Automation of processes during production of commercial oil palm seeds

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ABSTRACT

Guarantying the quality and genetic purity of hybrid oil palm seeds requires precision, control, traceability and constant validation of many processes; both in the field (identifying mother palms and pollen sources, pollination, identification of bunches etc.) and in the facilities where seeds are prepared (identification of batches, cleaning of seeds, germination etc.) for final selling. All these processes can be affected by human error which may have very negative effects on the final product (germinated oil palm seeds) that are offered in the international market to start new oil palm plantations. The objective of automating is to reduce human intervention as much as possible (in the form of hand written forms and reports mainly) to ensure a better control of the information, guarantee its integrity and increase productivity of the human asset.
This paper describes the changes done to old methods to accomplish the said objectives during the processes to producing and handling oil palm seeds at the ASD Costa Rica facilities in Coto, Costa Rica. Changes done included the use of mobile devices to capture data in the field and at the seed processing unit, the identification with barcodes of mother palms, pollen sources**,** seed batches and other key elements, all to guarantee the integrity of the information and traceability, and the reduction of possible human errors.

Keywords: Genetic purity, human error, integrity, barcodes, control, traceability, Costa Rica.

1. INTRODUCTION

ASD de Costa Rica has produced high quality oil palm seeds for the international market since 1986 (Sterling and Alvarado, 2002; Alvarado et al. 2010; Escobar and Chinchilla 2006). During this period, more than 314 million seeds have been sold in more than 30 countries in the tropics of America, Asia and Africa, equivalent to more than 1.8 million planted hectares. ASD' success is based in guarantying a high genetic purity of controlled pollinated seeds and more recently, of cloning materials. The official National Seed Bureau of Costa Rica supervises the production of seeds under guidelines that regulate field and laboratory processes to guarantee the highest standards in quality and genetic purity (Escobar and Chinchilla 2012).

As the demand for oil planting materials increased so did the complexity of the processes and the probability for human error to occur during shipping and handling. To cope with such potential problems, ASD built new facilities to separate processes during seed handling (Seed processing unit) and to increase labor efficiency, but still, during one particular year, 300 workers processed more than 40 million seeds. Labor is expensive in Costa Rica and so the inevitable waste of materials needed to keep the processes going.

It was soon realized that there was an increasing gap between progress achieved in genetic breeding which resulted in the development of an increasing number of seed varieties (besides the creation of novel clones) and old methods to record, handle and process the information. On the other hand, information taken at the seed garden (were selected mother palms and pollen source palms were growing) and at the physical facilities (where seeds are germinated) was not synchronized and data were taken by filling out by hand some predesigned forms. Such notes were retyped to enter data to special software creating new opportunities for human error due to mistyping, misinterpretations, damaged forms (dirt or moisture) or misplaced information.

Finally, some outdated software and hardware posed a problem for proper storage information. Data was stored in flat files (.dbf) where they could be modified (integrity issue). As the volume of data increased, so did the need of personnel to handle it, which increased costs. Besides all these potential problems, time taken to process data and generate reports for decision making was sometimes unacceptable to keep the process finely tuned. An additional unwanted situation of the manual (written) identification of genetic resources (individual highly valuable palms) in the field was the fact that it could be eventually identified and properly interpreted by third parties.

This paper summarizes the development of: i) a software solution; ii) a communication infrastructure (collection center, wireless network); iii) users training and hardware selection for mobile devices plus servers; and iv) a barcode identification system.

2. GENERAL ASPECT OF THE PROCESS

The project to modernize the identification of key elements, data taken and processing (to reduce sources of human errors), increase efficiency of the human resource and preserve information integrity was conducted both in the field (seed garden) and the seed processing unit, both located in Coto 49, in the South Pacific coast of Costa Rica.

The first step was to identify the different stages of this complex process, which consist of two phases. The first one (Fig. 1) is completed in the field: i) identification of the mother palms and the pollen source palms; ii) bagging of inflorescences before anthesis; iii) pollen harvesting; iv) controlled pollination; and v) seed-bunches harvesting. The second one (Fig. 2) occurs at the seed processing unit (SPU), where: i) the seed-bunches are shredded to separate its fruitlets, i) depulping of fruitlets; and iii) moisture adjustment of clean seeds, counting, heat treatment, soaking, germination, packing and quality controls.

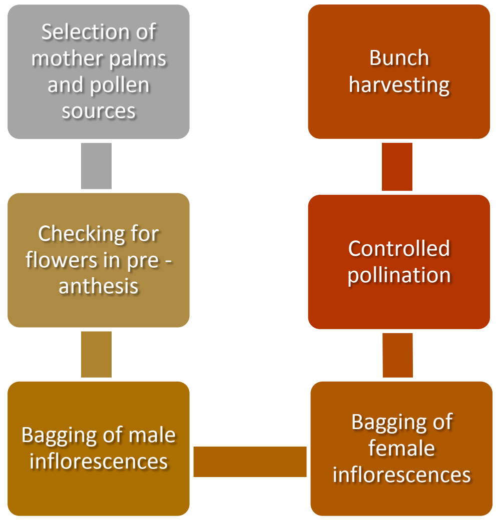

Figure. 1. Main activities carried out in the field before the seed-bunches are brought to the Seed Processing Unit (SPU)

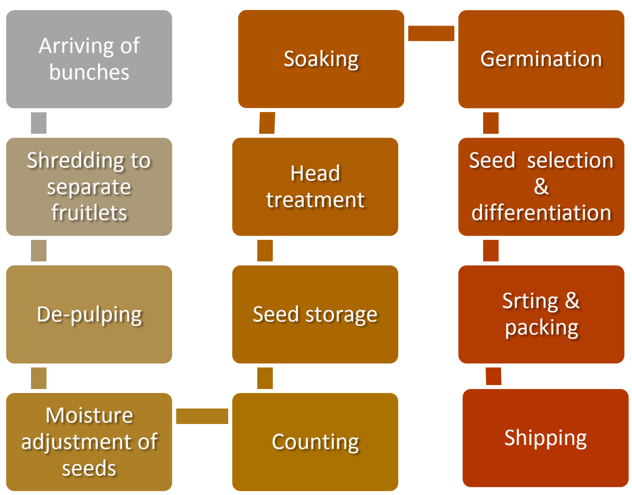

Figure. 2. Main activities carried out at the Seed Processing Unit where seeds are germinated and prepared for shipping.

3. THE SOFTWARE DESIGN SOLUTION

Five persons worked during one year and a half under the direction of a team leader to develop and implement the project. The solution was made up for three main areas: desktop, web and mobile. The desktop and web solution were developed using the Microsoft .Net Framework and ASP.net with C# as a programming language, using a Microsoft® SQL Server 2008 R2 data base used for information storage. Microsoft Visual Studio 2010 was used it as an integrated development environment (IDE).

The mobile application was develop utilizing the Microsoft .Net Compact Framework and C# as a programming language, by means of a SQL Server Compact (SQL CE) data base used for information storage. All the information resides in a single .sdf file which can be up to 4 GB. Microsoft Visual Studio 2005 was used as an integrated development environment (IDE).

The mobile devices used by field workers were Motorola MC55A0 wireless mobile computer (hand held), with Microsoft Windows Mobile 6.0 operation system. At the seed processing unit (SPU) we used the Samsung Galaxy Tab 2 (10-inch) with the Android 4.2 Jelly Bean operation system. The solution resides in a Dell Server PowerEdge PE2970 (model), with Microsoft Windows Server 2008 R2, x64 (includes Hyper-V™ v2), 8 GB RAM memory and two processors Quad-Core AMD Opteron ™ of 2.59 Ghz. The system is supported by a Raid Controller with 500 GB of storage capacity.

The web solution is placed online by IIS 6.0 (Internet Information Services). There an additional replication server (off line) with the same characteristics of the principal server, that works as mirror of the primary server (backup).

4. IMPLEMENTATION

A partial implementation of the system was performed, using the field tasks (Seed Garden) as a starting point, since these tasks are the beginning of the entire process.

In this part of the process, existing software was replaced with the new solution, partially adopting the use of mobile devices in the field (about 20% of users), increasing their use as the field tests were performed (communication and data entry) and we obtained feedback from users. There was nearly immediate acceptance by field workers, who overcame the learning curve in a relatively short time, mainly due to experience gained from using smartphones and the practical benefit accrued to them from directly recording information into devices using barcodes, thus supplanting the prevailing manual process.

Administrative users, in charge of assigning tasks, generating reports and handling the information from the desktop version of the system, showed some resistance to the change, mainly because they saw their work routine altered by the use of the tool (system), replacing the manual processes that they handled perfectly. However, with training and continued use of the tool, this situation was successfully overcome.

The situation was a little different at the SPU, since the implementation of the system was carried out in parallel with the previous system, mainly because of the impossibility of reproducing the movements done previously and not controlled (not registered) by the old system (legacy software), when the traceability of the seed was limited.

Resistance to change was greater in this stage of the process, since changes in the overall process were much more evident than in the field tasks due to their nature.

Finally, the workers adopted the new recording procedures and abandoned the use of the old system, and they started to show improvements in output, control, security and traceability that the new integrated seed production system promotes.

5. COMMUNICATION INFRASTRUCTURE

Besides developing new software (for mobile devices, desktops and web), the project also considered the implementation of a communication infrastructure, data storage (wireless network, database server), barcodes to identify key elements and training of the personnel to adapt and properly use the new technologies (Fig. 3). Workers can even make and print barcodes to be used in mother palms, pollen sources, bags etc.

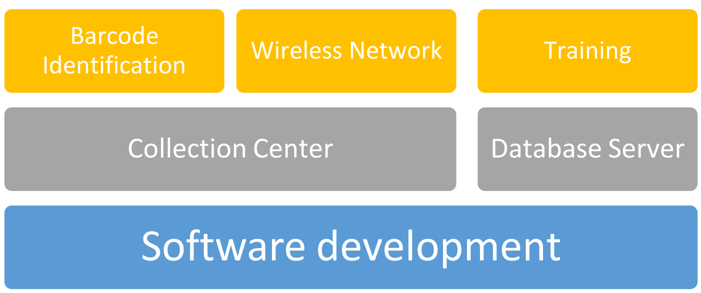

Figure. 3. Schematic representation of the different elements to modernize processes to produce and handle oil palm seeds for shipment to the international market.

To achieve objectives, it was necessary to extend the wireless web-local-area (LAN), both at the Seed Processing Unit and a new Data Collection Center in order to facilitate data transfer in real time (online), and avoiding its manual manipulation. Each worker can key in data in the mobile device (or the tablets) and send it right away to the Data Collection Center, where devices can be recharged or stored. Data stored in this center can also be sent by Wi-Fi to more than 50 mobile devices.

6. BENEFITS

6.1 Systematization. Individual experiments and mother plus pollen source palms were identified in the field using barcodes. Besides this, all other important elements of the process such as individual seed-bunches, pollen containers and bags to isolate inflorescences were also identified with barcodes.

The immediate benefits of these changes were exclusion of the expected sources of human errors, the accuracy of the information taken and the speed at which the information was recorded, processed and the reports were generated to take timely decisions. The information is now available online (24/7) and can be accessed depending on the security rights of the system. Reporting is almost instantaneous and there is no paperwork needed. Table 1 illustrates some savings achieved in labor (%) during some key steps of the process.

Table 1. Improvement in labor efficiency and units processed after implementation of the automation at the Seed Processing Unit of ASD Costa Rica

Labor efficiency			**Units processed**	
Seed selection	Seed counting & batches set	Data management	Quantity	Seed lots stored
82%	40%	18%	87%	83%

6.2 Security. The information is stored in a database server with replications and a backup in case of contingency. There is not additional manipulation of data, however, any changes are recorded in a log file.

Data from mother and pollen-source palms or any other element, such as seed-bunches, are barcode identify and can only be obtained with the appropriate information in the system. On the other hand, any 'transaction' is registered in the database log indicating time, user, task involved process, area where the action occurred, etc.

6.3 Controls. Any process can be controlled, and is totally traceable, starting from the seed garden, through the seed processing and packing, until reaching the final customer. Planning and executing of each task is controlled by the system, and each user (employee) only gets access to his particular assigned interface.

The system 'keeps' a strict control of the of the different steps through the whole process which should be followed in sequence, showing any pending step or sequence error, which need to be fixed in order to continue with the sequence, which guarantees the traceability (origin and final destination of a given batch of seeds).

6.4 Field equipment. The use of rugged mobile devices in the field avoids loss of information due to splashing liquid, heat dust and drops from up to 1.8 meters, which correspond to the standards IP64 sealing. These mobile devices also prevent mishandling and loss of information, compared with the misplacement of the old system methods (Figure 4).

Figure. 4. Comparison of old and new methods (manual entry of data on a paper form) and the introduction of a mobile device for this same purpose

7. CONCLUSIONS

A digital control of all activities involved in commercial oil palm seed production at ASD de Costa Rica adds values to all his products in particular by guarantying genetic purity and traceability of all process. Any recognized source of human error has been reduced to a minimum and processes have been improved in terms of efficiency and reliability.

8. REFERENCES

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