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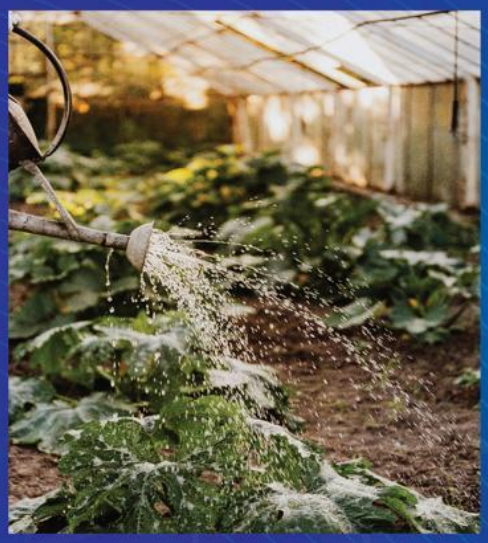

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MOBILE-BASED APPLICATION FOR AGRICULTURAL CROPS OF SILANG, CAVITE

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ABSTRACT

Farmers' awareness on fast-moving developments in technologies affects the agriculture operations. Smartphones have been useful in agriculture for their mobility and accessibility. The mobile-based application for agricultural crops of Silang was designed to provide information about crops. Information includes health benefits of the fruits, uses of the crops, and how its different parts can be develop to another product. The application is the first step towards understanding the benefits of the by-products of the crop in interactive way. The software development was anchored on agile model. The performance of the application was evaluated by 40 persons composed of subject matter experts including crops farmers and agriculturist, IT experts and potential users. The developed application was rated using Core App Quality Standard utilizing the criteria of Visual Design and User Interaction, Functionality, Compatibility, Performance and Stability, and Security. The app's performance was adherent to the standard as verified by the app's overall rating of excellent. The application will be able to help the crop farmer to get information in utilizing wastes into by-products, hence would be an opportunity to augment their income. It is recommended that the application may be added with crops available from other regions and consider a dynamic and cross-platform version of the app to maximize potential users.

Keywords: Agricultural crops, by-products, information system, Philippines

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INTRODUCTION

Agriculture has a great impact in life and in every economy. It is the backbone of the economic system (Azam, 2017) that provides not just food and raw materials but also employment to a large population. Competing in agriculture, the Association of South East Asian Nation (ASEAN) countries are not surprise to be the strongest in this field (Hoang, 2020). One of the evidences was stated by Food and Agriculture Organization (FAO), for there are crops that is becoming widely marketed and spread and a lot of countries are patronizing it. One of these countries is the United States which trades about $13 billion amount of goods and foods from ASEAN countries (US-ASEAN Business Council, 2019). Philippines as a member of ASEAN countries also exports agricultural goods to its neighbouring countries. In 2016, FAO estimated about 41.7% of the country's land is provided for agriculture. The country utilizes 33% of its area, contributing 9% to the GDP (Cahapin et al., 2019). The Department of Agriculture [DA] (2020) reported that there is 0.5% agricultural growth in the country within the period of April to June 2020. They have recorded 5% of growth in the country's crop production and it is part of the 53.7% of the country's total agricultural output. ASEAN Statistical Yearbook (2020) recorded that in 2019, the country produced 8,095.2 metric ton of corn and 2,637.2 metric ton of cassava, making it the top 3 and top 5 respectively on major commodities from 2010-2019 of ASEAN. Other crop production made in 2018 based on the records of ASEAN Statistical Yearbook are coffee which produced 60.3 metric tons; coconut with 14,726.2 metric tons; banana with 6,144.4 metric tons; mango with 725.1 metric tons and; pineapple with produced 711.4 million US dollars in 2019.

Agricultural sector plays an important role on every people living in Silang, Cavite as the municipality was considered as the highest in profitability and average in profit per hectare in cropping system. As of 2015, the Office of the Provincial Agriculturist reported that Municipality of Silang has the widest range area intended for agriculture in Cavite which counts 9,318.41 hectares. Ranked second for the crop production in the whole province reaching 37,708.92 metric tons produced, pineapple gave the strongest production with 20,350.00 metric tons followed by coffee recording 1,341.20 metric tons produced. This settles pineapple and coffee are the main products and as of 2019, the value of pineapple production costs up to P 1,522,031,250. Silang depends on agricultural economy since most of its lands are underdeveloped for infrastructure. Labios et al. (2019) stated that having a right soil type, considering the nutrients it has for a crop, can be factor for it to grow crops and produce good products. Moreover, Onwuka & Mang (2018) claimed that soil temperature

is also a factor in crop's growth because it acts as heat storage during the presence of sunlight and gives it off during at night. Calleja-Cabrere et al. (2020) stated that temperature also plays a part in a crop's growth. The higher the temperature also means a higher chance of loss in crops, resulting to claim that upland is more appropriate for crop farming than medium latitude areas. Hence, Silang is blooming with plants that mainly give off the products that are of export quality, thus giving the province a growth and its people an occupation as one of their sources of income.

In Silang, 3,563 farmers were given a job in 2019 because of agricultural activities, having a progression from the 2015 record of the Office of the Provincial Agriculturist counted 3,696 farmers. However, food wastes become one of the rising problems due to lack of technology and processes that would cater post-harvest intervention. The potential to develop by-products from the food wastes and remnants are not yet explored. Elss et al. (2005) claimed that agricultural products even its wastes or remnants could have a profitable impact on industry through the consumption and promotion of by-products. Farmers can take part on agriculture and digital technologies can give everyone an innovation opportunity. According to Aradhana (2016), technology will be useful in agricultural system for the farmers to select crop for cultivation mapping using different grounds parameters crop production method, fertilizer and tools. As the farmers adopt from the new techniques and production arises, more farmers will benefit from the technology. Adaption of technologies generates sustainability that is vital to contribute to the farm sector's financial practicality. Technology development is progressing at fast pace information on the cost and benefit of adopting technology in agriculture. Using of technologies in the agricultural sector leads to increase in production and sufficient food available to individual (Kapur, 2018).

The environment of Silang, Cavite matches its economic availability to grow and produce products that could give the provinces' jobs and inflate their earnings. The development of mobile application for agricultural crops would give information how crops can be developed and utilized as a new product. Silang has a large area provided for agriculture, a lot of crops have started emerging and being available on the local market. Farmers settle on the crop itself to offer in the market while several parts of the crops can still be used to produce another product, hence, will reduce the waste of raw materials. Alberto et al. (2019) stated that soil temperature in Cavite may vary among the places resulting in difference too in the plant's growth. In cooler places like uplands, the production of chemical responsible for the plant growth is higher compared to the places with a higher temperature. Identifying soil type

will be a great help to know what is right for the crops and it will add to the success of the province's land production. The new user of smartphones continues to grow in different sectors. Their levels of education, skills in farming and needs for information are also changing. New technology makes farms smarter, more productive and increases the farmers harvest every year. They may be used to develop suggestions and recommendation or new tools and technologies to enhance operation and increase the profits. In order to build this new tool, it would be further evaluated by the standards on what platform it was developed. Automation and machine with AI technology could have a huge advantage in harvesting and determine if the crops are ripe for picking and could boost the production compared to human picking. Robotics and autonomous machine-like drones are helping the farmers to gather data to have better information and decision for handling the fields and improve the quality of the soil. One of the major contributors of waste in the world is Philippines and most of it came from the fruit waste industries. To have a vital development of mobile application, it is important to maintain and update the data to reach people and get the newest information for the farmer's better experience. The importance of mobile phones for the enhancement of farmers to business towards agriculture is contributing in the economy for the future of the sustainable food and primary source of income.

Agriculture and technology may be different from each other but can be a factor to an improvement. It is very essential to utilize the importance of technology in our agricultural sector. The development of application can give insights to farmers obtain new and innovative uses of different parts of crops. Information dissemination using technology offer ways and new opportunities for farmers that can be tried using technologies that are available to them.

Objectives of the Study

The general objective of the study was to develop a mobile-based interactive information system for agricultural crops of Silang, Cavite. Specifically, it aimed to: (1) design the interactive information system of the android application in a wireframe; (2) develop the mobile application that features agricultural products, location of the crops, required soil type of crops, and soil temperature; and (3) assess the acceptance functionality of the developed application using Core App Quality standards.

MATERIALS AND METHODS

The development of mobile-based application for agricultural crops was anchored on descriptive-developmental approach. Richey (1994) describe the development research as

"the systematic study of designing, developing and evaluating processes that meet the criteria of effectiveness and consistency". In this study, the purpose was to obtain and present facts regarding software quality criteria on android development standard. In addition, this type of research focuses on attempts to determine or identify present issues through data collection (Ethridge, 2004; Fox & Bayat, 2007).

For the development of the application, the machine specifications used were 64-bit Windows 10 Home, AMD Ryzen 5 2500U with Radeon Vega Mobile Gfx 2.00GHz with 1 TB hard disk drive (HDD) and 8GB RAM. The software used in coding the application was Android Studio and Adobe Photoshop CS6 for the logo and icons.

Software Method: The study followed the agile model for software development. According to Dingsøyr as cited by Schmidt (2016), agile software development has been part of every company's daily work routine and adapted its way of developing projects. It is not developed but it "evolved from the personal experiences and collective wisdom of consultant".

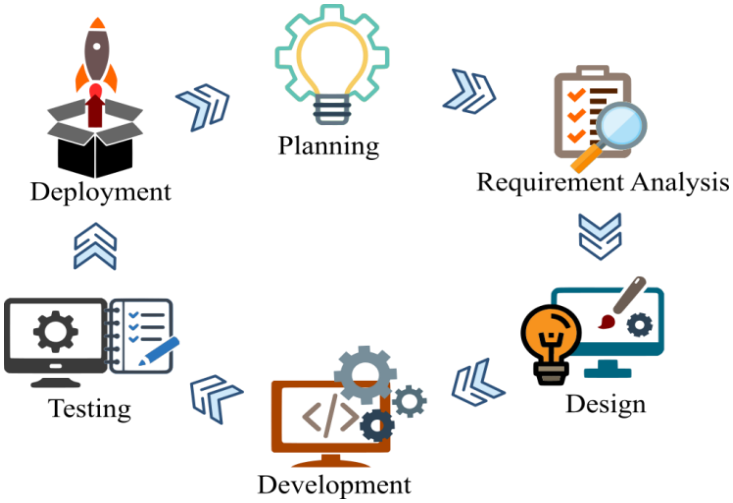

Figure 1. Agile Software Development Model

As illustrated in Figure 2, the agile model (Bencito et al., 2020), encompasses the steps followed to develop applications where these phases are planning, requirements analysis, designing, developing, testing, and deployment of the application. It is efficient to use as a software development for it urges a change in the system based on what the end-users needs and feedbacks. Planning phase. This phase deems plan, analyzing what is exactly needs to be done. A critical thinking how the plan would be executed is a must in this phase before handling it out to program design. The problem was identified and the goals were established. The goals were analyzed if it would fit for the beneficiaries of the study. The tasks for a certain time and date were set. Requirement analysis phase. The system and software

requirements are then formed based on what are the real needs of the user and then redefined until the project team and the user's satisfaction are both meet. The researchers used various approach in gathering data such as interview, observation and researches. The gathered data from the Municipal Agriculture of Silang, cooperatives and the Department of Trade and Industry (DTI) were organized to form a precise information.

Design Phase: Design phase shows executing a design on how the plan would work from the analysis phase. Wireframes and mock up designs for the application's architectural design was made.

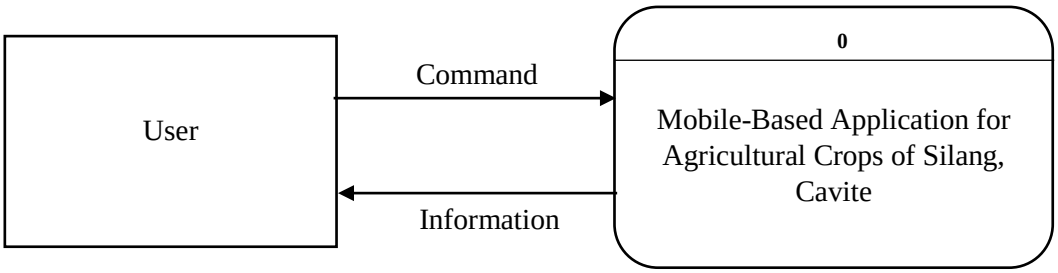

Figure 2. Context Diagram of Mobile-Based Application for Agricultural Crops

Figure 3 shows how the application works by the farmers/users giving command to the system and the system would give back the output or information, whether a user wants to know a location for crops, soil's temperature and type, or view crop's information by clicking its parts. Development phase. This phase converts all the plans and design into interfaces and codes. The mock up designs and wireframes were started to be implemented into a real system application.

Testing phase: This phase is the most critical part of the program where it is tested strictly then extracts the bugs and errors. The program is tested to ensure the objective of the study is met and to safeguard the user's experience is error-free. The system was deployed to the target users after a number of stress tests done from the solicited feedbacks.

Deployment phase: This phase covers the installation, maintenance, retirement process. The program is now deployed to target users and the project is implementing its functionality. If there are bugs or any feedbacks from the users that are needed to be fixed, it will be sent back to development and testing phase.

Population Frame and Sampling Scheme

The study used a convenience sampling on determining evaluators of the application. Taherdoost (2016) described this sampling design as affordable and time conserving since the

researchers can select the system evaluators who are accessible and reachable. The evaluators were consists of 29 potential users, 7 IT experts and 4 subject matter experts.

Evaluators of the Project

The subject matter expert evaluators of the developed application met the criteria of: (a) employee of the DA (b) a farmer, and (c) farmer's cooperative members.

The potential user evaluators of the study were the students who: (a) enrolled for current semester, (b) in Computer Science, Information Technology, Computer Engineering or any computer related program and (c) college students.

IT expert evaluators of the developed application were: (a) a graduate of Computer Science, Information Technology, Computer Engineering or any computer related program (b) working in the IT industry with job functions related to his field of study, and (c) teaching IT related subjects in his field of specialization.

Data Gathering

The researchers made a letter of request to have an interview with the agriculturist of Silang, Cavite. After approval, the researchers conducted interview with the agriculturist of the Municipality of Silang, Cavite. Another endorsed interview from the Municipal Agriculturist was held at the farmer's cooperative to gather data from the farmers. The last endorsed interview was held at the local DTI Office for the product's data. After data collection, the researchers designed and developed the system model. The researchers prepared a questionnaire for evaluation and it was disseminated to the evaluators. The data was sorted, organized, tabulated and interpreted the results accordingly.

Instrument

The study used a standardized questionnaire (Core App Quality) for software development. The questionnaire was modified based on the requirements of the study and system functionality. The farmers, IT students, and IT expert-respondent were requested to check the number of responses to specify the degree of their agreement on the indicators by using a 5-point scale. The mean ratings were interpreted and described based on their level of perceptions on the given indicators as follows: 4.20- 5.00; Excellent, 3.40- 4.19; Very Good, 2.60- 3.49; Good, to some extent 1.80- 2.59; Fair, 1.00- 1.79; Poor.

RESULTS AND DISCUSSION

The researchers designed a wireframe to plan how the application would be developed as illustrated in Figure 4 below.

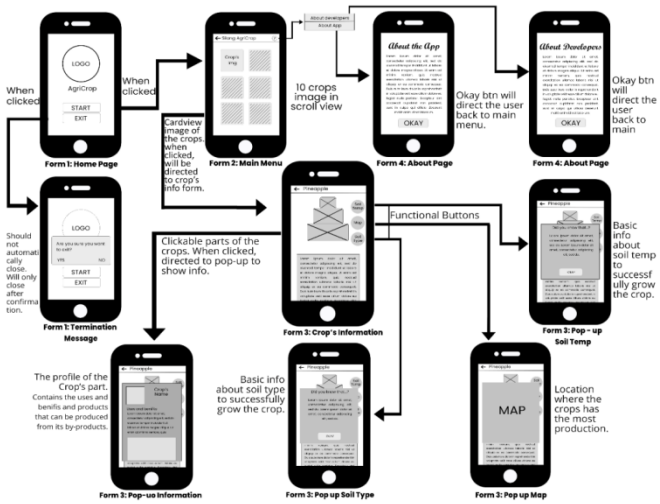

Figure 4. Wireframe of the application

To determine the flow of forms and buttons inside the application, Figure 4 illustrates a wireframe the researchers created as a blueprint of the system. It helped the researchers to control how the system would be created in organized way. The start button leads to main menu where the crops are placed and it included the About module. Every crop has a form that would appear when clicked, containing the information about the crops in interactive way. This information helped the farmers to formulate new ideas about the products that can be made out of every crop's part. The application that provided information depending on what the user wants to know about the crops. The system was developed using Android Studio as an Integrated Development Environment (IDE) and Adobe Photoshop for wireframing, mock up designs, vector art of crops, buttons, icons and the application's logo. The modules are as follows:

Figure 5. Main Menu

Figure 5 depicts the main menu of the application where it contains the 10 dominant crops in Silang where the users can choose what crop wants to know the information. This form also contains the About menu that has two (2) options: About the Developers and About the Application.

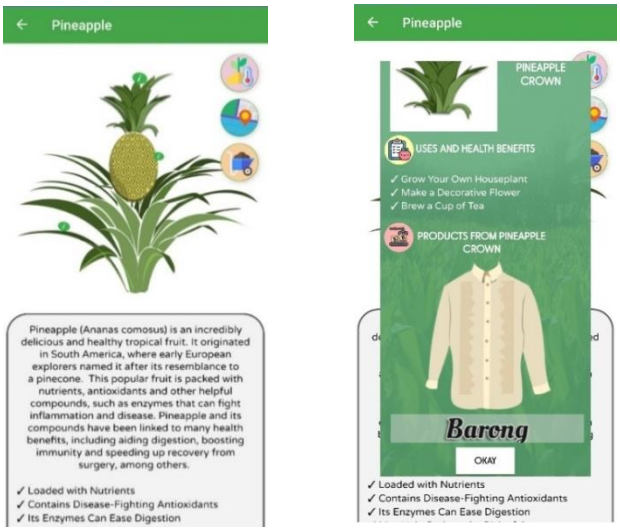

Figure 6. Crops Information View

Figure 6 shows the crops and its information such as its scientific name, its benefits and the reference link where the user can validate the information. The three (3) buttons on the right side encompasses the information for soil temperature where it can be successfully grown, crop's map, and soil type required to grow a healthy crop. The clickable part contains information about the crop part's materials such as uses and health benefits.

Figure 7. Crops Information Buttons

Figure 7 displays the information in map's button. The same output for crop's map's button, and soil temperature and soil type's button. The map feature holds the information where the

most dominant crop plantation and the companies that manufacture the crop products can be found around Silang. The development of mobile based 2D interactive system for agricultural crops was tested and evaluated by forty (40) evaluators consisting of four (4) farmers and employee of DA as subject matter experts, seven (7) IT Experts, and twenty-nine (29) students as potential users using Core App Quality.

Table 1. Overall Result of the Android-Based application from the evaluation of Potential Users of the App, Subject Matter Experts, and IT Professionals

Indicators	Mean	Standard Deviation	Verbal Interpretation
1. Visual Design and User Interaction	4.46	0.13	Excellent
2. Functionality	4.37	0.06	Excellent
3. Compatibility, Performance and Stability	4.39	0.11	Excellent
4. Security	4.42	0.05	Excellent
Overall Mean	**4.41**	**0.04**	**Excellent**

Scale: 4.20-5.00 Excellent; 3.40-4.19 Very Good; 2.60-3.39 Good; 1.80-2.59 Fair; 1.00-1.79 Poor

As seen in Table 1, the overall result of the developed application of agricultural crops obtained a composite mean score of 4.41 with a standard deviation of 0.04 and verbal interpretation of Excellent. The highest ($\bar{x}$ =4.46) was obtained by Visual Design and User Interaction with 0.13 standard deviation to denote a verbal interpretation of excellent. On the other hand, the lowest ($\bar{x}$ =4.37) was Functionality with standard deviation of 0.06 with a verbal interpretation of excellent, respectively.

Visual Design and User Interaction

The visual design and user interaction obtained a composite mean of 4.46 and 0.13 standard deviation to denote excellent. This means that the app's design conform to the core app quality standard of android application. The app evaluators perceived its features as complementary to the users' appreciation on the design, customized icons and not redefine or misuse android user interface patterns (Asiado et al., 2021). Lumpapun & Nuttanont (2017) mentioned that icon used in the app symbolizes the whole system. Its usability is defined by "findability, recognition, interpretation, and attractiveness" and should contain certain qualities. The Android version 8.0 (API level 26) adaptive launcher icons are introduced that manifests much more updated look for shortcuts, dialogs, and overview screens. Further, as stated by Lumpapun & Nuttanont (2017), buttons are one of the most conventional elements a developer can use in different platforms and its functions is to start actions or activities.

Higher error rates are recorded associated with buttons, hence, spacing between buttons and the ordered mapping of buttons are enhanced.

Functionality

The functionality obtained a composite mean of 4.37 and 0.06 standard deviation to denote excellent. The results suggest that the developed system does not access the user's private information like contact information, messages, or even the system's log. Only the location, which is a minimum permission, is accessed for the map feature of the system. The developed app can be operated in full screen and handles fast transition between displays without having a problem. The secure digital (SD) card installation is readily available as early as API level 8 but in contrast, the users opt not to install the application in external storages for it may cause problem whenever the external storage is unmounted. This procedure could kill the process, making the application unavailable for the users and some for worst reasons, the application may be broken.

Compatibility, Performance and Stability

The compatibility, performance and stability obtained a composite mean of 4.39 and 0.11 standard deviation to denote excellent. The result shows that the users are convinced that the system is loading quickly without any problems that would cause delay, reflecting that the users accept the application based on this term. As per Google Play standard, the application can normally load in 16 ms for transitioning from one view to another. When issues are encountered, there are other ways to maintain and improve the application's quality to avoid crashes, frozen screen and slow rendering. Craig (2015) stated that software development kit (SDK) is essentially needed in developing an android application since it holds the packages or tools for the developer's disposal. There are more SDK tools a developer could use for more updated features of the application (e.g. Android Device Monitor, Thread Monitor, Allocation Tracker, Network Statistics and Screen Capture). The application followed the guidelines for conserving the battery while the application is not in used and not consuming the power of the device even in idle. Bao (2016) claimed that power management of the application affects its usability and different of power management commits using an open card sort process is dominant for different categories.

Security

The security obtained a composite mean of 4.42 and 0.05 standard deviation to denote excellent. The result indicated the application is not saving the user's private data, such as location. The intents and broadcasts also follow the standard to secure the best practices. According to Smyth (2019), intents are the list of operation to be performed. It is the

mechanism to launch another activity and implement the flow. It can be explicit or implicit, depending on what is stated to perform the activity. The libraries, software development kits and dependencies of the application are updated. As Google Play standard, a platform should have updated libraries if the developer would want to develop an application for multiple APIs, rather than coding to support earlier versions, this would control the earlier version for a layer of compatibility. The application is loaded with application's bundles such that the execution of application form background can consume the device's resources like RAM.

CONCLUSION AND RECOMMENDATIONS

The mobile-based agricultural system was designed to provide information about the crops available in Silang, Cavite. The information contained 10 most dominant crops of Silang based on the gathered data. The gathered data included the health benefits of the fruits, uses of the crops, how its different parts can be developed into other products, facts about the crops, required weather temperature, the soil type required for different crops, and where in the province the crops have dominant plantation. All these information are featured on a 2D interactive android application that provided the images for learning visualizations of farmers, students, and other users. The municipality of Silang is considered as the highest in profitability and average in profit per hectare in cropping system. The developers were able to design an interactive system for agricultural crops that could help the farmers utilize resources about the crop, provides information about the plant and gain ideas in maximizing their income. The overall assessment result of the application was excellent from the evaluation in terms of visual design and user interaction, functionality, compatibility, performance, stability and security. Once the developed application is implemented, it can help farmers on how to maximize the crop's potential, lessen the food waste and turn it into an economic income. The by-products featured in the app are environment-friendly and will reduce the methane production as greenhouse gasses acquired from the incorrect disposal of plant remnants, food wastes and rotting crops (Abdel-Shafy & Mansour, 2018). The application was a first step towards understanding the benefits of the by-products of every dominant crop presented in an interactive application. The economic benefit of the study is promising by producing new ideas to create job opportunities. It may also promote the agricultural sector of the municipality and of the province.

In doing future studies, it is recommended that the application may be improved where both orientations are supported (landscape and portrait), make it dynamic and available to other platform. Other crops from other regions may be considered and integrated in the app.

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