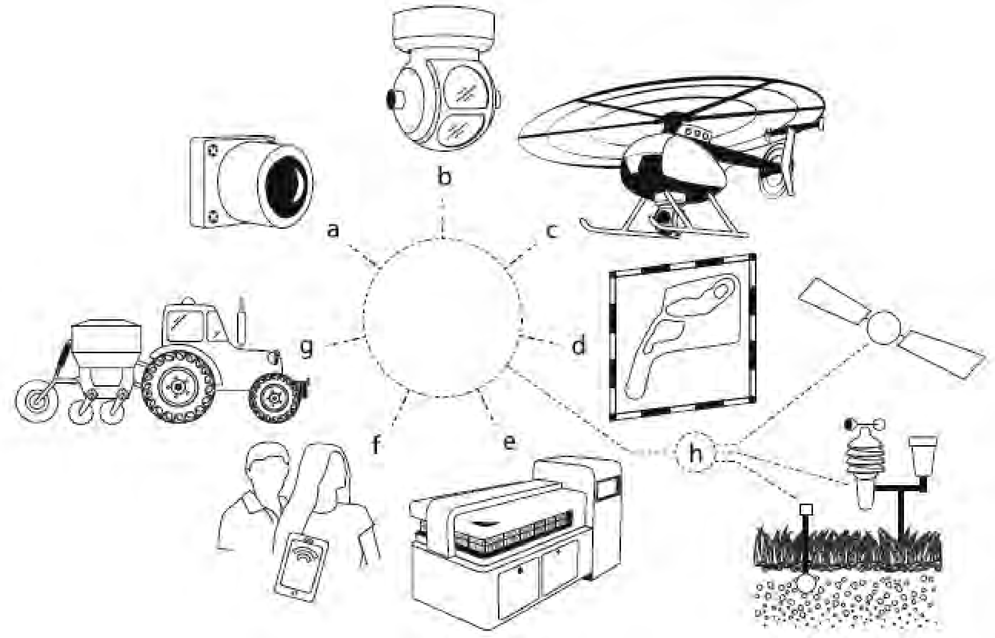

Fig. 2 UAS and related resources for high-tech precision agriculture [13]

Precision agriculture helps protect turf and molehills from harvesters, predicts impending drought at an early stage, and maps molehills as rough terrain to draw conclusions about potential harvest losses.

Internet technologies helps agriculture in getting bigger and integrated status of drones. The content of dry matter in plants is monitored by satellite. If corn is harvested when the dry matter content is below 30%, then there will be too little starch, and more than 35% would lead to higher storage losses. This means that with the footage we receive from a satellite or with the help of a drone, it can be adjusted so that 30 to 35 percent of corn will be harvested.

4.3 Data collection for agricultural purposes

In the case of large agricultural areas, it becomes impossible to monitor the state of crops. Than drones are used to map and monitor ripening with multispectral cameras. On that way farmers can take measures to revitalize plants in real time. By receiving images, farmers can quickly establish that there is a disease or weak protection of the tree due to drought, so that they can react immediately.

The prerequisites for using drones in agriculture are:

- choose the purpose of using the drone (is it monitoring crops, is it planting...),
- select processes that will benefit greatly from the use of drones,
- search for the type of drone for use in a given area,
- study the instructions for working with the drone, so as not to bear the responsibility,
- selection of additional hardware (multispectral camera for crop monitoring or sensors for soil condition assessment)

- selection of software (for navigation and management, for processing data and images, for mapping, etc.),

- decision on the optimal type of image processing

- the latest generation of mobile technology for internet connection transmission.

In the monitoring of agricultural crops, small aircraft as agro-drones are used to record the condition of agricultural crops. To them help several types of cameras in different wavelengths of the solar spectrum, which are saved as photographs. The photo is analyzed and if it is clearly green then it is a good crop. If the color of the edge is red then the leaf is damaged. If the color is brown - then the humidity is reduced.

The use of drones is different in the monitoring of agricultural crops [14], from:

• Growth, development and health of crops (phenophases and stages of development), • Crop feeding needs (time, place and spatial arrangement), • Appearance of diseases, plant pests and weeds,

• Determining the appearance of microdepressions after tillage and soil preparation, water retention, drainage conditions, irrigation needs,

• Density, composition, height, estimation of biomass and yield of agricultural crops, • Determining the right time to harvest based on crop condition.

Data collection consists of the following stages:

1. Marking the surveillance area and uploading GPS information,
2. The drone performs a flight pattern according to predetermined parameters and collects the necessary data.
3. The drone sends the data it recorded for processing,
4. The drone sends timely information in a readable format to the farmer.

It is very important to follow the general instructions, but also to know the rules of work in agriculture. In terms of technological solutions for the introduction of drones, it is known that the maximum payload of UAVs in agriculture is up to 22 kilograms, with a spraying width of up to 5 meters and for treating an area of up to 10 hectares. When spraying with a drone, it is possible to increase the use of pesticides, to control the spraying even at high temperatures outdoors, to effectively treat areas under vegetable pests and other diseases. Very important is the method of dosing, spraying and prevention in the field. There are a standards for appropriate time when it is necessary to spray, and the need for workers is reduced in times of high UV radiation or heat, and in addition, the safety of vegetables or fruits is guaranteed.

In Serbia it is manual use of technologies, control systems on self-propelled and attached machines. With the use of drones in agriculture, the application of solar energy as a power source can be expected that solar cells will be integrated into the drone. After that it would be a standard for longer supply and autonomous operation of unmanned aerial vehicles. Solar energy can drive pumps and use sensors for precise irrigation.

5 Conclusion

The need for food is one of the basic necessities of life, but in the absence of it, in scientific circles, several methods have been used to provide healthy, fresh, long-lasting and timely raw materials. One of the solutions to this problem is agricultural technology, which can not only maintain the quality of planting and harvesting, but can also serve, inform, monitor and supply agricultural goods indoors or in the field. Drones can be controlled remotely using consoles or mobile phones and digital devices. Most often, the management of drones is regulated by laws, and the duration of the flight can be from half an hour to several hours.

The combination of technical innovations, which include the mechanical principle of flight with software for determining GPS coordinates and creating 3D models of individual plants, represent applied science in the field. It is very rewarding to use drones in the research process of marketing new plant hybrids that will be resistant to diseases, droughts or floods. Drones will speeds up the time from research, through improvement to the introduction of hybrids to the market. By introducing phenotyping as a selection process for varieties that are compatible with exogenous factors.

Agro drones can help a lot because they have digital sensors to diagnose fungal infections or low chlorophyll content.

Certain adjustments need to be made in education, training and defining safety rules when introducing drones for mass use. What is found in legal practice are the obligations of users that drones must be safe for other people, objects or vehicles, which is regulated by laws and especially for special purposes such as military needs, spraying against pests or patrolling in closed or open space.

6 References

[1] Upadhyaya Ashutosh, Pawan Jeet, Prem Kumar Sundaram, Anil Kumar Singh, Kirti Saurabh, Manmohan Deo, Efficacy of Drone Technology in Agriculture: A review. Journal of AgriSearch, 9 (3): 189-195, https://doi.org/10.21921/jas.v9i03.11000

[2] Rani A., Chaudhary A., Sinha N., Mohanty M. and Chaudhary R. 2019. Drone: The green technology for future agriculture. Harit Dhara 2(1): 3-6.

[3] Verma A., Singh M., Parmar R.P. and Bhullar K.S.. 2022. Feasibility study on hexacopter UAV based sprayer for application of environment-friendly biopesticide in guava orchard. Journal of Environmental Biology 43(1): 97-104.

[4] Watts A.C., V.G. Ambrosia, E.A. Hinkley, Unmanned aircraft systems in remote sensing and scientific research: classification and considerations of use, Remote Sens. 4 (6) (2012) pp.1671-1692.

[5] Lan, Y., Huang, Y., Martin, D. E., & Hoffmann, W. C. (2009). Development of an airborne remote sensing system for crop pest management: System integration and verification. Transactions of the ASABE, 25, 607-615.

[6] Zakon o vazdušnom saobraćaju, sajt https://www.paragraf.rs/propisi/zakon-o-vazdusnom-saobracaju-republike-srbije.html

[7] Pravilnik o bespilotnim vazduhoplovima, sajt https://www.pravno-informacioni-sistem.rs/SlGlasnikPortal/eli/rep/sgrs/drugidrzavniorganiorganizacije/pravilnik/2020/1/2/reg

[8] Sajt Direktorat civilnog vazduhoplovstva Srbije, http://www.cad.gov.rs

[9] Lejon, E., & Frankelius, P. (2015). Sweden innovation power—Agritechnica 2015. Jo¨nko¨ping: Elmia.

[10]Mulla, D. J. (2013). Twenty five years of remote sensing in precision agriculture: Key advances and remaining knowledge gaps. Biosystems Engineering, 114, 358–371.

[11]Oljača V. M., Pajić M., Gligorević K., Dražić M, Zlatanović I., Dimitrijević A., Miodragović M., Mileusnić Z., Radojević R., Živković M., Petrović D., Radivojević D., Urošević M., Topisirović T., Radičević B., Ećim O., Balać N., Dizajn, klasifikacija, perspektiva i moguća aplikacija dronova u poljoprivredi Srbije, Agricultural Engineering 43, No.4. 2018, pp.29-56

[12]Rokhmana, C. A. (2015). The potential of UAV-based remote sensing for supporting precision agriculture in Indonesia. Procedia Environmental Science, 24, 245–253.

[13]Per Frankelius, Charlotte Norrman, Knut Johansen. Agricultural Innovation and the Role of Institutions: Lessons from the Game of Drones. J Agric Environ Ethics (2019) 32:681–707, https://doi.org/10.1007/s10806-017-9703-6

[14]Oljača V. Mićo, Gligorević K., Pajić M., Zlatanović I., Dražić M., Radojičić D. Marković Dr, Simonović V., Marković I., Đokić M., Dimitrovski Z. (2016). Primena drona u poljoprivredi. Zbornik radova DPT-2016. Beograd. str. 1-10.