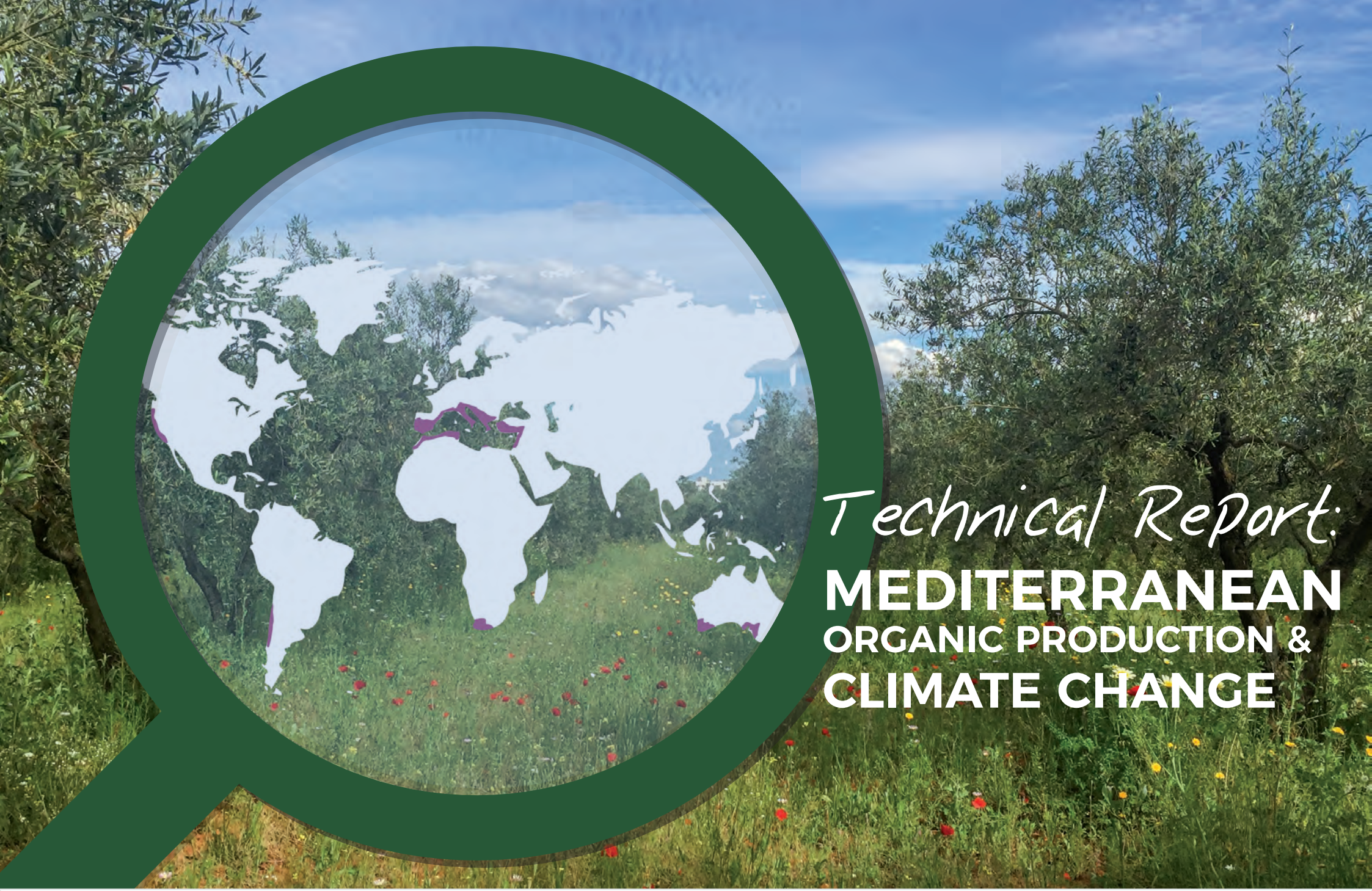

Technical Report:

MEDITERRANEAN ORGANIC PRODUCTION & CLIMATE CHANGE

ecovalia

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The graphics are created from the same research and presentation of Aguilera, E. 2018. Presentation of the research "Mediterranean Organic Production and Climate Change: State of Knowledge" in the Mediterranean Forum Organic Production and Climate Change.
Bibliographic references in this technical report are only those mentioned in this document. For all the bibliographies used in the original study, please see the reference in the original one.

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PRESENTATION

At Ecovalia we have recently published research about " Mediterranean Organic Production and Climate Change: State of knowledge" carried out by the Chair of Organic Production Clemente Mata of the University of Córdoba.

This work was based on a bibliometric study carried out in order to know the current situation, in terms of the scientific literature under the Mediterranean climate, about the different agricultural and livestock production sectors, both in organic and conventional. After an exhaustive review, the 1,023 works that were the basis of the above mentioned report were selected using rigorous criteria and scientific quality.

This complete research can be downloaded for free of charge from our website (www.ecovalia.org). However, we have considered appropriate to elaborate this technical report summarizing the results and conclusions. For further information, we recommend reviewing the full report "Mediterranean Organic Production and Climate Change: State of Knowledge ".

Regarding the statistical data referred to in each sector, those mentioned in the original study have not been used, but have been updated with recently published information from the same source (MAPA: Spanish Ministry of Agriculture, Fisheries and Food)

These scientific studies carried out in the Mediterranean climate zone, have provided strong arguments supporting many advantages of organic farming in mitigation and adaptation of climate change in relation to other production systems.

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FULL REPORT

The finding of climate change began a few decades ago, based on observations indicating the rise in average temperatures of the planet over the last century and the increase in extreme climate conditions (floods, hurricanes, heat waves, etc.).

According to the latest report of the Intergovernmental Panel on Climate Change, IPCC (IPCC, 2013), which synthesizes the latest scientific evidence on climate, climate change is an unquestionable process, as evidenced by the increase in temperature in water and air, the degradation of snow cover and ice and the rise in sea level. The changes are affecting many natural eco-systems.

According to the 2013 IPCC report, human influence on the climate system is clear, and the main cause is anthropogenic emissions of greenhouse gases (GHG), which are now the highest in history.

GHGs are gaseous components of the atmosphere, which can have a natural or artificial origin. They can absorb and emit radiation. This property is generated by the greenhouse effect. The heating capacity of these gases, or global warming potential, is measured in CO_2 equivalents.

In relation to anthropogenic emissions, the role of agriculture and livestock in GHG emission is well known. Although official estimates show a relatively minor role in global GHG emissions, particularly in industrialized countries (eg. Spain, MAGRAMA, 2013), it is particularly worrisome that the global agricultural emissions grew 1% annually between 2000 and 2010 (Tubiello et al., 2013, 2015), representing 11% of anthropogenic GHG emissions in 2010 (Tubiello et al., 2015). On the other hand, a large part of the emissions from deforestation are due to agricultural expansion, as well as the emissions associated with the production and use of inputs, which are not included in the category “Agriculture”.

Therefore, there is a need for more integrated assessments of agricultural GHG emissions. For this reason, the Life Cycle Assessment (LCA) offers a good methodological framework for this task. From this perspective, agricultural emissions would represent 25% of global emissions in 2010 (Bennetzenet al., 2016).

In conclusion, the emissions attributable to agricultural activity include:

- **Direct emissions of nitrous oxide (N_2O) from the soil. Direct emissions of methane (CH_4) from flooded soils.**
- **Emissions from the burning of crop residues (N_2O and CH_4). The CO_2 released in burning of crop residues is not considered, because it has been previously fixed by crops.**
- **Emission or sequestration of carbon coming from the balance of Soil Organic Carbon (SOC).**
- **CO_2 (mainly) from the use of fossil fuels in machinery and heating.**
- **Methane emissions (CH_4) from enteric fermentation of animals.**
- **Methane and nitrous oxide from the use of animals' excreta.**
- **Indirect agricultural emissions, which take place outside the farm. These include:**
  - "Upstream" emissions, referring to the production of inputs (fuel, electricity, fertilizers, pesticides, machinery, buildings, etc.)
  - "Downstream" emissions which include indirect emissions of N_2O (mainly from off-farm transformations of volatilized NH_3 and leached NO_3).
  - Emissions from deforestation.

Besides the role of agriculture as a GHG emitter, we saw that agriculture itself is affected by a changing environment, and at the same time we also know that agriculture can play another role, such as sink-holes by capturing CO_2.

In this way, agriculture should not only be recognized as a polluter, but also as an affected party and even as a protector. However, there are different food production models, but not all of them act in the same way against climate change.

The model of industrialized agriculture is currently the most established one and is precisely the one which launches the most beneficial practices to these GHG emissions such as the use of nitrogen fertilization of chemical synthesis and the methane emissions originating from intensive livestock farming.

On the other hand, organic production is a professional system and is the only process regulated by a common European standard for all Member States (Council Regulation EC 834/2007 on organic production and labelling of organic products concerning organic production, its labelling and control and EU Regulation 2018/848 of the European Parliament and the Council of 30 May 2018, applicable from as of 1 January 2021).

In organic production, the use of synthetic chemicals such as fertilizers and pesticides are specifically excluded. Organic agriculture systems depend on the symbiotic fixation and handling of organic materials as sources of fertility. Organic farming incorporates as a basic principle the maintenance or enhancement of soil fertility and biological activity through the management of organic matter. The soil, as a natural resource and a living environment of the ecosystem, is considered the key element in achieving the ecological balance of the agricultural exploitation.

Pursuing this balance, supported by eco-friendly farming techniques, is the purpose that identifies this type of production. These techniques avoid the use of synthetic chemicals and relay on others such as increase in biodiversity, the use of companion planting and crop rotations, the use of cover crops, green fertilizers, biological pest control, the use of local varieties, the use of manure ...

As for organic livestock, it is also a systematic production respectful of the environment and earthbound. It is characterized by ensuring animal welfare, animal health based on the prevention and using native breeds recommended for its rusticity, hardiness and adaptation to adverse weather and field conditions.

No less important, is that organic production systems are less vulnerable to changes (caused by climate or the appearance of pests / diseases, for example) and more resilient, so that they have greater capacity to absorb disturbances, without significantly altering their characteristics of structure and functionality; being ableto return to a state of balance. These characteristics prioritize the adaptation to climate change of organic production systems is higher than in other types of systems.

In summary, organic agriculture has been linked to higher levels of biodiversity (Birkhofer et al., 2008, Tuck et al., 2014), decreases in erosion rates (Reganold et al., 1987), increased energy efficiency (Gomiero et al., 2008, Smith et al., 2015), improved soil quality (Gomiero et al., 2011), better quality of food products (Zalecka et al. 2014) and better economic performance (Crowder et al., 2015) in contrast with conventional agriculture.

Other meta-studies point out that organic agriculture contributes to increase soil organic carbon (Gattinger et al., 2012) and provides environmental benefits despite these lower efficiencies (Reganold and Watcher, 2016). Organic agriculture practices can be considered “preventive” measures to counter position “curative” measures that address the consequences of environmental impacts (Garnier et al., 2014).

OBJECTIVE

To carry out the study "Mediterranean Organic Production and Climate Change: State of Knowledge" the objectives listed below are made.

Overall objective

Review of the scientific literature on agricultural production and climate change (adaptation and mitigation of greenhouse gas emissions) in the Mediterranean area, with emphasis on organic agriculture and organic livestock.

Specific objectives

- Quantify scientific publications on GHG emissions in Mediterranean agriculture, classifying them according to the geographic area, the type of production, the type of emission and the type of management.
- Learn about the GHG emissions figures in major Mediterranean agricultural systems.
- Determine the influence on ecological balance management in GHG emissions per unit area and product, and its comparison with the conventional management.
- Identify potential GHG mitigation options as the most important alternative management practices, emphasizing those associated with organic agriculture, in order to identify those that should be supported or developed.
- Compare GHG emissions from different systems and types of emission with the number of scientific publications in order to identify research needs.
- Identify the main sources of uncertainty and gaps in information currently available.

RESEARCH METHODOLOGY

Extremely rigorous methodology followed in carrying out the research "Mediterranean Organic Production Development and Climate Change: State of Knowledge" was based on the creation of a database on agricultural GHG emissions in the Mediterranean climate areas using as a search tool the Web of Knowledge. The search was completed reviewing successively the bibliography of each work found.

This search focused on studies undertaken in regions with Mediterranean climate and articles until 2017 through the selection of keywords and paying special attention to meta-analysis studies. Finally, 1,023 studies that are the basis of the research were selected according to the scientific rigor applied in this methodology.

As for the categorization of studies they have followed different criteria such as:

- By type of climate, making difference between Mediterranean, limit and no Mediterranean.
- By type of management, separating Conventional (CON), Organic (ORG) and Organic / Conventional (O/C) management.
- By type of emissions, differentiating Soil N_2O, Soil CH_4, Carbon sequestration, CH_4 Enteric, Manure management and Life-Cycle Assessment (LCA).
- For general production, grouping it by Arable crops, Woody crops, Pasture and Forest land and Livestock.
- By specific type of production.
- By the methodology followed to study emissions identifying between the IPCC factor, modeled, measured (</> 3 years) or revision.
- By the geographical location of research indicating Global Region by Country or Autonomous Communities.

RESEARCH METHODOLOGY

Statistical data of the bibliometric analysis was complemented with a qualitative analysis of the results shown in the reviewed articles, particularly those including ecological management or analyzing relevant practices for organic farming.

Among the articles published about GHG emissions in Mediterranean agriculture and livestock in all countries in the Mediterranean biome, 42% were carried out in Spain.

However, only 12.33% of these articles published in Spain have considered the organic production.

Image 1. Number of articles on GHG emissions under Mediterranean climate by country. Studies covering more than one country are excluded. The number of articles including organic management is reflected in parentheses.

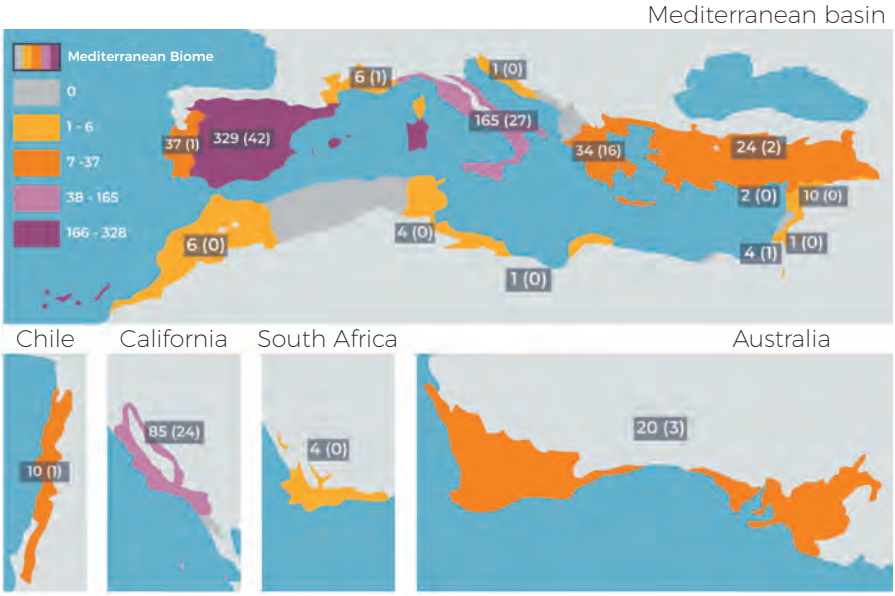
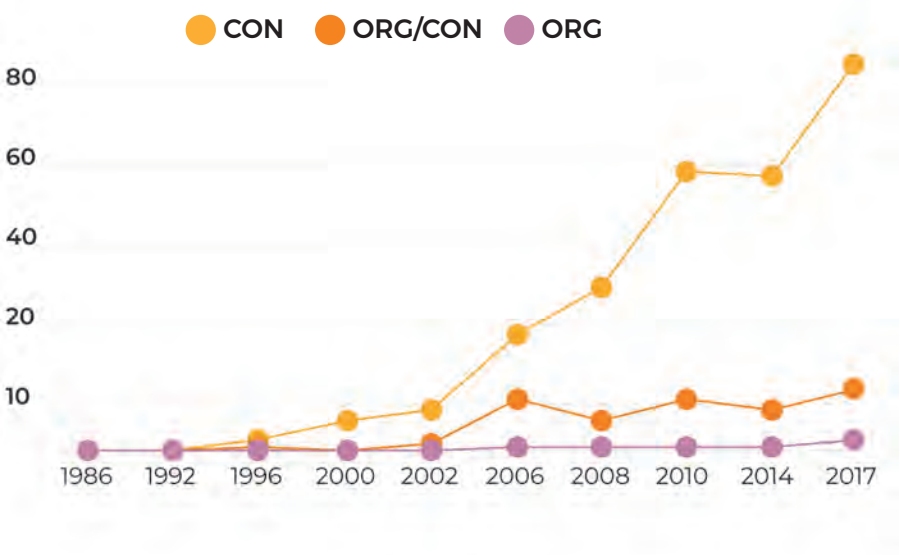


Image 2. Number of articles on GHG emissions under Mediterranean climate in Spain by Autonomous Communities.
Studies covering more than one community are excluded. The number of articles including organic management is reflected in parentheses.

In recent years, the rate of articles including organic management has grown little compared to a strong growth in conventional. It would be fair to strengthen scientific research about greenhouse gas (GHG) emissions in organic farming and livestock, especially is necessary in those less studied sectors. Furthermore, considering the specificities found in the Mediterranean region aiming towards the use of certain indicators.

Figure 1. Articles on GHG emissions in Mediterranean agriculture and livestock.



ACV y mediciones de GEI bajo clima mediterráneo

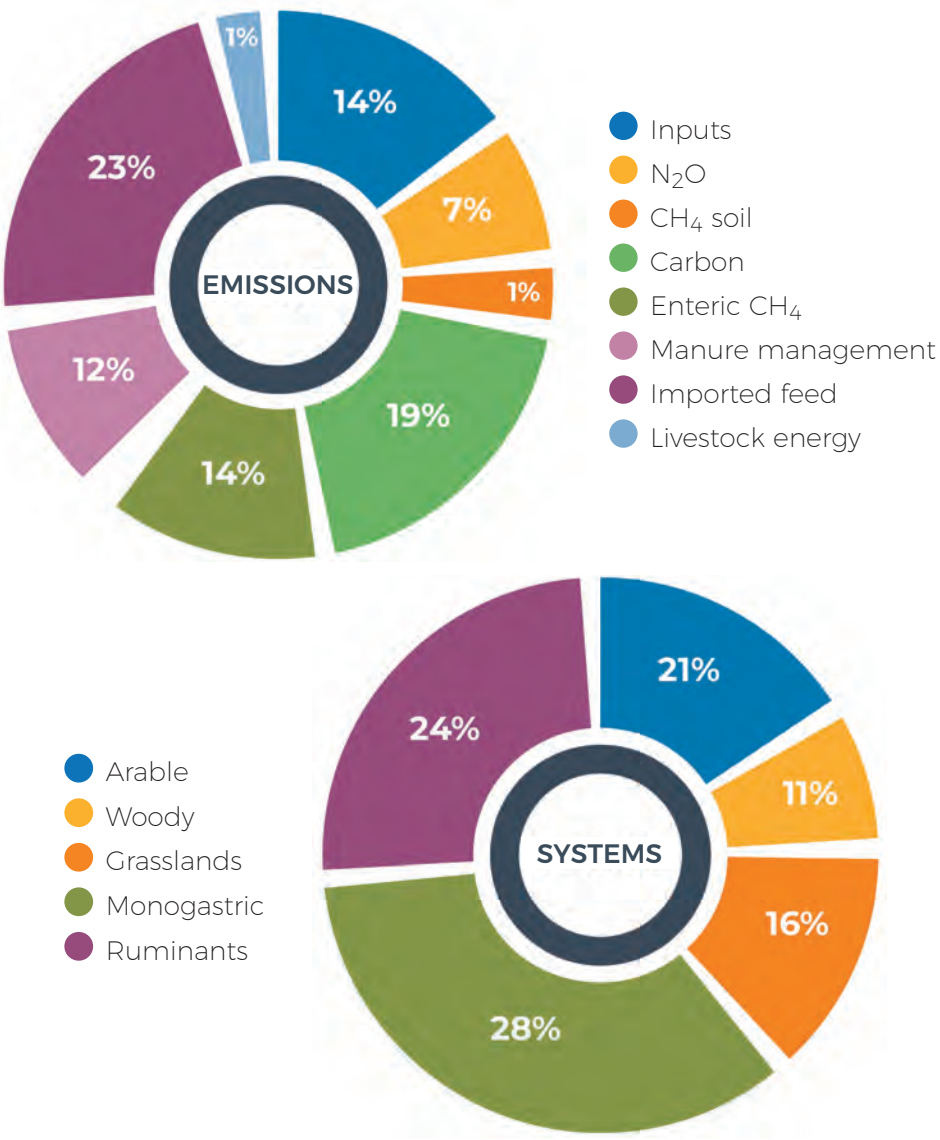
According to the information obtained from the research "Mediterranean Organic Production and Climate Change: the State of Knowledge", GHG emissions from agricultural production in Spain represent approximately 75 million tons of CO_2eq per year, without including carbon sequestration, whose approximate mitigation potential, according to the strategy 4 per 1000, would be about 24 million tons of CO_2eq per year.

It's worth emphasizing the fact that total emissions are dominated by livestock, where imported feeds represent the largest percentages, followed by enteric methane and manure management. In addition, a part of the vegetable production and related emissions is aimed at local feed production.

Furthermore, the total amount of emissions associated with the vegetable production and grasslands (inputs, N_2O and CH_4 soil) is similar to the mitigation potential of carbon sequestration. N_2O plays a relatively minor role in emissions of plant production and with higher emissions due to the inputs production. In this sense it can be confirmed that GHG emissions from food production are dominated by livestock and also half of emissions are associated with imported feed. Moreover, the magnitude of Carbon sequestration potential is similar to all agricultural emissions and the emissions from inputs production are higher than soil emissions.

The results of the meta-analysis about the response of N_2O emissions and carbon sequestration to management changes in Mediterranean conditions show a high potential of Mediterranean organic agriculture to reduce N_2O emissions (Aguilera et al., 2013a and Cayuela et al., 2017) and promote carbon sequestration (Aguilera et al., 2013b, Vicente-Vicente et al., 2016 and Francaviglia et al., 2019) much higher than in the temperate climate conditions prevailing in Central and Northern Europe.

Figure 2. Distribution of GHG emissions in Spain, depending on the type of emission and the type of production system.



WINTER CEREALS

The winter cereals belong to the grass family, Gramineae (Poaceae) and include species as relevant to worldwide human and animal food such as wheat, barley, rye and oats, as well as hybrids such as triticale.

In Spain, 206,119 hectares were cultivated under organic production in 2017, representing 3% of the total surface of winter cereals. 37% of that area is concentrated in Castilla La Mancha, followed by Andalucía (32%) and Aragón (9%). Only the first two account for more than 69% of the State's surface of organic cereals. (MAPAMA - The Ministry of Agriculture, Fisheries and Food-, 2018).

On a product basis, barley is the most cultivated cereal in organic production (68,699 ha), followed by oats (53,083 ha), and wheat (50,504 ha). The cereal that has the highest percentage of cultivated area in organic production in related to its total cultivation area is oats (11%).

Winter cereals is closely associated with low GHG emissions per hectare, which is reduced under organic management mainly due to the absence of synthetic fertilizers, and partly to carbon sequestration as well.

Main results and proposal for improvement:

- **Carbon sequestration could be promoted more with the use of genetic material better adapted to ecological management and local agroclimatic conditions, such as old varieties.**
- **The use of machinery is the largest source of emissions in ecological management, which indicates that a great part of the mitigation potential is related to the use of machinery such as minimum tillage, which saves fuel, or self-production of fuel practices, which avoids the use of fossil fuel derivatives.**

Thus, it should be noted that there is an average 42% decrease of the carbon footprint in organic management. In addition, we must point out that the traditional variety of cereals can achieve C-negative footprint in organic management.

Figure 3. GHG emissions per hectare in winter cereals.

(Kg CO_2 eq/ha)

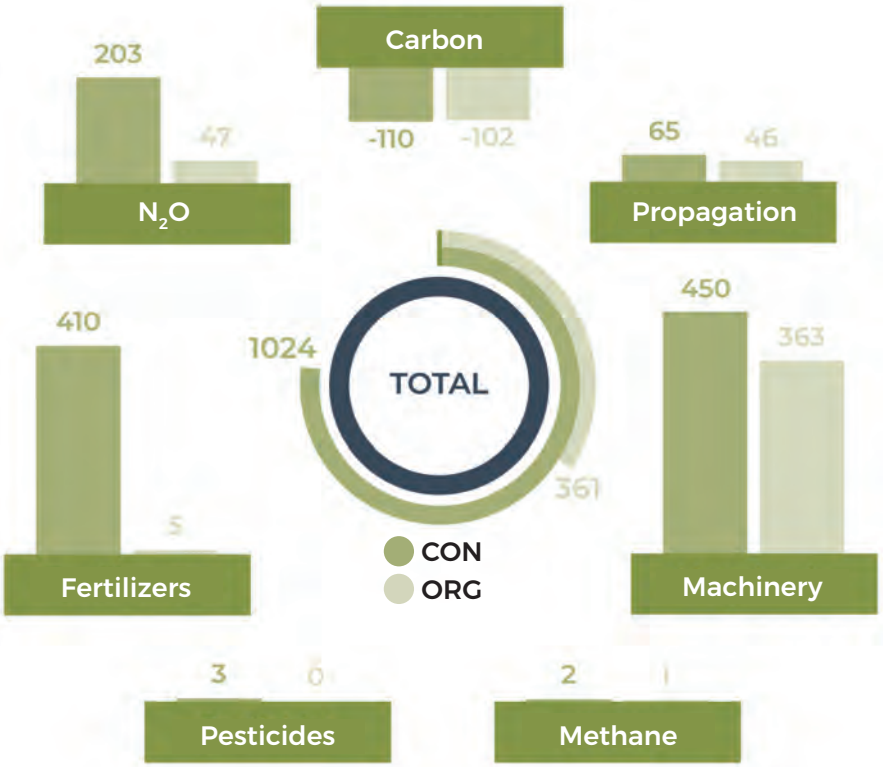
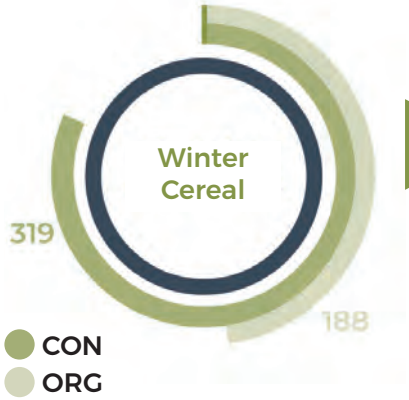


Figure 4. C footprint per kg of product in winter cereals.

(Kg CO_2 eq / kg of product)



An average 42% decrease in C footprint per kilo of product in winter cereals under organic production.

HORTICULTURAL CROPS

Horticultural crops or vegetables are edible plants that are cultivated generally in irrigated land, outdoors or in greenhouses. They include a wide variety of crops from different botanical families. This group also includes fruits from herbaceous crops such as melon, watermelon or strawberry. In addition, roots and tubers are included, as well as green harvested legumes , such as beans, peas or beans.

In organic horticultural production, according to MAPAMA (2018), the same Autonomous Communities as in the previous years remain as leaders: Andalusia (43% of the national organic horticultural cultivation area, and 8% of the total organic horticultural cultivation area of the community.), Murcia (19 % and 6%, respectively) and Castilla-La Mancha (17% and 6%, respectively); between the first two, account for more than 60% of national organic surface of horticultural crops.

In Spain, the surface under organic horticultural cultivation is 20,537 hectares, which represents 7% of the total surface dedicated to vegetables.

Main results and suggestions for improvement:

- **Following the analyzed studies, it can be assumed that horticultural crops are associated with generally high emissions of GHG per hectare, which are reduced under organic management mainly due to the absence of synthetic fertilizers and carbon sequestration.**
- **At the same time, emissions per kg of product are also on average lower in organic management.**
- **Irrigation, and particularly the use of electricity, is the largest source of emissions in organic, which indicates that a great part of the mitigation potential is found in the decrease in these emissions, which can be achieved by saving water (for example, efficiency in irrigation systems), on the one hand, and the use of renewable (particularly, photovoltaic solar energy) on the other.**

- Carbon sequestration can be promoted by incorporating crop residues into the soil (directly or after composting) as well as by linking to livestock and agro-industry.

In this way, we can say in general that the average decrease in carbon footprint under organic management is 32% in outdoor and 17% in greenhouse.

A large proportion of the mitigation potential is given by water management.

Figure 5-1. GHG emissions per hectare in outdoor horticultural cultivation.
(Kg CO_2 eq/ha)

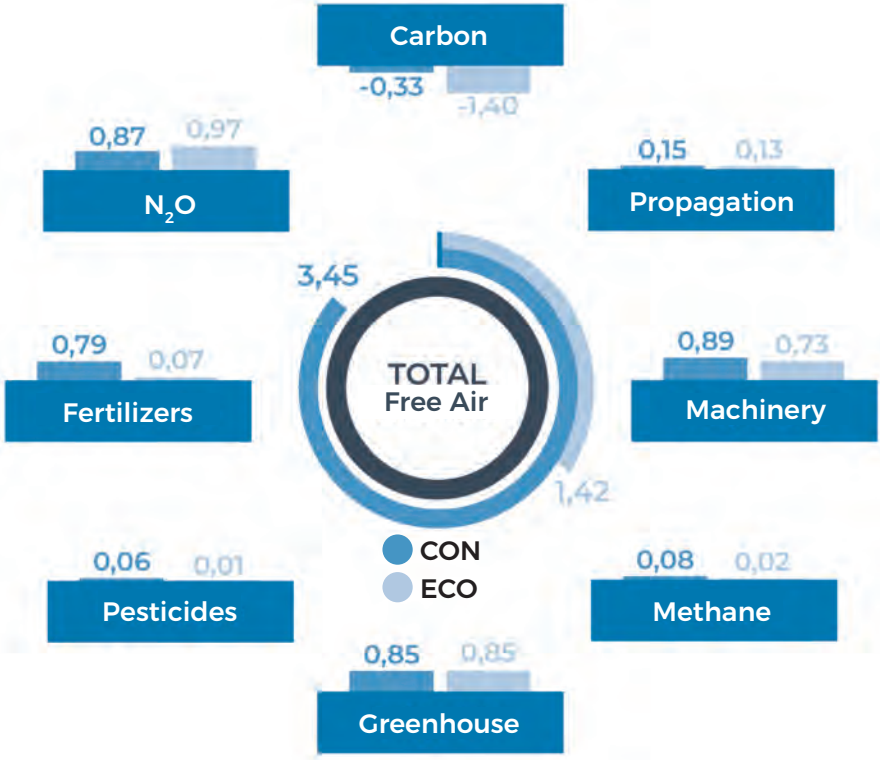


Figure 5-2. GHG emissions per hectare in horticultural greenhouses.
(Kg CO_2 eq/ha)

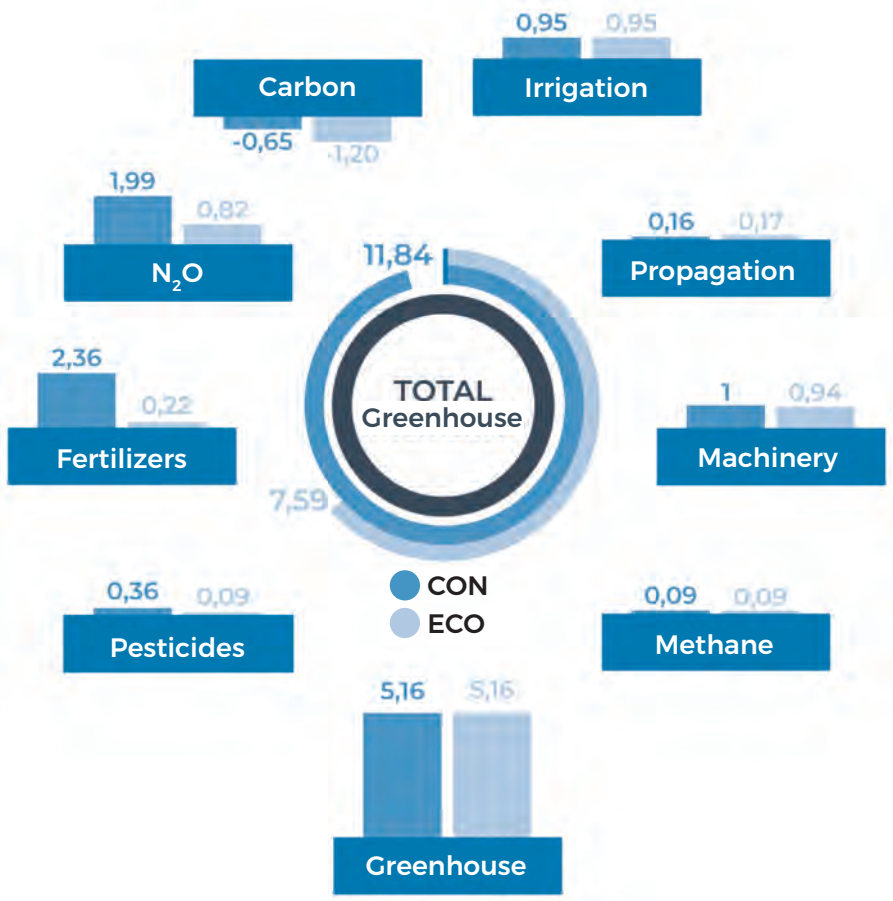
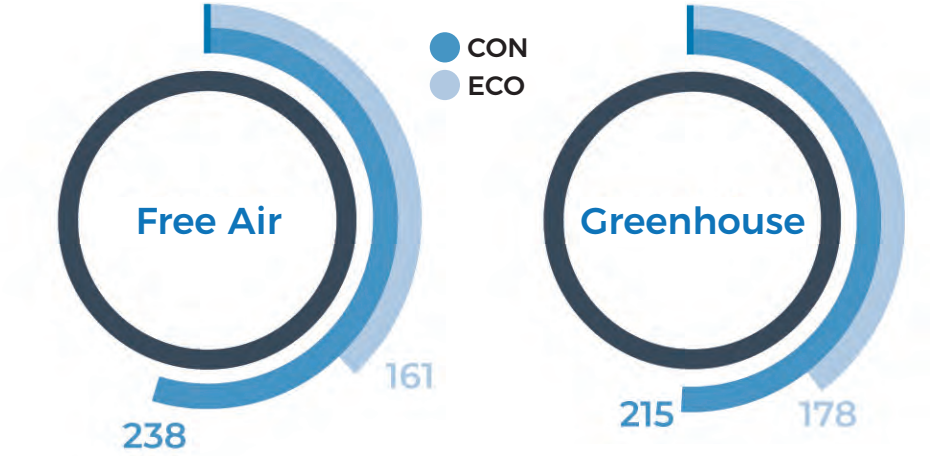


Figure 6. C footprint per kg of product in outdoor and greenhouse horticulture.
(Kg CO_2 eq / kg of product)



The average decrease in C footprint per kg of vegetables under organic management is 32% in outdoor and 17% in greenhouse.

A large proportion of the mitigation potential in vegetables is given by water management.

OLIVE GROVE

The olive grove is one of the most representative crops of the Mediterranean basin, and its main derivative product, olive oil, is also a fundamental part of the"Mediterranean diet" and its health benefits.

The area of organic olive grove was 197,114 hectares in 2017 (MAPAMA, 2018), which represents 7% of the olive groves areas in Spain. 38% of this area is concentrated in Andalusia, closely followed by Castilla la Mancha (33%). Together with Extremadura (15%), these 3 Autonomous Communities account for 86% of the organic olive grove area in the country. On the other hand, the percentage of organic olive grove area in Andalusia (5%) is significantly lower than the national average while in Castilla la Mancha (15%) and Extremadura (10%) is higher. The organic olive grove in Spain represents 40% of the permanent crops in organic farming.

The olive grove has a number of features that give a great potential as a mitigating tool for GHG emissions.

Among the main results obtained as a result of the analyzed studies, we can highlight the following:

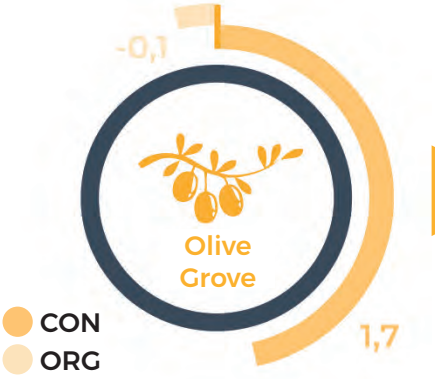
- **The organic olive grove helps mitigate GHG emissions mainly through carbon sequestration in the soil, which can have a similar magnitude in terms of CO_2 equivalent to that of other emissions. This means that it can be a carbon-neutral crop.**

- **The high carbon sequestration in organic management produces thanks to the application of cover crops, pruning residues and organic amendments. These three practices have a high potential for C sequestration, and all of them are based or can be based on resources of the farm itself, such as composted Alperujo applied as an organic amendment. This means that these practices do not depend on external sources, which could be limited locally, so they can spread throughout the territory.**

Carbon-Negative footprints in organic management are not always produced since there are cases where management practices such as cover crops are not applied. There is, therefore, a great potential to reduce the carbon footprint under organic management if these practices are expanded more globally. In conclusion, we can say that the average reduction in carbon footprint in olive groves is over 100% in organic: from 1.7 kg CO_2eq / litre in conventional to -0.1 kg / litre in organic.

Figure 7. C footprint per kg of product in olive grove.

(Kg CO_2 eq/kg of product)

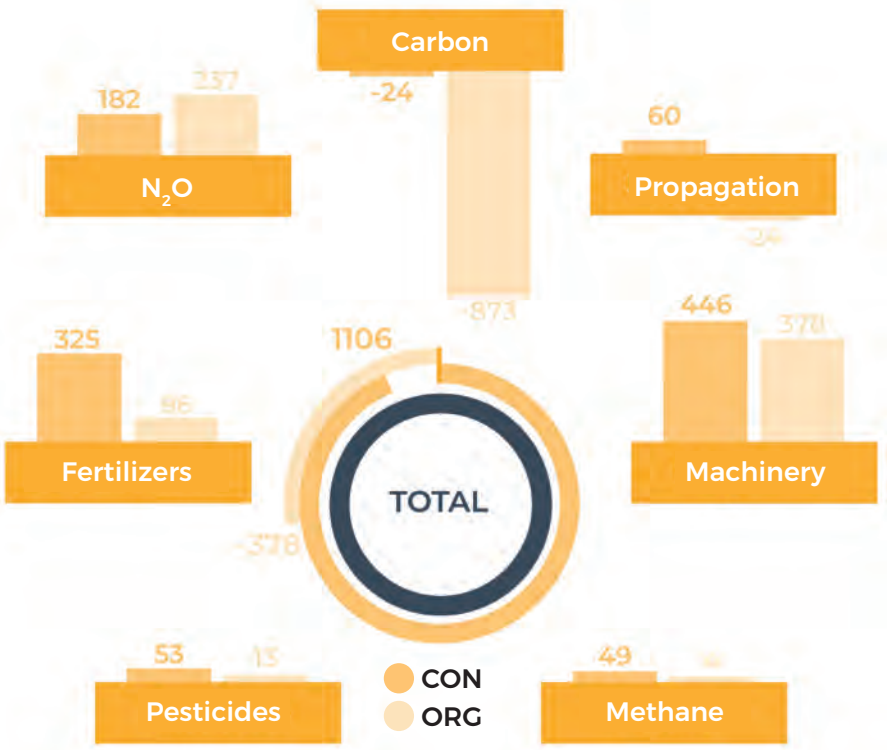


An average 100% reduction in C footprint per kilo of product in olive grove under organic production. 1.7 kg CO_2 eq /litre in conventional to -0.1 kg / litre in organic.

A large proportion of the mitigation potential in olive grove is given through C sequestration produced through the application of cover plants and organic amendments (composted “alperujo”, moist spent olives) and the reincorporation of pruning residues without using external inputs.

If these cultural practices were spread widely, C footprint in olive grove could be even lower.

Figure 8. GHG emissions per hectare in olive grove.
(Kg CO_2 eq/ha)



VINEYARD

The vine is a very representative crop of the Mediterranean basin and climate, although its distribution extends to both the temperate climate and subtropical climates. Wine, the main product derived from the vine, is also part of the "Mediterranean diet" and its health benefits.

In 2017, 0.94 million hectares of vineyards were grown in regular plantations in Spain. Most grape production (95%) goes to wine-making, while the remaining 5% is used for table grapes, and barely 0.02% for raisin production (MAPAMA,2018).

Organic vine was cultivated in 2017 to 106,897 hectares which represents 11% of the total surface of the Spanish vineyard. 53% of this surface concentrates in Castilla-La Mancha followed by large distance Catalonia (13%), Murcia (11%) and Valencia (10%). These 4 Autonomous Communities account for 88% of the state area of organic vineyard.

Furthermore, the highest percentage of organic vineyard area in relation to the regional total is in Murcia with 51%, followed by Catalonia (27%), Balearic Islands (20%) and the Community of Valencia (18%).

Main results and suggestions for improvement:

- **The vineyard has a number of characteristics that give a great potential as a mitigation tool for GHG emissions. In this way, the organic vineyard helps mitigate GHG emissions mainly through carbon sequestration in the soil, which can have a similar magnitude in terms of CO_2 equivalent to the rest of emissions.**

- **Studies indicate that there is a high response of soil carbon to changes of management in the vineyard. Carbon sequestration in organic management is produced through the application of cover plant and organic amendments. In addition, the pruning residues could be incorporated into the soil. The three practices have a high potential for carbon sequestration and are based or can be based on the farm's own resources, such as composted pomace applied as an organic amendment.**

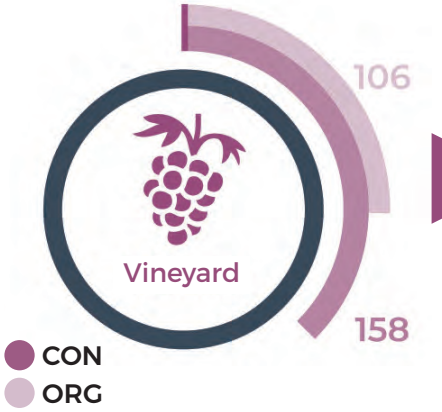
- On the other hand, most emissions are produced due to the use of machinery, a reduction in tillage will therefore save fuel and reduce its Carbon footprint.

As main conclusions we can confirm that there is an average decrease in the carbon footprint of 33% in organic, largely due to the C sequestration.

C negative footprint could be achieved in organic management if the recommended practices is implemented more generally.

Figure 9. C footprint per kg of product in vineyard.

(Kg CO_2 eq / kg of product)

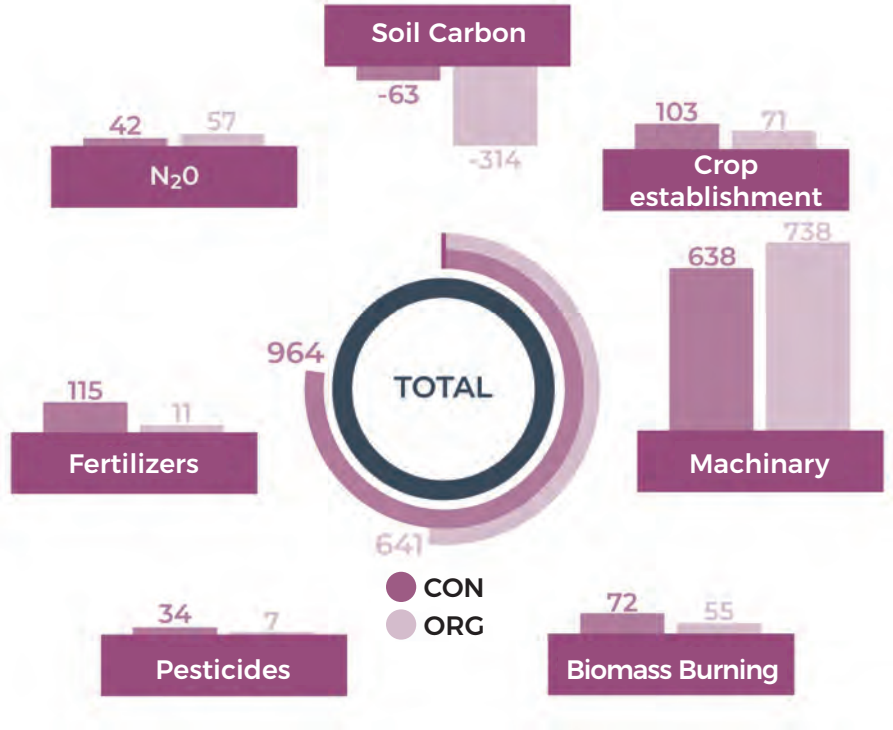


An average 33% decrease in C footprint per kg of product in vineyard in organic management.

A large proportion of the mitigation potential in vineyard is given through C sequestration produced through the application of cover crops and organic amendments and the reincorporation of pruning residues. Promoting these cultural practices is highly recommended.

Figure 10. GHG emissions per hectare in vineyard.

(Kg CO_2 eq/ha)



NUTS

The fruit trees of nuts include a heterogeneous group of woody crops that are harvested seeds with low water content, generally rich in fats, proteins and trace elements. Some of the most representative species are almond, hazel, walnut, chestnut, pistachio or cashew. Most of them are widely cultivated in Mediterranean climate.

Nuts were grown in organic in 2017 on 146,977 hectares in Spain, which represents 17% of the area of nuts, one of the highest percentages of all crop groups. 37% of this area is concentrated in Andalusia, followed by Castilla-La Mancha (23%), Murcia (20%) and Valencia (5%). These 4 Autonomous Communities account for 86% of the state area of organic nuts. (MAPAMA, 2018).

The nuts have characteristics that could contribute to mitigate climate change mainly through carbon sequestration. However, most of this mitigation and adaptation potential is currently underutilized, perhaps because in many cases these are crops with low production level located in very poor soils where the most common practice of management is the maintenance of bare soil (totally or partially), and where pruning residues are not usually used.

Among the main results, we list the following:

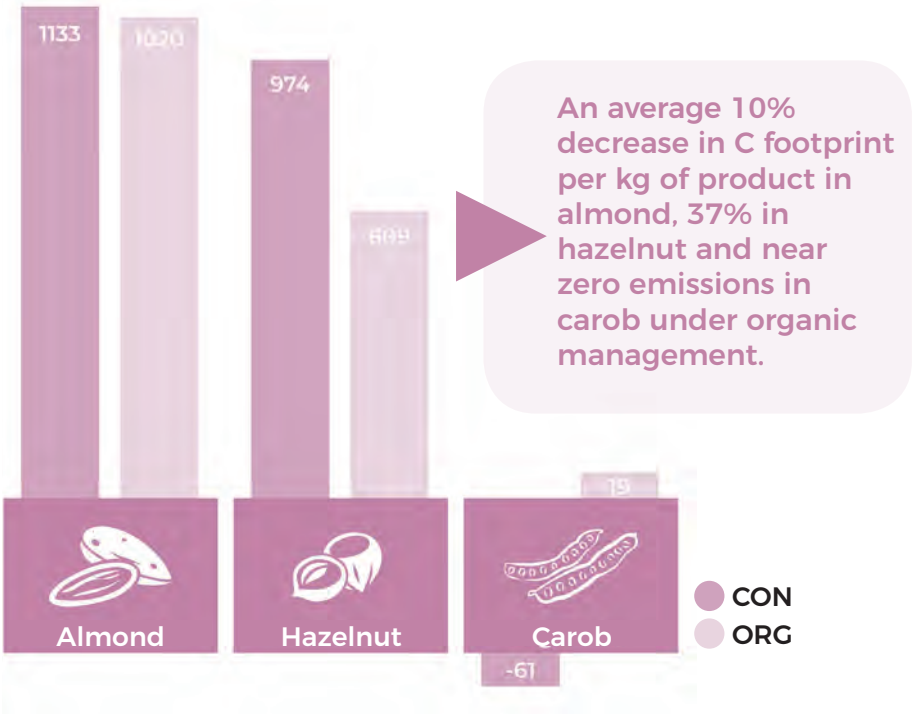
- **Organic nuts are associated with generally low GHG emissions. Carbon sequestration is promoted significantly with cover crops, but these are not often set up in depressed areas, which affects their performance in terms of carbon footprint.**
- **Proper management of the cover crop is important to help promote crop yield (and not to reduce) and optimize C sequestration and other ecosystem benifits.**

- **Carbon sequestration in organic management could be promoted more with the wider application of cover crops and the use of organic amendments. In addition, the pruning residues could be incorporated into the soil. The three practices have a high potential for C sequestration, especially if it is mainly the resources of the farm itself. There is great potential to reduce the carbon footprint of organic management, and can reach negative values, if these practices are expanded.**

Overall, through the analyzed studies we can confirm that the average decrease of the carbon footprint is 10% in almond, 37% in hazelnut and near zero emissions in carob. In addition, C negative footprints could be achieved in organic if the recommended practices are more generalized.

Figure 11. C Footprint per kg of product in nuts.

(Kg CO_2 eq/kg of product)

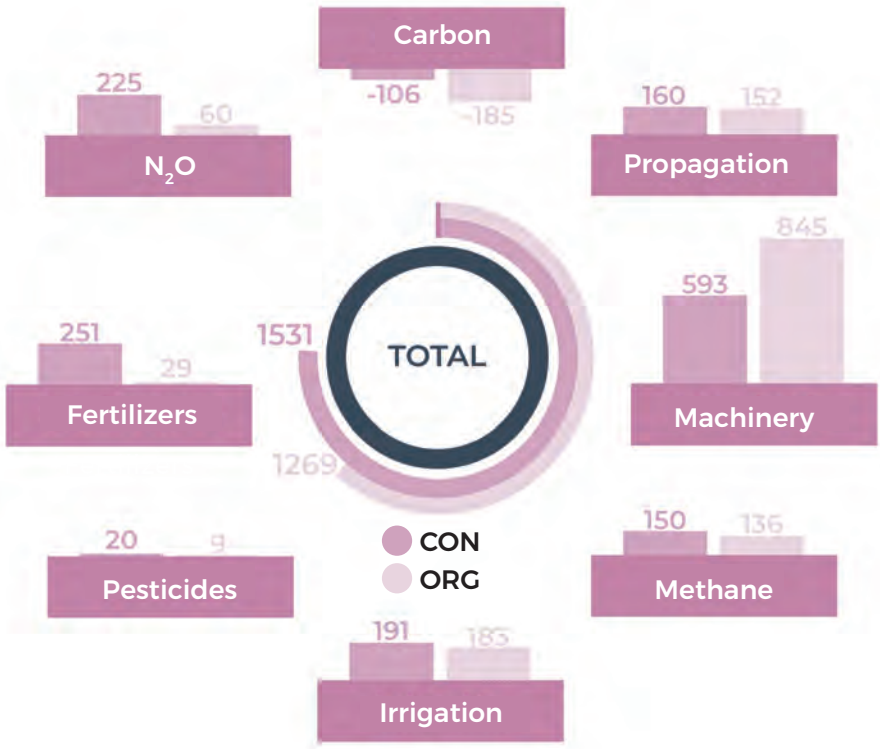


An average 10% decrease in C footprint per kg of product in almond, 37% in hazelnut and near zero emissions in carob under organic management.

Through recommended practices such as application of cover crops and organic amendments and reincorporation of pruning residues, C negative footprints could be achieved in organic.

Figure 12. GHG emissions per hectare in nuts.

(Kg CO_2 eq/ha)



NON-CITRUS FRUIT TREES

Fruit trees include a heterogeneous group of woody crops that high water content fruits are harvested, generally rich in sugars, fibre and vitamins. Some of the most representative species are peach, apple, plum, pear, banana (although the banana is not a woody crop, it is usually included within the group of fruit trees) or mango. Many of them are widely grown in Mediterranean climate.

Fruit trees were grown by organic management in 2017 in 9,833 hectares (including fruit trees, subtropicals and banana), which represents only 3% of the area of fruit trees in Spain, one of the lowest percentages of all crop groups. 26% of this area is concentrated in Andalusia, followed by Extremadura (16%), Community of Valencia (9%) and Murcia (6%). These 4 Autonomous Communities account for 57% of the state surface of organic fruit trees. In Spain, in 2015, organic fruit trees with the largest cultivation area were fig trees (7%), apple trees (7%) and apricots (6%). (MAPAMA, 2018).

Main results and suggestions for improvement:

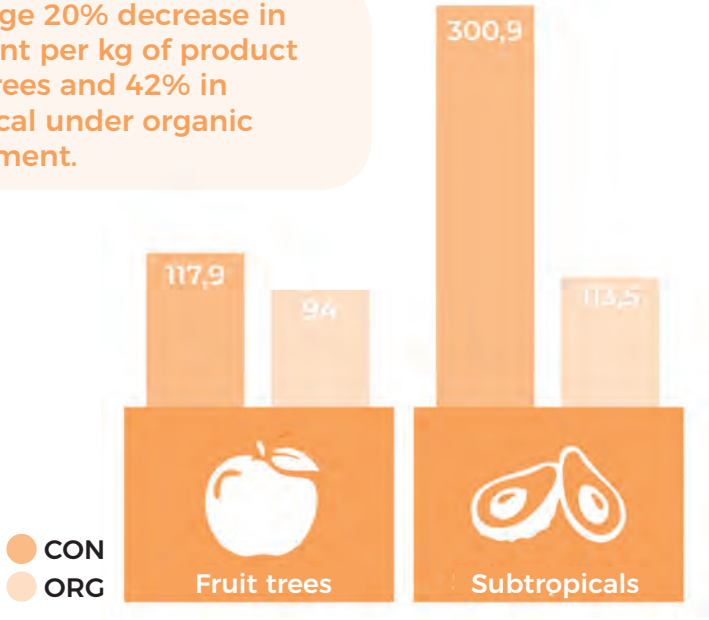
- **Fruit trees are associated with generally high GHG emissions per hectare, which are reduced under organic management due to carbon sequestration and the absence of synthetic fertilizers.**
- **Emissions per kg of product are also lower on average in organic but may differ in each case.**
- **Carbon sequestration in organic could be promoted more with wider application of cover crops, pruning residues and organic amendments. These practices have a high C sequestration potential, and, except for the amendments, can be based on resources from the farm itself, which means that they do not depend on external sources (which could be limited at the local level), so they can potentially spread throughout the territory.**

- Proper management of the covers is important to help promote crop yield (and not to reduce it) and optimize the C sequestration and other ecosystem benifits.

Figure 13. C Footprint per kg of non-citrus fruit product.

(Kg CO_2 eq/kg of product)

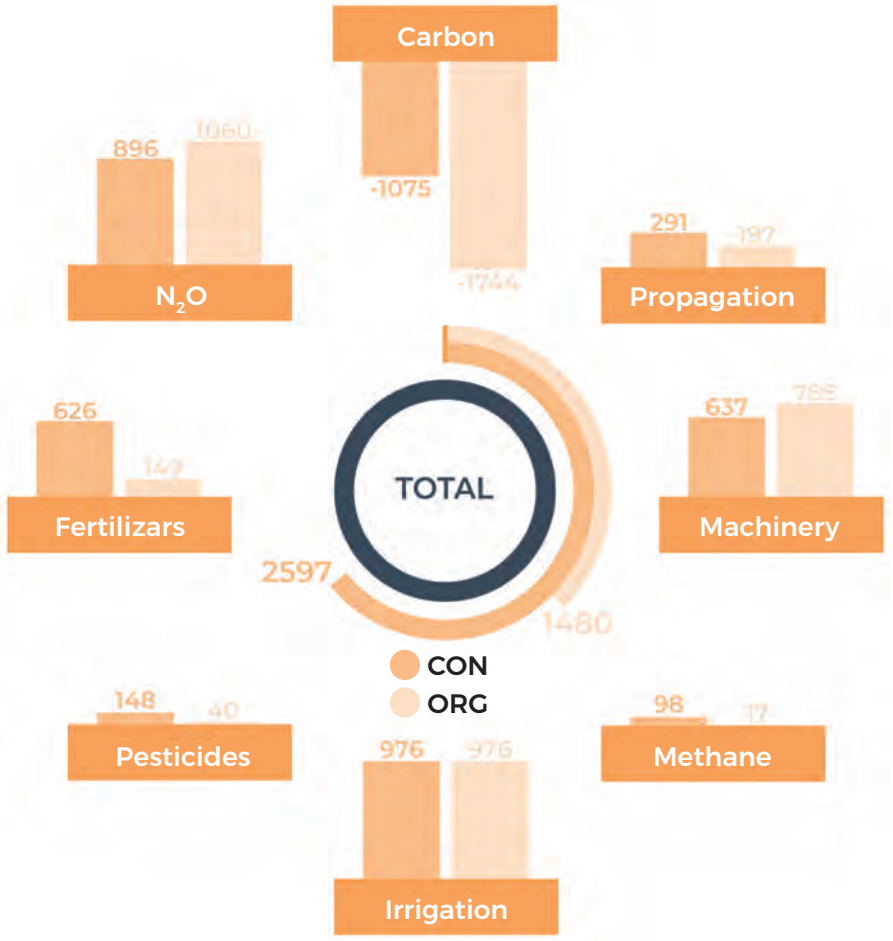
An average 20% decrease in C footprint per kg of product in fruit trees and 42% in subtropical under organic management.



Through recommended practices such as application of cover crops and organic amendments and reincorporation of pruning residues, C negative footprints could be achieved in organic.

Figure 14. GHG emissions per hectare in non-citrus fruits.

(Kg CO_2 eq/ha)



CITRUS

Many areas in the Mediterranean are important regions for citrus exportation. In fact, 6 of the 8 largest exporters of oranges and mandarin oranges globally in 2013, are Mediterranean countries (Spain, South Africa, Egypt, Turkey, Greece and Morocco) (FAO, 2018).

Organic Citrus fruits were grown on 12,087 hectares in 2017, which represents only 4% of the citrus area in Spain, one of the lowest percentages of all the crop groups.59% of this area is concentrated in Andalusia, followed by Murcia (19%), and the Community of Valencia (18%). These three regions account for 96% of the state surface of organic citrus. (MAPAMA, 2018).

Citrus fruits are woody crops, which means that they store carbon in their biomass and have characteristics that could contribute to mitigate climate change mainly through carbon sequestration, which would also imply improving the potential for adaptation.

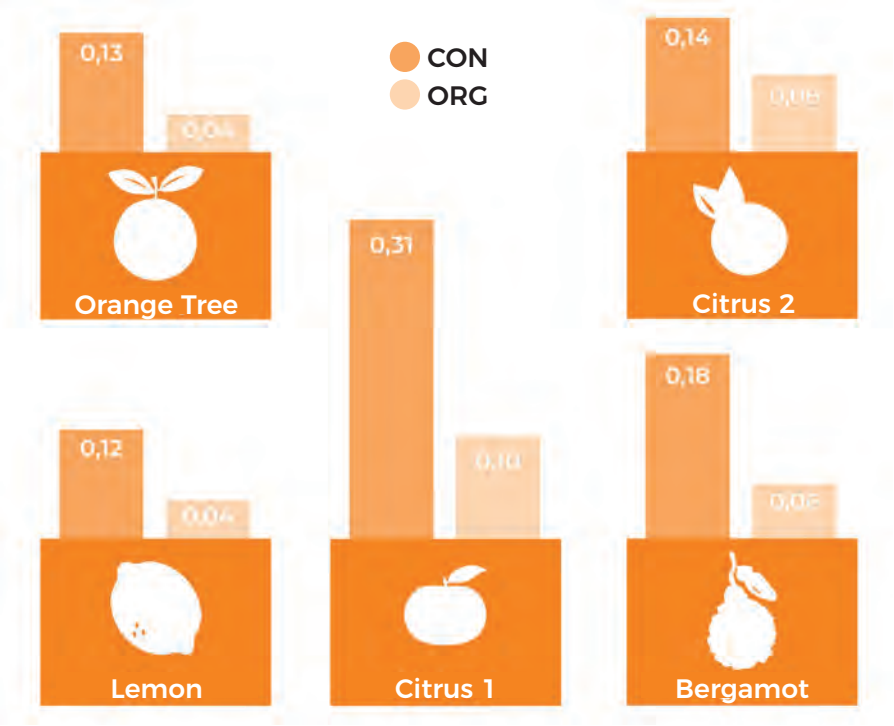
After analyzing the different studies, we found that citrus fruits in organic management are associated with lower GHG emissions than conventional ones, both per hectare (47% - 90% less) and per kg of product (44% - 69% less).

Moreover, carbon sequestration in organic could facilitate more with wider application of cover crop, the use of organic amendments and incorporation of pruning residues into the soil. This means that these practices do not depend on external sources that may be limited at the local level, so they could spread throughout the territory.

In conclusion, the decreases in the carbon footprint are slightly more than 60% in several studies without taking into account the C sequestration, which may mean that this percentage is even higher. In addition, C sequestration can offset about 50% of emissions.

Figure 15. C Footprint per kg of citrus product.

(Kg CO_2 eq/kg of product)



> 60% decrease in C footprint per kg of product in organic citrus in several studies without taking into account the carbon sequestration.

C sequestration in organic citrus can offset about 50% of its emissions.

Figure 16-1. GHG emissions per hectare in citrus trees.

(Kg CO_2 eq/ha)

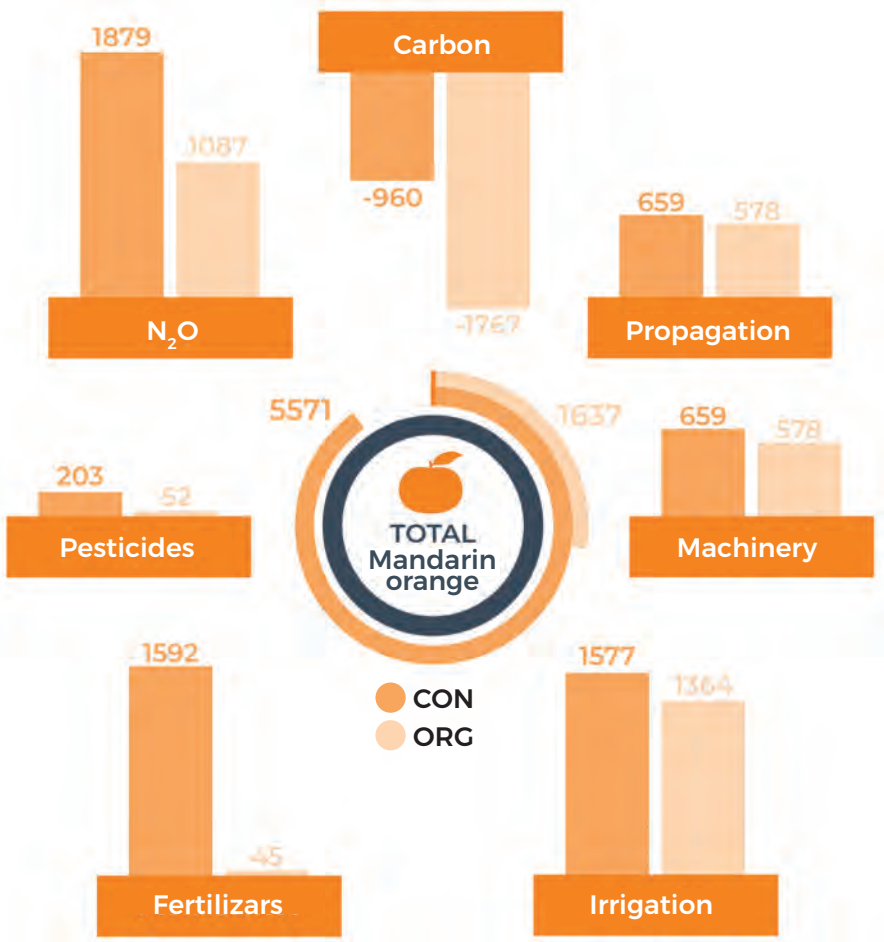
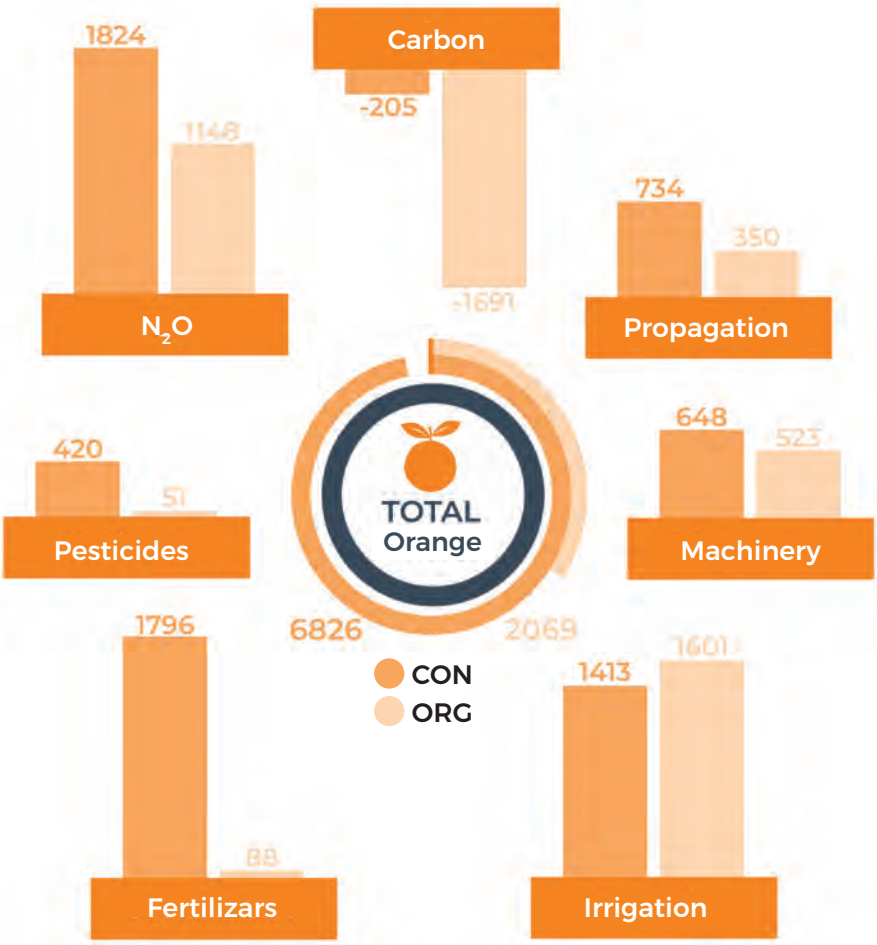


Gráfico 16-2. Emisiones de GEI por hectárea en cítricos.
(Kg CO_2 eq/ha)



RESULTS
LIVESTOCK FARMING

Monogastric animals are represented by pig and poultry. On the other hand, ruminant animals include cattle, sheep and goats.

The organic pig sector represents an extremely small proportion in comparison with the total livestock population in this sector. Castilla y León is the Autonomous Community that produces the most tons of organic pigs.

In Spain, poultry production has been the sector in livestock productions that has experienced the greatest increase in its populations in the last decades.

As with the production of pork, organic poultry represents a very small percentage of the total national production. The Autonomous Community that produces the most organic poultry meat is Galicia.The percentage of cattle population in organic production is higher than in other species, although it is still a low percentage of 3.5% (MAPAMA, 2017). Andalucía is the Autonomous Community with the largest production of organic beef, with 78% (MAPAMA, 2017).

Sheep farming in organic management systems is on a rising trend. The organic sheep population was 16,943 heads for dairy sheep (0.55% of the total) and 565,574 for meat sheep (4.39%) in 2016 (MAPAMA, 2017). Within the organic production of the sector, the autonomous communities that had the largest production were the Canary Islands in dairy production (47% of production) and Andalusia in meat production (83% of production) (MAPAMA, 2017), while it is Galicia that stands out with 43% of organic bovine milk production (MAPAMA, 2018).

LIVESTOCK FARMING

Regarding goats, in the organic exploitation of this species, Andalusia is the autonomous community that stands out in both types of uses, with 69% of dairy production and 59% of meat production (MAPAMA, 2017).

A small number of studies on livestock and GHG emissions in Mediterranean systems were found. However, the existing information shows that the main component of the carbon footprint of livestock is due to the feed production and deforestation to expand the cultivation area of raw materials for animal feed.

Accordingly, since ecological livestock is linked to the soil, the extensive model on permanent pastures is particularly important, which leads to a high storage capacity of C.

The pastures favor the C sequestration, by reducing tillage and increasing cover crops that are associated.

In the case of wood pastures, such as meadows, there is an increased C sequestration, especially under the canopy of trees. Wooded grasslands also contribute to the mitigation of climate change by storing carbon in woody biomass and producing renewable energy (firewood).

Therefore, from the point of view of organic production, some of the most interesting strategies to reduce the C footprint are those focused on reducing the dependence on food from crops and the profitable uses to grassland, which has no other possibility for proper treatment. There is also a great potential in the use of biomass sources currently underutilized for animal feed, such as crop residues and agroindustry. Furthermore, weshould consider the role of extensive livestock in fire prevention, which avoids the massive C release into the atmosphere.

GHG mitigation of organic livestock can also be addressed indirectly through increased productivity. This approach would include practices such as herd optimization and feed optimization.

The research "Mediterranean Organic Production and Climate Change: State of Knowledge" study highlights that the expected trends in climate patterns threaten agricultural production in the Mediterranean basin, making necessary the adoption of measures that increase the resilience of the productive systems, counteracting the losses in production and in the quality of the soils that are forecast.

Organic farming has a high potential for adaptation to climate change and resource depletion, mainly through 3 types of practices:

- **Biodiversity Management: diversity at different levels is the basis of the resilience of ecological systems. It includes diversification at different scales, framed within the concept of functional biodiversity. It covers from the number and type of crop varieties and livestock breeds, the associated wild species, to biodiversity at the landscape scale.**

- **Organic matter management: agro-ecological practices that encourage the increase of organic matter in soil serve the dual objectives of promoting climate change mitigation through carbon sequestration, and adaptation to its effects, the positive impact of organic matter on the physical properties of the soil.**

- **External inputs reduction: This strategy, associated with the absence of synthetic fertilizers and pesticides in organic farming, also has benefits on adaptation and mitigation, to reduce dependence and vulnerability to the effects on the peak in fossil fuels, while it also reduces emissions associated with its use.**

Organic farming has a high potential for adaptation to climate change and resource depletion.

Mitigation efforts must be coordinated with those of the adaptation and reduction of the rest of the impacts on the environment.

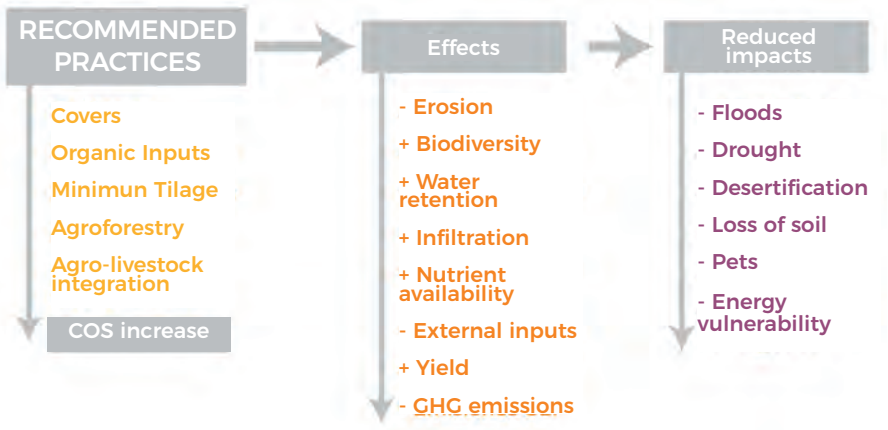
In this sense, agroecological practices manage to reduce both the impacts and risks associated with climate change.

The three agroecological adaptation strategies are:

- Biodiversity management
- Organic matter management
- Use of renewable energy

More research is necessary to develop the full potential of agroecological practices for adaptation to climate change, emphasizing possible interactions with other aspects of sustainability.

Image 3. Adaptation through the organic matter management.



In the research "Mediterranean Organic Production and Climate Change: State of Knowledge", a number of different conclusions are set out according to the number of studies carried out so far, the methodologies used in this research and the GHG emissions under organic management in Mediterranean conditions.

Regarding the studies carried out, although there is a large number of studies, there are significant gaps for some types of emission, production and management. This is because of the fact that a lack of information on livestock prevents deriving conclusions in organic management.

In addition methodological problems have been identified, in some cases as methodological shortcomings (studies on N_2O), in others for identifying important methodological biases that may harm the evaluation of organic management (estimation of C sequestration) and in others for not being adapted to Mediterranean conditions (studies on manure management and Enteric CH_4). Finally, it features the need to integrate the knowledge about GHG emissions and biogenic sinks in Mediterranean conditions in the models of Life Cycle Assessment (LCA) estimation of the total C footprint, its omission in LCA penalizes the ecological systems with low inputs and extensive.

The conclusions regarding GHG emissions under organic management in Mediterranean conditions include the existence of strong evidence that organic crop management contributes to climate change mitigation through:

- Reduction in N_2O emissions using organic fertilizers and lower inputs.
- Increased carbon sequestration, for example, through the cover crops or the use of traditional varieties.
- Excluding emissions from the production of synthetic fertilizers and pesticides.
- Reduction of total C footprint per kg of product in most of the crops studied.

Once characterized the cultural practices that most favor the reduction of C footprint, there is a great deal of additional potential for organic improvement, as GHG emissions are more linked to specific practices than to management itself.

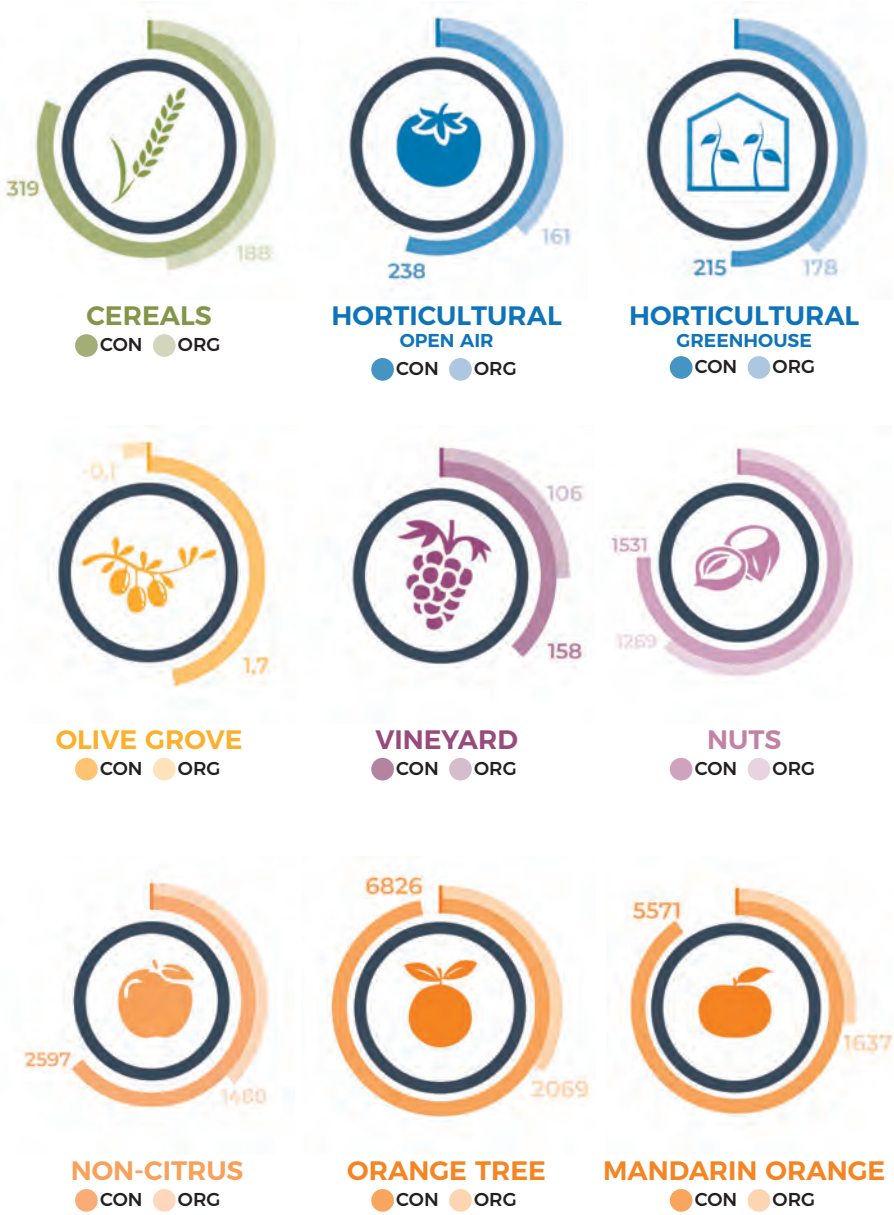
Some of the most promising practices are:

- Application of cover crops
- Reincorporation of pruning residues
- Recycling of waste of agribusiness
- Reduced tillage
- Use of renewable energy
- Using traditional varieties

The effectiveness of practices varies in every situation, it is therefore not easy to generalize, and more studies are necessary in each specific condition.

However, we can point out some of the crops in which there is greater evidence of a strong mitigation in organic management, those are winter cereals, olives, subtropicals and citrus

Image 4. Average Emission Reduction in organic crops. (Kg CO_2 eq / ha)



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