

Device for coupling to picking bags to collect data and generate yield maps for perennial crops

Lucas De Ross Marchioretto¹⁸¹, Vinícius Martins Timoteo¹⁸², Luciano Gebler¹⁸³, Cláudio Leones Bazzi¹⁸⁴

Abstract

In orchards containing perennial crops, input management, including activities such as fertilization, pruning, and manual thinning is typically conducted at a block scale, thereby overlooking variations within the blocks. The creation of yield maps can be a useful tool to address heterogeneity and assist with decision making. To address this issue, a device equipped with batteries, a controller, a GPS module, and an RFID module was developed for attachment to picking bags. This facilitates further processing to generate yield maps. The devices are capable of generating yield maps to help to identify yield heterogeneity inside the apple blocks.

Keywords: Precision agriculture; Perennial crops; Precision harvest.

1. Introduction

The worldwide population is expected to increase up to 2.3 billion people by 2050. To reach out to the population needs, agricultural output has to tail for the demand for food, fiber, and energy, while simultaneously, urbanization increases and the availability of workers in rural areas decreases (FAO, 2009). In this context, the optimization of resources management is extremely important to circumvent waste of time and profits.

With the current management of inputs, such as fertilizers, land, water for irrigation, etc., it should be unsustainable to increase food production to cope with the demand. Although, for precision agriculture, sensors not always have to be the most expensive and precise, instead, they can be accessible and even useful to improve the precision on the allocation of inputs into a farmland. (Cobbenhagen et al., 2021).

¹⁸¹ Scholarship holder at Embrapa Grape and Wine. ORCID: 0000-0002-6677-4696. Email: lucasdeross@hotmail.com

¹⁸² Federal Technological University of Paraná. Email: vtimoteo@alunos.utfpr.edu.br

¹⁸³ Embrapa Grape and Wine. ORCID: 0000-0001-9622-5578. Email: luciano.gebler@embrapa.br

¹⁸⁴ Federal Technological University of Paraná. ORCID: 0000-0002-7726-144X. Email: bazzi@utfpr.edu.br

The availability and affordability of sensors and controllers could be useful for precision agriculture with fruit crops, in the sense of creating harvesting maps to subsidize the decision-making at a tree level, rather than whole blocks. In this sense, a device attached to fruit picking bags was created to collect data and create yield mapping for tree-fruit crops.

2. Methods

The harvesting of apple fruits is done manually by small teams of up to ten people harvesting both sides of the tree rows, filling the picking bags and discharging the fruits into the bins placed in the middle of the rows or embarked on apple bin trailers coupled to tractors moving itinerantly between all the rows.

The devices were placed in a plastic box, activated, and attached to the front of the picking bag (Figure 1). It consisted of an ESP32 controller programmed to collect GPS points from the GPS module every five seconds, along with the box identification. This module also prompts date, time, latitude, and longitude. There is also a *Radio Frequency Identification* (RFID) module, so every time the worker approaches the bin to discharge the picking bag, the RFID makes a reading of the tag attached to the bin, for the ESP32 controller to make a register. Thus, with the track of GPS points and the RFID reading, it is possible to know which trees collaborated to fill this bin. All data are stored on an SD card for subsequent processing. The whole hardware was fed by two Li-ion batteries of 3.7 V connected in series. Also, a module TP4054 was attached looking for managing charge of the batteries.

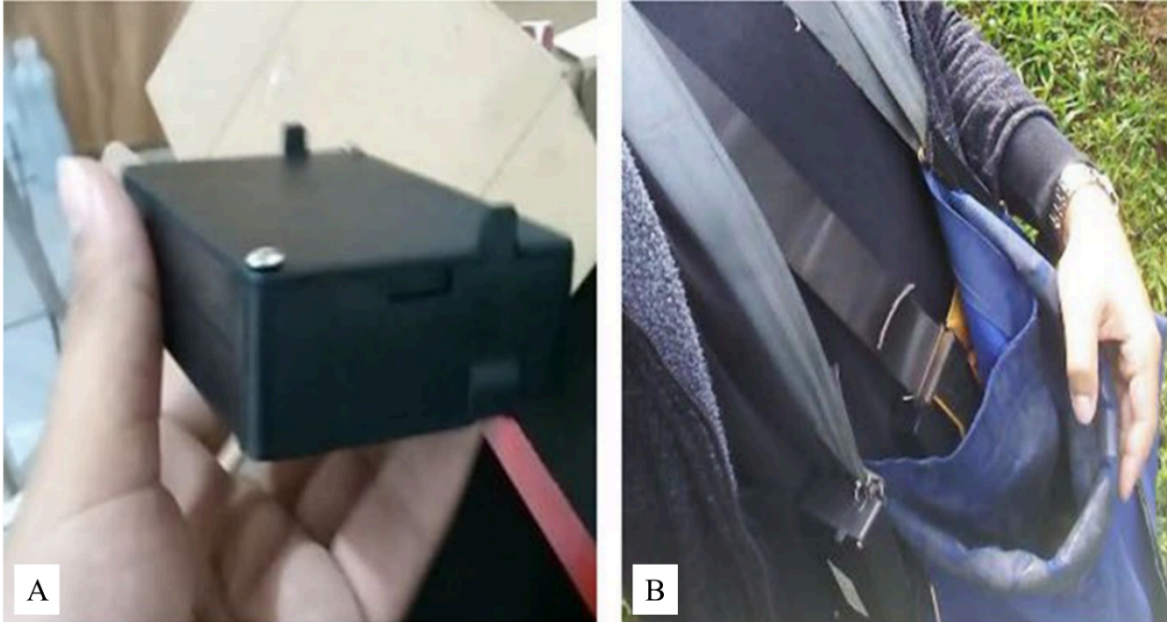


Figure 1. Automatic fruit picking bag: (A) box containing the ESP32 controller, GPS, SD card, and battery management modules; (B) device attached to the picking bag.

Source: Bazzi et al. (2022)

3. Results and Discussion

The data stored in the micro-SD cards consists of picking bag ID, bin ID, date, time, latitude and longitude, as well as the RFID readings every time a worker approaches the bin for discharging. This data can then be used to generate yield maps in perennial fruits. In an experiment carried out in Vacaria-RS, Brazil, it was possible to calculate variograms and generate yield maps with the application AgDataBox (Bazzi et al., 2019). It was possible to identify the location of the apple trees which contributed to filling the bin (Figure 2).

Regarding the methods for data interpolation, it is possible to do it through the calculation of the centroids and further ordinary kriging, or inverted distance weighting. In addition, as the time is also registered, it is possible to determine the speed of harvest of the worker individually.

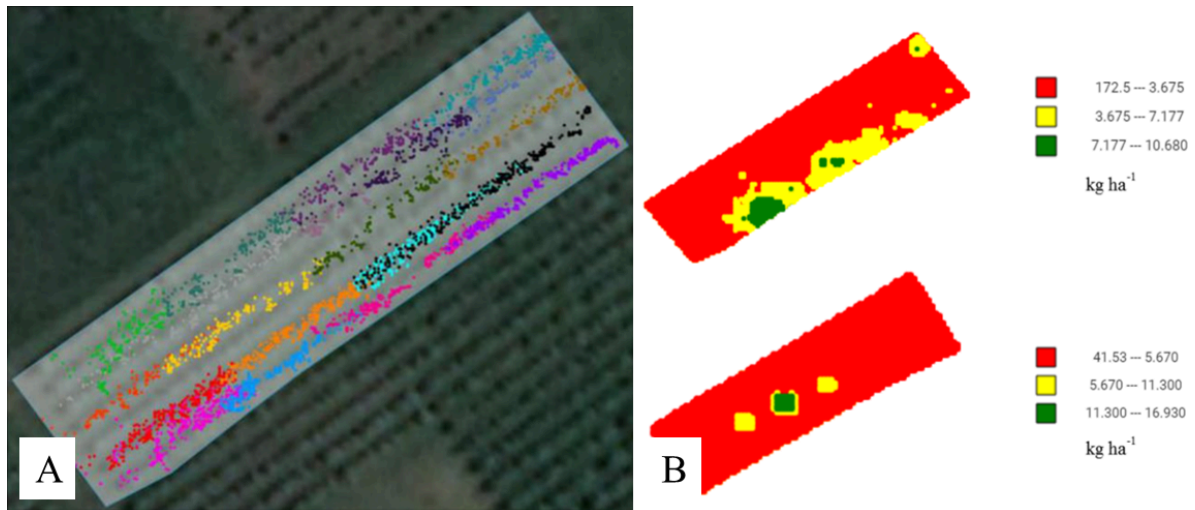


Figure 2. Generation of yield maps for orchards: (A) Image depicting the location of the apple trees necessary to fill the bin; (B) map generated with AgDataBox.

Source: Bazzi et al. (2022)

4. Conclusion

The equipment was effective in what it was designed for, that is, it collected the coordinates and tracked the path of the apples from the trees to the bin. The generation of yield maps in perennial crops is an important tool to give the fruit producer a better idea on the management zones inside the blocks, as nowadays, the management is done in whole blocks, ignoring the heterogeneity of the area. In addition, by tagging the bin with RFID tags, it could be possible to trace back quality parameters from the packing house, being possible to make fruit quality maps. Another functionality is the counting of how many times the picking bags reached the bin, as the worker has to approach the RFID tag of the bin, making it possible to manage the number of bags a worker collected throughout the day, helping in the management of the human resources as well as the payments.

Acknowledgements

The authors would like to thank Fapesp (Proc. 2022/09319-9) for the funding;
The partnership FAPED/CNPTIA/JACTO (Proc. 23800.24/0055-0) for sponsorship grant;
EMBRAPA, CNPq and CAPES for financial support.

References

BAZZI, C. L.; JASSE, E. P.; MAGALHÃES, P. S. G.; MICHELON, G. K.; SOUZA, E. D. de; SCHENATTO, K.; SABJAK, R. AgDataBox API – integration of data and software in precision agriculture. **SoftwareX**, v. 10, 100327, July/Dec. 2019. DOI: <https://doi.org/10.1016/j.softx.2019.100327>.

BAZZI, C. L.; MARTINS, M. R.; CORDEIRO, B. E.; GEBLER, L.; SOUZA, E. G. de; SCHENATTO, K.; PAULA FILHO, P. L. de; SOBJAK, R. Yield map generation of perennial crops for fresh consumption. **Precision Agriculture**, v. 23, p. 698-711, 2022. DOI: <https://doi.org/10.1007/s11119-021-09855-2>.

COBBENHAGEN, A. T. J. R.; ANTUNES, D. J.; MOLENGRAFT, M. J. G. van de; HEEMELS, W. P. M. H. Opportunities for control engineering in arable precision agriculture. **Annual Reviews in Control**, v. 51, p. 47-55, 2021. DOI: <https://doi.org/10.1016/j.arcontrol.2021.01.001>.

FAO. **Global agriculture towards 2050**. Rome, [2009]. Available at: https://www.fao.org/fileadmin/templates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf. Accessed on: April 21, 2025.