

## Use of drone to aid in the evaluation of soybean trials: A mini-review

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### Abstract

Rural producers are increasingly investing in technologies that allow them to produce more in less time, without the need to increase the planting area or the amount of input used. To this end, the use of technology tools has guaranteed efficiency in productivity and improved time, labor and decision making. The development of technologies focusing on drones has contributed to land use analyzes in precision agriculture. The objective of this study is to discuss, through a literature review, the use of drones to help evaluate soybean trials. The results demonstrate that drones have been widely used in soybean cultivation with varied applications and excellent results. Drones have been used to improve production, environmental preservation, economic sustainability, savings in the acquisition of fertilizers and agricultural pesticides, for monitoring areas, among other contributions to rural areas, ensuring efficiency and effectiveness in the production process and resulting in production economy. The importance of carrying out studies to demonstrate the advantage of using drones in soybean cultivation and disseminating knowledge in rural areas is highlighted, bringing knowledge to producers about the chain of agents involved, ranging from manufacturers to the final consumer.

**Keywords:** UAV, rural production, precision agriculture, technology.

## Uso de drone para o auxílio na avaliação de ensaios de soja: Mini-Revisão

### Resumo

Os produtores rurais estão investindo cada vez mais em tecnologias que permitem produzir mais em menos tempo, sem que haja a necessidade de se aumentar a área de plantio ou a quantidade de insumo utilizado. Para tanto, o uso das ferramentas tecnológicas tem garantido eficiência na produtividade e melhoria de tempo, mão de obra e tomada de decisões. O desenvolvimento de tecnologias com foco nos drones tem contribuído para análises de uso da terra na agricultura de precisão. O objetivo desse estudo é discorrer através da revisão de literatura sobre a utilização de drone o auxílio da avaliação dos ensaios de soja. Os resultados demonstram que os drones tem sido amplamente utilizado na cultura da soja com aplicações variadas e excelentes resultados. Os drones tem sido usado para melhorar a produção, preservação ambiental, sustentabilidade econômica, economia na aquisição de fertilizantes e defensivos agrícolas, para o monitoramento de áreas, entre outras contribuições para o meio rural, garantindo eficiência e eficácia ao processo de produção e resultando em economia de produção. Destaca-se a importância da realização de estudos para demonstrar a vantajosidade do uso de drones na cultura da soja e difundir o conhecimento no meio rural, levando conhecimento aos produtores sobre a cadeia de agentes envolvidos, que vão desde os fabricantes até o consumidor final.

**Palavras-chave:** VANT, produção rural, agricultura de precisão, tecnologia.

### 1. Introduction

Agriculture has undergone a revolution in recent years with the development of technology that comes every year, advancing towards providing greater competitiveness to the productive sector, considering that new forms of production have used technological tools in all branches of production. The demand for agricultural products and production has increased in recent years, mainly due to global population growth and thus the challenges facing rural producers have become increasingly complex (Gonçalves; Cavichioli, 2021).

The search for new technologies and advanced solutions, that can improve productivity and efficiency in the production sector has been prioritized by the agricultural sector. The diffusion of technologies in agribusiness presents challenges for both agricultural firms and rural producers. But, there are ways for both to innovate. A central factor for this to occur is the development of technologies, that are intended to be offered in the agricultural market according to a broad and in-depth analysis of the profile of their potential user (Gonçalves, 2023).

Precision agriculture in Brazil is a new and current topic, and has great potential. Brazilian producers have been using this methodology to maximize cultivation and make planting areas more productive, and efficient using technologies and tools available on the market. The constant evolution of precision agriculture, demonstrates the need to invest in studies and research in the area and one of the forms of development is the use of Unmanned Aerial Vehicles (UAVs) or Drones (Oliveira et al., 2020). According to Ahirwar et al. (2019) a UAV or drone, is a flying device that can fly a pre-set course with the help of an autopilot and GPS coordinates.

Drones or UAVs, have been spreading around the world to characterize any and all unmanned flying objects, be they of any purpose (professional, recreational, military, commercial, among others), origin or characteristic (Pix Force, 2016). The Brazil is one of the pioneer in the use of drones in agriculture. Several agronomists, administrators and businesspeople rely on the use of these devices to maximize gains in farming, and to make quick decisions; avoiding production losses such as pest infestation; geological survey; thermal or visual imaging; in observing areas with nutrient deficit and less stressful as it is safe and can fly for hours as long as the vehicle allows it (without human fatigue in an airplane) (Ahirwar et al., 2019; Dutta; Goswami, 2020).

Some Brazilian companies import drones, support equipment, spare parts and data analysis programs, however, the number of technology companies in Brazil has been growing in terms of national production of UAVs, for national and international commercialization or use own (Shiratsuchi, 2014). The application of drones in agriculture has stood out as an innovation capable of transforming the way agricultural activities are carried out in small, medium and large farming areas, mainly sugar cane, corn and soybeans (Mogili; Deepak, 2018; Gonçalves; Cavichioli, 2021).

As noted, the use of UAVs in agriculture has great potential, including in soybean cultivation, with Brazil being one of the largest producers of this grain, which is mainly exported to the Asian continent. The objective of this study is to discuss, through a literature review, the use of drones to help evaluate soybean trials.

## **2. Material an Methods**

In this current research study, we conduct a bibliometric analysis to explore drone applications in agriculture. Scientific articles were selected through the Google Scholar, Elsevier, Web of Science and Scopus platforms, applying publication date as search criteria, taking into account articles published from 2018-2024, in order of relevance and with research from pages in Spanish, English and Portuguese. Some older articles before 2018, 5 years or more old, were used to guarantee the bibliographic reference of the study.

Case study articles from the last 5 years that were relevant to the topic and demonstrated the use of the tool in practice were used as inclusion criteria. Articles older than 5 years and articles without direct relevance to the topic were excluded from the research. The descriptors used were: drones, application of UAVs in agriculture, types of drones, soybean production in Brazil, soybean production in the State of Goiás, crop monitoring, quad copter, spraying system, modern agriculture.

## **3. Bibliographic review**

### *3.1 Soybean production in Brazil and the State of Goiás*

The soybean (*Glycine max* (L.) Merrill) is known worldwide for its relevance in terms of the use of its products in human and animal nutrition, and economic value in the national and international market (Oliveira et al., 2016). Being the main oilseed cultivated throughout the world, in addition to being the most important source of protein in animal and human nutrition. This crop, as it is cultivated in different regions of Brazil, presents variability in its productive performance, which leads breeding programs to select, in different environments, productive genotypes with desired characteristics (Matei et al., 2018; Schwalbert et al., 2020). In Brazil, soybean production is of paramount importance as it is the main crop of Brazilian agribusiness. The significant growth of soybean cultivation and the expansion of agriculture throughout Brazil, which occurred during the period of evidence of the industrial policy of import substitution, placed the product as an ideal crop to supply the world

demand, which was in full growth. The expansion of soybean cultivation was considered pioneering, making the 1970s a period of great development, especially for the Central-West region (Martins et al., 2009). According to data from the National Supply Company (CONAB) (2023), soybean production in Brazil in the 2022/2023 harvest was 154,566.3 million tons (Embrapa, 2023), which places the country as the largest producer in the world. The State of Goiás produced 17,734.9 million tons in the same harvest with a planted area of 4,547.4 million hectares.

Thus, in addition to constituting one of the main global commodities, the soybean complex composed of (soybeans and their derivatives such as oil and bran) has great economic importance for the Brazilian market with the increase in domestic consumption and revenue from exports (Oliveira et al., 2016; Song et al., 2021). Of the total soybeans produced in the country, 60.7% are for the foreign market and 30.3% are used in the domestic market (Embrapa, 2023).

### *3.2 Agriculture 4.0*

According to Oliveira et al. (2020), agriculture had a boost for improvement and evolution in the 20th century, with the so-called Agriculture 1.0, using animal traction for various activities. Agriculture 2.0 appears by replacing animal traction with the combustion engine, while the development of agricultural machinery was carried out. Later, Agriculture 3.0 was born, with the development of the Global Positioning System (GPS), used to this day, helping to manage planting.

Currently, the so-called Agriculture 4.0 is widespread incorporating connectivity and automatic, using machines, vehicles, drones, robots and animals with sensors. Thus, the so-called agriculture 4.0, the set of advanced technological innovations created to optimize, improve and monetize. Considering the high demand for new technologies and improved planting, with the use of the same area this type of agriculture has become essential. This agriculture is made up of the incorporation of connectivity and automation, with the use of machines, vehicles, drones, sensors, geolocation systems and artificial intelligence, allowing the collection, analysis and use of data in real time (Amarante et al., 2019; Araújo et al., 2021).

Agriculture 4.0 is the use of technology to optimize production processes, aiming to make better use of productivity, reducing time and costs. The constant evolution of technology has enabled improvements in processes in numerous sectors and in agribusiness it could not be different, artificial intelligence, in combination with the use of satellites, can be used to perform soil analysis remotely and identify deficiencies in each square meter this one.

With this, a specific fertilizer formula is designed to carry out the correction and, after the mixture is made, the machine goes to the field to carry out fertilization, programmed for application in the right measure according to the needs of that specific area (Ferreira et al., 2023). According to Villafuerte & Valadares (2019) and Furtado et al. (2023), Agriculture 4.0 has been studied as a disruptive innovation in Brazilian agribusiness. According to the authors, this approach involves the integration of technologies such as the Internet of Things (IoT), Big Data, robotics, artificial intelligence and others, to make agricultural production more efficient and sustainable. Agriculture 4.0 is an improvement in precision agriculture that already used GPS and remote sensing technologies as a way of improving the use of inputs and reducing production costs. The use of agriculture 4.0 has great potential as a way of reducing environmental impacts, using more precise and sustainable management practices (Silveira et al., 2021).

### *3.3 Use of drones in agriculture*

Drone is a word of English origin, which is called "drone" because of the noise it makes. Which is very similar to the sound of a bee (Barbizan; Cavichioli, 2022). According to Souza et al. (2019), the use of UAVs more popularly known as drones is a way of monitoring the development of different cultures. It allows obtaining aerial images of large areas at low cost, highlighting the high resolution with 4 and 8 K resolution cameras and thermal cameras, and enabling the use of this tool on a large scale. Furthermore, drones have the function of estimating parameters that involve biophysical and biochemical issues that are of great importance for agricultural management practices. It also helps in evaluating the behavior of genotypes and impacts of biotic and abiotic stress, and contributing to decision-making by producers and property managers.

According to Ahirwar et al. (2019) rural producers and smart farms are looking for cheap and effective methods to regularly monitor their harvests, minimizing losses and maximizing production gains. Cameras adapted with high resolution and an infrared sensor system on drones help farmers react and improve the health conditions of crops, apply fertilizers, insecticides, fungicides and herbicides, check evapotranspiration, water stress monitoring,

nutrient disorders, diseases monitoring, weeding, spraying, soil collection (Dutta; Goswami, 2020) among others (Figure 1).

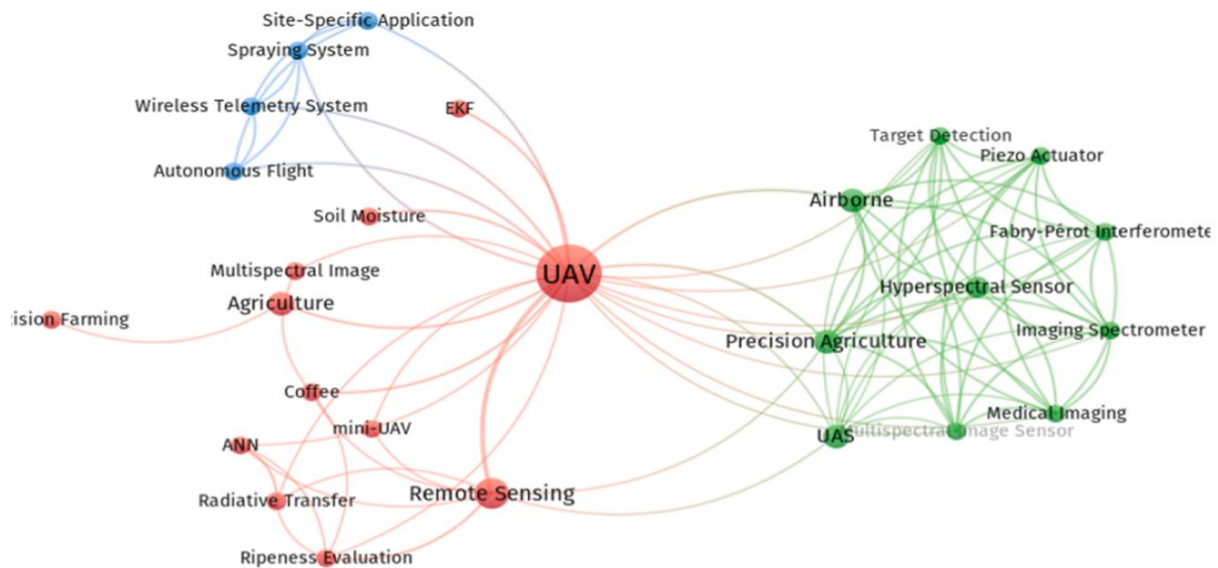


Figure 1. Possibilities of using UAVs in potential areas and subareas for agriculture. Source: Rejeb et al. (2022).

Pereira and collaborators (2023) describe in their study that the use of drones by their nature requires airspace compatible with their operation, therefore, there are limitations and restrictions on the part of the National Civil Aviation Agency (ANAC) in Brazil, which is responsible for operations in Brazilian airspace. In 2017, ANAC issued approval to the special regulation with guidelines aimed at the use of UAVs, which is the Brazilian Special Civil Aviation Regulation – RBAC - E n° 94, which aims to enable operations with the use of drones, always valuing the safety of people. Drones have been widely used in agriculture for monitoring crops, spraying pesticides and fertilizers, mapping soil, detecting plant diseases and other agricultural tasks as seen previously. There is a claim that the application of drones in agriculture can significantly improve the efficiency and precision of agricultural operations, as well as reduce environmental impact (Giraldeli, 2019), this claim is supported by several authors (Puri et al., 2017; Rose; Chilvers, 2018; Ahirwar et al., 2019; Kalamkar et al., Mogili et al., 2020; Dutta; Goswami, 2020; 2020; Rejeb et al., 2022).

Corroborating this understanding, Poloni (2016), highlights that drones are increasingly used in agriculture, with their low-flying flights that help identify flaws in the crop, especially soybeans, lack or excess of water and the need to apply pesticides. Also according to Ferreira (2017), the use of autonomous drones to take photos of soybean plantations helps with pest management and control, improving and reducing operational costs and which can lead to increased profits and reduced environmental impacts.

In its basic application, a UAV presents conventional photo recording, allowing a producer or rural precision agriculture company to make visual assessments of the evolution of cultivation, mapping failures in planting and/or fertilization, identifying reboleiras, among others (Alves, 2023). In agriculture, the most used drone is the delta wing type due to its small size and simple control.

However, they are very susceptible to strong winds, but in general they are the ones that present the least operational problems for new users. This type of drone has a delta wing that creates lift for flight, and has a propeller-type engine at the rear that propels the model forward (Pix Force, 2016). One of the benefits of implementing drones in agriculture is the reduction in labor costs. The use of drones can also increase efficiency and improve crop yields. Farmers can attach sensors and cameras to drones to collect data about their crops, including moisture levels, plant health and soil conditions (Javaid et al., 2022).

Using this information, farmers can make decisions about irrigation and fertilization and detect potential problems before they become serious problems (Jorge; Inamasu, 2014). Paiva (2023) demonstrates in his literature review study the role of drones in controlling pests, diseases, exploration of difficult-to-access areas,

where they highlight the importance of these in checking possible points of deforestation and fire outbreaks, mapping and georeferencing, demarcation and limitation of areas. The authors also point out that the use of drones contributes to the localized application and the exact amount required of agricultural pesticides and fertilizers, contributing to both the economic and environmental sustainability of the property. With the advancement of technology and its wide application in agriculture, drones demonstrate that they have come to establish themselves, where they are increasingly powerful, managing to do the job more quickly, thus, the producer saves time and saves money, being able to focus their attention on another area.

In soybean cultivation, monitoring is essential as it is a production that demands adequate management, precise applications of pesticides, focused identification of pests and others, such as *reboleiras* and the need for spraying at strategic points (Bourscheidt et al., 2023). Thus, thanks to these new technologies applied in agriculture, it is possible to obtain a relationship between problems that interfere with crop development and the processed aerial images. Ribeiro et al. (2022) highlight that drones can be equipped with multispectral cameras, in addition to software capable of reading infrared images, finding potential pest spots and problems involving irrigation, through unhealthy spots in large fields, providing the opportunity to solve the problem in the exact location of the occurrence with the application of the pesticide. Localized application can significantly reduce the volume of pesticides, and in certain cases 0.1% of the total volume of a common application is used.

The study coordinated by Furtado et al. (2023) concluded that the use of drones is promising, with projections increasingly present in the field, whether on large or small rural properties, as it reduces time and costs for producers, consequently increasing productivity. It is observed that according to Oliveira et al. (2020) in precision agriculture, the use of a drone follows some steps, namely: flight planning; overlapping flight; obtaining georeferenced images; image processing; mosaic generation; analysis GIS tool and generating reports. Taking into consideration the steps mentioned above, an accurate mapping of an area can be obtained, bringing several benefits to the farmer such as: monitoring of plantations and crops; drought and pest detection; location of pests; productivity estimates; agricultural mapping and water mapping (Otto et al., 2018).

Bevilacqua et al. (2023) in their study also positions themselves to emphasize the benefits of using drones in agriculture, highlighting that the positive impacts that devices like these can generate, from an improvement in crop monitoring, to the management of production methods and the correct management, generating direct impacts on improving the performance of rural activities. One of the most important drones to use is the spray drone, widely used in agriculture. For this process to be carried out, it is necessary to carry out an assessment, aiming to identify the area to be sprayed, in addition to the crop that will receive the spraying. Furthermore, it is necessary to define the type of spray nozzle, the shape of the jet and the appropriate flow rate (Mogili; Deepak, 2018; Barbizan; Cavichioli, 2022).

#### *3.4 Case studies on drone use in soybean farming*

The use of drones in soybean cultivation has been studied over the years. And most studies have demonstrated the advantages of this technique for improving production, greater efficiency and effectiveness in the use of agricultural products, which represents savings in production costs (Rani et al., 2019). Other applications of drones in agriculture (Figure 2).

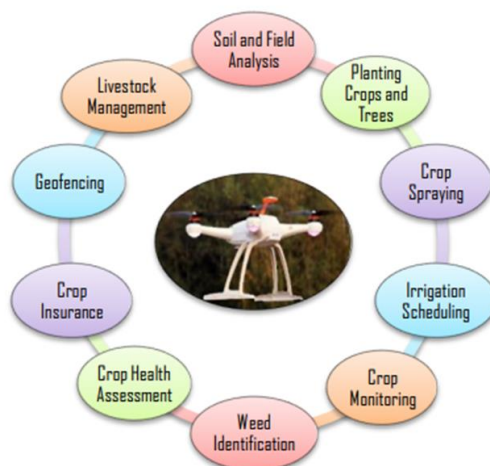


Figure 2. Applications of drones in modern agriculture. Agriculture 4.0. Source: Rani et al. (2019).

Thus, Silva & Cavichioli (2022), in their study, demonstrated that with the use of drones the producer can save 6% on agricultural pesticides, productivity per plot can increase between 16-20%, and also, where in two hours the UAV can map an area of up to a thousand hectares, where it would take an employee around two days to carry out this service.

The study coordinated by Oliveira (2022) on the efficiency of applying insecticides to control soybean caterpillars via drone, demonstrated that the drone is effective in applying correct dosages and efficiently, bringing positive results on agricultural production. The author also considers that another point that causes a positive impact is the absence of crushing plants, thus reducing losses and increasing the profitability of crops. Similar results on the use of drones, Rodrigues (2022) reported on the effectiveness of using drones to control weeds and Asian rust in soybean crops, concluding that the application of herbicides and fungicides using drones provided a good weed control and maintained the health of the crop free from fungi and did not affect crop productivity.

Still in this study, the researchers discuss that with adjustments in application technology using drones, there may indeed be improvements in the quality of spray application. In another study on the use of drones to obtain precision application maps in soybeans, developed by Tomasini & Moscon (2022), the authors highlighted the importance of drones as a tool for saving production costs, highlighting that imaging technology in NDVI helped to significantly reduce the need for herbicide application. However, the delay in processing the images may have affected the results, considering that if they had been obtained more quickly, the savings on products and application costs would have been greater.

According to Teixeira (2023), the drone makes it possible to identify planting flaws using images obtained by a drone, the results demonstrated in a study, that with the use of the DJI Phantom 4 Pro UAV it was possible to capture photos with the quality necessary to create a digital elevation model and orthomosaics with good spatial resolution and precision, which guaranteed an excellent result of the study and the effectiveness of the result. In the study by Calderon et al. (2023) researchers verified the use of drone remote sensing over an agricultural area in the Juruá Valley, State of Acre, Brazil, through the analysis of the vegetation index, based on GLI calculations.

The results of this study, also demonstrated that the use of drones as a tool for analyzing agricultural areas proved to be of great value for monitoring, characterization, management and use of soil. This is because the tool was of great value in the analyses. Alarcão Júnior & Nuñez (2023), in a study on the use of drones in agriculture 4.0, demonstrated in their conclusions that they can improve the efficiency and precision of agricultural operations and also reduce environmental impacts.

The authors also report that drones can be used as a way of monitoring crop growth in real time, mapping plantation areas, spraying pesticides and fertilizers and detecting diseases. As you can see, the use of UAV or drone is of great importance in several areas of application in soybean cultivation. Being able to demonstrate accurate results and with the use of the right technology, bring results that are converted into time and cost savings for the rural producer. Technology, when used in favor of production and with the use of tools to help

the farmer, brings good results and advantages to the means of production.

#### 4. Conclusions

The use of drones in agriculture has gained prominence over the years and it is noted that academia has increasingly invested in studies to disseminate the subject, together with scholars and rural producers. Although the scenario is one of growth in relation to the use of drones, it is noted that in many cases producers still do not have a formed conception of the advantage that the use of drones can enhance production, the environment, the economic sustainability of rural enterprises, the economy in the acquisition of fertilizers and pesticides, among others, mainly in soybean cultivation, which demands new studies and contributions so that there is greater knowledge in the chain of agents involved, ranging from manufacturers to the final producer.

It is necessary to be clear that in soybean cultivation, the use of drones currently allows farmers to identify specific problem areas, saving time and resources when implementing targeted solutions. Furthermore, drones can also be used to spray fertilizers or pesticides, making the process more efficient and precise.

#### 5. Authors' Contributions

*Bruno Borges Ferreira*: elaboration of the idea, reading, writing and correction. *Eliomar Soares Ferreria*: reading, writing and corrections. *Daniel Noe Coaguila Nuñez*: orientation, description of the topic, corrections and publication.

#### 6. Conflicts of Interest

No conflicts of interest.

#### 7. Ethics Approval

Not applicable.

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