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Agricultural production trends towards carbon neutrality in response to the EU 2030 Green Deal: Economic and environmental analysis in horticulture

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Abstract: The European Green Deal to tackle climate change sets emission reduction targets for 2050. Particular attention has been paid to the agricultural sector, where there is a strong need to reduce carbon emissions and re-establish the natural carbon cycles. The concept of carbon neutrality is emerging in a scenario where it is necessary to reduce carbon dioxide (CO_2) emissions from cultivation to near zero. The quantification of carbon emissions was carried out by the carbon footprint (CF) of conventional, organic and zero residue potato cultivation in Sicily. In order to provide farmers and consumers with answers regarding the most sustainable cultivation regime, the results showed that the organic and zero residue methods have the best results in terms of emissions; the latter instead revealed the positive results in economic terms. It becomes a new model to follow in the pursuit of sustainability as it is based on the reduction of synthesis inputs and is free from the constraints imposed by organic production standards.

Keywords: carbon footprint; economics; sustainability; zero residue

The process of raising awareness of climate change, which has affected the agri-food operators and consumers in recent decades, has led to a growing interest in products with a reduced impact on the environment. The sustainability of mankind and natural ecosystems is therefore threatened by the continuing increase in concentrations of carbon dioxide (CO_2) and other greenhouse gases (GHGs) in the atmosphere that fuelling the phenomenon of climate change (WHO 2005). GHG emissions in the agricultural sector come from a multitude of sources such as emissions from enteric fermentation of livestock, manure management, production and maintenance of machinery, transport of materials and production of crop protection products and fertilisers (Adewale et al. 2016). Intensive agriculture, with high levels of input, has a significant impact on the environment, causing land degradation, declining biodiversity, soil depletion, air and water pollution and substantial atmospheric emissions. Sustainable agriculture, including organic farming and zero residue farming (Adewale et al. 2016), i.e. reduced use of chemicals, reuse of crop residues for organic fertilisation, no-till, energy efficiency strategies and sustainable packaging, can better respond to reducing the impacts of climate change, allowing food production systems to maintain a balance between productivity and environmental conservation. A slowdown in the intensity of activities, and therefore in the inputs used in this sector, as during the COVID-19 pandemic, has an impact on our societies, markets, and industries. The lockdown imposed by governments to stop the proliferation of the coronavirus has decreased GHG emis-

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sions on all continents. The decline in CO_2 equivalent (CO_2-eq) emissions is estimated at 5% of carbon output in 2020 (Becker et al. 2020). Once a reduction in atmospheric is achieved, maintaining them would be difficult without significant structural changes in the sector. It is therefore urgent to deploy collective intelligence in the post-pandemic world and envision far-reaching changes to our methods of production and business models (Bonnafè 2020). Thus, in order to promote economic sustainability, the concept of 'carbon neutrality' introduced in 2002 (Natural Capital Partners 2020) offers a powerful tool to reduce the vulnerability of territories and the food system (Foti et al. 2017; Becker et al. 2020). It is a means of production in which the total of CO_2 during production is neutral, i.e. equal to zero; this does not translate into enterprises not emitting carbon but offsetting it (Natural Capital Partners 2020). This research is based on the study of carbon footprint (CF) in potato production. Agricultural production today does not offer a wide range of carbon-neutral products, partly as a consequence of the limited dissemination of this concept among the sectors. The aim of the research is to analyse potatoes in Sicily (Italy), according to conventional, organic and zero residue methods, towards carbon neutrality, in order to understand their sustainability performance. This study aims to provide producers, consumers and the scientific community with a framework for GHG emissions in order to identify the most impactful phases in the life cycle of potato crops. This is only possible through a comparison of different methods in order to raise awareness of the environmental burdens that each of us has the power to change. This will enable operators in the sector and consumers to align their practices and purchasing decisions with low-carbon objectives (Meisterling et al. 2009).

MATERIAL AND METHODS

Carbon footprint (CF) as an operational tool to support carbon neutrality. Agriculture has significant GHG production. In EU countries, gas emissions from agriculture make up 9–10% of all emissions, placing this economic sector in third place. They are generated primarily by animal, plant production and land-use change (Kolasa-Więcek 2018). Agriculture contributes 10% of total CO_2 emissions in Europe (Solazzo et al. 2016). The intensive use of resources in developing countries to meet crop production and deforestation is responsible for the majority of GHG emissions (Lubowski and Rose 2013; De Pinto et al. 2016). The wide use of mineral fertilisers, especially nitrogen fertilisers, plays a key role in ensuring global food security nowadays.

The first step to becoming carbon neutral is the quantification of carbon emissions through the CF, in order to identify the practices to achieve improvement. The CF describes the amount of GHG emissions that a particular product or service will cause during its lifetime, expressed in CO_2-eq, and it is able to describe how human activities can impose different types of impacts on global sustainability (Council of the European Union 2006). Since the issue of global warming has assumed a prominent place on the global environmental agenda, the use of the CF has become common, even if in a modified form compared to the past. The European Union (EU), through the Green Deal, has established that Europe must achieve climate neutrality by 2050, supporting enterprises committed to a green economy transition (European Commission 2019). The concept of a CF has been in use for several decades but it has been known as an indicator of the life-cycle impact category of global warming potential (GWP) (East 2008; Finkbeiner 2009). Therefore, it may be viewed as a hybrid, deriving its name from 'ecological footprint' and conceptually being a GWP indicator (Browne et al. 2009). Its use is associated with money transactions in the form of taxes, carbon offsets, or an increase/decrease in consumer choices, thus facilitating comparisons between different goods or services. A carbon credit is an instrument put in place to provide a free market solution to carbon offsetting. It is a transactable, non-tangible instrument representing a unit of CO_2-eq (Natural Capital Partners 2020). It can be understood as a 'pass' to emit GHGs and still remain neutral, as it shows that the buyer has offset emissions elsewhere in the world (Becker et al. 2020). Despite the prevailing differences between calculations, the mass of CO_2-eq based on the 100-year GWP has been accepted as the reporting unit of the CF (WRI/WBCSD 2004; BSI 2008). In the agricultural sector, in order to mitigate climate change, it is, therefore, necessary to quantify GHG emissions related to the activities, materials and energy used. Enterprises, especially agricultural ones, are called upon to increase their capacity to provide zero-emission or sustainable products in order to have a positive impact on the economic system in an increasingly environmentally conscious global market. Carbon neutrality means having a balance between emitting carbon and absorbing carbon from the atmosphere in carbon sinks. Removing carbon oxide from the atmosphere and then storing it is known as carbon sequestration. To achieve

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net zero emissions, all worldwide GHG emissions will have to be counterbalanced by carbon sequestration. A carbon sink is any system that absorbs more carbon than it emits (European Commission 2019). CF is an operational tool that allows farms to become aware of their environmental impact and shows them the way to become carbon neutral; at the same time, it allows the consumer to choose more environmentally friendly products. In the agricultural sector, this calculation is carried out through the Life Cycle Assessment (LCA) methodology, and a CF can be seen as a subset of a LCA in which only the GWP impact category is studied (SETAC 2008; Wiedmann and Minx 2008; Finkbeiner 2009). This study contributes to discussions on GWP footprints related to food. The CF, on the one hand, offers valid help for farmers to choose less impactful practices and, on the other hand, guides consumers in their purchasing choices. Consumers are now leaning towards healthier and more environmentally friendly products if the product is easily recognisable on supermarket shelves. An important product factor that needs to be considered is the level of similarity between the standard, healthy and sustainable product. Furthermore, a product with a high level of similarity is more easily recognised and accepted as an alternative product, with the potential for a higher level of substitution (Hoek et al. 2017). Often this argument is reduced to simply measuring the carbon emissions of a food product without highlighting the differences with existing alternatives in order to define which farming process has lower carbon emissions.

Data requirement. The early potato in Sicily represents an element of value due to its presence on the market from March to May, anticipating of three months the harvesting of the traditional potato. This prerogative makes it comparable to valuable horticultural species, such as e.g. zucchini and eggplant, and not to the traditional potato considered an extensive herbaceous species of open field (Timpanaro et al. 2021). As shown in Table 1, compared to the whole national territory of Italy, where an area of about 14 000 ha is cultivated, almost half of them are located in Sicily with a production of 1.5 million quintals (q) which generate more than EUR 114 million of production.

Table 1. Economic importance of early potatoes in the study areas (2020)

	Surface (ha)	Quantity (thousand quintals)	Value (thousand EUR)
Sicily	6 910	1 495.4	114 394
Italy	13 849	3 318.4	749 050
Sicily/Italy ratio (%)	49.9	45.1	15.5

Source: Authors' own elaboration on ISTAT (2020) data

The early potatoes grown under conventional, organic and new trends in zero residue crops have a high interest for adaptability and rusticity of the cultivated species and pedoclimatic characteristics of the vocal territories that allow for an earlier ripening and marketing calendar, as well as for the growing market demand from northern European countries. The organic cultivation method differs from the conventional one due to the absence of synthetic chemical products, while the concept of zero residue production, which falls within the scope of integrated agriculture, requires the use of non-organic products characterised by molecules that degrade rapidly on the product and that comply with 'safety' timescales for which the residue found is less than 0.01 mg/kg (European Commission 2006). However, what differentiates the zero residue productions from the integrated ones is the possibility, in the latter, to use products, even if respectful for the environment, that have a higher residue on the final product. The zero residue product instead has lower residual percentages, protecting more the consumers' health. What also differentiates the two cultivation methods is the presence in integrated agriculture of a widespread and certified production disciplinary, unlike the zero residue method.

The data relating to cultivation processes were collected through face-to-face interviews using a questionnaire administered to farms, specialised in conventional, organic and zero residue potato cultivation. The analysed sample consists of 10 farms in organic farming, 10 farms in conventional farming and 10 farms following the zero residue method. They have been chosen following the principle of equal conditions so are located in the same area, have the same technical-managerial characteristics, entrepreneurs with same professional skills, in order to have as the only discriminating element the cultivation regime applied, that is biological, conventional, and zero residue (Scuderi et al. 2021).

The cultivation cycle lasts 4 months, and the data considered refer to the year 2020. The sample considered has an observation period of three years, so the following are the results for the first year, and other evaluations will be carried out thereafter. The farms examined in relation to soil, climate and management characteristics were chosen within the same municipality, located in the same district, in order to reduce endogenous and exogenous factors capable of bringing

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variability to the results. The analysis considers the entire potato cultivation cycle, i.e. preliminary soil tillage, fertilisation, crop treatments, irrigation and harvesting operations. Table 2 shows all the inputs used in the different cultivation methods. The conventional one is characterised by the application of mineral fertilisers containing N, P and K by means of furrowing machines. The organic method, on the other hand, is characterised by the application of manure to provide the crop with proper nutrition. Zero residue potato fertilisation is also characterised by the application of mineral fertilisers as in conventional farming. In the conventional method, herbicides are also applied to the crop through two treatments, which is not the case in the organic system, as the use of synthetic products is not permitted by law. Weed control in the zero residue method is carried out by means of a single application, and not two as in the conventional method, of the same synthetic product used in conventional potato and characterised by a reduced crop residence time. With regard to crop protection against different pathogens, the conventional method uses chemical synthesis products. Only permitted substances are used in the organic method, while in zero residue agriculture, two treatments are carried out with substances allowed in organic farming and one with synthesis products. Fuel is used in farm equipment to prepare fields, plant seeds, manage pests and weeds and harvest the crop. Its consumption is slightly higher in organic farming due to the non-use of synthetic chemicals and more tillage to control weeds. In zero residue farming, however, the amount of fuel used is significantly lower than in the other two methods due to fewer tillage and crop treatments. No substantial differences were found be-

Table 2. Inputs used in early potato cultivation in organic and conventional farming (unit data)

Input	Unit	Organic potato (P org)	Conventional potato (P conv)	Zero residue potato (P)
Seeds	kg/ha	3 200	3 000	3 000
Fertiliser NPK (7-14-21)	kg/ha	–	1 200	–
N	g/ha	–	84	–
P	g/ha	–	168	–
K	g/ha	–	252	–
Fertliser N (26); **SO_3**	kg/ha	–	1 200	–
N	g/ha	–	312	–
SO_3	g/ha	–	390	–
Fertiliser N (13); **K_2O**	kg/ha	–	1 200	–
N	g/ha	–	156	–
K_2O	g/ha	–	552	–
Organic fertiliser (manure)	kg/ha	3 600	–	–
Fertiliser NPK (7-5-12)	kg/ha	–	–	1 500
N	g/ha	–	–	105
P	g/ha	–	–	75
K	g/ha	–	–	180
Fertiliser N (urea)	kg/ha	–	–	900
N	g/ha	–	–	342
Herbicides (glifosate; metribuzion)	kg/ha	–	5.32	–
Herbicides (metribuzion)	kg/ha	–	–	1.51
Pesticides (mancozeb; fosetil-Al; copper oxychloride)	kg/ha	–	5.72	–
Pesticides (cymoxanil; copper oxychloride)	kg/ha	–	–	5.11
Organic pesticides (copper oxychloride)	kg/ha	10.8	–	–
Diesel	L/ha	230	225	180
Water	L/ha	2 430 000	2 430 000	2 430 000

Source: Authors' own elaboration

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tween the cultivation methods with regard to irrigation; on average, nine irrigations are carried out with a volume of 243 m^3 per distribution. Now it is possible to analyse the harvesting phase, which in all cases is carried out with potato digging machines; what distinguishes the three cultivation methods in this phase is the crop yield. While in conventional cultivation, it amounts to about 30.5 tonnes/ha, in organic cultivation, it drops to about 25.2 tonnes/ha, and in zero residue farming, it is about 29.8 tonnes/ha.

Environmental and economic methodologies. The study is based on the investigation of the CF of 1 kg of potatoes grown according to the three methods mentioned above in order to study the GWP of the production, expressed as kg of a product obtained. Potatoes are a widely used product on the tables of European and non-European consumers. LCA methodology was chosen to conduct the study; it is a compilation and evaluation of the inputs, outputs and the environmental impacts of a product system throughout its life cycle (ISO 14040:2006). According to the ISO standards, the LCA consists of four steps: goal and scope definition, inventory analysis (life cycles inventory analysis), impact assessment and result interpretation (improvement assessment) (ISO 14040:2006). In the first step, the functional unit (FU) describes the primary functions fulfilled by a product system and indicates how much of this function has to be considered in the LCA study (Brentrup et al. 2001). Thus, it is used as a reference when quantifying inputs and outputs in the inventory analysis. In this study, FU describes the production function for which all inputs and outputs used in the three cultivation methods are normalised to the production of 1 kg of harvested potato. In addition, the aim is also to provide information on the ecological function of the cultivation process, so the processing was also carried out per unit area, choosing ha as FU. The system boundary instead ensures that all emissions associated with the inputs are included (Suh et al. 2004). In this study, farming practices, tubers used for sowing, machinery, fertilisers and pesticides were considered, using the farm gate as a boundary. They, therefore, go from cradle to farm gate, analysing what happens up to the harvesting of the product and leaving out, on the other hand, the transport of the potatoes to the post-harvest establishments until they are placed in the distribution points and then on the consumers' tables. Two types of data were used for the analysis: primary data, collected directly in the field and covering the entire production process, and secondary data, covering the production phases of fuels, fertilisers and pesticides, obtained from the Ecoinvent v.3.6 database (Moreno Ruiz et al. 2019). The GWP generated by the use of machinery and fertilisers was calculated according to Nemecek and Kägi (2007). For the calculation of emissions due to pesticide use, the Ecoinvent approach was used, in which all pesticides applied for crop production were assumed to end up as emissions to the soil. The amounts of pesticides used as inputs were thus simultaneously calculated as outputs (emissions to agricultural soil). The substances specified in the inventories were used as references to correlate the corresponding emissions (Falcone et al. 2019). Furthermore, no allocation process was carried out within the analysis, so 100% of the emissions refer to 1 kg of potatoes obtained according to the three methods considered. In order to realise the CF of conventional, organic and zero residue potatoes, the software SimaPro 9.1. was used, within which the method IPCC 2013 GWP 100a developed by the International Panel on Climate Change (IPCC) was selected. This method lists the IPCC climate change factors with a time horizon of 100 years (IPCC 2013). With regard to the economic analysis, market prices for conventional, organic and zero residue potatoes were analysed for the year 2020 in order to calculate the gross production value for each type of product (Figure 1). The analysis also included the calculation of all production costs in order to determine the farmer's net income in relation to both the area cultivated and the working hours.

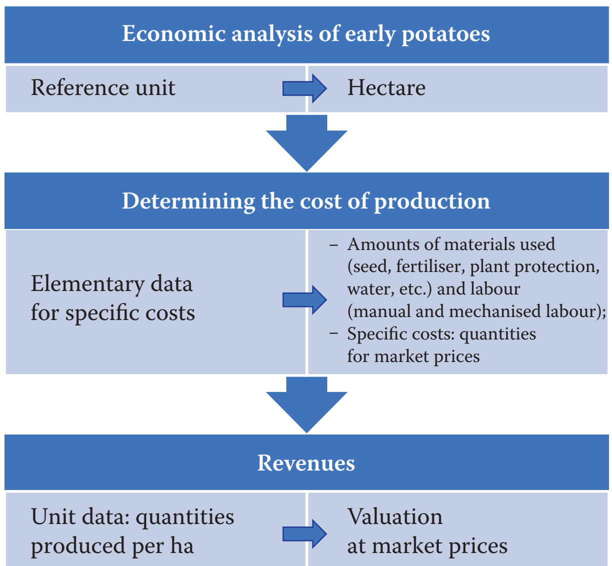

Figure 1. Cost and revenue methodology

Source: Authors' own elaboration

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RESULTS AND DISCUSSION

The GWP of crop production is determined by nitrogen oxide emissions from N-fertilisation, the combustion of fossil fuels in agricultural machinery, including irrigation (Nemecek et al. 2011). GWP is analysed per unit area (ha) and per fresh mass (1 kg of potatoes). Both were chosen because the environmental impacts of crop production are related to both – area of land occupation and yield (Nemecek et al. 2012). The GWP per ha represents the intensity of agricultural input use (Seda et al. 2010). Table 3 and Figure 2 on the results of the CF per unit area (ha) show that the GWP, related to a 100-year period as established by the IPCC, is higher in the conventional potato cultivation process due to the high amount of mineral fertilisers used compared to organic and zero residue potato cultivation. The first one has a value of 8 887.17 kg CO_2-eq, against the 5 985.61 kg CO_2-eq of zero residue potato and 5 014.85 kg CO_2-eq of organic potato. The best results are obtained from organic cultivation, which is characterised by the use of organic fertilisers and a lower amount of inputs used compared to conventional and zero residue cultivation.

Table 4 and Figure 3 (results per kg of fresh mass produced) highlight that the GWP is lower in organic and

Table 3. Carbon footprint (CF) per unit area (ha)

Impact category	Zero residue potato (P)	Organic potato (P org)	Conventional potato (P conv)
IPCC GWP 100a (kg CO_2-eq)	5 985.61	5 014.85	8 887.17

IPCC – International Panel on Climate Change; GWP – global warming potential
Source: Authors' own elaboration

Table 4. Carbon footprint (CF) per fresh mass produced (kg)

Impact category	Zero residue potato (P)	Organic potato (P org)	Conventional potato (P conv)
IPCC GWP 100a (kg CO_2-eq)	0.198	0.196	0.284

IPCC – International Panel on Climate Change; GWP – global warming potential
Source: Authors' own elaboration

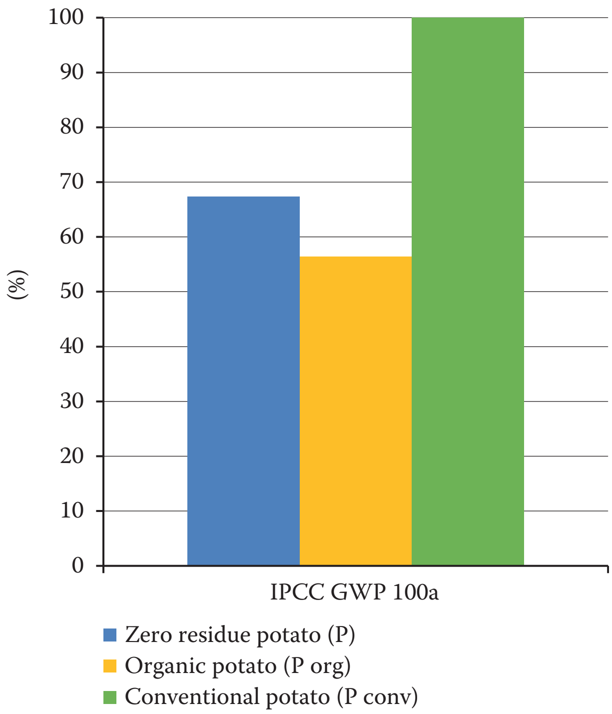

Figure 2. Carbon footprint (CF) per unit area (ha)

IPCC – International Panel on Climate Change; GWP – global warming potential
Source: Authors' own elaboration through SimaPro 9.1 software

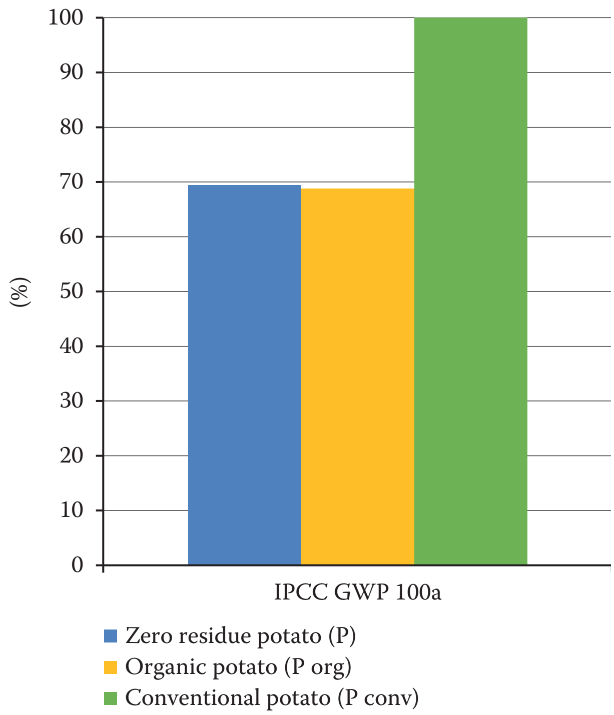

Figure 3. Carbon footprint (CF) per fresh mass produced (kg)

IPCC – International Panel on Climate Change; GWP – global warming potential
Source: Authors' own elaboration through SimaPro 9.1 software

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in zero residue potatoes (with a marginal difference between the two) than in conventional potatoes. The first one achieved a value of 0.196 kg CO_2-eq, compared to 0.198 kg CO_2-eq for zero residue and 0.284 kg CO_2-eq for conventional potatoes. This shows that despite higher yields in conventional, environmental sustainability is pursued to a greater extent by organic and zero residue potatoes, even at the expense of lower yields.

The organic cultivation process as well as the product obtained are more sustainable and have a lower GWP than the conventional regime, while compared to the zero residue method, there is a difference in terms of the cultivation process that becomes irrelevant in terms of the product obtained. In general, crops with high N requirements, highly mechanised production practices or high water demand are expected to have the highest GWPs (Nemecek et al. 2012).

Table 5 shows the results of the economic analysis for potato cultivation using conventional, zero residue and organic methods. Three conditions were considered for each indicator: the prevalent condition (i.e. that which actually occurred in the cultivation process for the year in question), the minimum condition (i.e. the minimum results obtainable from cultivation), and the maximum condition (i.e. maximum levels of production obtainable, estimated in relation to previous agricultural years). The best results in terms of net income are offered by zero residue production, where the advantage is represented by lowers production costs.

From an environmental point of view, the application of organic regime as a carbon-neutral protocol certainly represents a tool for achieving high sustainable performance and agroecological objectives in potato cultivation. As the graphs show, the results obtained from the zero residue cultivation method, which pursues a model very close to that defined by organic production standards, do not differ much from the latter, so also it pursues the objective of reducing carbon emissions, becoming a valid tool for the pursuit of sustainability. In addition to the environmental benefit, the economic aspect must also be taken into account so that the zero residue method offers a more advantageous prospect for farmers. Implementing this approach to neutralising emissions and incorporating carbon offsetting into the farm's sustainability policy and strategy allows meeting the growing expectations of new consumer generations that pursue environmental and sustainability goals (Scuderi et al. 2016; Becker et al. 2020). Value communication is vital for the new generation of consumers willing to pay a premium price for brands with an environmental purpose (Schaufele and Hamm 2017; Steenis et al. 2018). The research suggests how adopting agroecological approaches, such as the organic method and zero resi-

Table 5. Summary economic indicators

Economic indicator	Unit	Conventional potato (P conv)	Zero residue potato (P)	Organic potato (P org)
Yield (prevailed data)	t/ha	30.51	29.82	25.20
Yield (min. data)	t/ha	18.01	20.03	20.01
Yield (max. data)	t/ha	48.05	42.02	30.01
Sale price (prevailed data)	EUR/t	0.42	0.45	0.55
Sale price (min. data)	EUR/t	0.35	0.40	0.45
Sale price (max. data)	EUR/t	0.55	0.62	0.71
Gross production value (prevailed data)	EUR/ha	12 810.42	13 410.51	13 860.34
Gross production value (min. data)	EUR/ha	6 300.21	8 000.18	9 000.24
Gross production value (max. data)	EUR/ha	26 400.26	25 200.01	21 000.42
Production costs (prevailed data)	EUR/ha	10 965.31	10 587.24	11 875.24
Production costs (min. data)	EUR/ha	9 587.24	9 568.03	9 254.23
Production costs (max. data)	EUR/ha	11 895.01	11 786.11	12 852.21
Net income (prevailed data)	EUR/ha	1 845.20	2 823.03	1 985.06
Hours of work	h/ha	327.08	319.27	349.19
Net Income (prevailed data)	EUR/h	5.64	8.85	5.69
Gross production value/hours of work	EUR/h	39.22	42.06	39.71
Net value per yield	EUR/t	60.49	94.73	78.77

Source: Authors' own elaboration

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due, can benefit producers. Reducing the CF of crops is essential in achieving a reduced environmental impact. Several studies have compared biodiversity between different types of farms: conventional, organic, where only limited use of copper or sulphur compounds is required, and integrated management farms where many of the pesticide inputs are replaced by alternative pest management strategies (Kromp 1990; Moreby et al. 1994; Alvarez et al. 2001). They highlighted the positive effects of organic and integrated management. The study suggests that high amounts of nitrogen are linked to carbon emissions and consequently to biodiversity loss; reduced fertiliser use can bring variability to the system by improving its biodiversity and functions.

CONCLUSION

The climate change we are witnessing every day requires the commitment of people and institutions to reduce GHG emissions. To this purpose, the European Green Deal sets ambitious targets that can only be achieved through the cooperation of all sectors. Focusing on crop production, the research is based on a CF analysis of conventional, organic and zero residue potato crops to understand which of them can be applied in the pursuit of sustainability. Recent trends are directing both sector operators and consumers towards the production and purchase of carbon-neutral products, thus demonstrating the existence of alternatives to the cultivation methods hitherto used, such as conventional and organic. Growing consumer habits in purchasing sustainable products are also confirmed in the case of potato production, which shows considerable attention to environmental issues. The research results show that the organic potato cultivation method is very sustainable in terms of carbon emissions, followed by the slightly higher zero residue method in terms of impact but also economic results. The choices of the modern consumer are generally directed towards the propensity to pay more for an organic product due to the values it represents, however between a conventional product and one with zero residue, more respectful of human health, the consumer's choices can be directed to the latter.

In the process of ecological transition, therefore, organic production cannot be the only model of sustainability. Farmers need to have an alternative if this method does not suit their growing environment or for other reasons they do not want to adhere to these production standards. Zero residue production also benefits from higher net income and a higher gross production value/hours of work ratio, so it ends up playing an important role from a social point of view as well, supporting the local economy. In this context, it can also be encouraged by regional policy, which is interested in maintaining adequate levels of development.

The zero residue approach offers an alternative model of sustainability as it is based on the reduction of synthesis products and is also well adapted to areas that are not suitable for organic farming. The orientation towards the European Green Deal 2030 is certainly a goal to strive for, and this research shows that production models other than organic can be more sustainable and provide a viable alternative for farmers who do not want to produce organically. The hope is to find more carbon-neutral products on supermarket shelves in order to lower the emissions generated by production processes and re-establish the natural carbon and nitrogen cycles.

Productions in the next millennium will be distinguished by a high level of environmental, social and economic sustainability through the agroecological transition that will characterise the future Common Agricultural Policy (CAP) 2023/2030. To this end, future agriculture, both – through the applications coming from the digital transformation and the agroecological transition, will face a strategic challenge that could restore a central role to primary production for the importance it plays in every country.

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