Chapter N 019

Information systems applied to the analysis and improvement of the production process of hazelnuts

**Abstract.** The attention to the different phases of the life cycle of agri-food products by producers, as well as consumers, is an aspect that is evolving at the same speed as the agricultural sector is introducing innovations brought about by digital transformation.

It therefore becomes necessary to evaluate the sustainability of the entire agri-food chain to understand where and how to intervene for improving its efficiency and quality.

This work aims, through a case study relating to an Italian agricultural company operating in the hazelnut sector, to analyze the impacts of its production process from the raw material to the final treatment, before the hazelnuts are delivered to the company of transformation.

The goal is to assess the potential critical issues in the hazelnut production, with a view to improving the efficiency of the life cycle stages using innovative information systems set up ad hoc. A system that is able to support the company in the management and analysis of company data, which can be updated directly, continuously and in a coordinated manner.

**Keywords.** Information systems, life cycle, production process, hazelnuts, agri-food, digital transformation

# Introduction

Agriculture and in particular agro-food products have their own specific life cycle. The attention of the producer and the individual consumer converges on this aspect. And it is therefore increasingly necessary to evaluate the entire chain of agri-food products to understand where and how to intervene to improve their production.

This work aims to analyze the life cycle impacts of hazelnuts, produced, transported and treated by the Calabria Hazelnut Enhancement and Protection Consortium and finally delivered to a processing center in the Viterbo area, in order to improve the production chain.

For the analysis of the production chain, a specific software prepared by the consortium was used that supports the same companies in the management of company data, which can be updated directly, continuously and coordinated by the individual producers, and which allows corrected the data collected in the preliminary phase and calculate the results of the product life cycle using the data originated by the Consortium.

# Review of the literature

The hazelnuts are followed from production to the consortium warehouses and the data relating to all the outgoing and incoming flows from the production process have been collected in the field or obtained from the application of forecast models or, when necessary, obtained from existing databases, or even from the information of the same producers or the same agronomist who follows all the production (Roversi, 2020).

Today the LCA methodology represents an interesting methodology for farms, unfortunately it demonstrates several limitations that mainly concern the laboriousness of the analysis, in fact the resources required in terms of cost and time, in several cases, are very difficult to find, and sometimes some data are incomplete and imprecise (Notarnicola et al., 2017).

In fact, current experiences demonstrate the need for further refinements for the development of specific tools for agricultural production. Furthermore, the scarcity of these experiences does not allow the creation of those databases essential to identify the characteristics of the life cycle of the same product obtained in different areas.

# Material and methods

The research question of this work is to analyze the potential impacts in the production of hazelnuts, along their life cycle, from the production of the raw material, up to the exit of the consortium warehouse in order to make the activity improved through innovative information systems (Mucelli, 2000). To carry out an analysis of the process, from production to raw processing of the hazelnut by the Consortium, it was necessary, first of all, to identify the different macro-phases that appear to be:

1. the agricultural production phase of the hazelnuts at the member farms;
2. transport from farms to consortium warehouses;
3. the cleaning and drying phase inside the warehouses;
4. delivery of the product to the Viterbo processing company.

From the analysis of the different phases for hazelnuts, the most important phase of the life cycle is that of cultivation. This is mainly due to the production and arrangement of the land, pruning and the use of organic pesticides.

The set of all these data allowed the creation of a database from which it was possible to create a specific software that allows you to correctly manage the data collected in the preliminary phase, create an easy-to-understand model and calculate without too much difficulty the product life cycle results (Amendola and Calabrese, 2018).

The model contains within it processes which in turn are formed by flows, in and out, consisting of the data collected within the various companies of the Consortium members.

The proposed information system consists of an application accessible to users through the internet. The components of the system are:

* a relational database for storing and managing data and maps of the production units;
* a WebGIS interface with navigable and searchable maps, containing basic cartographic layers, map of companies and production units;
* a Content Management System (CMS) for the complete management of the database and for the dynamic generation of statistical reports on management and production data, with access rights and functions differentiated by user profile.

# Results and discussions

The study, with a view to improving the production chain, considers a territory of 300 hectares of hazelnut groves, with planting plantations measuring 5x4 meters, a total of 500 hazelnut trees per hectare. For the development of the database, for the purpose of using the dedicated software for calculating the hazelnut production cycle (Bazzerla, 2017), the following data were identified:

1. pruning of hazelnut trees per hectare (see table 1);
2. cleaning of hazelnut trees per hectare (see table 2);
3. organic system per hectare (see table 3);
4. hazelnut harvesting methods per hectare:
* mechanized collection (see table 4);
* manual harvesting (for land that does not allow mechanized harvesting) (see tab. 5);
1. data collection on hazelnuts transport methods:
* the first goes from the company to the consortium warehouses (see tab. 6);
* the second goes from the warehouses of the Calabria Hazelnut Enhancement and Protection Consortium to the laboratories of the Viterbo processing company (see table 7).

Table 1. Pruning per hectare.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Number of workers | Chainsaws | Liters of petrol | Gasoline for compressor | Compressed air scissors | Paraffin oil to oil chains |
| 2 | 2 | 20 | 7 liters | 2 | 4 liters |

Source: n/s processing of consortium data

Table 2. Cleaning per hectare.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Number of workers | Tractors | Desel fuel | Brush cutter | Gas |
| 2 | 2 | 7 hours of work per hectare about 50 liters | 2 brushcutters cut pulloni | 10 liters |

Source: n/s processing of consortium data

Table 3. Biological system per hectare.

|  |  |  |
| --- | --- | --- |
| Number of workers | Biological plant protection | Tractor |
| 1 | 400 liters per hectare 3 times a year | 10 liters of diesel |

Source: n/s processing of consortium data

Table 4. Harvest per hectare

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Number of workers | Number of machines | Number of tractors | Diesel fuel | Average quintals of hazelnuts per hectare |
| 5 | 1 car takes 3 hours per hectare | 1 | 25 liters | 20 quintals |

Source: n/s processing of consortium data

Table 5. Manual harvest per hectare.

|  |  |
| --- | --- |
| Number of workers | Average quintals of hazelnuts per hectare |
| 5 | 5 quintals per day per hectare |

Source: n/s processing of consortium data

Table 6. Transport of hazelnuts per hectare.

|  |  |  |  |
| --- | --- | --- | --- |
| number of quintals | transport by mechanical means | consumption | average distance |
| 20 quintals per day per hectare | 1 tractor | 10 liters | 10 km |

Source: n/s processing of consortium data

Table 7. Consortium warehouse transport.

|  |  |  |
| --- | --- | --- |
| Number of workers | Cost of transport for third parties | Kilometers traveled |
| 1 | 1200 euros | 700 km from the consortium deck to the factory in the Viterbo area |

Source: n/s processing of consortium data

After listing the main processes of hazelnut production and storage, the necessary data were collected in the system for the analysis of the impact assessment (Pernigotti, 2011).

In particular, the impact associated with the production and storage of hazelnuts was taken into consideration and the emissions caused by agricultural vehicles and the combustion of fuel, in this case diesel, used for the various agricultural machines were calculated (see tab. 8).

Table 8. Carbon footprint calculation.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | EF CO2 (kg) | EF CH4 (kg)  | EF N2O (kg)  | TOTAL (kg) |
| N. Workers/ha | 2 |  |  |  |  |
| No chainsaws | 2 |  |  |  |  |
| Fuel consumption/per person | 10 liters | 23,25  | 0,0013 | 0,00191 | 23,25  |
| Compressor petrol consumption/ha | 7 liters | 16,27  | 0,0009 | 0,00134 | 16,28  |
| Compressed air scissors | 2 |  |  |  |  |
| Paraffin oil for chain/ha | 4 liters | 17,53  | 0,001  | 0,0001  | 17,53  |
| CAMPAIGN OPERATIONS |  |  |  |  |  |
| N. Workers/ha | 2 |  |  |  |  |
| N. Tractors | 1 |  |  |  |  |
| Diesel consumption/ha | 50 liters | 145,52  | 0,0077 | 0,00766 | 145,53  |
| Brushcutters | 2 |  |  |  |  |
| Gasoline consumption per decesp/ha | 10 liters | 23,25  | 0,0013 | 0,00191 | 23,25  |
| BIOLOGICAL SYSTEM |  |  |  |  |  |
| N. workers/ha | 1 |  |  |  |  |
| Biological plant protection product/ha | 400 liters |  |  |  |  |
| Number of steps year | 3 |  |  |  |  |
| Diesel consumption tractor | 10 liters | 29,10  | 0,0015 | 0,00153 | 29,11  |
| MECHANIZED COLLECTION |  |  |  |  |  |
| N. workers/ha | 5 |  |  |  |  |
| N. machines/ha | 1 |  |  |  |  |
| Harvest duration/ha | 3 h |  |  |  |  |
| Diesel consumption/ha | 25 liters | 72,76  | 0,0038 | 0,00383 | 72,77  |
| Oil consumption for transport | 10 liters | 29,10  | 0,0015 | 0,00153 | 29,11  |
| Average harvest/ha | 2000 kg |  |  |  |  |
| MANUAL COLLECTION |  |  |  |  |  |
| N. Workers/ha | 5 |  |  |  |  |
| Average harvest/ha | 500 kg | 750 |  |  | 750,00  |
| HAZELNUTS TRANSPORT |  |  |  |  |  |
| Quantity | 2000 kg |  |  |  |  |
| Transport by mechanical means | 1 consumption |  |  |  |  |
| Diesel consumption | 10 liters | 29,10  | 0,0015 | 0,00153 | 29,11  |
| Average distance traveled | 10 km |  |  |  |  |
|  |  |  |  |  | 1.135,93 kg CO2/ha |

Source: n/s processing of consortium data

Finally, Table 9 highlights the emission levels of the vehicles used, a level that could further lower if the hazelnut is processed directly at the consortium headquarters rather than transporting it to the company headquarters in the Viterbo area.

Tabella 9. Total Co2 emission.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Density(kg/m ^ 3) | Calorific value(MJ/kg) | EF CO2(kg/TJ) | EF CH4(kg/TJ) | EF N2O(kg/TJ) |
| Gas | 770 | 43,57 | 69300 | 3,8 | 5,7 |
| Diesel | 910 | 43,16 | 74100 | 3,9 | 3,9 |
| GN | 0,552 | 56 | 56100 | 92 | 3 |
| LPG | 590 | 46,49 | 63100 | 62 | 0,2 |
| Paraffin | 850 | 40,2 | 73300 | 3 | 0,6 |
|  |  |  | EF CO2 (kg/kg product) |  |
| Pesticides |  |  | 1,5 |  |  |

Source: n/s processing of consortium data

# Conclusions and future perspectives

This study aims to computerize the entire chain of hazelnut production and their collection at the Calabria Hazelnut Enhancement and Protection Consortium.

What emerges, in line with the majority of LCA studies carried out in the agri-food sector, that having an information system within each individual company of the consortium facilitates production and collection activities (Del Borghi et al. 2020).

The production and maintenance phase of the hazelnut groves in fact contributes over 60% to the total work before reaching the raw material, while that of harvesting and storage is only 40%.

Within the supply chain, the agricultural process that generates more attention and work is undoubtedly that of the maintenance of hazelnut plants both to have a greater production of hazelnuts and to maintain the land (Zinnanti et al., 2019).

Furthermore, as regards the collection, a significant fact is the diversification from manual collection from mechanized collection, the mechanized one being connected to the consumption of fossil fuels, entails higher costs, but at the same time greater collection in less time (Zampori and Pant, 2019).

Therefore, it can be hoped that the use of information systems in LCA studies applied to the agricultural sector, especially in the core sector, is extremely useful as well as important for improving production. Finally, as regards LCA of hazelnuts, regarding its transport and warehouse, an information system would help the storage part by reducing costs by more than half and reorganizing the supply chain of the entire work activity (Zampori and Pant, 2019).

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