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PRECISION AND DIGITAL AGRICULTURE: PERSPECTIVES AND CHALLENGES FOR FARMERS IN THE STATE OF PARANÁ

AGRICULTURA DE PRECISÃO E DIGITAL: PERSPECTIVAS E DESAFIOS DOS PRODUTORES RURAIS DO ESTADO DO PARANÁ

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ABSTRACT

"Big data", Internet of things, "Agri 4.0", digital twin, robotics and several other concepts tend to materialize in rural areas and become tools in agricultural management involving Precision and Digital Agriculture. The objective is evaluating perspectives and challenges of the use of precision and digital agriculture in the managements adopted in commercial crops in the state of Paraná, Brazil. To this end, sixty rural producers around the state were interviewed through a questionnaire to understand the technological reality. Many rural producers in Paraná already have smartphones and internet access, but with a lack of knowledge in basic concepts about Digital Agriculture, and with a reduced number of those who already use Precision Agriculture. Many believe that it is possible to improve property management and agricultural management with Digital Agriculture, and only a few already use a digital agriculture platform. However, there are still many challenges to be overcome by the public and private sector, such as quality mobile telephony, compatible machines and specialized technical assistance.

Keywords: Agri 4.0. Agricultural management. Digital platform. Internet of things.

RESUMO

A "*Big data*", internet das coisas, "Agro 4.0", gêmeo digital, robótica e vários outros conceitos tendem a se concretizar no meio rural e serem ferramentas na gestão agrícola envolvendo Agricultura de Precisão e Digital. O objetivo de avaliar perspectivas e desafios da utilização de agricultura de precisão e digital nos manejos adotados em culturas comerciais no estado do Paraná, Brasil. Para tal, foram entrevistados sessenta produtores rurais nas regiões do estado, através de questionário para compreensão da realidade tecnológica. Muitos produtores rurais paranaenses já possuem smartphones e acesso à internet, porém com déficit de conhecimento em conceitos básicos sobre Agricultura Digital, e com número reduzido daqueles que já utilizam Agricultura de Precisão. Muitos acreditam ser possível melhorar a gestão da propriedade e os manejos agrícolas com a Agricultura Digital, sendo que apenas alguns já utilizam uma plataforma de agricultura digital. Porém, ainda há muitos desafios a serem superados pelo setor público e privado, como telefonia móvel de qualidade, máquinas compatíveis e assistência técnica especializada.

Palavras-chave: Agro 4.0. Gestão agrícola. Internet das coisas. Plataforma digital.

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INTRODUCTION

The Brazilian agricultural sector, known as Brazilian agribusiness, is constantly evolving. Slowly, rural producers from the most isolated places, without mastering the communication system then, start using digital means of communication now, through the internet and smartphones. In chronological order, subsistence agriculture passed to intensive cultivation with agricultural machines and later advance to precision and digital agriculture (VILLAFUERTE *et al.*, 2018).

The management which considers the spatial variability and allows the localized application of inputs, such as fertilizers and correctives, contemplates Precision Agriculture (PA) (BASSOI *et al.*, 2019). With identification of management units based on topography, terraces, soil type, which allow increased management efficiency in PA (RAMPIM *et al.*, 2012). PA encouraged machine industries to unite the use of electronics and information technology, producing agricultural machines with on-board electronics, giving a leap to the development of PA, with the incorporation of specific equipment starting in the 2000s in Brazil (VILLAFUERTE *et al.*, 2018).

Subsequently, the evolution provided the arrival of Digital Agriculture (DA) or Agri 4.0, characterized by the use of analytical methods and solutions to process data and build decision-making support systems in crop management, being possible by reconciling information technology applied to agriculture (MASSRUHÁ; LEITE, 2018). In addition, the concept of Internet of Things, or IoT, is adopted, defined as the interconnection via the Internet of devices connected to machines, sensors, and implements, which aim to share data, with a focus on reducing operating costs, increasing productivity and creating new business and service opportunities (BORÉM, 2020).

The development of Remotely Piloted Aircrafts (RPAs) or Unmanned Aerial Vehicles (UAVs) is also an important technology for PA and DA. The application in the agricultural area has been favored and facilitated by the current stage of technological development (NICOCELLI NETTO, 2020). The UAVs or drones are some equipment which capture images of the agricultural area linked to the interpolation and transformation of data in specific software, generating index maps which demonstrate the health of crops, soil conditions and management and even estimation of crop productivity.

In property management, it is important to ensure availability and access to processed data and information, so that the farmers can use the cell phone to obtain information to guide their decisions, such as the choice of cultivating, sowing time, climate forecast, phytosanitary management, in addition to the prospects of the financial market (MASSRUHÁ *et al.*, 2014). For this, several software models which communicate between all agents in the production chain are used, such as the sale of agricultural inputs, to capture the needs of consumers, tracking of goods, besides the various processes involving the agricultural production system (ASSAD; PANCETTI, 2009).

Regarding new technology advances, accelerated in recent years, there is the concept of Digital Twins, characterized by integrating and processing physical and virtual data throughout the entire lifecycle of a product, involving a high volume of data that can be processed by advanced analysis on digital platforms (TAO *et al.*, 2019). These Digital Twins not only represent real states, but can also reproduce historical data and simulate the future. (VERDOUW; KRUIZE, 2017).

Some studies have focused on showing the reality of precision agriculture in each region, as there are cultural and social differences which can restrict or accelerate the process of adopting new technologies. The study by Soares Filho and Cunha (2015) questioned a group of producers in the Southwest of Goiás about the adoption of PA. In addition, the study by Lavorato and Braga (2017) analyzed the costs of soy production using PA in Mato Grosso do Sul.

In the state of Paraná, the study by Pires Junior *et al.* (2018) sought to present the reality of PA in the micro-regions of Pitanga and Cascavel, being limited, as the state has other important producing regions. Similarly, these studies sought to inquire the producer about the equipment, services and technologies adopted, as well as the positive and negative points of the use of PA, but without considering DA, being essential to understand the technological evolution of agriculture.

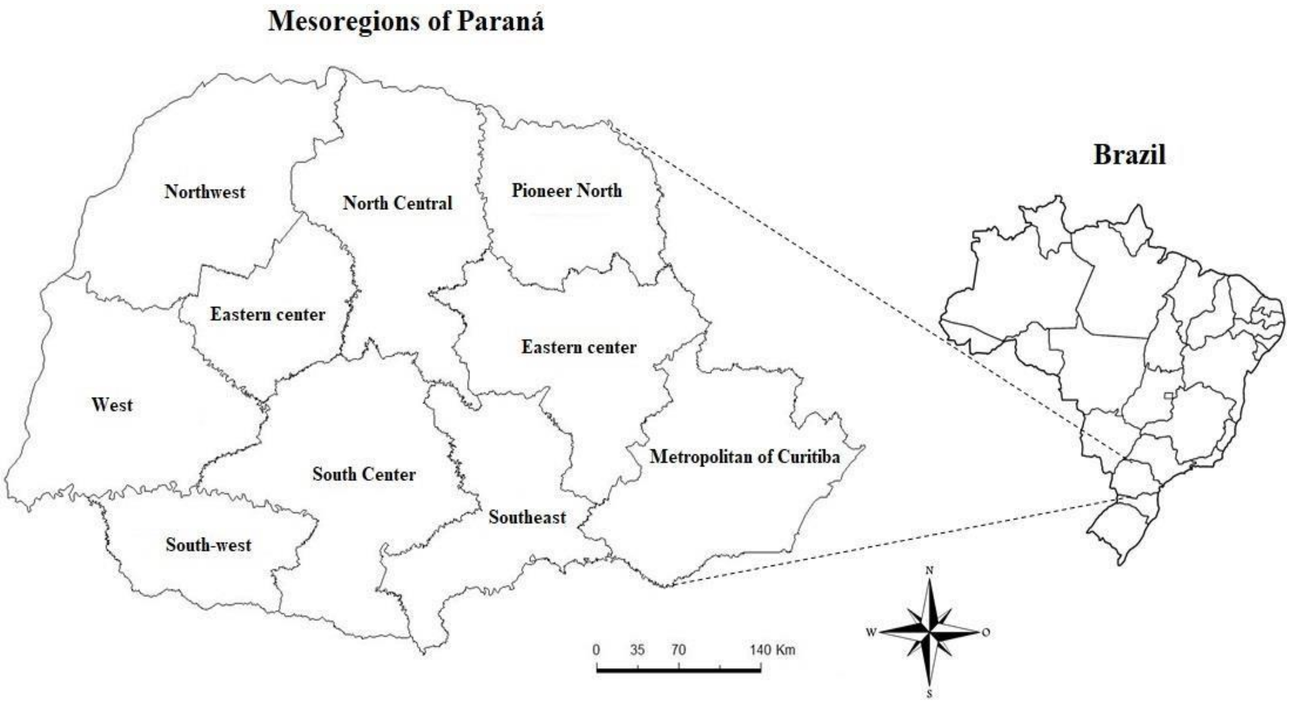
Agricultural production must integrate several areas of knowledge, to use the tools available along with agroclimatic data, besides adequate technical knowledge aiming at assertiveness and efficiency in the recommendations generated for current agriculture (BASSOI *et al.*, 2019).

Thus, this study was developed with the objective of evaluating perspectives and challenges of the use of precision and digital agriculture in the managements adopted in commercial crops in the state of Paraná, Brazil.

METHODOLOGY

The study was carried out in the state of Paraná, located in the southern region of Brazil, which has ten mesoregions geographically divided by the Brazilian Institute of Geography and Statistics (IBGE) (Figure 1), with 14.7 million hectares used in production farming in 305,000 rural establishments (IBGE, 2017).

Figure 1 - Mesoregions in the state of Paraná, South Brazil



Source: the authors.

The direct evaluation of digital agriculture in the state took place through a digital interview with sixty (60) farmers, with the aid of a questionnaire directed at them. Google's questionnaire platform was used to facilitate the completion and acquisition of data through the link: https://forms.gle/23WkFyS9VfynvTEt8. The interview was conducted from July 2019 to February 2020 through the WhatsApp messaging app, and through agronomists who have direct contact with rural producers, who were randomly selected in different regions of Paraná.

The questions asked in the questionnaire were organized based on studies already carried out with PA by Soares Filho and Cunha (2015) and Pires Junior *et al.* (2018), which take into account the negative and positive points of services and equipment, and improved to obtain information about DA (knowledge and tools) by Paraná producers, being defined as:

- Paraná Regions
- Age
- Schooling
- Property Area
- What are your main sources of information about new technologies for agriculture?
- Do you use Precision Agriculture?
- Have you ever used application at a varied rate in your crop?
- Which technological items do you have?
- Do you have internet access in your property?
- How is the quality of mobile phone access within the property perimeter like?
- Do you know what is "Digital Agriculture" or "Agri 4.0"?
- Do you use satellite images of your crop?
- Do you use GPS and automatic pilot?
- Have you ever used drones in your crop?
- Do you know the meaning of "management zones"?
- Do you know what is "Digital Agriculture Platform"?
- Do you use any Digital Agriculture platform? Which one?
- Do you believe it is possible to improve the crop managements with Digital Agriculture?
- What are the limitations which prevent you from acquiring the technologies of Digital Agriculture?

From the data collected by the questionnaire, they were classified according to the responses obtained. The first diagnosis carried out with the interviewed producers was about the personal and socioeconomic characteristics, to understand the profile of the rural producers, and later, investigations were carried out on the technological uses with a focus on agribusiness.

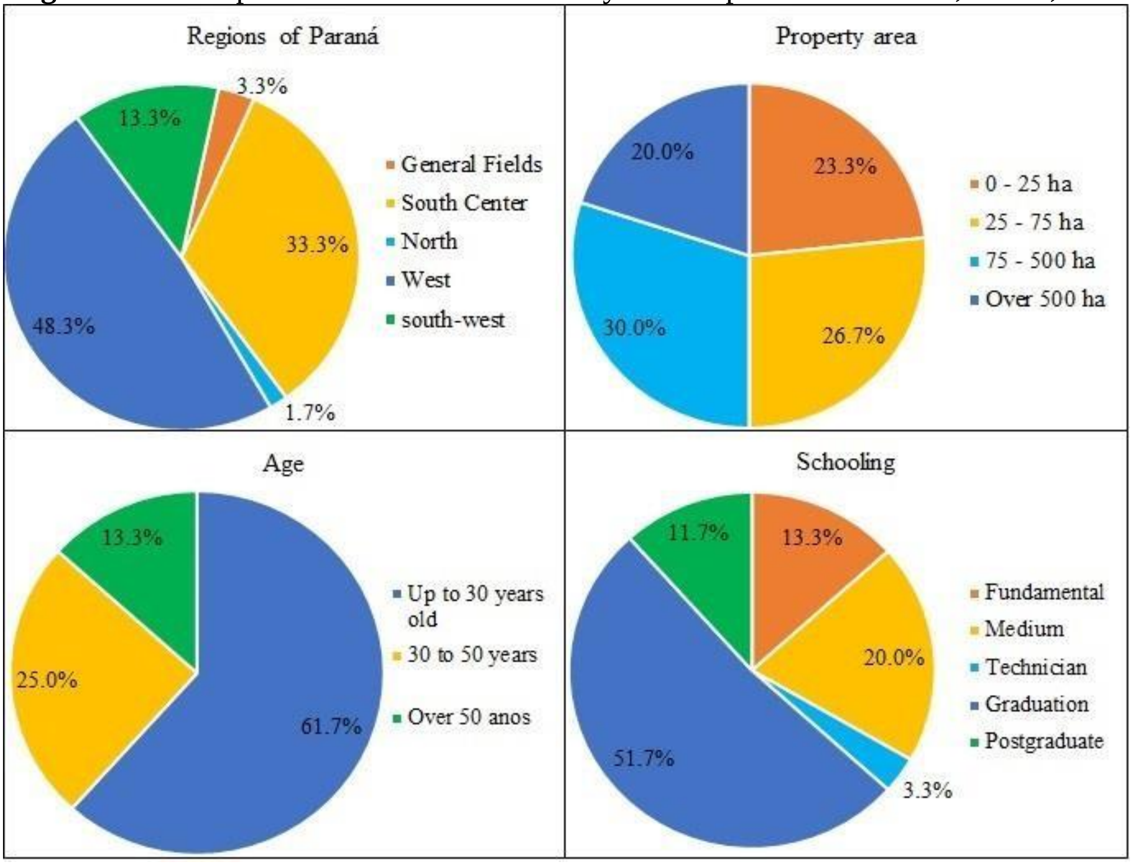
RESULTS AND DISCUSSION

The first diagnosis made was regarding the geographic region of the state (Figure 2), and it was observed that 81.6% of respondents were concentrated in the West and Center-South region due to the agronomists who helped being from these regions, which represent two regions with great importance in the agricultural sector of the state. On the other hand, there were few respondents in the North region; It is noteworthy that in total the state should produce 20.38 million tons of soybeans in the 2020/21 harvest (DERAL, 2020).

The diversity of properties is confirmed by evaluating the size of the properties, as shown in Figure 2. An adequate representation was obtained, with four well distributed classes, from small rural producers (less than 25 ha) to large farms (over 500 ha).

When evaluating the age range of rural producers, they were divided into three groups (Figure 2), and it was possible to note that rural producers of different ages were interviewed, with the youngest being 18 years old to the oldest being 72 years old. It was observed that 60% of respondents were up to 30 years old, which is interesting from the point of view of evaluating and discussing future prospects for digital agriculture. In Figure 2 it can be seen that more than 50% of the producers have an undergraduate degree and 11% already have some specialization or postgraduate degree. On the other hand, there is a considerable number who only have primary and secondary education (about 33%), which is mainly justified by the lack of opportunity and access to education in the final decades of the twentieth century by the current elderly. The education of rural producers directly impacts the adoption of new technologies, it appears that there is a greater search for studies by farmers and their children from the 21st century onwards.

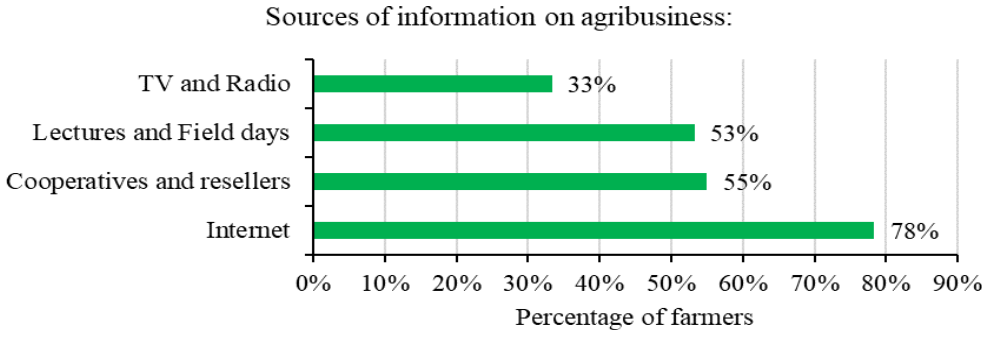
Figure 2 - Descriptive characteristics of surveyed rural producers. Paraná, Brazil, 2020



Source: the authors.

Rural producers were asked about their sources of information on issues related to agribusiness, highlighting that 78% of them claim that the internet is used for such, which is even higher in relation to physical presence in lectures and in companies in the sector, 53 and 55% respectively (Figure 3). A different result to the Southwest of Goiás under study until 2015, in which, for a group of 43 farmers, the main sources of information on PA are agricultural consulting companies and fairs and exhibitions (SOARES FILHO; CUNHA, 2015). The difference in result may be related to the speed of use of smartphones, especially with the intensification of applications and internet access in the last years of the 2010s and early 2020s.

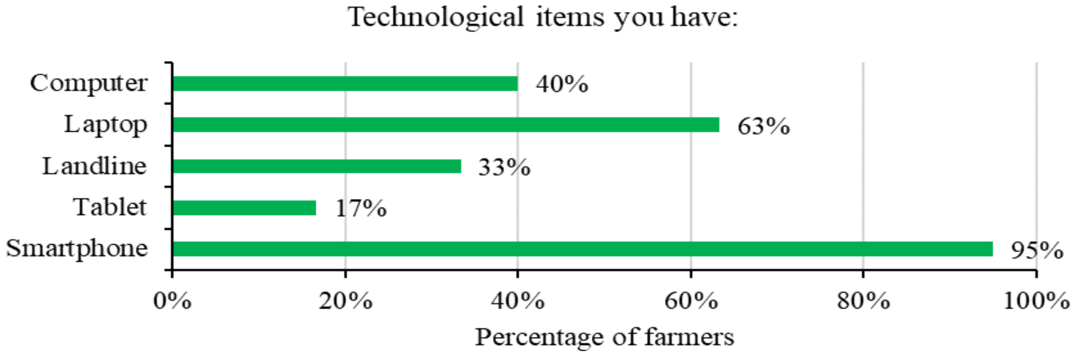
Figure 3 - Sources of information of the rural producers. Paraná, Brazil, 2020



Source: the authors.

When asked about which items or technological tools they have, the result found on smartphones stands out, in which 95% of respondents say they already have it (Figure 4), indicating that several tools such as digital platforms in an API application system can already be acquired by rural producers. A similar research by Silveira and Schwartz (2011), with rural produces from Rio Grande do Sul (RS) in 2006, revealed that 88.5% of rural family producers in Santa Maria, RS, had a mobile phone and that this communication technology is already the third most used one, only behind radio and television, confirming that smartphones already had the potential for use in the early 2010s.

Figure 4 - Technological items which rural produces say they have. Paraná, Brazil, 2020

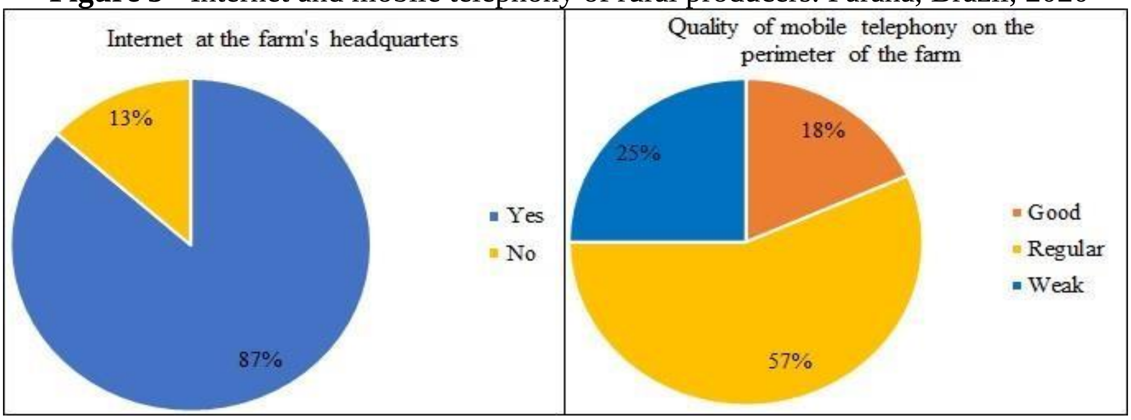


Source: the authors.

With the positive diagnosis regarding smartphones, it is necessary they have the internet available for updates and the operation of many tools. Thus, they were asked about the presence of internet at the farm's headquarters, to which 87% already have access. On the other hand, the quality of mobile telephony throughout the property's perimeter still seems to be limited, as 82% still judge this service as Poor or Fair (Figure 5). This fact highlights the improvement of the internet system for use on rural properties in view of digital agriculture.

It is noteworthy that the advance of telecommunication in the rural area and the insertion of the internet meant that there was a fast and growing initiative by developers and programmers to create platforms for use in agribusiness, enabling a new market, and with great prospects for investment and growth over the next few years. However, as highlighted by Nicocelli Netto (2020), one of the greatest challenges for the expansion of DA still is the lack of connectivity in the field.

Figure 5 - Internet and mobile telephony of rural producers. Paraná, Brazil, 2020



Source: the authors.

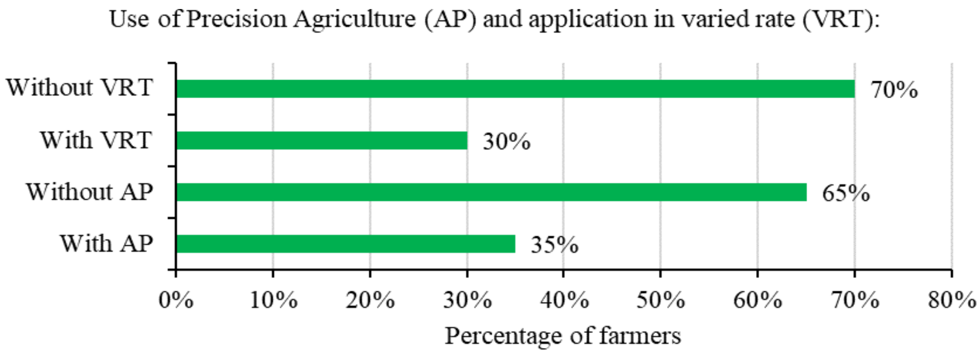
In search of improvements in internet coverage in these areas, several companies (AGCO, Climate, CNH Industrial, Jacto, Nokia, Solinftec, Tim and Trimble) got together and created ConectarAGRO, an association that facilitates the expansion of 4G mobile internet, and which has already served more than 5.1 million hectares of productive areas in Brazil (CONECTARAGRO, 2020).

In assessing the use of PA, as shown in Figure 6, only 35% of rural producers in Paraná adopt some PA technique, a result close to that found by the Kleffmann Group survey in three producing areas in Brazil (Mapitoba, Midwest and South), which obtained 45% of respondents with PA technology in use on the property (MOLIN, 2017).

In addition, when asked whether they use the application of inputs at a varied rate, as correctives and fertilizers, which is one of the most used technologies by the PA, the number of rural producers is even smaller, represented by only 30% (Figure 6). Soares Filho and Cunha (2015) verified 91% of rural producers in the Southwest of Goiás using PA technology with variable rate of inputs, probably due to the presence of larger areas and with the use of high technology in this Brazilian region. In international level, for example Australia, the use of variable rate in 2009 was already of 20% among rural producers, and it may have increased after the last decade (ROBERTSON *et al.*, 2012).

There are several challenges for PA, most of which are in understanding the main causes of variability in the characteristics of soils and plants which interfere with adequate and specific agronomic recommendations for application at variable rate (BASSOI *et al.*, 2019). Within this context, in Paraná, with the presence of a large number of properties and of different sizes, there is a diversity of production systems, requiring careful evaluation for correct recommendation. In Paraná, the reduced size of properties is a considerable factor which reduces adherence by rural producers due to the high cost of investing in PA technologies.

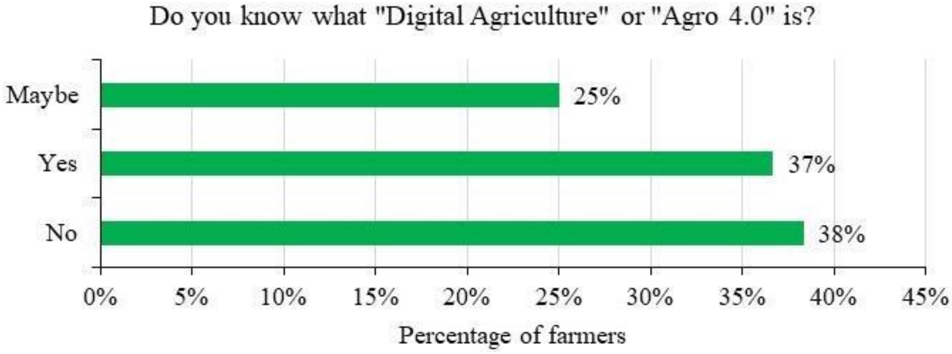
Figure 6 - Use of Precision Agriculture (PA). Paraná, Brazil, 2020.



Source: the authors.

Only 37% of the rural producers interviewed know and understand the definition of the term Digital Agriculture or Agri 4.0, and some (25%) still have doubts about the concept (Figure 7). According to Borém (2020), Digital Agriculture can be seen as an evolution of Precision Agriculture, which goes beyond the generation of data, but is intended for agricultural management, with acquisition, processing and analysis of spatial and temporal data, serving as a fundamental tool for the rural producer in decision-making.

Figure 7 - Knowledge about Digital Agriculture. Paraná, Brazil, 2020



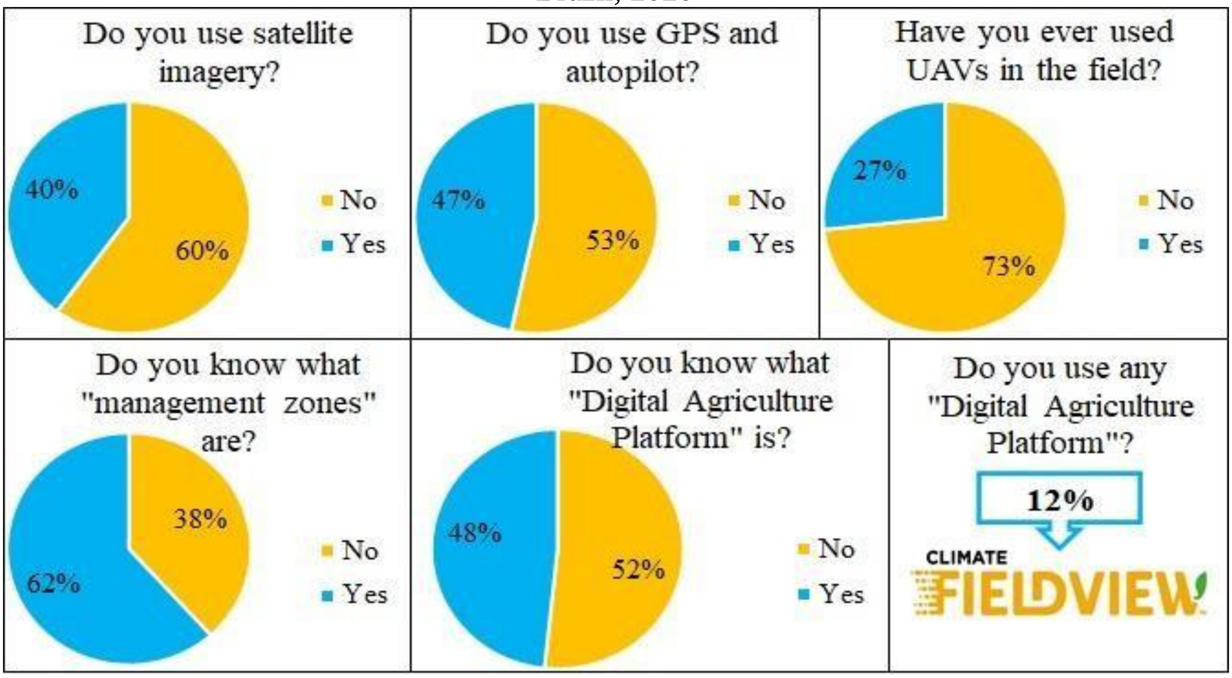
Source: the authors.

The use of satellite images is adhered to by only 40% of rural producers (Figure 8). This result was similar to that found in Goiás, where 34% of rural producers use satellite images in the mid-2010s (SOARES FILHO; CUNHA, 2015). In Figure 8, it is possible to verify that the use of satellite images ranges from the simple delimitation of the area of a property for environmental projects to the use in PA and DA, since vegetation indices and establishment of management zones as mentioned by Bernardi *et al.* (2014) and/or management units can be generated (RAMPIM *et al*., 2012; SANTI *et al*., 2016).

The use of UAVs, although less used than satellites, is a reality in only 27% of the crops in Paraná (Figure 8). Over the last decade, UAVs technologies have evolved and expanded the possibility for applications and utility. Airborne images in PA include not only weed mapping, but also vigor mapping, nutrient deficiency detection, pest susceptibility, biomass estimation, and pasture monitoring (SANTOS *et al*., 2019).

The application of the use of UAVs is similar to the use of satellite imagery, but the aerial UAVs images obtained are of greater accuracy and higher quality and can be used to assess spatial variations in crop biomass and potential crop productivity using the Normalized Difference Vegetation Index (NDVI) (MULLA, 2013). With this information, it allows for more detailed investigation and recommendation with greater efficiency to increase the productivity of production systems.

Figure 8 - Digital and Precision Agriculture Technologies used by the rural producers. Paraná, Brazil, 2020



Source: the authors.

In the present study, the result on the use of GPS and autopilot did not reach half of the rural producers (47%) (Figure 8), being below the general evaluation of producing areas in Brazil surveyed by the Kleffman Group, in which 60% demonstrate using automatic pilot (MOLIN, 2017). As well as in the work by Soares Filho and Cunha (2015), in which 68% of respondents in the Southwest of Goiás use autopilot. Such researches involved larger producing areas, making it possible to introduce PA technologies more quickly. With the advancement of GPSs (Global Positioning Systems), PA gained more space by installing machines for harvesting, initially for grain, enabling the reading of the spatial variability of crop productivity (BASSOI *et al.*, 2019).

The term management zone is known by most respondents from Paraná (62%). One of the techniques adopted in PA and DA is the determination of management zones, which can be defined as portions of an area within the same plot or between plots that have similar soil and plant characteristics, and can be treated as an equal area concerning their characteristics or productivity levels, so similar managements can be used.

When asked about the use of any digital agriculture platform, 12% of respondents have used the Climate FieldView platform (Figure 8). This Climate Corporation platform is among the first ones, as it was launched in 2017 in Brazil, with the aim of revolutionizing the way Brazilian rural producers manage their properties with data science tools. Data collection is carried out from a small device connected to agricultural equipment in the crop which receives information about what is happening on the machines in real time and manages to quantify factors such as sowing speed and productivity. The connection is made via Bluetooth to the tablet and optimizes the collection time of this information, thus, it arrives in high resolution and in real time (HORTA; PIMENTA, 2017).

Other companies which perform this type of monitoring of machine operations are John Deere's Operations Center, Farmers Edge's FarmCommand and Solinftec's SGPA. The most diverse sensors on the machines pass information through the Controller Area Network (CAN), which transfers data and processes them in a cloud, so that users can then access them on computers, tablets and smartphones (QUEIROZ *et al.*, 2020).

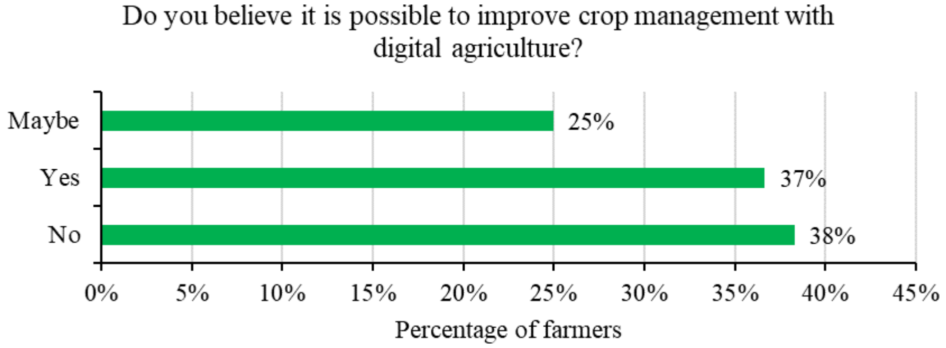
An interesting advantage of some platforms such as Climate FieldView is that there is no need for real-time internet connectivity for its operation, as the machine transfers the data through the drive connected to the CAN port to the tablet's internal memory temporarily, which in turn stores it in the cloud to be processed in sequence using the internet.

Numerous startups have developed solutions in the form of digital platforms, such as Agrosmart, Strider, InCeres, Datafarm, FarmBox and Granular. Many of them are acquired by multinationals in the agricultural sector, which benefits improvements in their development (VILLAFUERTE *et al.*, 2018). The most recent one launched in August 2020 in Brazil is Basf's Xarvio Field Manager, with the aim of efficiently revolutionizing the management and control of weeds, planning and spraying at a variable rate based on satellite images and UAVs.

There is a potential for the use of DA by rural producers in Paraná, as only 38% believe that it is not really possible to improve the managements adopted in production (Figure 9). Similar result to the Kleffmann Group survey, which when asked if they intend to continue investing in new technologies, 58% of respondents answered affirmatively (MOLIN, 2017).

The result also demonstrates the producer's distrust in DA, since when added the answers “maybe” and “no”, 63% of producers still do not see DA as a promising tool or one which will solve their problems. This fact may be related to small producers, which is a reality in the state of Paraná, and it is pertinent to highlight that half of the interviewees in this study have less than 75 ha. Therefore, the smaller the property, there is a tendency for the machines to be less compatible with the technology and, consequently, less trust by the producer.

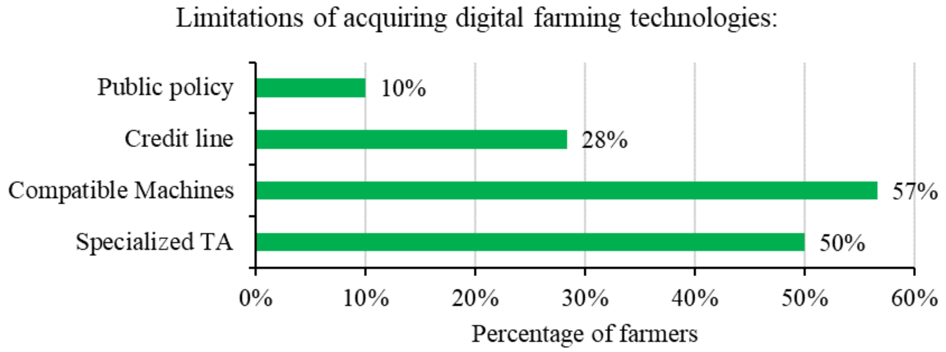
Figure 9 - Rural producers trust in Digital Agriculture. Paraná, Brazil, 2020



Source: the authors.

As shown in figure 10, the main limitations for the use of DA, highlighted by rural producers, are the lack of compatible machines (57%) and specialized technical assistance (50%). The difficulty of compatibility of machines and software for use was also considered a limiting factor in Australia (ROBERTSON *et al.*, 2012). As also seen in the work by Soares Filho and Cunha (2015), in which the lack of qualified staff is a major limiting factor to the use of PA, being observed by 80% of the rural producers. It is necessary that machines and equipment become more suitable for rural producers, and that there is training for technicians, producers and service providers to adopt the new technologies available (BASSOI *et al.*, 2019).

Figure 10 - Limitations on the use of Digital Agriculture. Paraná, Brazil, 2020



Source: the authors.

Among the factors that limit the adoption of digital agriculture by small rural producers, the high acquisition cost, large dimensions and the need for trained professionals to operate and maintain this equipment stand out. Therefore, efforts are needed to serve small rural producers with these PA and DA technologies, as they are responsible for feeding about a third of the world population, both by associations, assistance from city halls and cooperatives, making it possible to share PA technologies and DA systems (QUEIROZ *et al.*, 2020).

According to Sarker (2019), DA also addresses environmental issues, as sustainable agricultural development is now a priority issue to feed the growing population in the future around the world, with the global needs for optimizing natural resources. Electronics play a fundamental role in the development of tools that enable the reduction of harmful agents to the environment, such as fungicides and insecticides used in abundant quantities to reduce the effects of pests and diseases (JIMENEZ *et al.*, 2010).

The strengthening of PA technologies and advances in DA tools in a greater number of rural properties are related to the reduction of the cost of technologies, more qualified labor both on the properties and for the use and application of PA and DA, especially at times when high crop productivity is achieved and high prices have been established as a moment for rural producers to invest in new technologies. Furthermore, it is necessary to strengthen the importance of cooperatives, city halls, farmer entities and associations to join forces to make use of PA and DA.

FINAL CONSIDERATIONS

Most rural producers in Paraná already have smartphones and internet access, but with a lack of knowledge in basic concepts about Digital Agriculture, and with a reduced number of those who already use Precision Agriculture.

Many believe that it is possible to improve property management and agricultural management with Digital Agriculture, and only a few already use a digital agriculture platform.

However, there are still many challenges to be overcome by the public and private sector, such as quality mobile telephony, compatible machines and specialized technical assistance.

With the ever faster advancement of technology and already evolving to Agri 5.0, studies like this are suggested to spread the reality and update the rural producer, who is directly involved in daily activities in the rural field.

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