Energy flow and greenhouse gas emissions in organic and conventional sweet cherry orchards located in or close to Natura 2000 sites

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ABSTRACT

An energy analysis in orchards is useful to deciding best management strategies. The objective of this study was to evaluate, by selecting organic and conventional sweet cherry orchards located in/or close to Natura 2000 sites (a) the energy flow between the two farming systems and (b) the effect of farming system to gas emissions (CO_2, CH_4 and N_2O). Twenty farms [(2-conventional and 2-organic) × 5-locations] were selected during 2003—2004. Means averaged over all locations for insecticides and fungicides application, fuel, insecticides, fungicides, non-renewable energy inputs, energy shoot outputs, energy fruit outputs, energy shoot + fruit outputs, fruit production, shoot efficiency, fruit efficiency, shoot + fruit efficiency, non-renewable energy efficiency, gas emissions were higher in conventional than in organic orchards, while fertilizer application, harvesting, fertilizers, labor, total energy inputs, renewable energy inputs, intensity and non-renewable energy consumption were higher in organic orchards. Means averaged over two farming systems for fertilizer, insecticide and fungicide application were higher in GRL2 and GRL5. The means averaged over two systems for transportation had the highest value in GRL4 and the lowest in GRL5. Finally, means averaged over two farming systems for labor had the highest value in GRL2. Non-renewable energy inputs as percent of total inputs were 82.63 and 52.42% in conventional and organic sweet cherry orchards respectively. The results show that organic farming systems could reduce non-renewable energy inputs and gas emissions in an efficient way in areas related to Natura 2000 sites.

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1. Introduction

The role of agriculture in the preservation of natural habitats, wild fauna and flora is a main issue. The Habitats Directive (92/43/EEC) on the conservation of them has established the European ecological network Natura 2000. A habitat type includes specific factors (ecological conditions) which allow the species to survive and to reproduce successfully. If the habitat quality changes (e.g. due to anthropogenic impact) or the ecological requirements of a species change, it is forced to retreat from its place of residence [1]. In addition, extensive practices in agricultural areas allow the formation of habitats

with a specific biodiversity [2]. Abandonment of these practices causes species impoverishment, the prevention of which was achieved through the establishment of environmental sensitive areas by the Common Agricultural Policy.

Sweet cherries (*Prunus avium* L.) are cultivated in the EC (European Community) mainly in Italy, Spain, France, and Germany and their production is $\sim$530,000 Mg yr^{-1} [3]. In Greece sweet cherry production is $\sim$48,000 Mg yr^{-1} [3]. Recent European commission policy measures encourage organic farming [4] and offer a realistic production method to sweet cherry farmers. The Prefecture of Pella in northern Greece has a long time tradition in sweet cherry production where sweet cherries have been cultivated for over 100 years. Several of the sweet cherry orchards are located in or close to Natura 2000 sites. Although production of organic sweet cherry is lower than conventional, its price is often twice the price of the conventional. These high prices in addition to the EC instituted subsidies are essential for a farmer to convert to organic farming.

In the Perfecture of Pella, organic farming, may contribute to biodiversity maintenance [5–7] in nearby agricultural land and especially sweet cherry orchards areas, besides the economic benefits. The last 15 years there is a tendency of abandoning cherry cultivation, and generally farming in Pella, due to migration of the rural population to the nearby cities. This results in land use changing especially in areas related to Natura 2000 network. Recently, major issue for each member state of EC is the conservation of special areas under climatic change, which is a limiting factor for cultivated and wildlife species in Natura 2000 sites. Direct effects of climatic change on species physiology and habitats modifications lead to population decline of native species and population enhance of invasive species [8].

Although climate change impacts on nature reserve networks have been investigated [9–15], little attention has been paid to specific conservation sites. Farmers in areas related to Natura 2000 sites are seeking methods and practices for minimizing cultivation cost in order to attain a better income [16]. Energy analysis can indicate ways for more effective energy use without impairing the economics of crop production. A combination, environmental and energy analysis of a production system may be more useful for the application of best management practices [17–21], especially in areas related to Natura 2000 sites. Fossil energy in agricultural sector must be used in a sustainable manner [22] considering that fossil fuels are a limited source of energy and a source of CO_2 emissions in the atmosphere [23,24]. Development of agricultural systems with low inputs of energy could lead to reduction of agricultural CO_2 emissions [25–32]. On a global basis the agricultural sector consumes about 5% of the total fossil energy used [33]. To reduce environmental impacts of agriculture, methods to understand and assess the impact on nature need to be employed. One of the methods suggested is the Life Cycle Assessment (LCA) method [34–36].

The objective of this study was to evaluate, by selecting organically and conventionally cultivated sweet cherry orchards located in or close to Natura 2000 sites in northern Greece, (a) the differences in energy flow between conventional and organic farming systems and (b) the effect of farming system on greenhouse gas (CO_2, CH_4 and N_2O) emissions based on the used fossil energy and fertilizers.

2. Materials and methods

Two organic and two conventional sweet cherry orchards were selected in each of five locations in the Prefecture of Pella, northern Greece (Fig. 1, Table 1). Farmers cultivate a local sweet cherry variety called "Tragana d'Edessa". The experimental design in each location was a random complete block design with two replications. The size of all studied orchards was about 0.6 ha. The age of sweet cherry trees in the selected orchards was about 20 years for both farming
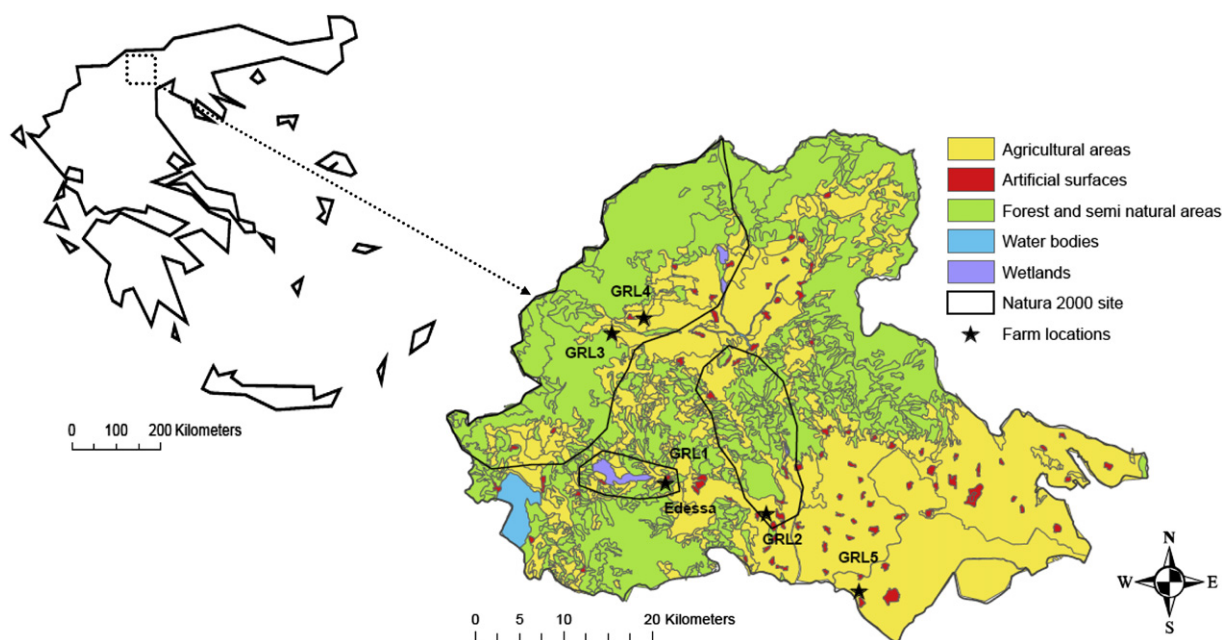

Fig. 1 – Land use and selected farms (asterisks) related to Natura 2000 sites (dashed lines) in Prefecture of Pella, northern Greece.