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Emergy evaluation of Sicilian red orange production. A comparison between organic and conventional farming

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Abstract

This study examines, by using emergy analysis, the production of red orange in Sicily in order to evaluate resource use, productivity, environmental impact and overall sustainability. Four different sicilian farms were studied in order to compare conventional with organic production. Several indices derived from the emergy evaluation were used: the emergy yield ratio (EYR); the environmental loading ratio (ELR); the index of sustainability (SI). Organic orange production appears to use more renewable resources and less purchased energy and materials.

Keywords: Blood oranges; Emergy method; Sustainability index; Organic agriculture

1. Introduction

Modern agricultural production systems are dependent upon large quantities of increasingly scarce non-renewable resources to maintain their high yields. Simultaneously, there is evidence that many modern, highly mechanized systems of food production can degrade soil, water and genetic resources. Recognition of the fact that conventional modern agriculture deviates from ecological principles has inspired a new generation of scientists and agricultural practitioners who are working to reintegrate the principles of ecology into agriculture [31,32]. While the goal of farming in a manner that is more mimetic of natural systems may be firmly incorporated into the tenets of the alternative agriculture movement, measuring the sustainability of agricultural systems by the criterion of how closely their function resembles natural systems is a relatively new area of research, and understanding how ecological principles translate into agricultural practice remains an important task. This paper is an attempt to evaluate the sustainability of the production of Sicilian red oranges, by using the emergy analysis [15] as a methodological platform.

2. Methodology

2.1. An overview on Sicilian red oranges

The best quality of the Sicilian orange supply is represented by the production of pigmented oranges, best known as “red” (blood) oranges, “Tarocco”, “Moro” and “Sanguinello” [28].

They provide some special flavours and organoleptic characteristics that cannot be found outside Sicily, and in particular outside the east side of Sicily and in the south and south−west of Mount Etna. It is in this part of the island − nowhere else in the Mediterranean or in America − that these oranges have found the right environmental conditions to best show their genetic characteristics, such as their intense red colour and the perfect acid/sugar ratio [19]. Red orange growing in Sicily is extremely important in some areas (Map 1), which are specifically suitable for their pedological and weather conditions. Temperature ranges between morning and night, sometimes of beyond 20 °C, contribute to the synthesis of

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anthocyanins [26]. Anthocyanins that do not exist in blonde varieties, not only give an essential sensory contribution, as they help to typify the product and promote its image, but they also play a more important biological role. In fact, they are used in ophthalmologic therapy as active principles; they contribute to the regeneration of the visual purpura in the treatment of ulcers and in angiology, thanks to their epithelium-repairing and capillary-permeability modulating properties. They are also used in those physiopathological conditions characterized by an excessive production of free radicals [2,6,10,13,20]. The prevailing anthocyanin in blood oranges is the cyanidin-3-glucoside, which has a powerful antioxidant action and is therefore useful in preventing cardiovascular diseases and the development of some types of cancer [1]. They also reduce the effects of ageing and help to prevent hypercholesterolemia. The characteristics of the land and climate are essential for producing the pigments that give red oranges their characteristic colour in some Sicilian territories. The essential factor is, indeed, whether the above-mentioned sudden change in temperature occurs when oranges ripen. This phenomenon, a characteristic of the Mediterranean, does not exist in tropical areas from which citrus fruits come. This provides fruits with valuable, unique organoleptic characteristics. With respect to their peculiar biological characteristics and their unique geographical origin, Sicilian blood oranges have gained the PGI EU recognition (Protected Geographical Origin), according to the EC Regulation n. 1107/96 and the consequent ‘‘Disciplinare di Produzione Arancia rossa di Sicilia" (Circolare del Ministero per le Politiche Agricole – Gazzetta Ufficiale Repubblica Italiana n. 240 on 14th October 1997). The production of ‘‘red’’ oranges in Sicily brought back from Italian official statistics (National Institute of Statistics – ISTAT) has only recently overcome 1000 tons. Although a great increase in production has been registered, the product exportation seems to be very limited. Exportation growth seems to be stable or slightly declining. It can be traced back mainly to the growing presence of other countries (Spain, Greece, Morocco, Turkey) on main citrus markets. These countries are able to compete thanks to a price policy, which is fostered by their extremely low cost factors. On the other hand, there is no appropriate and effective policy aimed at promoting those productions, even if Sicilian productions have nearly unrivalled qualities. Italian goverment has not done enough to develop organisation models fit for carrying out adequate policies for product differentiation [27]. Finally, as regard to the Sicilian red oranges, some tourists consider their holidays in Sicily an opportunity to eat typical and traditional agricultural products, which remind them of Sicily’s ‘‘nature, sun and landscape’’ and the ‘‘authenticity, quality and taste’’ of its local products. Their most appreciated products are, therefore, ‘‘sicilian blood oranges’’ [22,23].

2.2. Emergy analysis and sustainability

Emergy is defined as the sum of all inputs of energy directly or indirectly required by a process to provide a given product when the inputs are expressed in the same form (or type) of energy, usually solar energy. Most often, inputs to a process are the result of another process (or a chain of processes), in which energy has been concentrated and upgraded [24]. Thus, the total emergy input is derived by summing up all inputs, as previous defined (expressed in equivalent energy of a single form, such as solar energy) used in the chain of processes that yielded the output in question. The total solar emergy of an item can be calculated as the product of its available energy content by its solar transformity. It is usually measured in solar emergy joules (sej), while solar transformity is expressed as solar emergy joules per joule of product (sej/J). When an item is expressed in units different than joules, for instance as grams, the quality factor is emergy/mass (sej/g).

The solar transformity gives a measure of the concentration of solar emergy through a hierarchy of processes or levels. Transformity can be considered a quality indicator, according to Lotka-Odum’s maximum power principle (Odum and Pinkerton, 1955).

Once the total number of input flows has been identified and the total emergy driving a process has been evaluated, a set of indices and ratios can be calculated.

Three main emergy flows can be recognized when evaluating a system:

- renewable flows from within (R);
- non-renewable flows from within (N); and
- flows imported from outside the system (feedback flows, F).

Sometimes referred to as purchased flow (other works have widely described these concepts, see Refs. [24,25,33,34]).

The renewable flows (R) are: flow limited, free and locally available. The non-renewable flows (N) are: stock limited, not always free and locally available.

The feedback flows (F) may be: stock limited, never free, never locally available, always imported.

The above characteristics of emergy flows make it possible to calculate different and useful indices. In the present study we apply three main indicators, that have been widely discussed elsewhere, and we shortly describe below.

- The environmental loading ratio (ELR) is the ratio of purchased (F) and non-renewable indigenous emergy (N) to free environmental emergy (R). It is an indicator of the pressure of the process on the local ecosystem and can be considered a measure of the ecosystem stress due to production activity.
- The emergy yield ratio (EYR) is the ratio of the emergy of the output (Y), divided by the emergy of those inputs (F) to the process that are fed back from outside the system under study. It is an indicator of the yield compared with inputs other than local inputs and gives a measure of the ability of the process to exploit local resources accounting for the difference between local and imported. The higher the EYR, the higher this ability, which is not a negligible factor in economic systems.