

WHEN CHICKENS GRAZE IN OLIVE ORCHARDS, THE ENVIRONMENTAL IMPACT OF BOTH CHICKEN REARING AND OLIVE GROWING DECREASES

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Introduction

Chickens can graze in olive orchards without negative effects on olive yield, instead fertilizing and weeding the orchard, while the latter can provide the grazing space without additional land use (Rosati et al., 2009, 2012). Chicken manure is naturally (and freely) spread and costs for its disposal are eliminated. Small feed savings might be achieved when chicken turn weeds into feed. Olive trees provide shade and mitigate harsh climatic conditions, improving chickens welfare and grazing activity (Dal Bosco et al, 2014), which in turn improves meat quality (Dal Bosco et al., 2016). However, a clear analysis of the environmental advantages of combining chicken and olive orchards has not been performed. In the present paper, we studied the environmental advantages of combining chicken and olive trees using the life cycle assessment (LCA) approach. In particular, we compared the impact of an olive orchard, with and without grazing chickens, to assess the benefits of the animal presence in the orchard. We also compared the impact of free-range chickens, when the birds graze on land used only for grazing vs. grazing in an olive orchard, thus with no additional land use (i.e. the land use is already accounted for in the assessment of the orchard impact).

Methods

Life cycle assessment

To compare the environmental impact of an olive orchard with and without chickens, and of free-range chickens inside or outside of the orchard, we used a cradle to gate life cycle assessment (LCA). The LCA allows calculation of the environmental impact of a production line, considering all the processes involved in the product, thanks to the use of databases with information on the impact of individual processes, in our case production of a tonne of olives or of chickens. The impact is calculated in terms of energy consumption and emissions of pollutants.

We followed the ISO 14040 e 14044 standard, using the Ecoinvent database following the Eco-Indicator99 method, which includes 11 impact categories, including 6 categories involving human health (i.e. carcinogens, respiration organics, respiration inorganics, climate change, radiation, and ozone layer), 3 categories involving ecosystem quality (ecotoxicity, acidification/eutrophication and land use), and 2 categories involving resource consumption (minerals and fossil fuels). Data were then elaborated using SimaPro 8.0. software.

We included fertilization and pesticides for the olive orchard and for the cultivation of feed ingredients, the animal rearing and olive grove per se, all the transportation for all materials and products, and the direct and indirect land use. All cultivation processes (soil tilling, sowing, weeding, fertilizing harvesting, etc.) were included in the calculations. Emissions from manure were also considered.

Approach and assumptions

We considered a typical olive orchard in central Italy, with or without chickens, and a typical free-range chicken system, with grazing in an olive orchard or in another pasture used only for the chickens.

We assumed that the environmental impact of free-range chickens is identical when the chicken graze in the orchard or in another pasture of the same area, but dedicated only to chickens, except for the land use due to grazing, which can be excluded when grazing in the orchard, since it is already accounted for in the olive system. In other words, one hectare of orchard, is one hectare of land use, whether it also hosts chickens or not. Therefore, once land use of that hectare has been included in the orchard LCA, it needs not be calculated again in the chicken-

in-orchard system. The chicken outside the orchard, instead, use an additional hectare of land (i.e. used only for grazing), which need to be included in the impact assessment.

For the orchard system with or without chickens, we assumed that all operations (and relative impacts) were identical, except for weeding and fertilization, which, based on field experience and previous literature, were assumed to be provided by the chickens in the olive-with-chicken system. Therefore, the impact relative to weeding and fertilization was calculated only for the pure orchard, but omitted for the olive-with-chicken system, where no additional impact related to the chickens was calculated, since such impact was already accounted for in the free-range chicken system.

Below we describe the characteristics of the orchard and chicken systems considered for the LCA.

Free-range chicken system

We considered a chicken density of 1000 birds/has, with three 100-day cycles/year. Necked-neck chickens reaching 2.8 kg, consuming a standard diet with a conversion index of 3.3 kg of feed/kg of chicken were considered. As mentioned above, the only difference between the chicken system in the orchard and outside the orchard was the land use, which was considered nil when chickens grazed the orchard (since the orchard land-use is already accounted for in the orchard impact).

Olive system

A typical olive orchard for central Italy was considered, with 277 trees/ha, manual pruning and harvesting, permanent green cover, mowing twice per year, fertilized with 250 kg/ha of urea and 50 kg/ha of both potassium sulphate and triple phosphate, 20 kg/ha of copper sulphate as pesticide and yield of 4,5 tonnes/ha of olives. As mentioned above, when chickens grazed the orchard, fertilization and weeding were assumed to be provided by the birds and were omitted from the calculations (since the chickens' impact is already accounted for in the chicken system).

Results

Free-range chicken system

Within the 6 categories involving human health (i.e. carcinogens, respiration organics, respiration inorganics, climate change, radiation, and ozone layer) the chicken system had the greatest impact through respiration inorganics and climate change. Of the 3 categories involving ecosystem quality (ecotoxicity, acidification/eutrophication and land use), the highest impact was due to land use. Of the 2 categories involving resource consumption (minerals and fossil fuels), fossil fuels had the largest impact. When chickens grazed the orchard, the impacts were identical except for land use which was reduced by 18%. Land use represented about two thirds of the total impact when data were normalized, therefore grazing in the orchard (rather than land not otherwise used), reduced the normalized impact by about 12%.

Olive system

Within the 6 categories involving human health the olive system had the greatest impact through respiration inorganics followed by climate change and carcinogens. Of the 3 categories involving Ecosystem quality, the highest impact was again due to land use. Of the 2 categories involving resource consumption, fossil fuels were again the most impacting. When chickens grazed the orchard, however, most impact values were reduced to almost zero, except for ecotoxicity (reduced to 11%) and land use (not reduced at all of course, since one ha of olives remains the same also when chickens are added). Since the difference between grazed and non-grazed orchard was in the fertilization and mowing (not necessary with the chickens), this results imply that these two practices had the greatest impact, while pesticides (copper sulphate) had negligible impact in comparison. Therefore, excluding land use, the chickens basically reduced the orchard impact to almost zero.

Discussion

Combining chickens and olive orchards appeared to bring about reductions in the environmental impact of both systems. Particularly, using the orchard for grazing reduced the land use relative to the free-range chickens, while the bird fertilized and weeded the orchard, thus reducing the orchard impact to almost nil, except for the land use. The LCA method used and the assumptions made in this work completely overlook other benefits like the possible contribution of grazing to the feed (thus reducing feed consumption), the positive effect of trees on animal welfare, grazing activity, and therefore meat quality and yield. Additionally, animal manure in the quantity produced by the animals here considered has better nutrient and amendment effects on the soil compare to the fertilization considered in the non-grazed olive orchard, and this is also overlooked in the LCA analysis.

Including these effects would make the animal-orchard combined system even more desirable under the environmental point of view. Further studies with a broader approach to sustainability might contribute to better assess these effects. These results were obtained with the particular case of olives and chickens but can easily be extended to other tree-animal combinations. In fact, when using more strictly herbivorous species (e.g. sheep), grazing can actually contribute substantially to the animal feed requirements, much more so than with chickens, allowing for even greater environmental benefits.

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References:

- Dal Bosco A.; C. Mugnai; A. Rosati; A. Paoletti; S. Caporali; C. Castellini. 2014. Effect of range enrichment on performance, behaviour and forage intake of free-range chickens. *Journal of Applied Poultry Research*, 23: 137–145; doi: 10.3382/japr.2013-00814.
- Dal Bosco A., Mugnai C., Mattioli S., Rosati A., Ruggeri S., Ranucci D., Castellini C. 2016. Transfer of bioactive compounds from pasture to meat in organic free range chickens. *Poultry Science* 00:1–8.
- Rosati A., Castellini, C., Dal Bosco, A., Mugnai, C., Paoletti, A., Caporali, S. (2012) Olive agroforestry: an inverse approach to agroforestry. In "What priorities for European agroforestry", M.R. Mosquera-Losada, A. Pantera, A. Rosati, J. Amaral, J. Smith, C. Dupraz Editors. Book of abstracts of the 1st European agroforestry conference, 9-10 October 2012, Brusseles. ISBN: 978-84-96351-79-0, pag 24.
- Rosati A., Caporali S., Paoletti, A. (2009) Olive, Asparagus and animals: an agroforestry model for temperate climate in developed countries. *Proceedings of the III OLIVEBIOTEQ (For a renovated, profitable and competitive Mediterranean olive growing sector)*, Sfax, Tunisia, 15-19 December 2009, ISBN: 978-9938-9513-0-1, 229-233.