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Assessing environmental impacts of nursery production: methodological issues and results from a case study in Italy

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ABSTRACT

A nursery is a primary system, providing materials used in secondary areas of production such as horticulture, orchards, or forestry. Although the young plants produced in a nursery constitute the fundamental unit of many manufacturing processes, the application of environmental indicators in nursery systems is rare. Several studies indicate that the role of the nursery specifically in the impact assessment of fruit products is usually underestimated or not acknowledged. Reference models for the application of an environmental assessment method, such as ecological footprint analysis (EFA), in nursery systems are also scarce.

In this study, a general model of a nursery system is developed taking into consideration the available literature on the topic, adopting a life cycle approach, and the suitability in the application of several environmental assessment methods.

An EFA was applied to a real case study in northern Italy in order to validate the model. Strengths and weakness of two units (100 grafted plant to be sold and one hectare production surface) are discussed in the light of the results obtained in the case study. Among other case specific results, plastic had the highest relative environmental impact in the nursery system (about 80% of the value of the total footprint), making it the main resource used which should be re-considered to improve the environmental performance of the system. According to the proposed model, the nursery stage accounts for almost 17% of the entire environmental impact of the main orchard system connected to the nursery in the case study.

1. Introduction

1.1. Environmental impact assessment of food products

The evaluation of sustainability is nowadays an important aspect in the study of agricultural systems and the number of projects and methods for impact assessment of food production systems is increasing (Notarnicola et al., 2012). Although several studies highlight the importance of harmonising impact assessment protocols (van der Werf et al., 2013), each framework for environmental product declaration on foods developed specific guidelines and rules. One of the most widely used declaration protocols for food products is the International EPD® System, standardised as type III labelling (ISO 14025). This declaration system works with rules based on a hierarchical approach following the international standards ISO 9001, ISO 14001, ISO 14040, ISO 14044, and ISO 21930. As a consequence, the life cycle approach is a mandatory procedure and reference is made to life cycle based information as content for consideration for product category rules (PCRs) (Del Borghi, 2013). In the International EPD® system, fruit products are covered by a general PCR (fruits and nuts – 2012:07) for the sector and five other specific PCRs (Cerutti et al., 2013a). Another important international framework for environmental declaration is the Product Environmental Footprint (PEF). This protocol was developed by the European Commission's Joint Research Centre and is based on existing methods that have been tested and used extensively (European Commission, 2013). In

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this framework, Product Environmental Footprint Category Rules (PEFCRs) are used, but, up to now, the protocol has covered the testing phase and as yet there are only draft PEFCRs available for fruit.

In both these contexts, the role of the nursery in the impact assessment of fruit products is usually underestimated or not acknowledged (Cerutti et al., 2013a). Nevertheless, several studies (Milà I Canals et al., 2006; Bessou et al., 2013) have already pointed out that not including the impact of the nursery in the evaluation of the environmental performance of an orchard could lead to misleading results.

Furthermore, nurseries can be defined as primary systems, which produce the raw material used in related activities, such as fruit farming. The plants produced in the nursery constitute, therefore, the fundamental unit of many manufacturing processes (Hartmann et al., 2002). It is clear how useful it can be to acquire information about the sustainability of a basic production system for the quantification of production systems connected to it.

Moreover, despite increasing application of environmental assessment methods, such as life cycle assessment (LCA) and ecological footprint analysis (EFA), in the fruit sector (Cerutti et al., 2013a), studies with detailed application of the indicator to the nursery sub-systems are very rare. As a consequence, methods for modelling nursery systems for environmental assessment methods are as necessary as specific quantification of the impact of nurseries (Russo and De Lucia Zeller, 2008).

The objectives of this work were:

(I) to model nursery production systems for the application of an environmental assessment method;
(II) to validate the model thorough the application of the EFA to a real case study; and
(III) to verify the applicability of the method in terms of significance of the results compared with environmental impacts of the whole orchard.

1.2. The nursery system and its environmental impacts

Europe is one of the most important areas for nursery systems (AIPH, 2011). In 2011, Europe produced 44.1% of flowers and potted plants in the World, compared to 12.9% in China and 11.8% in U.S.A. (AIPH, 2011). The nursery industry in Europe is well rooted: in 2012 the EU28 production of flowers and plants counted 21.096 million euros (DG AGRI, 2013)with highest values in Netherlands (6.552 million euros), Italy (2.699 million euros), Germany (2.483 million euros) and France (2.303 million euros). Taking into account the number of holdings, in 2007 (last year of statistics specifically for nurseries) more than 40,000 farms were present in the EU27 Countries, with peaks in Poland (9120 farms), Italy (8450 farms), Hungary (4390 farms) and France (3560 farms) (DG AGRI, 2013).

The nursery is conventionally divided into three parts (Vezzosi, 1985): the nursery buildings; the propagation area, and the final cultivation area. The nursery buildings are made up of structures that allow production and marketing activities; for example, they include warehouses that hold fertilisers, pesticides, stock materials, the offices for administrative activities, loading and unloading area, possibly sheltered from the rain, garages containing machinery and agricultural vehicles, and the exhibition area for customers (Hartmann et al., 2002; Russo and De Lucia Zeller, 2008).

The propagation area includes facilities for the multiplication of plants, with the objective of providing guaranteed and healthy commercial material. It is not present in all nurseries: some of them purchase raw propagation materials from other nurseries. However, it is essential that the nurserymen produce and sell high-quality plants that fulfil the requirements of a highly competitive market (Vezzosi, 1985).

The cultivation area is the largest nursery surface; it is divided into different sections, depending on the different species and on the development stage of the plants (Russo and De Lucia Zeller, 2008). The cultivation area can include the raw material collections, where the mother plants from which propagation material (such as cuttings or buds to be grafted) is produced are grown. The area is not present in all nurseries and is usually associated with large propagation centres (Hartmann et al., 2002).

The cultivation area can also include the seedbed where seedlings are produced, and the rooted cuttings area where cuttings are produced: this area can take place in a field or on benches, which can be associated with basal heating and nebulisation (fog and mist) systems (Zamanidis et al., 2013). The grafting area is a cultivation sector that can be located in the open field or, in the case of grape, in a dedicated room. Finally, the storage plant area is the warehouse, in which the plants are stationed before selling (Fideghelli and Sansavini, 2005).

Nursery activity, which plays a relevant economical role in the agriculture sector, also represents a source of potential risk for the ecosystem because, as a form of specialised and intensive agriculture, it highly consumes environmental resources that are not easily replenished (such as groundwater). Moreover, nursery activity greatly contributes to the contamination of surface water and groundwater due to the consistent use of fertilisers and pesticides (Cambria and Pierangeli, 2011). The use of chemicals such as herbicides, fungicides, and insecticides is massive in nursery activity since the market requires plants with a high-quality aesthetic aspect and phytosanitary laws (with some variations in the different countries) impose the absence of pests and diseases in commercialised materials.

Nurseries that produce plants in containers use different types of mulching such as plastic semi-permeable sheets; alternatively, pots are placed on concrete floors that severely limit or completely prevent the infiltration of water into the aquifer (Bilderback, 2002). In addition, the use of plastic for pots, covers, and irrigation systems leads to relevant resource consumption and environmental pollution due to their disposal. The areas covered by heated greenhouses or plastic tunnels often use a large amount of diesel oil to ensure satisfactory thermal regimes for the crops. Furthermore, this resource is also used for field operations by means of machinery (Latimer et al., 1996).

1.3. Impact assessment methods applied to nurseries

According to recent studies (Cerutti et al., 2011; Bessou et al., 2013; Cerutti et al., 2013a), the application of environmental assessment methods have given lower importance to nursery production as compared with other agricultural production systems such as orchards. In the case of fruit production, the small number of studies on environmental impacts is bound by the lack of knowledge on the impact of plant production, while all the other inputs, such as fertilisers and pesticides, are well known.

Although in some perennial plantation systems its relative contribution may be negligible (Yusoff and Hansen, 2007), the nursery production process may play an important role for plants that need special production agrotechniques in the early stages, such as specific growth substrates (Ingram, 2012) or plastics for greenhouses (Russo and Scarascia-Mugnozza, 2005; Khoshnevisan et al., 2013). A recent study on protected crops (Cellura et al., 2012) confirmed that the most significant impacts in such cultivations are related to the use of materials for building greenhouses and plant

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