System for management, control and monitoring of a seed house

10.56238/homeinternationalanais-104

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ABSTRACT
Seed houses start from the principle of knowledge and valorization of Creole seeds so that they are stored, selected and distributed, aiming to ensure the reprod ution and multiplication of species. The use of technological tools can contribute to the optimization of processes performed in the management of these houses, resulting in a higher quality of stored seeds and the preservation of agrobiodiversity. The present work presents a prototype of a system to be implemented in a specific house of sowers, and that should be responsible for facilitating the processes of management, control and monitoring of activities. It is composed of hardware and software, where the hardware is an embedded system developed to enable the monitoring andcontrolley of the temperature and humidity of the environment. And the software consists of a web application responsible for the management and monitoring of information, interconnected with the embedded system through an API. It was concluded that the developed prototype is presented as a tool to facilitate the processes of management, control and monitoring of the seed house , besides contributing to the preservation of agrobiodiversity and regional ecosystems.

Keywords: seed house**,** management, control, Monitoring, embedded systems.

1 INTRODUCTION

Improve the management capacity with accurate data, from technologies that allow continuous monitoring and control, even at a distance, of the most varied information, can make the difference in a world that lives in the information age , and that increasingly requires efficient management, based on results with agility, practicality and reliability available services.

Therefore, the search for the optimization of procedures performed has led organizations to seek the formation of systems that allow the administration and management ofactivities . Accordingly, the systems seek to act as a kind of facilitators of internal and external processes, each with its intensities, relationships and specificities (REZENDE and ABREU, 2000).

This study consists of presenting a prototype of a web management system, integrated with an embedded control and monitoring system, which aims to optimize the processes performed in a seed house. They are fundamental to ensure the biodiversity of the species and the diversity of life present in the ecosystem of the regions, and in this case, they are dwellings of Creole seeds. Creole agrobiodiversity is constituted from genetic resources considered resulting from evolutionary processes (mutation, migration, hybridization, selection). It can be considered a biological, social, cultural, economic and environmental heritage that indigenous populations, farmers and traditional farmers receive. Thus, seed houses can be seen as a symbolic element with important relevance for peoples and humanity, since they provide agroecological preservation (KAUFMANN, 2014).

The study for the elaboration of the System is the result of collaboration with the Centro de Agricultura Alternativa do Norte de Minas (CAA/NM), a non-profit organization of farmers and family farmers in the North of Minas Gerais, with operations for more than 30 years in this region of the State of Minas Gerais. In general, it develops actions around sustainability, agroecology and the rights of traditional peoples and communities, and seeks to value agrobiodiversity and the conservation of regional ecosystems. In this context, the institution has an Area of Experimentation and Training in Agroecology (AEFA), located in the rural area of Montes Claros - MG, aimed at being a space of educational character, training and experimentation involving environmental management, agroecology and sustainable agriculture.

And in the search for the preservation of agrobiodiversity and the conservation of regional ecosystems, there has been since 2009 in AEFA, a Regional Seed House that assumes the principle of knowing and valuing the seeds of the region to store them, select them, distribute them and towards ensure the reproduction and multiplication of varieties collectively. This ensures the preservation of the lineage of different varieties of Creole seeds, providing an important cultural weight, along with autonomy and freedom of the peoples and communities.

The strategy currently used is an Agrobiodiversity Sharing Management, for conservation and monitoring of great diversity of Creole seeds that are being managed and preserved in the seed houses of small family farmers in the Communities of Northern Minas gerais and Jequitinhonha Valley.

The currentphysical structure of the AEFA Regional Seed House was built on a steep slope, and the place of seed storage and conservation consists of a closed, windowless room, which has to control the environment conditions, an air conditioning and an air dehumidifier . In addition, the control of seed entry and exit, as well as the existing quantity, validity and tests performed with each species, is performed manually, with notes made in notebooks and papers. This has alreadycaused losses in the management of the House, since there has already been loss of some of these materials and thus, consequently, lack of fully reliable information.

It is essential that the temperature and humidity conditions are in accordance with the storage parameters, since the function of the House is to properly store the seeds that will guarantee future harvests and preservation of Creole seeds. Therefore, the main problems observed are very high humidity conditions and unregulated temperature, due to the construction and location characteristics of the House. Consequently, many seeds stored there have high moisture content, to be seen by the presence of fungi typical of humid regions in many varieties, in addition to the unfeasibility of multiplication.

Figure 1 shows how seeds stored in irregular conditions of RH (Relative Humidity) and temperature behave.

Figure 1 : Behavior of seeds under irregular storage conditions.

Reflexos do excesso de UR e temperaturas inadequadas sobre as sementes em condições de armazenamento	
Excesso de umidade	Desenvolvimento de patógenos, aumento da respiração e da deterioração. Dificulta a emergência num futuro processo de semeadura.
Temperatura alta ou instável	Desenvolvimento de patógenos, aumento da respiração e da deterioração. Início e interrupção do processo de germinação de forma antecipada/adequada.

Source: Adapted from SEEDNEWS. Available in: < https://seednews.com.br/artigos/258-quality-of-seeds-moisture-and-temperature-edicao-November-2014 >.

In view of all the points already mentioned, we note the need for a more detailed management of the House of Without entities, recording in the best possible way information such as: available amount of seeds, dates of receipt and harvest, origin, transgenic tests, humidity and production cycle, among other information. In addition, it is of paramount importance to keep the temperature and RH within a range suitable for good use, which can ensure a better quality of the stored seeds.

2 GOALS

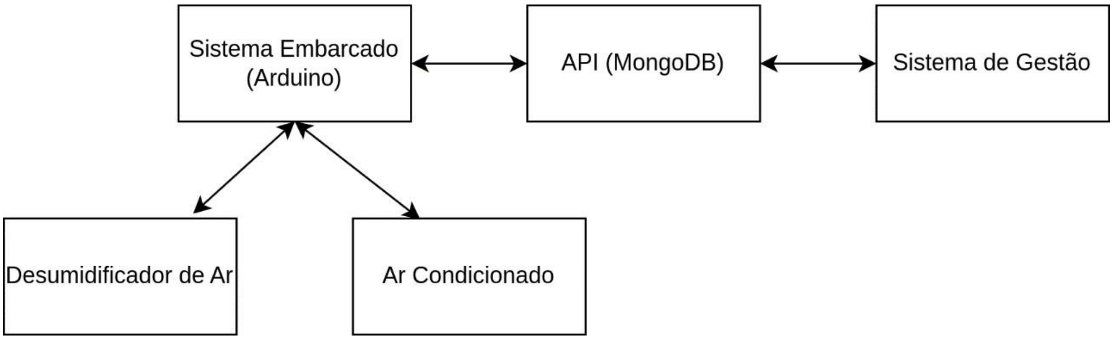
The present work aims to present the development of a prototype of a system to be implemented in the Seed House of AEFA, and that should be responsible for facilitating the processes of management, control, monitoring and organization of the activities performed there. It enables the existence of a database/catalog of information of seeds that pass through the House, in addition to facilitating processes of issuance of general reports, such as monitoring the performance of the Seed House, use ofseeds, number of stored species, validity of each, and number of guardians / municipalities served.

In addition, the system should be responsible for controlling and monitoring the environment conditions of the House, collecting temperature and humidity values in real time and making the necessary adjustments by controlling the functions of an air conditioner and an air dehumidifier, in order to always maintain the appropriate range of operation of these equipments, which are responsible for controlling the temperature and RH of the seed storage site.

3 MATERIALS AND METHODS

For the development of this prototype, the system was built from three main parts: an embedded control and monitoring system, aweb management system, and an API to integrate the two systems mentioned above. Such systems are based on hardware and software, respectively, and communicate through the API so that it is possible to perform the proper operation of the system. Figure 2 presents a block diagram, demonstrating the idea of system operation.

Figure 2: Block diagram on system operation



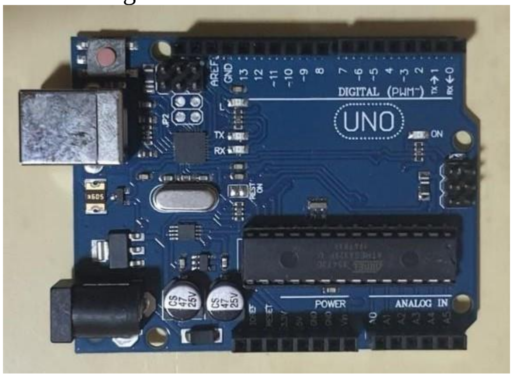
Source: Own authors

3.1 EMBEDDED SYSTEM

An embedded system, or embedded system, can be defined as one that manipulates data within larger systems, and performs specific functions. Typically it is designed to perform a function or a range of functions and not to be programmed by the end user, as with personal computers. In addition, it usually interacts with the environment in which it is inserted, and collects sensor data to be able, through actuators, to make changes to the environment (VARGAS, 2007).

The systemand equipped of this prototype consists of a hardware developed with an Arduino board, as shown in Figure 3, which is an open source electronic platform, and is based on hardware and software that have ease of use. This platform enables data acquisitionand device control for interaction with the outside world. The type of board chosen was Arduino Uno, which was the first Arduino plate with USB, besides being a reference in this type of platform, being considered the most used board (ARDUINO, 2022; SOLDA FRIA, 2022).

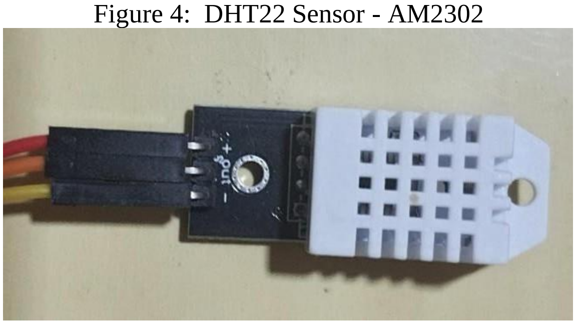
Figure 3: Arduino Uno Plate



Source: Own authors

For the prototype assembly, an 830-point protoboard was used as a test plate, and several jumper wires for the achievement of the necessary connections. To allow the reading of the temperature and humidity of the environment, two sensors of type DHT22 - AM2302 were used, as shown in Figure 4. This sensor model, which can also be marketed in module, can perform temperature measurements from -40 to 80°C, and humidity from 0 to 100% RH. It was chosen for performing measurements with good accuracy rate, besides being easily accessible.

Figure 4: DHT22 Sensor - AM2302



Source: Own authors

Given the data presented in Figure 5, regarding the measurement of humidity, the sensor error is 2%. And with respect to temperature values, measurements may have an error of 0.5 ºC, as shown in Figure 6.

Figure 5: Technical data on the measurement of the DHT22 - AM2302 sensor. Moisture

Parameter	Condition	min	typ	max	Unit
Resolution			0.1		%RH
Range		0		99.9	%RH
Accuracy [1]	25℃		±2		%RH
Repeatability			±0.3		%RH
Exchange		Completely interchangeable			
Response [2]	1/e(63%)		<5		S
Sluggish			<0.3		%RH
Drift [3]	Typical		<0.5		%RH/yr

Source: Temperature and humidity module. Available at <https://www. filipeflop.com/img/files/download/Datasheet_DHT22_AM2302.pdf>.

Figure 6: Technical data related tothe measurement of the DHT22 - AM2302 sensor. Temperature

Parameter	Condition	min	typ	max	Unit
Resolutio			0.1		℃
n			16		bit
Accuracy			±0.5	±1	℃
Range		−40		80	℃
Repeat			±0.2		℃
Exchange		Completely interchangeable			
Response	1/e(63%)		<10		S
Drift			±0.3		℃/yr

Source: Temperature and humidity module. Available at <https://www. filipeflop.com/img/files/download/Datasheet_DHT22_AM2302.pdf>.

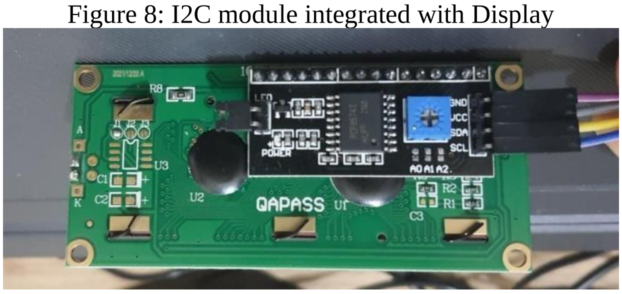
To enable a real-time visualization of the values of temperatura and humidity in the physical environment of the Seed House, a 16x2 LCD Display with Blue Backlight was used, represented by Figure 7. This 16x2 model was chosen because it is large enough to present the necessary information.

Figure 7: 16x2 LCD display with Blue Backlight

Source: Own authors

In addition, the Display already comes with the I2C communication module, as shown in Figure 8, which provides the connection between Display and Arduino by only 4 wires, two for data, and two for power.

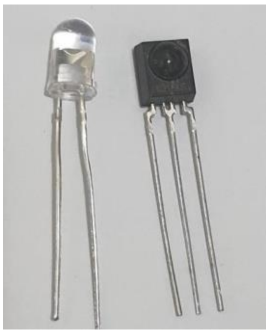
Figure 8: I2C module integrated with Display



Source: Own authors

To carry out the process of temperature and humidity control, an infrared emitting LED was used to send signals to the air conditioning equipment and air dehumidifier, an irm3638-3V infrared sensor that is responsible by reading the code of each remote control of the equipment, a button that, when pressed, allows the configuration of a new remote control, and a common LED that when lit, indicates precisely that this process is in Progress. Figure 9 shows the models used for the infrared emitter LED and irm3638-3V sensor.

Figure 9: LED infrared emitter and infrared sensor IRM3638-3V



Source: Own authors

Finally, for the programming of the Arduino board, the Arduino IDE, official software of the Arduino platform, was used, which allows the development, compilation and upload of the code to the plate.

3.2 API

The API format system was developed using JavaScript through Node.js which is a JavaScript runtime based on Google's V8 interpreter, which allows the execution of Server-side JavaScript code, and the Web Express Framework for Node.js.

This application is responsible for storing sensorreadings and intermediation of communication between the web system and hardware. And for the storage of data received from sensors, it uses a NoSQL database, which is a solution considered an alternative for relational databases, and which is a proportion inhigh scalability and performance (CHAGAS et al., 2022).

The NoSQL database chosen for the execution of the job was MongoDB, which is known to have high performance and flexibility, being considered the main NoSQL database. It usesdocuments similar to the JSON format to store the data, and thus allow a higher performance for a large amount of data, such as those obtained in sensor readings (GUEDES, 2022).

3.3 WEB MANAGEMENT SYSTEM

The web management system is focused on the general management of the Seed House, allowing to improve the process of control of input, output and general issues of seed storage , in addition to monitoring in real time and through reports, the data d andtemperature and humidity obtained by the hardware.

For the development of this system, initially a phase of requirements analysis was carried out with people involved in daily life and who have technical knowledge regarding the procedures performedin the Seed House. Through these requirements, a modeling of diagrams was elaborated using UML, which is a diagrammatic language, which can be used for specification, visualization and documentation of software systems (DA SILVA and VIDEIRA, 2001).

For system coding, the Python programming language was used, in version 3.10, through Django, in version 3.2, which can be defingone as a high-level Python web framework that stimulates rapid development, combined with a clean and pragmatic design. Complementary libraries to aid development, allied with JavaScript, HTML and CSS languages together with the Bootstrap Framework, which is a front-end framework used for the development of web applications and mobile-first sites, i.e. with the layout adapted according to the screen of the device used by the user. It was used for the development of the visual structure of the system (DJANGO, 2022; ROVEDA, 2022).

And for data storage, the open source relational database manager system, PostgreSQL, whose use has grown significantly, in view of its practicality and high compatibility with different standards language (DE SOUZA, 2020).

4 RESULTS AND DISCUSSION

4.1 EMBEDDED SYSTEM

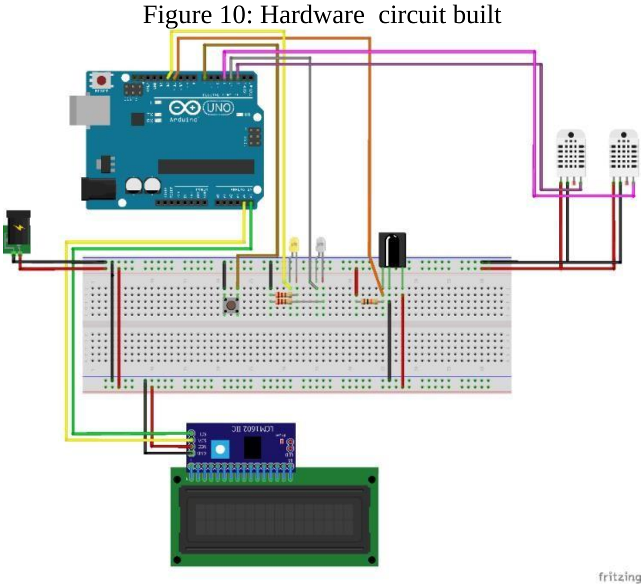
In order to improve the work and results developed in the Seed House, the prototype, which has an embedded system that allows interaction with the physical environment, when performing Real-time temperature and humidity readings, and control equipment that adjusts ambient temperature and humidity levels (air conditioning and air dehumidifier).

To enable these functions, through the electronic components already presented in thesection of methodologies and methods, the circuit presented in Figure 10 was developed. This circuit, through dht22 sensors performs continuous readings of temperature and humidity of the environment, making this data available in Arduino Uno, which are displayed on an LCD display.

Through serial communication with a computer via USB port, Arduino also forwards the data to the API system, which makes the storage of this data. Using this means of communication, the Arduino receives the setpoint values of the air conditioner and the air dehumidifier , automatically adjusting these equipments, through the led emitting infrared present in the circuit.

The infrared commands used to control these equipments are previously configured by reading the signal sent by the remote control of each equipment. For signal reading, the circuit has an irm3638-3v infrared sensor, and a button. When you press the button, the system goes into read mode, triggering an indicator LED, and the signal received by the infrared sensor is recorded in the Arduino memory.

Figure 10: Hardware circuit built



Fontand: Own authors

The LCD display present in the circuit, also receives from Arduino the data read from the sensors of model DHT22, and has as function to allow the monitoring of the temperature and humidity of the Seed House locally, so that the collaboratorspresent in the House, can monitor the operation of the system. Figure 11 shows how the display presents this information, considering TAs as current temperature in degrees Celsius, TI as ideal temperature, AU as current air relative humidity, and UI as ideal relative air humidity.

Figure 11: Presentation of information by LCD display

Source: Own authors

4.2 API

This application was built to receive and store the data of readings of the sensors sent by the hardware built with the Arduinous board, and to play the role of an intermediate system with the management system. It was developed with JavaScript through Node.js, using the Express Framework for Web Development, in API format, whose operation is based on HTTP requests, to save and query data.

After each reading of the sensors, Arduino makes a POST-type request for the API, sending the data in JSON format, containing temperature and humidity, an identifying code sensor, and in the event of an error in reading, the temperature and humidity information is replaced by the error obtained during the process. After receiving this data, the API processes and saves the information obtained in MongoDB. Figure 12 shows how the data is passed in JSON.

Figure 12: JSON Format View


```
{
    "_id": "637bdab0643e48a051fb58ff",
    "erro": "OK",
    "sensorId": 1,
    "temperatura": 23.8,
    "umidade": 68.5,
    "data": "2022-11-21T20:08:16.691Z",
    "cloudSaved": false,
    "__v": 0
}
```


Source: Own authors

Because readings are done following a fixed frequency, generating a large amount of data over time, using MongoDB provides higher performance and increased easy to query the data, performing filters for building struturessuch as charts and reports.

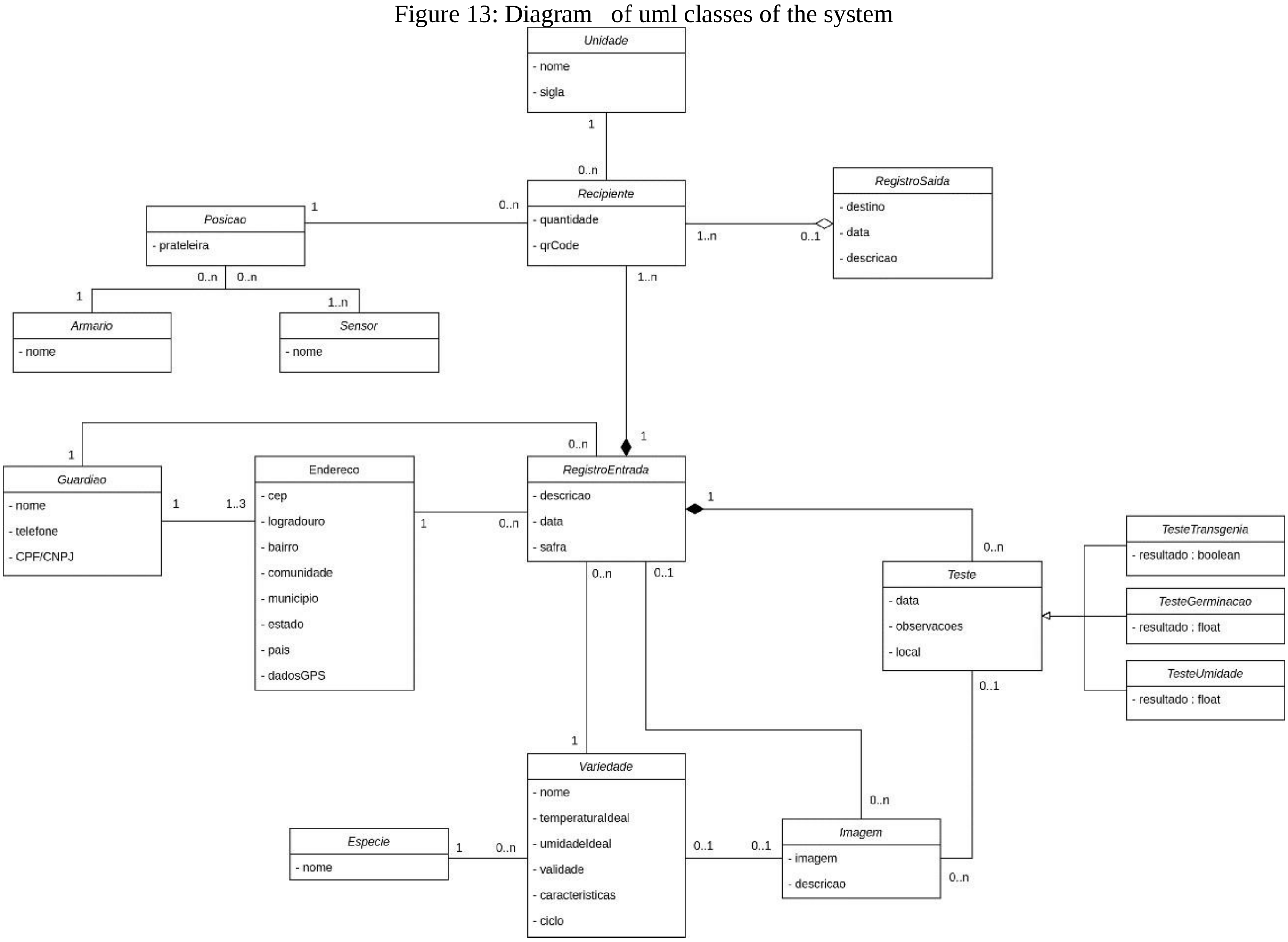
For data querying in the API, several formats are made available, each using a specific route, accessed by GET-type HTTP requests with specific parameters for each query type.

4.3 MANAGEMENT SYSTEM

The process of construction of the management system had to count on the constant dialogues with the people most involved with the day-to-day of the Seed House and who know how it works. This interaction provided a clear and concise contribution to the construction of the software, as well as to its programming, being possible to raise in the best possible way the necessary requirements for the development of the system.

Then, from the defined requirements focused on the management system, the UML class diagram was elaborated that describes the basic structure required. Figure 13 presents this diagram.

Figure 13: Diagram of uml classes of the system



Source: Own authors

From this structure the system code was then implemented. It was developed in web format, in order to allow easy access of any device without the need for installation, requiring only a web browser.

In addition to the general management function of the Seed House, the system also has the function of real-time monitoring of the Seed House, following the data of the temperature and humidity readings performed by Arduino. For this, the system has a screen, called "Dashboard" that functions as an information center, where it displays the current temperature and humidity of the Seed House, considering an average of the temperatures measured by the two sensors present, a report of the latest readings performed, a temperature graph and over the last 24 hours, representing the variations that occurred in this period, and a graph of variety of stored seeds. Figure 14 displays a preview of this screen.

Figure 14: System Dashboard

Source: Own authors

For monitoring the Seed House, in addition to the Dashboard, the system has a notification board that, in addition to other varied alerts, informs when the temperature and humidity are outside the ideal values set in the settings of the system. Such operation values can be set manually by the user, or the values recommended by the system can be used, based on the varieties present in the semester house. Figure 15 shows the system notification board.

Figure 15: System notification board

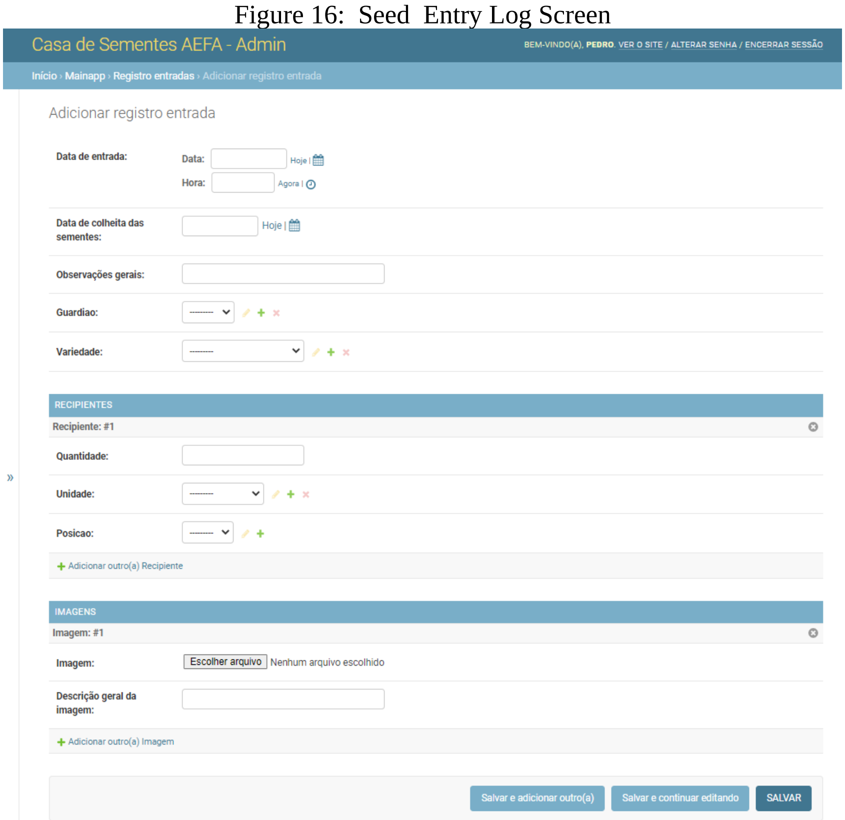
Source: Own authors

As functions for the management of the Seed House, the system includes the management of varieties and species of seeds, guardians, inlets and outputs of seeds, containers (unit for seed storage, PET bottles are usually used, because they have a good characteristic of and tests performed with seed groups, such as germination , moisture and transgenic tests, to verify their quality and situation.

When considering the process of arrival of new seeds for the House, they are registered in the system, through the function "Entry Registration", where it is possible to register the entry of a "lot" of seeds, containing important information such as variety, guardian (responsible farmer by sending the batch), harvest date and place of origin. Figure 16 shows screen dand input record.

Also added to the Entry Register are individual containers, where the unit (kilograms, liters, etc.), the storage location of the container in the Seed House (cabinet), general observations and photographic records of the seeds that arrived can be indicated. The storage location of the container is selected according to the locations previously registered in the system, representing the available cabinets, each linked with the physical sensor of temperature and humidity closest to its position.

Figure 16: Seed Entry Log Screen

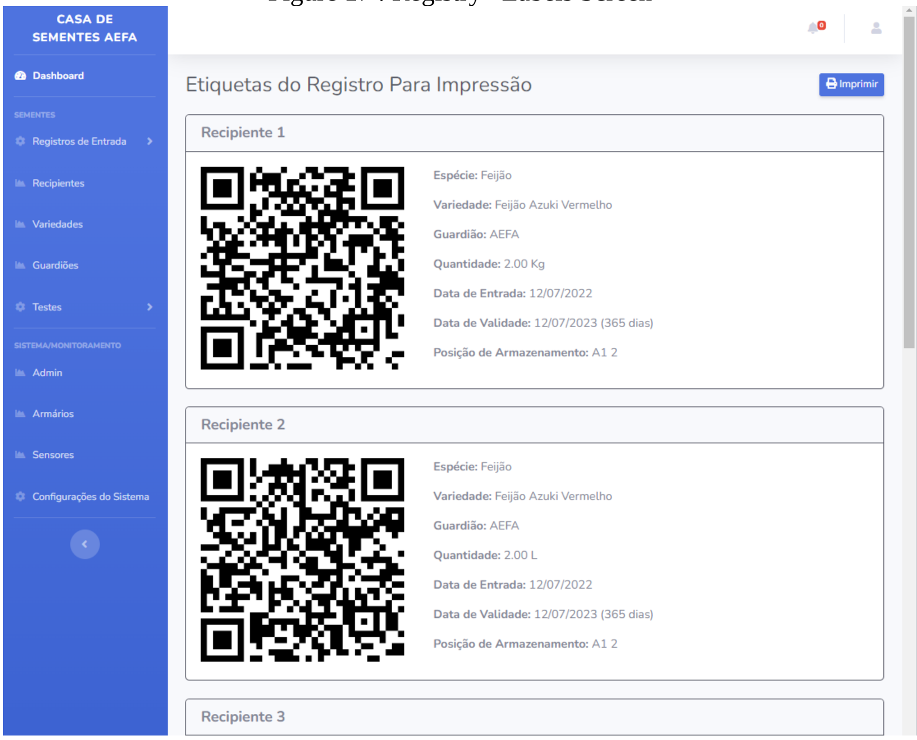


Source: Own authors

Thus, the system can have a closer evaluation of the values of the ambient conditions of each container, because such values may not appear uniformly within the space, making that according to the position of the container, there is an error in relation to the general average of the values. In addition, storage locationinformation helps you find more easily where each seed is.

At the end of the entry record, identification labels are generated by the system for each container registered in the registry. Each label provides information about the seeds present in each container, in order to facilitate physical identification within the House, in addition to having also a QR Code which facilitates the location of the container in the system, for the realization of various events, such as the registration of tests for the seed. Figure 17 displays the label screen of the record.

Figure 17 : Registry Labels Screen

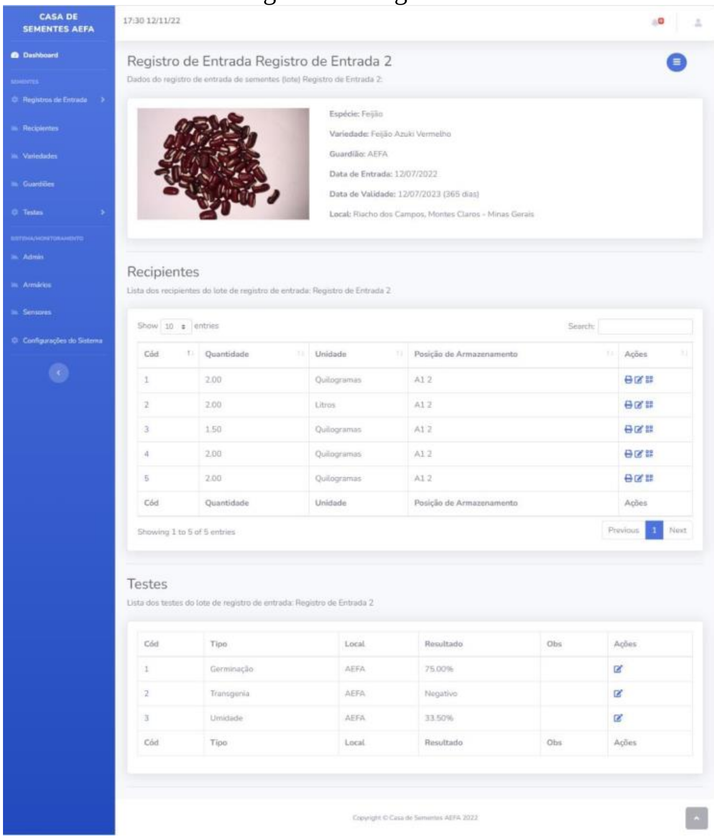


Source: Own authors

All system roles are linked to specific levels of access, defined for users and groups within the system, where to access a particular role, the user or the group to which this user belongs must have permissions to access such resource. This is a common and essential feature, and has been included in the Seed House gerensystem through the functionalities offered by Django Framework authentication.

The system also brings different forms of seed bank analysis, from the screen, which as shown in Figure 18, functions as a seed sheet, describing its entire history, in which based on the test results, and the variation of temperature and humidity in each container, makes it possible to evaluate the quality. In addition, over time it can become a rich database, which possibilita perform other types of varied analyses, such as mapping main places of origin, and where the seeds that have the highest quality arrive.

Figure 18: Log screen

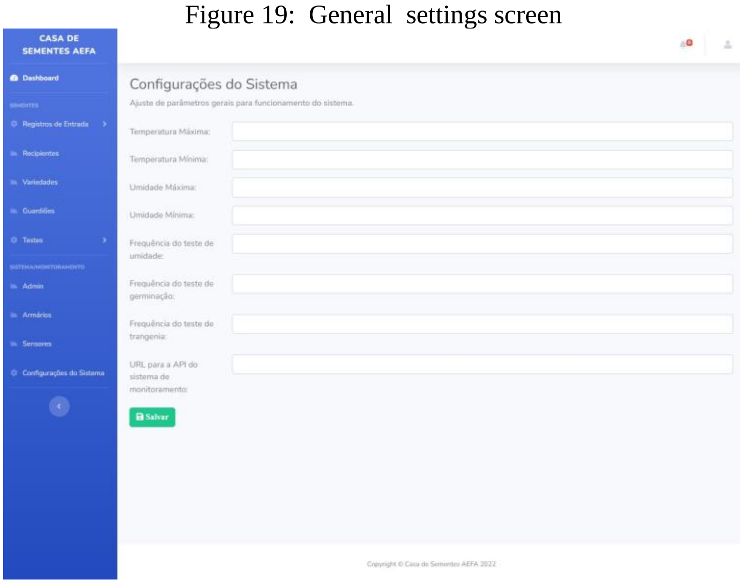


Source: Own authors

Another fundamental function of the management system is the definition of general parameters of operation of the Seed House system, where people with permissions can make the configuration of the parameters shown in Figure 19, which presents the system's configurations screen.

In general, the management system brings several useful resources that aim to facilitate the management and monitoring of the Seed House. Its use for data logging makes it possible to delete other methods such as spreadsheets and papers.

Figure 19: General settings screen



Source: Own authors

5 CONCLUSION

It was concluded that the developed prototype presents itself as a technological tool capable of facilitating the processes of management, control, monitoring and organization of the activities performed by the AEFA Seed House. With a financial investment maior, it is possible to improve it , using more advanced materials in its construction.

Good control, tied to good information organization and agile and effective monitoring, should ensure higher expectations of seed duration, and reduction of losses both in the storage process and in planting. This can be proven over time by observing the results of the seed quality tests performed by the House.

The implementation of this system can also actively contribute to the preservation of agrobiodiversity and regional ecosystems, considering the important role played by seed houses as a dwelling place for Creole seeds, tied to a better management of their processes, proporci on the way that several varieties of Creole seeds can reach more families and more generations, and thus ensure the transmission of culture and agroecology.

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