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THE USE OF DRONES IN AGRICULTURE: A LITERATURE REVIEW BETWEEN 2012 AND 2022

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Abstract: With the development of the *Global Positioning System* (GPS) in agriculture, decisions regarding issues involving planting started to have a greater contribution of technology. Currently, the so-called Agriculture 4.0 is widespread, incorporating connectivity and automation, using machines, vehicles, drones, robots and animals with sensors. The general objective of this article was to analyze the bibliographic production centered on the use of drones in agriculture in Brazil in the period between 2012 and 2022. researches. To fulfill the research objectives, the Systematic Bibliographic Review (RBS) model was used. Through the model, 15 articles were found that deal with the use of drones in Brazil between the years 2012 and 2022. The results show the convergence between the selected articles with regard to the contribution of drones in monitoring the property, in terms of refers to the control of pests, diseases, invasive plants, water deficit, nutritional deficit and the use of pesticides and fertilizers in exact quantity and place on the property. The studies addressed in this article suggest the need for more information to producers regarding the applicability of drones on the farm.
Keywords: Drones; Agribusiness; Precision agriculture; Agricultural Aviation; RBS.

INTRODUCTION

Between the 1970s and 1990s, Brazilian agribusiness was greatly encouraged by the development of science and technology, enabling the use of regions previously considered unsuitable for farming. Brazil came to be seen as a protagonist that dominated tropical agriculture, thus increasing its competitiveness in the international market (FERREIRA et al., 2022).

Estimates show that the Brazilian population may grow 40% over the next ten years and the world population must reach 9 billion inhabitants. This fact will require that agricultural production increase its productivity by 60% by 2050. In view of this, Brazil has a great responsibility to become, in the next 10 to 20 years, one of the main food producers in the world (ARTIOLI; BELONI, 2016).

Agribusiness in Brazil has been introducing technical progress in the agricultural sector over the last few decades, with emphasis on the association of chemical inputs (fertilizers, nutrients and pesticides). Brazil has great prospects for agribusiness, due to its characteristics and heterogeneity, especially in relation to soil and climate, so that such characteristics place agribusiness as the engine of the national economy (PINHEIRO JÚNIOR; BISPO, 2019).

In Brazil, Precision Agriculture (PA) plays an important role in this scenario, as it addresses the optimization of production, processes and costs, helping agribusiness to increase productivity by spending less and avoiding waste (ARTIOLI; BELONI, 2016).

With the use of new technologies, along with good farming practices, Precision Agriculture (PA) has enabled the improvement of production systems in agriculture, optimizing resources and mitigating effects on the environment (OLIVEIRA et al., 2020. With more precise technology, the farmer will be able to identify, for example, which are the areas with the greatest infestation of pests, making the application of pesticides more efficient in the affected areas.

Agriculture had momentum for improvement and evolution in the twentieth century, with the so-called Agriculture 1.0, using animal traction. Agriculture 2.0 arises by replacing animal traction with a combustion engine. Some time later, Agriculture 3.0 was born, with the development of the *Global Positioning System* (GPS), used until today, helping to manage planting. Currently, the

so-called Agriculture 4.0 is widespread, incorporating connectivity and automation, using machines, vehicles, drones, robots and animals with sensors (OLIVEIRA et al., 2020).

The Brazilian Association of Aeromodelism (ABA) defines UAV as "a vehicle capable of flying in the atmosphere, outside the ground effect, which was designed or modified not to receive a human pilot and which is operated by remote or autonomous control" (OLIVEIRA et al, 2020).

Pino (2019) points out that drones can be classified due to the type of control they use, and can be autonomous (no need for a human pilot to control it from the ground. It is guided by its own integrated systems and sensors); monitored; supervised (The operator pilots it, although it performs some tasks autonomously); pre-programmed (pre-conceived flight plan and there is no way to modify it) and remotely controlled (piloted directly by a technician using a console).

The development of drones emerged as an important AP tool. However, there is little information in the literature about the practical use of drone images and simple vegetation indices, as a management adjustment tool, with the aim of increasing productivity and also reducing production costs (DE SOUZA et al., 2019).

Artioli and Beloni (2016) add that drones in Brazil become allies of the AP because they are precise, allow detecting and monitoring large areas in real time and, through the generated images, are able to locate where to fight pests or receive fertilization in a more specific way, avoiding waste.

Given this scenario, the general objective of this research is to analyze the bibliographical production regarding the use of drones in agriculture in Brazil in the period between 2012 and 2022. research on the use of drones in agriculture.

To achieve this general objective, the method proposed by Conforto, Amaral and Silva (2011) is used, called Systematic Bibliographic Review (RBS), highlighting that the systematic review is characterized by being methodical, transparent and replicable, based on scientific rigor. The systematic process enables the author to compile data, refine hypotheses, define research methods and finally define directions for future research using the so-called RBS, which will be detailed in the chapter on methodology.

LITERATURE REVIEW

AGRICULTURAL PESTICIDE APPLICATION TECHNOLOGIES

The crop protection industry developed based on the chemical industry, combining knowledge of organic chemistry with agronomic sciences. It is included in the fine chemicals segment, characterized by manufacturing products with high unit value, when compared to products from other segments, such as basic chemicals (SILVA; COSTA, 2012).

With the end of the two great wars in the beginning of the 20th century, the chemical industries producing poisons used as chemical weapons, saw in agriculture a promising market for the sale of products that help in the fight against pests. The 1950s saw great growth in the use of such substances in the United States. Since that time, several campaigns have taken place in favor of the so-called "Green Revolution", which sought to end hunger in the world, with a great increase in productivity in the field and indiscriminate use of the environment (RIBEIRO et al, 2022).

Brazil is a major producer of grains and food on the planet and according to Simon et al. (2022), pesticides or agricultural defensives are chemical products used to control pests and diseases in plants, aiming to increase productivity and product quality. However, increased frequency of use, mode of

application, climatic conditions and biotic and abiotic characteristics can define the impact they cause on health and the environment.

Currently, the area treated with agricultural defensives grew in the 2021/2022 harvest by 12.1% compared to the previous year, mainly due to the increase in pests, diseases and weeds that are difficult to control, according to the `` National Union of the Product Industry for Vegetal Defense`` (Sindiveg). In 2021, the crop protection industry faced problems related to the increase in the exchange rate, shortages of raw materials from China, rising costs of sea freight, etc. Besides, in 2021, insecticides were used in 27% of the area treated with pesticides. Herbicides appeared in 23% of the area treated with pesticides (PEDRINI, 2022).

Andrade et al. (2021) complement by stating that great advances have been achieved in the spraying sector. Multirotor drones can spray in areas where there are outbreaks of disease in crops, replacing applications in total areas, resulting in significant savings in the use of products such as insecticides, herbicides and fungicides. Another advantage of using drones in spraying is the replacement of workers with knapsack sprayers by autonomous drones. This way, the risk of exposure of workers to chemicals is eliminated.

PRECISION AGRICULTURE

The literature on modern Precision Agriculture (PA) originated in 1929 in the United States, through discoveries made by professors at the University of Illinois, when they verified the great variability in the need to apply limestone between the different areas of an agricultural land. The first decade of the AP focused on identifying the variability of agricultural areas and the application of inputs through the development of sensor technologies and electronic monitors (SILVA; SILVA-MANN, 2020).

From the 1990s, there was a significant advance in research on PA due to the availability of satellite signals through the global navigation system, developed by the USA and better known as the *Global Positioning System* (GPS), becoming fully operational in 1995 From this, AP started to gather several tools, involving electronic sensors in computerized machines, Geographic Information Systems (GIS), in addition to different application technologies such as Variable Rate Technology (VRT) (SILVA; SILVA-MANN, 2020).

Precision Agriculture (PA) can be understood as a form of crop management that takes spatial variability into account. It is understood as a managerial posture that takes into consideration, the spatial variability of the crop with the intention of obtaining economic and environmental returns. It is recommended only if there is potential for economic and environmental return, in which case it is necessary to have spatial variability (INAMASU; BERNARDI, 2014).

The application of geostatistics in precision agriculture aims to characterize the spatial variability of soil and crop attributes and estimate the interrelationships of these attributes in space and time. The set of geoprocessing, or geotechnologies, including collection, processing, analysis and availability of information with geographic reference, presents great potential for managing agricultural and livestock production (BERNARDI et al., 2015).

With the use of new technologies, along with good farming practices, Precision Agriculture (PA) has enabled the improvement of production systems in agriculture, optimizing resources and mitigating effects on the environment (OLIVEIRA et al., 2020).

Practices related to PA in Brazil began with the importation of computerized equipment in the 1980s, but in a way that did not achieve the desired results. Only from 1995, with the beginning of the use of GPS signals and

with the increase of knowledge about AP by the national agribusiness, the opening of the trade of machines began, which over time incorporated information technologies, robotics and electronics (SILVA; SILVA-MANN, 2020).

In Brazil, PA is a very current topic, with great potential. Growers who have adopted this technology are maximizing crops and making planting areas more efficient. However, in Brazil there are few researchers who produce content on this topic, showing that the technology is still evolving (OLIVEIRA et al., 2020).

Still in relation to Brazil, agricultural production systems have undergone changes that point to the reduction of labor, but also to the intensification of its use. Due to the fact that Brazil is a reference country in agriculture and livestock, the use of automation, with machines, equipment, sensors and actuators, will be essential to help guarantee food security in the future, and these changes in terms of technology will increasingly help with regard to efficiency gains. Exemplifying adherence by producers in the national territory, a survey carried out by the Kleffmann Group, with 992 producers from the South, Midwest and Matopiba Regions (MA, TO, PI and BA), indicate adoption of some type of PA by 45% of respondents. (BASSOI et al., 2019).

AGRICULTURAL AVIATION

The beginning of agricultural aviation took place in 1911, in Germany. Forest agent Alfred Zimmermann controlled a caterpillar infestation with the help of agricultural aviation. In 1921 the United States used agricultural aviation for the first time in the State of Ohio for the same purpose. In 1923 the first agricultural aviation company was created, under the name of *Huff-Daland Dusters Incorp.* After the 1940s, agricultural aviation began to be used to control locusts and forest fires. The first aircraft built exclusively for agricultural use was the AG-1, in 1950 (SCHMIDT, 2006).

According to SINDAG (2004), the first agricultural flight carried out in Brazil took place in the city of Pelotas-RS, in 1947. National aviation, not only agricultural, had a great impulse in the late 1960s. In 1969 the Brazilian Company of Aeronautics SA (EMBRAER). In the same year, agricultural aviation was normalized, as well as an agreement with the Ministry of Aeronautics for the construction project of the first Brazilian agricultural aircraft. The project made its first flight in 1970, under the name of EMB-200 Ipanema (SCHMIDT, 2006).

Agricultural aviation has several advantages due to its particularities, whether by planes or helicopters. Due to the higher application speed in relation to the terrestrial environment, it is possible to take better advantage of the period of favorable climatic conditions for aerial spraying, start application right after the rainy season without difficulties in accessing the crop, minimize risks to the health of the operator, as there is no contact with the product, among others. In the case of the helicopter, we can also mention the greater maneuverability, combined with the ability to operate at lower speeds during the application (SAMSUDIN, 2020).

USE OF DRONES IN AGRICULTURE

Unmanned Aerial Vehicles (UAVs) were initially created for military purposes, seeking resistance to hostile environments and difficult access to humans. Currently, its use is mainly in agriculture (VIANA et al., 2018).

Through the development of technologies and the great need to build solutions, tools were created with the objective of enriching the use of information that occurs in the field, with the objective of helping rural producers to make decisions through the analysis of

more accurate data. The use of drones or UAVs adapted to the reality of agriculture and livestock, shows itself as a great advance, by enabling monitoring and actions through high resolution images and with precise location, without the need for the presence of a human on the spot. There are several uses for drones in agriculture and livestock, one of them being crop monitoring, using high-resolution images in order to find failures in planting, crop health, pest infestation, problems involving irrigation, etc. 2018).

The use of UAVs, more popularly known as drones, is a way to follow the development of different cultures. It allows obtaining aerial images of large areas at low cost, highlighting the high resolution, enabling the use of this tool on a large scale. It also helps in assessing the behavior of genotypes and impacts of biotic and abiotic stress, contributing to the decision-making of producers and property managers (DE SOUZA et al., 2019).

Trigo et al. (2018) point out that the use of drones has also been gaining prominence in livestock to assist in the management of herds, in search of healthier food and in the proper control of the business. It also has the objective of increasing productivity, in addition to meeting the demands for the search for new markets, internal or external.

Ribeiro et al. (2022) add that drones can be equipped with multispectral cameras, in addition to software capable of reading infrared images, finding potential points of pests and problems involving irrigation, through unhealthy spots in large fields, providing the opportunity to solve the problem in the exact place of occurrence with the application of the pesticide. The localized application significantly reduces the volume of pesticides, and in certain cases 0.1% of the total volume of a common application is used.

Thanks to these new technologies applied in agriculture, it is possible to obtain a relationship between problems that interfere with the development of the crop with the processed aerial images. This way, it allows the creation of maps to be carried out more precisely, aiming at a uniform development of the crop through vegetation indices. The indices allow understanding and rapid response applied at the exact moment (CAVALCANTE et al., 2022).

The sprayer drone is another important type of drone applied in agriculture. For this process to be carried out, it is necessary to carry out an evaluation, in order to identify the area to be sprayed, in addition to the crop that will receive the spraying. In addition, it is necessary to define the type of spray nozzle, the shape of the jet and the adequate flow rate (BARBIZAN; CAVICHIOLI, 2022).

Sausen et al. (2021) point out that spraying with a high accuracy rate carried out using drones reduces spending on phytosanitary products, by performing applications in the exact places where there is a need to use them, with emphasis on the multirotor model.

Drone spraying generally uses a low spray volume/ha and travel speed between 10-20 km/h, in addition to a combination of nozzle and working pressure that results in the production of fine droplets. It is also noteworthy that the propeller effect pushes the spray mixture downwards and moves the leaves at the top of the plants, which may result in improved spray deposition to the lower strata of the plant (OLIVEIRA et al., 2021).

In a country driven by agriculture, the demand for the application of effective means to increase agricultural productivity is remarkable. In this context, aerial spraying is an alternative chosen by many rural producers, given its efficiency, with less damage to the crop, preserving the environment (SAMSUDIN, 2020).

Brazil is one of the pioneers in the use of drones in agriculture. Its images and data allow

the rural producer to generate topographic maps and models for leveling and drainage, measure the height of plants and general conditions of the crop, locate weeds, pest infestations and even detect macronutrient deficiencies, such as nitrogen (MESQUITA et al. al., 2019).

The use of UAVs in Brazil is an increasingly consolidated reality, incorporating applications previously attributed to satellites and traditional aerial surveys. Currently, there are more than 75,000 pieces of equipment duly registered with ANAC, 62% of which are recording devices for professional and/or academic activities (LOBO et al. 2020).

METHODOLOGY

The research is exploratory and descriptive with bibliographical research. The vast majority of exploratory research involves bibliographical survey and analysis of examples that help in understanding the topic in question, dealing with questions that are configured in time and in the context of study, and cannot be resolved only with quantitative data (GERHARDT; SILVEIRA, 2009).

The exploratory research model uses mainly qualitative research techniques based on observations, allowing a problem to be elaborated in a more complex way (TOLEDO; SHIAISHI, 2009).

Gil (2002) points out that exploratory research aims at greater familiarity with the topic under study and the descriptive level is concerned with describing, analyzing or verifying relationships between facts and phenomena.

Lima and Mioto (2007) state that bibliographical research is a methodological procedure that is offered to researchers as a possibility in the search for solutions to their research problem. However, there is a need to carry out a tireless movement of apprehending the objectives, observing the stages, reading, questioning and critical dialogue with the bibliographic material. The authors complement by highlighting that it is not uncommon for bibliographical research to appear characterized as a literature review or bibliographical review. However, the bibliographical review is only one of the steps to carry out a research, while the bibliographical research implies an ordered set of procedures in search of answering the guiding questions of the research.

The advantage of bibliographical research is that the researcher can access a wider range of phenomena, warning that consulted data may contain errors and that bibliographical research may reproduce or even expand such errors if there is not a careful procedure of verification of sources, thus avoiding inconsistencies and contradictions (SOARES, PICOLLI; CASAGRANDE, 2018).

Specifically, to fulfill the objectives and answer the questions that guide this research, the method proposed by Conforto, Amaral and Silva (2011) of Systematic Bibliographic Review (RBS) was used.

Roadmap proposed by Conforto, Amaral and Silva (2011) was used, which suggests three macro stages for its conduction. The RBS *Roadmap* is organized in phases and steps. The first phase is called input and has eight steps. The second phase is called processing and its procedure takes place in three stages. The third phase is the output and consists of four stages (CONFORTO; AMARAL; SILVA, 2011).

The Entry phase consisted of the following parameters, highlighted in Chart 1.

Parameters	Prohibited
1.1. Problem	What are the publications related to the use of drones in Brazilian agriculture between 2012 and 2022 and indexed in Google Scholar (Academic)?
1.2 Purpose	To analyze the bibliographical production regarding the use of drones in Brazil, between 2012 and 2022.
1.3 Primary sources	Scientific articles
1.4 Search *strings*	"Drones" using the Boolean operator AND, in combination with the following terms: "Agricultura Brasil"; "Agribusiness", "Precision Agriculture in Brazil" and "Agriculture 4.0".
1.5 Inclusion criteria	Articles found through Google Scolar, between 2012 and 2022, dealing with the use of drones in agriculture exclusively in Brazil.
1.6 Qualification criteria	publication year
1.7 Tools	Microsoft Excel® software.
1.8 Schedule	Between 02/06/2023 and 02/12/2023. The database search was carried out between 11/11/2022 and 01/12/2023.

Table 1 - Systematization of the first phase of the RBS

Source: Prepared by the author based on Conforto, Amaral e Silva (2011)

The second phase, named by Conforto, Amaral and Silva (2011) as processing, follows an iterative process containing seven steps, with three steps, namely, search, analysis of results and documentation (steps 2.1, 2.2 and 2.3, respectively). Step 2.1 comprises the search for journals and database search. In step 2.2, the results are read and analyzed, the so-called reading filters. Finally, in step 2.3, the information that resulted in the number of articles analyzed, such as: number of articles excluded, number of articles found, etc.

It is noteworthy that the exclusion criteria involve the identification of duplicate articles, reading the title and abstract, in order to identify articles that do not directly address the proposed theme. The full reading took place only in the articles selected for analysis. It is also noteworthy that theses, dissertations, monographs, book chapters and articles published in congresses were eliminated from the analyses.

The processing phase for this work occurred with the use of *search strings,* with the following results: "Drones" AND "Agricultura Brasil", with a total of 15 publications, and after using the exclusion criteria, two were used articles for analysis; "Drones" AND "Agribusiness Brasil", with a total of 35 publications, and after using the exclusion criteria, three articles were used for analysis; "Drones" AND "Precision agriculture in Brazil", with a total of 61 publications, and after using the exclusion criteria, four articles were used. "Drones" AND "Agricultura 4.0", with a total of 89 publications, and after using the exclusion criteria, six articles were used.

RESULTS AND DISCUSSIONS

The analysis of the results of the Systematic Bibliographic Review (RBS) is discussed in this section. The steps proposed by Conforto, Amaral and Silva (2011) resulted in 15 articles found in Google Scholar following the inclusion and exclusion criteria already detailed in the chapter referring to the methodology. It is noteworthy the fact that a time limit was established, between the years 2012 and 2022, making up the last decade of publications. For the search, the terms "Drone", "Agriculture 4.0", "Agribusiness Brazil", "Precision Agriculture in Brazil" and "Agriculture Brazil" were used. Table 1 highlights the name, year of publication and objectives of each of the 15 articles analyzed.

Article Title	Publication Year	goal
1 Evaluation of RPAs for spraying different crops	2018	Study and validate the application of pesticides through RPAs (Remotely Piloted Aircraft), commonly known as drones.
2 Precision and digital agriculture: prospects and challenges for rural producers in the State of Paraná	2021	Evaluate perspectives and challenges in the use of precision and digital agriculture in the management adopted in commercial crops in the State of Paraná.
3 Use of technology in the traceability of the beef herd	2018	Present a project that proposes a solution for small or medium-sized beef cattle producers, through the use of technology, so that they can have all the information about the herd.
4 Diagnosis of the profile of drone users in Brazilian agribusiness	2016	Analyze the use of drones as a technological alternative in Precision Agriculture to help decision making.
5 Determination of the height of corn plants through the analysis of images obtained with ARP	2022	Determine plant height of 11 commercial and pre-commercial maize hybrids, through digital processing of aerial images obtained by ARP.
6 Potentialities of using drones in precision agriculture	2020	Familiarize the farmer with new technologies, such as the drone.
7 Precision Agriculture in Brazil: current situation, challenges and perspectives	2020	Provide a diagnosis of the current situation of Precision Agriculture in Brazil, identifying challenges and development prospects.
8 Potential use of a thermal camera attached to a UAV to monitor crops	2018	Conduct a literature review on the use of a thermal camera attached to a UAV for monitoring agricultural crops.
9 Decision-making aid in the management and planning of soybean planting	2019	Identify failures in the plant stand in a soybean crop grown in floodplain areas by capturing images and processing them.
10 The use of unmanned aerial vehicles (UAV) in sugarcane cultivation	2020	Define what drones and UAVs are, their applications and present the advantages for the producer.
11 Study of the functionalities of drones in agriculture	2021	Expose the functionalities of drones in agriculture, through relevant articles and websites.
12 Study on the functionality resulting from the use of an "unmanned aerial vehicle" (drone) in Brazil	2022	Analyze the responsibility arising from the use of "unmanned aerial vehicle" (drone) in Brazil due to the significant increase in registered units.
13 Remotely Piloted Aircraft (RPA) for pesticide application	2021	Develop and evaluate a remotely piloted aircraft (RPA) for pesticide application.
14 Technologies that support sustainable food production	2021	Provide information on some technologies that can be used by producers in the production process to put sustainability into practice
15 Use of unmanned aerial vehicles to detect pests and diseases in soybean crops	2022	Show the importance of using UAVs to detect the presence of pests and diseases in soybean plantations.

Table 1 - Name, year of publication and objectives of selected articles

Source: Prepared by the author (2023)

There is a wide variety of topics that can be addressed with regard to the use of drones in agriculture. From the detection of pests and diseases in the crop to the relevant legislation for the use of drones and the traceability of a herd. Articles that explain the general functionalities and the general panorama of the use of drones in Brazil are also of paramount importance for those who are starting in the subject.

Andrade et al. (2018) highlights the use of Remotely Piloted Aircraft (RPA) (drones) for spraying, in different cultures. The authors of the experiment used a herbicide solution for the tests at three different heights, along with three models of spray nozzles, aiming to find different application models, seeking greater efficiency and effectiveness of the applications. The authors highlight the speed and practicality of the application, in addition to being possible to control weeds without the need to use tractors, which increase soil compaction and greater investment in equipment. Parameters were established for the use of drones in crops such as peanuts, soybeans, corn and sugarcane. Neto, Sasaki and Alvarenga (2021) also studied issues related to spraying. The authors highlight the construction project of an RPA with a hydraulic spraying system, consisting of a hydraulic pump. It is also noteworthy that the tank has a capacity of 0.350 L. The experiments were conducted in the laboratory, three flight heights, with predetermined flow and speed. The authors state that the RPA presented satisfactory results, but suggest that further studies increase the capacity of the aircraft's tank and other conditions such as difficult access to the crops to be sprayed.

The drone user profile is approached by Artioli and Beloni (2016), when applying questionnaires to agribusiness professionals in different locations, evidencing the existence of a lack of information regarding the use of drones, including the real benefits, operationalization, ANAC regulations, acquisition costs, among others. Due to the growing demand for drones, a new market niche is evident, however, it must be highlighted the need for disclosure by drone manufacturers, creation of courses on the subject, technical assistance, among others.

With regard to sustainability, Sausen et al. (2021) point out that the so-called agriculture 4.0 offers sustainable solutions for food production, by contributing to the automation of agricultural operations, rationalizing the use of inputs. Particularly in relation to drones, the authors highlight the following advantages and contributions to sustainability: monitoring of the property, with exploration of areas of difficult access, checking the issue of deforestation and fire outbreaks and surveillance in general; mapping and georeferencing, with the demarcation of areas, limitation of areas and choice of the best areas for planting and identification of the property's geographical coordinates; monitoring of plantations, with sensors capable of monitoring each plant, identification of planting failures, attack by pests, weeds, diseases, irrigation failures, etc. and aspects related to greater safety of biological products.

With regard to the problem of pests and diseases, Silva and Cavichioli (2022) point out that the country is the largest producer of soy in the world, however, care for pests and diseases must be constant. The use of new technologies in such an important crop for agribusiness is a priority, and one of these new technologies refers to the use of drones, precisely to detect pests and diseases. The authors highlight the great importance of using UAVs, as they help in the early identification of pest and disease infestation, that is, the correction of problems can be done quickly and efficiently, thus highlighting the economy with agricultural pesticides, increased of productivity, in addition to mapping the area much faster and more efficiently, compared to an employee on the property.

In reference to legal issues, Neto and Furlaneto (2022) point out that it is required that the driver of a drone must respect administrative rules, flight regulations, in addition to always making conscientious use of the material. The authors add that it is of

paramount importance to expand preventive inspection in relation to the use of drones, in order to prevent accidents.

Monitoring the size of maize plants is addressed by Ferraz et al. (2022). The authors point out that remote sensing has been occupying more and more space in hybrid characterization evaluations, taking as an example the estimation of plant height through sensors attached to drones. It is noteworthy the fact that the results found between manual measurements and by capturing information through the drone did not differ statistically. It must be noted that data collection using drones fills space on the observational scale in remote sensing, providing high spatial and temporal resolution data, which is important for monitoring crop growth.

Traceability in beef herds is addressed by Trigo et al. (2018) in which the authors highlight the need for the producer to have all the information about the herd, such as number of animals, weight, vaccines, size of the confinement area, among others. In the research, the authors emphasize the importance of using the application for traceability, which controls the herd through daily reports. With all this information available, the producer will be able to speed up the work, in addition to obtaining permission to issue a batch for the slaughter industry, configuring a competitive advantage over competitors.

Kolling and Rampim (2021) analyzed the perspectives of Precision and Digital Agriculture in the State of Paraná. The authors identified a lack of knowledge in basic concepts about Precision and Digital Agriculture, showing more evidence of the need to help producers, with technical courses, lectures and practical classes on how certain elements of PA work, such as drones and all the advantages that they can provide to the farmer and his production.

Besides, regarding perspectives, Silva and Silva-Mann (2020) point out that technological innovations have contributed to more sustainable property management. The authors state that there is a commitment between private companies, research centers, universities and associations to disseminate drone technology, but there is still resistance from producers. The authors also highlight the need to encourage domestic industry and the development of new technologies in order to make the country more competitive.

In the same line of reasoning, Oliveira et al. (2020) seek to highlight the potential of using drones in agriculture. The authors highlight the lack of works that address the theme, noting that they can help producers to learn about new technologies, such as the drone, which has been highlighted among the new technologies used in agriculture, deserving greater attention from producers and workers in the field in general.

De Souza et al. (2019) explores decision-making in soybean management based on image processing. The authors highlight the importance of this practice contributing to decision-making, stating that it is possible to identify failures in the cultivation lines, management errors, sowing, germination problems, among others.

Viana et al. (2018) also show the importance of monitoring crops using a thermal camera coupled to a drone. The authors showed the applicability of the cameras, as they show everything from water stress to fruit damage, in addition to the aforementioned time factor for obtaining information on large areas.

The functionalities of drones in agriculture are highlighted by Gonçalves and Cavichioli (2021). The authors state that in today's agriculture, drones are indispensable, with great potential for growth in the agricultural sector, since they can provide increased productivity, improvement of production

processes, savings with the application of pesticides, etc.

Assaiante and Cavichioli (2020) highlight the use of drones in sugarcane cultivation and state that the use of drones in sugarcane cultivation is essential for the growth and evolution of the crop, due to the facts previously described in the present work.

FINAL CONSIDERATIONS

The general objective of this article was to analyze the bibliographic production centered on the use of drones in agriculture in Brazil in the period between 2012 and 2022. researches.

Through the selected articles, it was possible to find out points of convergence, in which the use of drones has several advantages for producers. Emphasis was placed on crop monitoring through images, which present various information, from crop water stress to fruit damage. It is also noteworthy that the use of drones can provide the possibility of increasing productivity, in addition to savings in the use of pesticides. It can also be highlighted as a highlight of drones, the traceability of herds, enabling the collection of information, helping the producer with the permission to issue a batch for the slaughter industry. However, only one of the selected articles dealt with the subject, showing that this can be a path to be explored by other researchers, in order to strengthen the theme of the use of drones to control herds.

It must also be highlighted the articles that detail questions about the performance of drones in the control of pests, diseases, exploration of areas of difficult access, verifying possible points of deforestation and fire outbreaks, mapping and georeferencing, demarcation and limitation of areas. All the factors mentioned in the articles addressed in this study, together with the localized application and in the exact necessary amount of pesticides and fertilizers, contribute to both the economic and environmental sustainability of the property.

Another convergence factor among the articles selected for this research lies in the fact that, in general, there is a lack of information for producers regarding issues involving the functionality and advantages of using drones in production. It appears to be necessary for associations and cooperatives to seek information, courses and technical support for producers, so that they can acquire the necessary knowledge to make the decision regarding the use of drones.

A study is indicated as future research that follows the line of comparison of costs and efficiency of spraying between the use of drones, tractors, airplanes and agricultural helicopters, aiming to present in a clear and practical way, the possible savings of spraying per hectare with the use of drones. It is also possible to indicate the carrying out of a case study in rural properties regarding the knowledge of producers regarding the use of drones in agriculture and its advantages, in addition to the possible openness to investments in this area.

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