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Goal of the study

The analysis of the energy performances and environmental burdens of an agricultural district in the southern Italy (Sicily).



In the district protected crops are cultivated in greenhouses, as: tomatoes, cherry tomatoes, peppers, melons, zucchinis.

The district is characterised by: -high level of specialization -different productive rotating cycles with an almost continue yield of different crops all over the year.

Goal of the study

The study is aimed to:

- The characterization of the energy and environmental impacts for common food products,
- The comparison among different products or production strategies;
- To assess and monitor the environmental impacts of the district production. This information can be useful for district authorities to plan and manage possible improvement actions.

The eco-profile of the district can represent a first step for a district Environmental Management System throughout the production chain and to achieve a product environmental labelling.

Goal of the study

Many Phases of the study:

To identify and characterize the agricultural district



To assess the environmental burdens related to the district products



Chosen representative firms, to carry out a LCA of their products

To define a data-

survey questionnaire

The investigated district:

The surface of the district is about 18 km² involving about 150 agricultural SMEs and 700 workers.



Yearly production of the district

The investigated district: data survey

Distribution of questionnaires to producers.

Collection of data on: -the production of greenhouses -the variability of the production techniques and of the consumption of water, fertilizers and pesticides.

Identification and investigation of a firm representative of the district.

The selected firm:

- produces all the main products of the district average size;
- employs both pavilion and tunnel greenhouses;
- uses common practises for the cultivations that are typical in the district.



Functional Unit (F.U.): 1 ton of protected crops







Main assumptions

- **Production of seeds is neglected;**
- CO₂ absorbed by the plants during their vegetative cycle has not been accounted, likewise the emissions due to dead plants;
- The disposal/recycling of wastes have been accounted: steel and aluminum wastes are recycled, plastics and construction wastes are placed in landfills, hazardous wastes are incinerated, residual food wastes are treated in composting plant;
- Productivity of average plants is: tomatoes 9.6 kg/m², cherry tomatoes 4.1 kg/m², melons 3.6 kg/m², peppers 6.2 kg/m² and zucchinis 2.7 kg/m².

Main assumptions

- Mass criterion is applied to allocate both impacts due to components of greenhouses and wastes from agriculture machines.
- Pavilions have a life span of 10 years; life span of foundations is 30 years. The plastic LDPE covers are replaced every 3 years, while nylon ropes to tie up tomato plants are replaced every year.
- The life-span of the tunnel structure (aluminum arcs) is 10 years. The plastic LDPE cover is replaced every year.

Main inputs and outputs, collected from local investigation

		IN PAV	ICHORS Y	IN TUNNELS	
	MELON	TOMATO	TOMATO	PEPPER	ZUCCHINI
INPUT					
Steel [kg]	161.8	60.5	141.2	-	-
Aluminium [kg]	-	-	-	10.0	23.1
Concrete [kg]	109.0	40.8	95.2	-	< -
Glass fibre resin [kg]	6.1	2.3	5.3	-) -
Plastic [kg]	29.4	19.8	46.3	36.8	84.3
Water [m ³]	111.2	62.4	48.5	80.0	129.7
Fertilizer [kg]	65.3	21.3	49.7	40.0	101.9
Manure [kg]	58.9	22.0	51.4	33.9	78.5
Pesticide [kg]	28.6	10.7	24.9	16.4	38.0
Packaging [kg]	52.8	89.3	86.7	86.0	111.1
Diesel [kg]	105.9	91.0	92.2	66.7	93.0
OUTPUT [kg]					
Organic waste	250.0	50.0	50.0	100.0	50.0
Construction waste	277.0	103.6	241.7	10.0	23.1
Packaging	52.8	89.2	86.7	37.0	84.9
Plastics	42.3	20.0	46.6	86.0	111.1
Hazardous waste	6.2	2.3	5.2	3.6	6.2



Energy and environmental impacts

Contribution to GER



Energy and environmental impacts

Impact	Cherry tomato	Tomato	Melon	Pepper	Zucchini	
	[1000 kg]					
Global Energy Requirement - GER [GJ]	21.6	15.6	22.6	17.0	26.9	
Global Warming Potential - GWP [kgCO _{2eq.}]	1278.0	897.1	1494.7	1100.3	1602.8	
Ozone Depletion Potential - ODP [kg CFC11 _{eq}]	4.6E-04	4.1E-04	5.2E-04	3.7E-04	3.8E-04	
Photochemical oxidation [kg C ₂ H _{4 eq.}]	1.1	0.9	1.2	0.9	1.1	
Acidification [kg SO _{2 eq.}]	8.4	5.1	9.5	5.9	10.8	
Eutrophication [kg PO _{4 eq.}]	3.2	1.8	3.7	2.8	5.5	

Energy and environmental impacts

Water consumption [10³ kg/F.U.]

Wastes production [kg/F.U.]



Yearly energy and environmental impacts of the district

Main Global Impacts indexes				
Global Energy Requirement -GER [10 ⁶ GJ]	1.55			
Global Warming Potential – GWP [10 ⁶ kgCO _{2eq.}]	95.67			
Ozone Depletion Potential – ODP [kg CFC11 _{eq}]	31.25			
Photochemical oxidation $[10^3 \text{ kg C}_2\text{H}_{4 \text{ eq.}}]$	76.27			
Acidification $[10^3 \text{ kg SO}_{2 \text{ eq.}}]$	601.91			
Eutrophication $[10^3 \text{ kg PO}_4^{3-}]$	268.48			
Water Consumption [10 ⁶ m ³]	9.78			
Wastes [10 ⁶ kg]	12.12			

Comparison with other LCA studies of tomatoes

INDEX	DETAILS	REFERENCES	
GER: 125 GJ;	Cultivated in greenhouses in	Williams et al. 2006	
GWP: 9.4 10 ³ kg CO _{2eq}	Northern Europe		
GER: 5.4 GJ	Cultivated in open fields in Southern Europe	Carlsson-Kanyama, 1998	
GER: 42 GJ;	Cultivated in greenhouses in	Carlsson-Kanyama, 1998	
GWP: 3.3 10 ³ kg CO _{2eq}	Sweden on in the nearby countries		
GER: 50.9 GJ;	Cultivated in greenhouses in	Nielson et al. 2006	
GWP: 3.4 10 ³ kg CO _{2eq}	Northern Europe	Nielsen et al. 2000	

With regard to the tomatoes in pavilions GER results 3 times larger (15.6 GJ) than the tomatoes grown in open air cultivations;

- Mediterranean greenhouses are characterized by lower GER and GWP than the northern Europe ones, due to the non-use of auxiliary heating systems in the former.

Conclusions

- Yields play the main role in the energy and environmental profile of vegetables, since it affects the specific consumption of fertilizers, water, pesticides, etc.
- Few differences are observed about the cultivation techniques of vegetables
- ✓ Differences into eco-profiles are mostly related to parameters as the typology of greenhouse structure and packaging. For all the assessed eco-profiles the packaging step and the greenhouses involve the most significant incidence on GER and GWP
- ✓ The highest impacts are related to the life cycle of zucchinis
- Tunnel and pavilion greenhouses have comparable eco-profiles of their products. The former presents lower environmental impacts.



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