Management systems in agrifood supply chain

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Abstract

The traceability chain can be difficult not only because the agro-food chains are very complicated, but also because the food industries operate continuous mixing of raw materials, semi-finished goods and products in order to optimize the formulations, reduce costs, standardize products.

The essential element in the technical sector to get a draw is the management of material flows "lots".

The "lots" are irregular and characterized by the fact that their management is made by filling and emptying totals. This process may generate situations of uncertain identity and may lose the traceability of lots.

The present study has as objective the agrifood lots management through an integrated model with the techniques Global Position System (GPS) for mapping production; a tool to identify the difference in yield in the field.

Keywords. Mapping, production, traceability, management, GPS techniques.

Introduction

The Precision Farming in the modern cultivation, it is proposed to manage the variability that exists within the parcel through the use of resources and technology solutions for:

- Optimize the use of productive factors (inputs);
- Reduce costs;
- Protecting natural resources.

For guaranteeing the safety of all food products all the aspects of the food production phases should be considered as a one only process which starts from primary production and ends in either selling or supplying food products to end consumers. It is important to consider every processing step of the production chain.

The indication of the “path” travelled by all European agrofood products has by now become compulsory: starting from January the 1st, 2005 EC Regulation 178/2002 has established the notions of food traceability and tracking as well as the concept of food safety [4].

Food traceability and safety are becoming notions of crucial importance to those who work in this sector in view of their potentially positive influenced on produce competitiveness and appreciation on the part of consumers [10].

To this end the *STAfA Department*, Mechanical Section, has started a specific line of research focused on the analysis and use of both traceability and tracking systems of the products in the agrifood sector.

It was made a thorough study of the area to identify some characteristics farms in the region Calabria (Italy). Were then analyzed the phases of harvesting and processing of olives [3].

The first step is knowledge of the variability present within the field: the mapping of production is the most widely used technique for collecting data on the variability in yield.

For this reason has been carried out a detailed analysis of the productive processes has been made through the determination of the "dynamic lot": a unit of processed product (either directly or indirectly) in a time unit (usually a workday), as a function of the peculiarities of the businesses involved (orographic features, level of mechanization, etc..).

Materials and Methods

Today the concepts of traceability of food and food security seem well defined and, in some cases, seem to discount the operators of agrifood sector in view of their need to increase their competitiveness [7].

The study carried out has highlighted that the application of traceability systems to the olive growing and olive oil production sector calls for a good understanding of the complexity of the businesses involved which have to be identified in terms of both their operations and the technology they use since, as mentioned, traceability systems depend on the peculiarities of the business in question even when the processed product/process is the same[6].

The present work showed that the implementation of traceability systems for the cultivation and production of agrifood sector requires a good understanding of the complexity of the companies involved, which must be identified both in terms of processing methods, both in terms of technology used.

Also legislators agree on the importance of food “safety” as shown by EC Regulation 178/2002, under which traceability is made compulsory within agrifood businesses (EC Regulation 178, 2002) [9].

Moreover there exist other non compulsory regulations, including UNI, EUREP-GAP regulations and the like, that define producer tracking and/or production phases traceability at different levels.

In this context, the Mechanics Section of the *STAfA Department* of the “*Mediterranea*” University of Reggio Calabria (Italy), has started a specific line of research focused on the analysis and use of both traceability and tracking systems of olive and olive oil products, throughout the entire territory of Calabria.

The objective of the present study is to define a methodology to determine the “dynamic lot”: a unit of soil surface ($m^2/workday$) gotten through the analysis of processed product, in unit of time, depending on the specific situations of the companies involved (orographic features, cultivar, level of mechanization, etc.) [5].

The survey conducted in Calabria has led to the detection of two highly representative olive growing farms practising two different typologies of olive growing.

A recap of the features of the farms under study is given in Table 1.

The steps for determining the "dynamic lots" within each company were:

- Identified areas for harvest;
- Allocation of a code to each area;
- Transfer of the plan of harvest to yard that is running the operation.

Table 1. Recap of the features of farms studied.

FARM	A	B
Location	San Giorgio Morgeto (RC) Cittanova (RC) Polistena (RC)	Delianuova (RC)
Olive groves surface [ha]	~130	~15
Position	Variable (0% ≤ slope ≤ 40%)	Variable (20% ≤ slope ≤ 40%)
Cultivars present	Carolea e Ottobratica	Sinopolese
Planting layout [m x m]	Variable from (6 x 6) to (7 x 8)	Variable from (10 x 10) to(12 x 12)
Planting density [plants/ha]	278	~ 100
Harvest method	shaker and nets	shaker and nets
Containers for olive handling	bins, boxes, pallets	boxes, bags
Harvest site manning	5 labourers	7 labourers

The data collected in the field must then be filtered by an operator to the computer to delete all values unlikely or incorrect, recorded at the lot, due to the malfunction of the mapping system or unexpected changes in operating conditions.

Figure 1. GPS during the measurement.

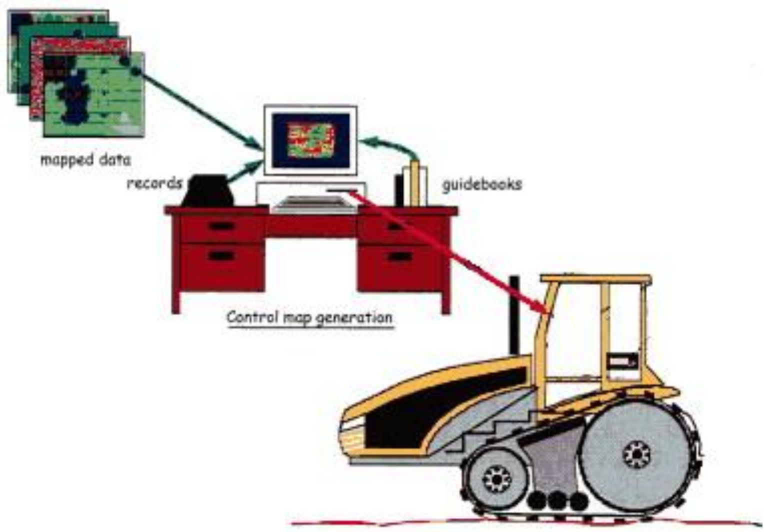
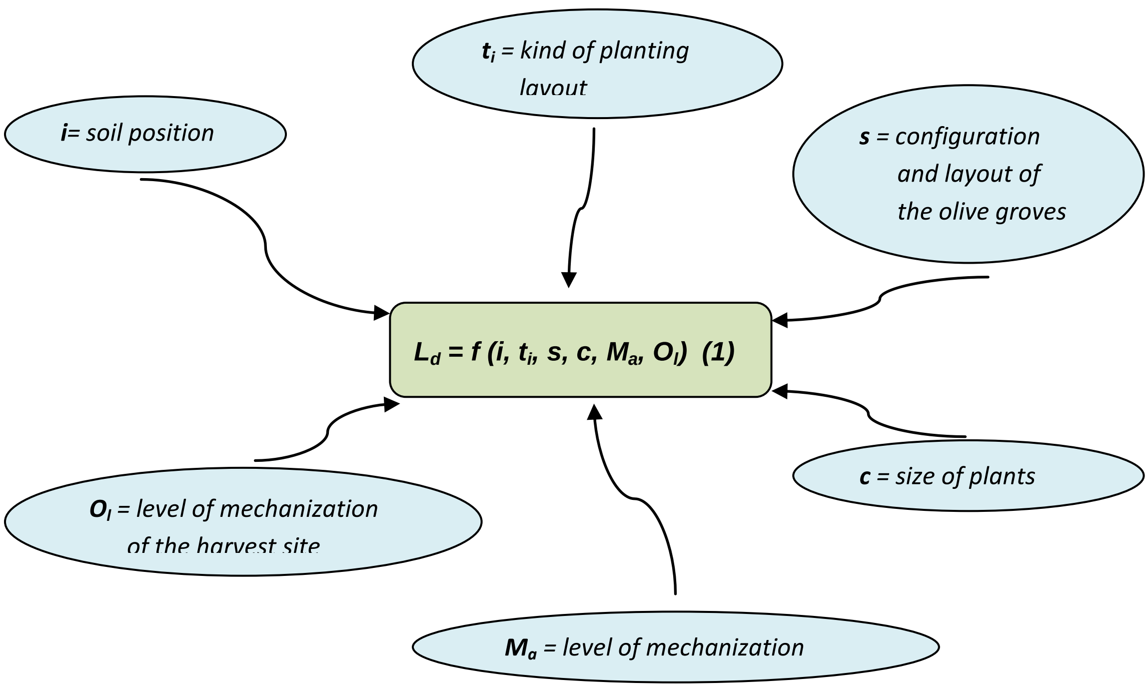


Figure 2. GPS data transfer information.

As a consequence, the different productive processes have to be managed in terms of lots with the indication, for each and every lot produced on a given day, of all the processing operations already implemented and to be implemented assuming that the level of mechanization and of mechanization of the harvest site remains unchanged. Now, in light of these remarks it has been decided to go ahead in this study by defining a logistic unit (lot) as a baseline reference for all cropping operations, harvesting included [11].

Relying on the results of a three-year research effort in this field the Section Mechanics, has detected a correlation model (still being developed as yet) to determine in quantitative terms(surface) a lot with the most relevant pieces of information on the production process, from the olive grove to the oil mill and to the next (if any) processing phases.

Given the high level of heterogeneity of the olive growing farms under study, the determination of the size of the dynamic lot (L_d) is likely to depend on the following variables:



The parameters contained in [1] turn out to be peculiar of the olive grove under study; as a result also the lot is necessarily going to have a variable size to be determined case by case.

The correlations observed have highlighted that, in terms of traceability, the dynamic lot (L_d) of reference depends on a number of farming-business parameters; therefore [1] can be determined, as a first approximation, through the following relation:

$$Ld = C_c \times O_g \times S_i \times c_i \qquad (m^2/day) \qquad (2)$$

where:

C_c = hourly harvesting capacity of the harvest site (plants/hour), as a function of the level of mechanization of the farm (M_a) and of the level of organization of the harvest site (O_l);

O_g = actual daily work hours (*work hours/day*);

S_i = Planting layout correlated to training typology (t_i), to configuration and layout of the olive groves (s) and to the size of plants (c);

c_i = Soil slope coefficient correlated to soil position (i).

The soil slope coefficient correlated to soil postion c_i given in (2) resulted from the relationship between the average equivalent plain surface ($\overline{S_{eq}}$) and the average sloping surface ($\overline{S_P}$) actually "processed" which is, in turn, derived from the average of the "processed" surfaces which varies according to the different farming-business features; i.e.:

$$c_i = \frac{\overline{S_{eq}}}{\overline{S_P}} \qquad (3)$$

Where:

$$\overline{S_{eq}} = \overline{S_p} \times \cos[\arctan g(i)] \qquad \left(\frac{m^2}{day}\right) \qquad (4)$$

The (4) accounts for the projection of the sloping surface ($\overline{S_p}$) on an horizontal plane (topographic surface), and i is the soil position (expressed in slope percentile) [1].

Results

The primary objective of the present study has been the detection of any mismatches, i.e. handling or registration errors likely to impair the tracking of the product in question. When these errors occur the portion or the lot of product in question must be excluded not only from the traceability line, but also from the food chain to suppress any sources of risk in compliance with EC Reg. 178/2002. The procedure in question has been implemented mainly to respond to the requirements of Documentability and check-ability.

Documentability has been obtained by means of a precise description of the productive process and of the control systems together with the indication of the procedures which define the operational procedures of the production process under consideration.

Checkability has been obtained by an accurate registration (in specific forms) of the activities carried out with relevant indication of both outcomes and people in charge. In line with the parameters in above, it has been possible to obtain a complete traceability of both operations and treatments given to the product during the different processing phase [8].

The graphs below highlight the variation in the number of plants harvested per day (as an average of the data collected over the 3-year period) as a function of the soil slope in different cultivars.

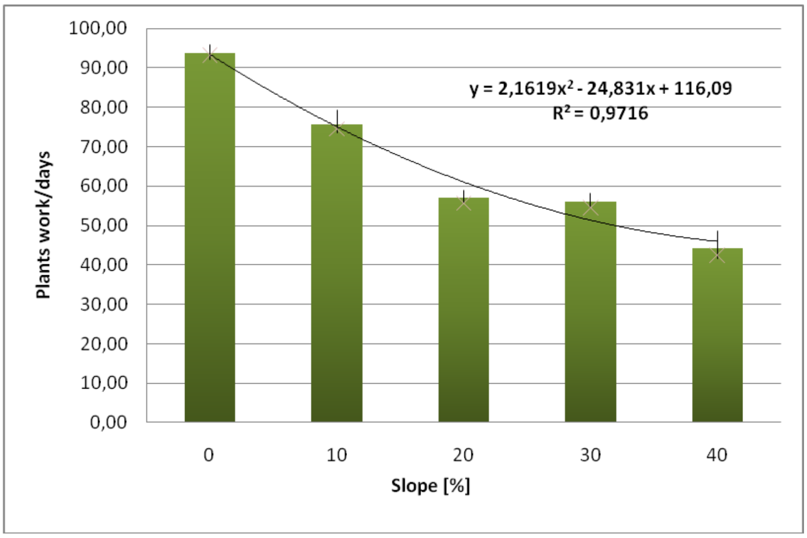


Figure 3. Surfaces and plants harvested variations in cultivar "Carolea".

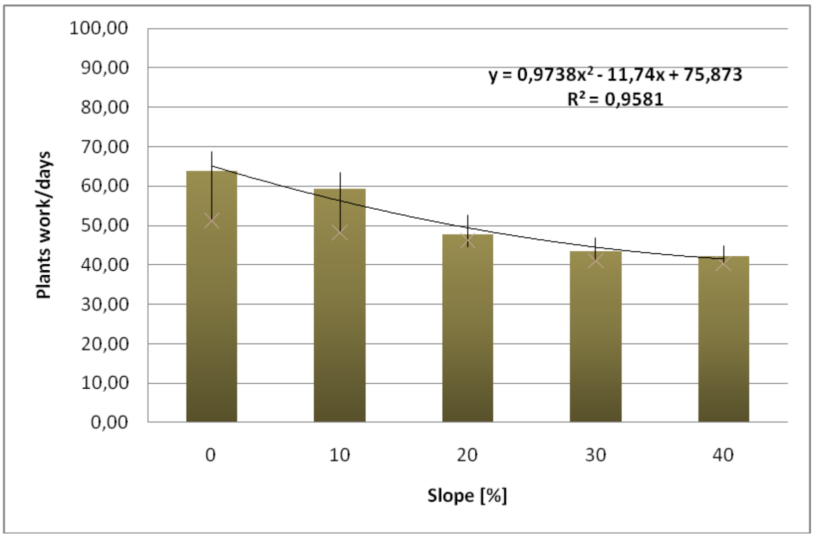


Figure 4. Surfaces and plants harvested variations in cultivar "Ottobratica".

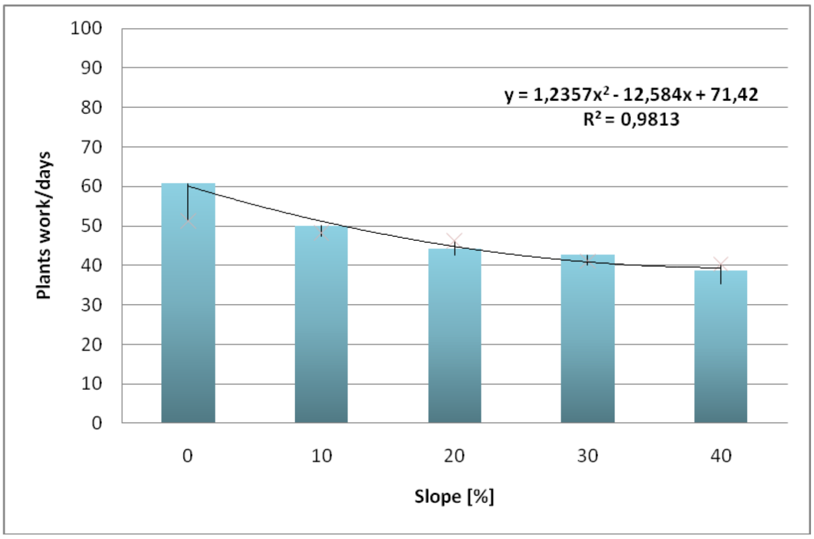


Figure 5. Surfaces and plants harvested variations in cultivar "Sinopolese".

Figures 3, 4 and 5 show a substantial variation in terms of surface (ΔS) harvestable as a function of the different cultivars and hence, of the different kinds of planting layouts (see Table 1) while keeping the following unchanged:

- Morphological-business conditions;
- Level of mechanization and organization of the harvest site.

The surface variation (ΔS), reported in the above graph has been obtained as the difference between the average harvested surfaces ($\overline{S_p}$) and those obtained from (4); i.e.:

$$\Delta S = \overline{S_p} - \overline{S_{eq}} \qquad (5)$$

The above graphs highlighted two aspects:

1. the number of harvested plants (and hence the size of the harvested surface) decreases with the increase in soil slope, when farming-business conditions are kept unchanged;
2. the surface calculated through (2) to determine the dynamic lot, is slightly smaller than the average one measured in field; this small difference can be considered neglectable if no other disturbing factors are at play.

The surfaces produced by the mathematical model (dynamic lots), integrated with the data collection by the satellite system, are in Figure 6.

Figure 6. Mapping production area of dynamic lot, in Calabria area.

The data collected during the above period concerned harvest operations which are considered to be crucial to the transit of information (in terms of both data implementation and transmission) from the olive growers and the oil mill. The different areas of land are function, primarily, from the heterogeneous nature of the olive tree and from the land slope.

More specifically, in the figure 6, the different areas of mapping productions depend of irregular cultivar position and slope soil. With GPS systems it is possible to identify punctually the local position and as a result make the proper management of the production work for others in oil mill.

Conclusion

The management systems are variables entity due to the high spatial and temporal changeability of natural resources (soil, climate, topography etc). The technology at the service of agriculture can help improve farm incomes and by reducing operating costs is due to the production unit. A concrete example of this application is the application of principles and technologies for the management of spatial and temporal variability of factors related to the production process in order to improve production and environmental quality.

The present study, synthetically presented in this paper, accounts for a contribution to defining a possible methodology to define “the lot” as a unit whose data must be used in implementing a system of traceability in the olive growing/oil producing sector; the lot is therefore the starting point of a traceability system in that all the pieces of information characterizing the produce in question have to be referred to the it. A wrong sizing of the lot of origin can result in the partial or total loss of the data that have to be transferred from the olive grove to the next phases of the production process. Incorrect calibration of the lot of sources can lead to loss of partial or total data that must be transferred from the olive grove to the next stages of the production process.

The results obtained have highlighted (see graphs of Figure 4) a neglect table difference between the actual average surface and the theoretical surface resulting from the relation studied and applied, thus indicating a good level of reliability and a hypothetical application of the above relation to other agrofood sectors.

The use of GPS and equipment related to it are tools that have marked a very strong trend in the way of doing agriculture. It is easy to imagine what could be disruptive and effective technology of this kind. For applications is only a matter of time, probably soon every car will be designed for site specific farming and not merely adapted. But for now it is not as easy to understand which tools for analysis and decision support arrangements may be made. An analysis of this instrument requires appropriate information systems that support agricultural decisions.

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