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Development of guide lines for the calculation of carbon footprint of peaches and apricots produced in Metapontino area (Basilicata): the project IQuaSoPO

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Introduction and objectives

According the recently published standard ISO 14067:2013 in the carbon footprint calculation of a products shall be included and documented separately:

- GHG emissions and removals arising from fossils and biogenic carbon sources and sinks
- GHG emissions occurring as result of direct land use change or soil carbon change
- Non CO2 GHG emissions and removals arising from manure or soil

Objectives of this study are:

1) To integrate the existent guide lines for calculation of carbon footprint of MEDITERRANEAN FRUIT products with GHG accounting rules related to emissions and removals occurring within orchard ecosystem between soil, plant and atmosphere:

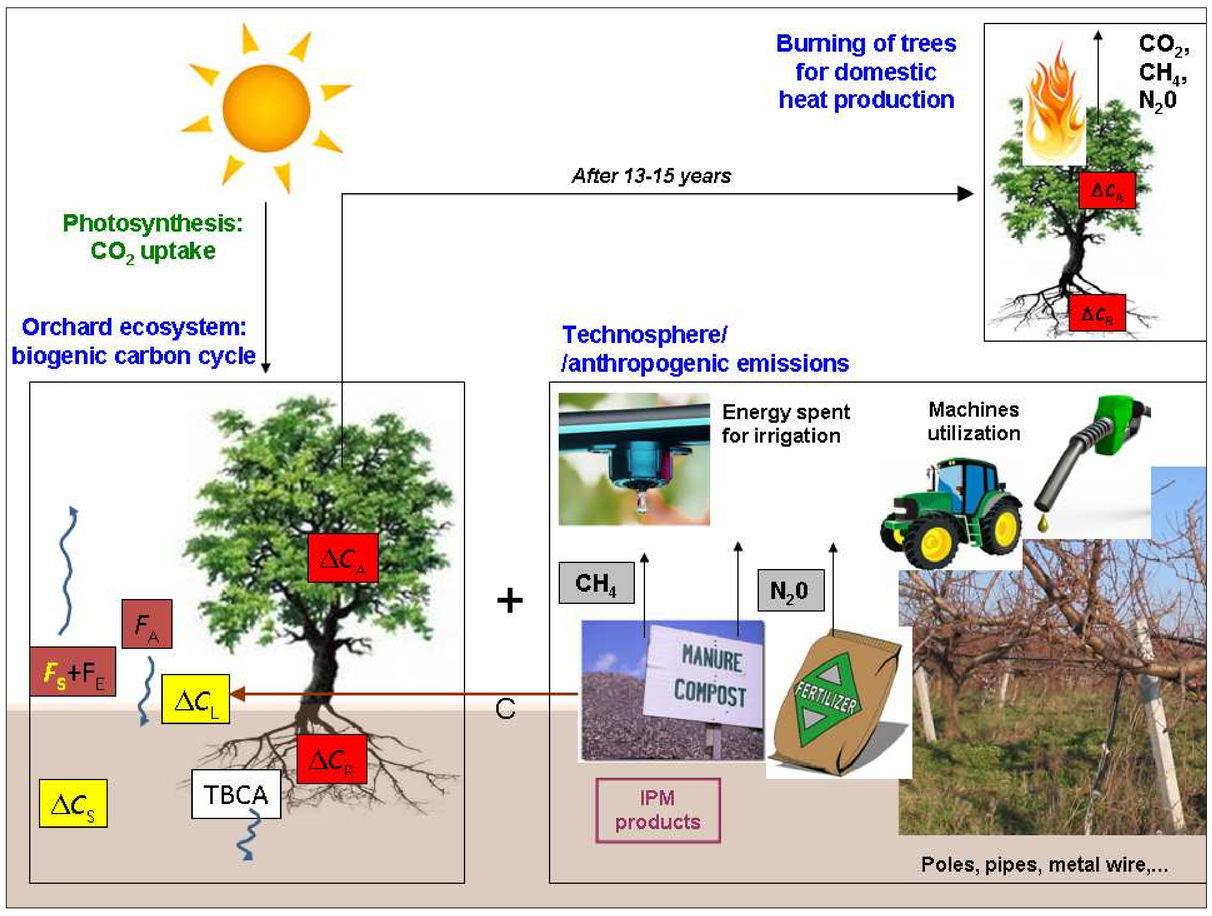
→N20 emission from soil due to mineratlization processes and nitrogen fertilization

→CO2 fixed in soil coming from carbon sources internal of the orchard (prunings, senescent leaves, thinned fruits) and external (compost, manure)

2) To adapt the guidelines for the calculation of carbon footprint of fruits, to the geographical specificities of peaches and apricots production in Metapontino area (territory located along the Jonic coast of the Italian region Basilicata, with 74000 hectars of cultivated lands, of which 21000 ha dedicated to fruit production).. These guidelines will be used by the local producers to easily assess and communicate the environmental sustainability of their products, which, in this way, will gain added value on the market.

The project "IQuaSoPO,, - Innovation, Quality, Sustainability - is a three year project, financed by the regional funds for rural development of Basilicata Region (RDF 2007-2013; measure 124), which aims to transfer good sustainable practices to local fruits producers. The general objective of the project is to enhance the competitiveness of the fruit production of Basilicata region on national and international markets.

Materials and methods



Anthropogenic and ecosystemic GHG emissions and removals related to a mediterranean fruit orchard life cycle

Three pilot fileds representative of the productive practices of peaches and apricots have been selected in the area of Metapontino. One hectare of these pilot fields have been dedicated to sustainable management practices starting from the beginning of 2013: no tillage, soil grass cover, recycling of prunings at field, compost and manure addiction. The charachteristics of boyh conventional and sustainable management practices have been examined for the development of carbon footprint calculation guidelines.

Hypothesis of LCA study

- Boundaries of orchard life cycle: from nursery to orchard removal (13-15 years)
- Yearly process considered: irrigation, fertilization, pest management, weed control, pruning, harvest
- Time boundaries: yearly cultural cycle
- Functional unit: 1 ha orchard.
- The result about GWP 100 years (CML 2001 method) are then divided to the mean yearly yield to obtain CO2eq/kg of product (peaches/apricots.)

Carbon balance in orchard ecosystem

Based on mass conservation concept - *Giardina e Ryan (Ecosystems, 2002, 5:487):*

OUT (Δt) = IN (Δt) - ΔC/Δt (1)

The outputs of carbon are equal to inputs, minus the variation of carbon reserves occurring in a time interval Δt

OUT (Δt) = FS (Δt) +FE (Δt)

FS (Δt) = fluxes of carbon released from roots, litter and soil, due to decomposition processes, heterotrophic and autotrophic respiration of soil occurring in a time interval Δt

FE (Δt) = carbon loosed due to erosion and leaching processes occurring in a time interval Δt

IN (Δt) = TBCA (Δt) + FA (Δt)

TBCA (Δt) = total belowground carbon allocation (roots, roots' exudates and mycorrhizae) occurring in a time interval Δt

FA (Δt) = fluxes of carbon to soil related to above ground biomass (soil grass cover, thinned fruits, senescents leaves and flowers, prunings) occurring in a time interval Δt

ΔC (Δt) = change of carbon content in soil (ΔCS), litter (ΔCL), roots (ΔCR), above ground tree structure (ΔCA) occurring in a time interval Δt

So we can write the (1) as:

(FS+FE) (Δt) =TBCA (Δt) + Fa (Δt) - Δ(Cs+C_L+Cr+Ca)/ Δt (2)

Results

The developed guidelines for calculation of carbon footprint of peaches and apricots in Metapontino are summarized in the table beside.

The change of carbon content in above ground biomass and roots (ΔCa, ΔCr) have been excluded from the accounting because these quantities of C are emitted in atmosphere in form of CO_2 at the end of life of the orchard, when trees are burned for the production of domestic heat; the typical life cycle of a peach/apricot orchard is maximum 13-15 years, a time frame which is considered short-medium in relation to the 100 years of global warming potential effect estimation.

To estimate the impact on global warming of fruit production it is important to look at what happen during the orchard life cycle and what remain after the orchard removal; with reference to equation (2), the developed guidelines suggest that it can be assessed just two terms:

- the yearly flux of carbon from soil Fs, expressed as biogenic CO_2 emissions, measured with closed chambers or estimated using literature data if available for fields with similar pedo-climatic conditions and similar orchard management practices
- the yearly change of soil (ΔCS) and litter (ΔCL) carbon content, expressed as biogenic CO_2 removals; performed using the european protocol for soil sampling (Stolbovoy et al, 2007), which requires 3 sample for a field < 5 ha.

The inclusion of N_20 emissions from nitrogen fertilization: constitutes an innovation element in food products carbon footprint calculation. It can been estimated based on the Tier 1 methodology contained in 2006 IPPC guidelines for Nationa Greenhouse Gas Inventory (volume 4 – chapter 11); some of the most recent updates of inventory database available on the market (ex: PE International 2013), include N_2O emissions within the use phase of fertilizers.

The developed guidelines need further improvement and the application to several real cases in order to become a reliable and affordable tool for market. Expecially the measurement of CO_2 emissions from soil are still too expensive methodology for farmers. Moreover the guidelines will be completed with the retailing phase in near future:processing, packaging, storage and transport (refrigerated/non refrigerated).

Pre-production phase		
Nursery	Production of seedlings	*Inventory data related to the specific breeding technique: plastics, substrates, energy for irrigation, fertilizers, pesticides.*
Orchard life cycle	Production of agricultural machinery	*Accounting of mass based on exploitation hours/total life cycle operating hours*
	Production of support and coverage structure: poles (cement, wood or alu-zinc), metal wire, connection hooks, cement blocks, plastic sheets.	*Interview about the number, material and weight of structural elements.Impacts of production divided equally per each year of the orchard life.*
	Production of irrigation pipes (main and secondary)	
	Production of plastic bins for harvesting	*Interview about material, capacity and number of bins, life cycle time lenght and disposal scenario*
Yearly agricultural operations	Production of productive inputs: mineral fertilizers, pest management products	*Data collection about the type and quantity of fertilizer/pesticide used and assimilation with the most similar indirect inventory data from databases or literature*
	Compost and manure storage and processing	*Tier 1 method for determination og CH4-N2O emissions from manure management (2006 IPCC Guidelines for National Greenhouse Gas Inventories - volume 4 - chapter 10)*
Transport of all above mentioned productive factors to field		*Linear distance between the production plant site and the field. Mean of transport selected based on most common practices*
Production phase		
Technosphere	Diesel consumtpion for agricultural machine utilization.	*Calculated based on machines' operating hours and power of the machine*
	Energy consumed for irrigation	*Normal conditions: draining system of waters from the upstream basins + gravity: 0,00706 kWh/m3. Emergy conditions: pumping systems for water transfer from one irrigation district to another (to be added diesel consumption)*
Orchard ecosystem: soil-plant-atmosphere	N20 emissions from soil due to nitrogen fertilization (denitrification processes)	*Tier 1 method for determination of N2O emissions from managed soils (2006 IPCC Guidelines for National Greenhouse Gas Inventories - volume 4 - chapter 11) Note: Some inventory database include N2O emissions in the use phase into data about fertilizers*
	CO2 emissions from roots, soil and litter, due to decomposition of organic matter	*Yearly direct measurement with closed chambers or use of literature data if available for fields with similar pedo-climatic characteristics and with similar orchard management practices.*
	Fluxes of carbon transferred to soil and litter from above ground biomass contributions (soil grass cover, senescent leaves and flowers, thinned fruits, prunings)	*Yearly soil and litter sampling and measurement of organic carbon stock according to European Protocol for soil sampling (3 samples for fields < 5 ha)*
End of life of the orchard		
Burning of trees for domestic heat production		*About 20 t biomass/ha. Accounting of non-CO2 GHG emissions arising from burning. The CO2 emitted is not accounted because correspond to the CO2 accumulated in the tree structure during its life cycle (45-75 t ha-1 CO2 in 15 years). Avoided emissions from domestic heat production with natural gas accounted*
Disposal/reuse/recycling of support and coverage structure: poles (cement, wood or alu-zinc), metal wire, connection hooks, cement blocks, plastic sheets.		*All materials except cement blocks and main irrigation pipes are re-used for 2 orchard's life cycles: half of the weight of material used accounted in one orchard life cycle. Cement elements are disposed in landfill, while metals and plastics are recycled, with a 20% of non recyclable scraps to landfill*

References

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IPCC (2006). Guidelines for National Greenhouse Inventories, Vol 4 – Chapters 10-11.. (Eds). Intergovernmental Panel on Climate Change (IPCC), IPCC/OECD/IEA, Paris, France.
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