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MOBILE APPLICATION FOR ADJUSTING AIR-BLAST SPRAYERS IN COFFEE PLANTATION

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KEYWORDS

Coffea arabica, application technology, digital agriculture, agricultural mechanization.

ABSTRACT

Mobile application development advances, particularly for smartphones and tablets, have allowed farmers to make decisions more assertively in their agrobusiness management. This article addresses the development and evaluation of an app aimed at people who deal with the pesticide application technology in coffee farming, more specifically, adjustment and calibration of sprayers. This mobile app provides the main data necessary for a correct calibration of air-blast sprayers to apply pesticides in coffee planting. Its functionalities include calculation of the application rate for each situation (L ha^{-1}) based on data obtained in the field, such as canopy volume. The app, called SprayCafé, was developed for the Android platform using the Java programming language in the integrated development environment Android Studio. After the development, the application was evaluated, based on a questionnaire answered by 139 users, who ranked the following requirements: ease of use, loading time, adequacy of screen resolution, data relevance, sequence of information, and applicability, among others. The system proved to be simple and robust; it was thus assessed as adequate to the field and to be of great value for coffee planting, especially because it allows safer and more adequate pesticide application. The graphical user interface is interactive and easy to use.

INTRODUCTION

The rapid technological advances and hardware improvements of mobile devices (smartphones and tablets) have enabled the development of more advanced operating systems. These advances have facilitated the development of applications (apps) with better resources and user services (Tanaka et al., 2020). Currently, Android is the most popular mobile platform in the world, with an active community of developers (Araújo, 2020).

Agriculture can benefit greatly from mobility and remote access to information provided by such mobile apps (Lopes et al., 2020). Being the source of food, the agricultural sector is among the most important business sectors. However, the development of agricultural mobile apps, commonly called AppMAs, has been neglected in terms of new technology applications (Karetsos et al., 2014; Jain et al., 2015). Costopoulou et al. (2016), when studying the availability of existing AppMAs on a global scale, found that there are few apps dedicated to the agricultural sector considering the significance of the activity across the globe.

In the crop protection, one variable that is difficult to determine is the pesticide application rate, mainly in tree crops. The rates used in coffee plantations generally vary between 400 and 800 L ha^{-1}, and can reach 1000 L ha^{-1}, irrespective of the vegetation volume (Covre et al., 2020). Therefore, this rate must be adjusted to allow satisfactory wetting of the plant canopy with minimum run-off loss (Gitirana Neto et al., 2016). However, as there is great variability in the volume of coffee tree canopies, a more refined methodology is necessary to tailor this rate to each situation. The adjustment of the application rate in relation to the volume of the canopy has proven to be a successful method to make applications more efficient (Sousa Júnior et al., 2017).

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In view of this, this study aimed to develop and evaluate a mobile app for Android, aimed at people who deal with the technology of application of phytosanitary products in coffee farming (more specifically, adjustment and calibration of sprayers).

MATERIAL AND METHODS

The Android Studio technology platform, version 2.1.1, made available by Android, was used to develop the agricultural mobile app. Programming was developed specifically to meet the needs of rural and technical producers regarding the application technology of phytosanitary products for coffee growing. Extra functions such as mobile internet access, 3D rendering, and high-resolution images were not used as the intention was to include the largest number of compatible devices and reduce the demand for processing.

The Java programming language was used in the Android Studio platform to deploy the application for Android. The API version recommended by Android Studio was version 16 - Android 4.1 (Jelly Bean).

Android Studio is an integrated development environment (IDE) that facilitates development of new projects for the Android platform. Available free under the Apache 2.0 license, it is a complete tool that offers several features, such as the layout editor, which allows users to drag interface components and preview the layout using various screen configurations.

The AppMA, called SprayCafé, encompasses the procedures for calculating the application rate of pesticides for different types of coffee trees. It was developed in the Portuguese language to increase the possibility of adoption in rural areas in Brazil, which is the world's largest coffee producer (Alves & Lindner, 2020). In the future it will be translated into English.

It allows the calculation of the application rate by two methods: the first is based on the fixed and predefined application rates used by producers in applications whose targets are located on the leaves of the coffee tree; the second considers the characteristics of the crop and the volume of the canopy, as measured by Tree-Row Volume *(*TRV), developed by Byers et al. (1971). For this purpose, the volume index (VI) information previously obtained in tests for deposition of sprayed liquid on coffee leaves according to different rates of application and canopy volume, performed by Alves et al. (2020), was used.

The operational routine was adapted from DOSAVIÑA computer program. This program had previously been developed by Gil (2008) for the calibration of sprayers on vines.

The SprayCafé app was created so that based on data collected from different coffee plots, it was possible to calibrate the air-blast sprayer, thus facilitating more assertive decisions. The initial interface of the app shows the user the main information about the purpose of the app and the steps to use and calibrate the sprayer.

After determining the sprayer's working speed under field conditions or directly inputting the speed, the user is directed to a screen where one of the methods to adjust the sprayer can be selected: (i) conventional, based on a predefined application rate, or (ii) from the TRV.

If the user does not opt for the calculation of the application rate (L ha^{-1}) using the TRV method, a pre-established application rate can be inputted. From this data, the app provides options for spray tips to meet the needs of the application in the crop.

If the technical manager chooses the TRV method, it is necessary to insert the dimensional data of the canopy of the trees collected in the different plots, so that the system determines the volume of the canopy of coffee plants (m^3 ha^{-1}). Subsequently, the app directs the user to the screen to calculate the application rate for the different plots, based on VIs specific to the coffee crop, to adapt the application rate to each distinct situation in which the crop is found. It is then possible to calculate the flow rate (L min^{-1}) for the choice of the spray tip.

To determine the application rate (L ha^{-1}), the SprayCafé app is based on the following formula (Equation 1).

$$\text{AR} = \frac{\text{TRV} \times \text{VI}}{1000} \tag{1}$$

In which:

AR - application rate (L ha^{-1});

TRV - tree row volume (m^3 ha^{-1}), and

VI - volume index (L 1000 m^{-3}).

Based on the determined flow rate, the program offers options of spray tip models. A database with different brands of hollow cone spray tips already exists; this app therefore focused on this tip model due to its preferential use in coffee plantations. In the future, if there is a demand, it would be possible to include new models and brands of spray tips. Among the options provided, the one that meets the calculated flow rate (L min^{-1}) should be sought, but considering that this flow rate should occur with the most appropriate pressure for the working conditions. The pressure unit used was the bar, also chosen due to its widespread use.

Since several spray tip models do not use the ISO 10625 (ISO, 2018) color-coding standard as a function of flow rate, it was decided to place the flow rate data for each model and manufacturer. However, there is also an option to use the ISO color-coding, giving the user the possibility to choose.

Following selection of the hydraulic tip that best meets the working conditions, the app calculates the new working pressure, which must be adjusted to apply the flow rate (L min^{-1}) set in the previous step, using (Equation 2).

$$\frac{\text{Flow Rate 1}}{\text{Flow Rate 2}} = \frac{\sqrt{\text{Pressure 1}}}{\sqrt{\text{Pressure 2}}} \tag{2}$$

In which:

Flow Rate 1 - flow rate of the known tip, L min^{-1};

Flow Rate 2 - tip flow rate calculated by the application, L min^{-1};

√Pressure 1 - known tip pressure, bar, and

√Pressure 2 - new working pressure for the required flow, bar.

Once the new working pressure of the sprayer is adjusted, the flow rate of the tip must be checked. It is necessary to collect the liquid, at the working speed of the engine (540 rpm at the power outlet) and in the known time, preferably 1 min. If the flow variations are greater than 10%

in relation to the calculated flow of the hydraulic tip, the tips must be changed.

The app also calculates the amount of phytosanitary product to be placed by the user in the sprayer tank. This is the last step of the calculation performed by the app to determine the correct destination of the phytosanitary product in coffee plantations. The app uses (Equation 3).

$$Pr = \frac{Tc \times D}{AR} \tag{3}$$

In which:

Pr - quantity of phytosanitary product per tank (kg or L);

Tc - tank capacity of the sprayer (L);

D - dosage of the phytosanitary product (kg ha^{-1} or L ha^{-1}), and

AR - application rate (L ha^{-1}).

The app was submitted for evaluation of use by volunteers with different mobile device models. It focused on users with links to the agricultural sector, such as agronomists, agricultural technicians, students of Agricultural Sciences, and farmers. The search for volunteers was made at random through social networks, coffee cooperatives and higher education institutions with a course in agronomy.

Initially, the installation of the app on smartphones was made available to volunteers who showed interest. Later, an evaluation in the form of a questionnaire was proposed to users of the app final version. The indication was to evaluate usability (Bastien, 2010) under the following aspects: ease of use, loading time, adequacy of screen resolution, sequence of information, and data relevance. Gender, age, and education were also obtained, among other information. The data were then compiled using descriptive statistics.

RESULTS AND DISCUSSION

The content of the SprayCafé app was made available through an installation executable file. After use, 139 questionnaires were returned. The user profile comprised both genders, with a predominance of males (62.59%). In regard to schooling levels, 43.88% were attending or had already completed higher education in the area of Agricultural Sciences. Of the users, 84.17% were between 15 and 29 years old (Table 1).

TABLE 1. Distribution of responses on the sociodemographic data of the SprayCafé app evaluators.

Parameter	Quantity	
	Absolute	(%)
Sex:		
Male	87	62.59
Female	52	37.41
Schooling:		
Postgraduate (Agricultural Sciences)	12	8.63
Postgraduate (other areas)	2	1.44
Higher education complete/in progress (Agricultural Sciences)	61	43.88
Complete/ongoing higher education (other areas)	1	0.72
Technical high school (Agricultural Sciences)	32	23.02
High school complete technical/in progress	23	16.55
Elementary school complete/incomplete	8	5.76
Age range (years)		
15-29	117	84.17
30-40	15	10.79
41-50	4	2.88
>50	3	2.16

Maia & Cunha (2011) developed and evaluated a desktop program (software) aimed at distance learning about application technology. The authors obtained results similar to those recorded now regarding sociodemographic data.

In general, the app met the users' objectives (Table 2), indicating good relevance of data (74.82%), easy use (86.33%), coherent sequence of information (88.49%), and good applicability (76.98%). As a result, both students and professionals dealing with application technology have an additional tool to better develop their activities, mainly regarding the application of phytosanitary products in coffee growing, through the use of different technological resources and information sources. The results also demonstrated the relevant contribution of the app to the teaching and learning spray process. They state the efficiency of distance education compared to the traditional study methods. This is due to the fact that the system makes the learning task more active (Maia & Cunha, 2011).

TABLE 2. Distribution of answers to questions about the environment, pedagogical design, and relevance of the SprayCafé app.

Parameter	Quantity	
	Absolute	(%)
Relevance of the data:		
Relevance to practice	104	74.82
Partly relevant to practice	20	14.39
Irrelevant to practice	0	0.00
No opinion	15	10.79
Is the application easy to use? (Self-explanatory)		
Simple	120	86.33
Complicated	5	3.60
No opinion	14	10.07
Is the sequence of the information presented adequate?		
Yes	123	88.49
No	0	0.00
No opinion	16	11.51
Applicability (in the company/in the organization/in the day to day/in the field)		
Great application	107	76.98
No application	8	5.76
No opinion	24	17.26

Thus, agriculture can benefit from the use of these new technological tools, such as portable devices. With this, decision making becomes more assertive, allowing optimization of work (Massruhá & Leite, 2016).

Maia & Cunha (2011), who developed the program Pulverizar, for teaching application technology, reported that the program proved to be simple, robust, and practical in complementing the teaching for the training of professionals in the field of Agricultural Sciences related to the area of application of pesticides. Similar to the present app, the authors showed the potential of this type of tool by achieving success in the use of digital technologies for the agricultural sector.

According to Reinaldo et al. (2016), Information and Communication Technologies (ICTs) directly influence educational methods by introducing digital resources, as they affect not only the teaching-learning process, but also the acquisition and transfer of knowledge. In their conception, smartphones should not be seen as "saviors" of teaching, but rather as resources to be used rationally to achieve modernization and diversification of educational methods.

The inclusion of smartphones provides a modern and attractive pedagogical resource, enabling the exploration of new learning opportunities, with the integration of technology (Medeiros et al., 2019). The use of mobile devices in the classroom as a pedagogical tool is possible, and thus far, we have far from exhausted their possibilities of use; however, this technology must be used with responsibility, commitment, and effort to transform information and knowledge (Pontes & Ramos, 2020).

Interoperability was achieved for this app, as evidenced in this study; the screen resolution proved to be appropriate for different mobile devices, the charging time was adequate for most users, and a considerable number of technical failures were not recorded during use (Table 3).

TABLE 3. Distribution of answers to questions regarding the functionality and interactivity of the SprayCafé app.

Parameter	Quantity	
	Absolute	(%)
Application loading/opening time (efficiency)		
Suitable	117	84.17
Inadequate	2	1.44
No opinion	20	14.39
Adequacy of mobile device screen resolution - Aesthetics and graphic quality		
Excellent	70	50.36
Good	42	30.22
Regular	10	7.19
Weak	3	2.16
Bad	0	0.00
No opinion	14	10.07
Did technical problems occur during use?		
Yes	6	4.32
No	133	95.68
Meeting your application technology expectations		
Satisfied	120	86.33
Dissatisfied	2	1.44
No opinion	17	12.23
Screen formatting (layout construction)		
Excellent	39	28.05
Good	61	43.88
Regular	17	12.23
Weak	2	1.45
Bad	0	0.00
No opinion	20	14.39
In your opinion, can the application be used by any professional or student of Agricultural Sciences?		
Yes	124	89.21
No	5	3.60
No opinion	10	7.19
When you had questions, did you resort to reports?		
Yes	69	49.64
No	66	47.48
No opinion	4	2.88
General evaluation of the SprayCafé application		
Excellent	59	42.45
Good	68	48.92
Regular	2	1.44
Weak	0	0.00
Bad	0	0.00
No opinion	10	7.19

The simple and intuitive layout of the SprayCafé interface was designed to facilitate the use of the device and to meet the expectations of various users. Similar results were achieved by Oliveira et al. (2018), when analyzing an app that evaluates the spray quality in field conditions, which suggests the need to adapt the technologies to the reality of the public.

Agriculture can benefit greatly from smartphone mobility (Lopes et al., 2020). The SprayCafé app allows the use of the program on mobile devices with low processing capacity, requiring only the Android operating system. This system has revolutionized the use of intelligent equipment in several areas, including agriculture, and its use is becoming increasingly common among rural producers. This points out that the future of agriculture will inevitably involve digital tools.

Mobile devices are increasingly accessible. The market for AppMAs is growing (Massruhá & Leite, 2016).

According to Regasson et al. (2018), apps for spraying and related activities represent 3.54% of a total of 621 applications for agriculture. An app is only significant and relevant if it provides a noticeable solution (i.e., if, in addition to functioning correctly, it satisfies a need or a desire). The authors concluded that the number of agricultural apps does not meet all the existing needs and desires, and therefore, there is ample opportunity for new projects like the one developed in this study.

The adoption of Good Agricultural Practices (GAPs) in the application of phytosanitary products, which favors deposition in the desired target, is one of the ways to increase the efficiency of the applications, besides reducing losses and avoiding environmental contamination. It is also essential to know the spraying equipment and plant architecture (Van Zyl et al., 2013). In this context, the app fits very well, as it allows the application rate (L ha^{-1}) to be adjusted to the volume of the coffee plant canopy (m^3 ha^{-1}), providing an appropriate application for each situation.

Given the great portability and ease of use of the SprayCafé app, the growers can obtain improvements in the pesticide application technology in the field, especially in coffee crop, through more assertive decisions in the adjustment and calibration of airblast sprayers.

CONCLUSIONS

The developed app, called SprayCafé, was proven to be simple and robust, allowing its users to make more assertive decisions in the field, regarding the adjustment and calibration of sprayers for the application of phytosanitary products in coffee crop.

The app is useful and has an interactive and user-friendly graphic interface, requiring little technical knowledge in digital agriculture.

The app evaluation by users revealed that its conception was adequate to the reality of the field. It therefore presents great applicability and potential for optimizing spraying on coffee crop.

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