Comparison of CO_2e emissions associated with regional, heated and imported asparagus

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ABSTRACT

Carbon footprint of Asparagus, a major crop with 300,000 ha worldwide, was based on primary farm data. These included four Asparagus sources to extent the short cultivation period in Germany a) forcing local asparagus by soil heating, or sourcing of imports b) from e.g. Turkey or Greece by truck or by c) ship or d) plane from Peru, different supply chains and the unproductive first years after planting within 11 years of an asparagus plantation - according to PAS 2050 for horticulture (BSI, 2012), using 1 kg asparagus as functional unit with system boundaries from plantlet to end of life at consumer stage. Environmental-friendly cultivation was with waste heat viz energy from a local soot factory; therein, PE tubing, and pumps for the hot water dominated in the product carbon footprint (PCF) of 1.75 kg CO_2e/kg for the heated local asparagus. In case of the Peruvian asparagus, air-freight played the major role in comparison to transport by container ship. Regional asparagus scored best with 0.82 – 1.3 kg CO_2e/kg including 29 g/kg biogenic carbon as offset, whereas air-freighted Asparagus from Peru had 8 kg CO_2e/kg similar to 12.2 kg CO_2 e/ kg air-freighted asparagus by Stoessel et al. (2012).

Keywords: Asparagus, airfreight, carbon footprint, import, greenhouse gas

1. Introduction

Asparagus is chosen as a prime example for a carbon footprint analysis with different produce sourcing and marketing strategies. With ca. 24,000 ha, asparagus is not only the largest vegetable crop in Germany, but a major vegetable with 300,000 ha worldwide with increasing popularity in a healthy diet. Expansion of the short cultivation period between May and June in Germany, however, can be achieved only by a) forcing asparagus by soil heating, sourcing by imports b) from e.g. Turkey or Greece by truck or by c) ship or d) plane from Peru. The objective of this contribution was to evaluate the carbon footprint of these four asparagus sources to aid consumer decision-making and determine GHG hot spots and climate-friendly sourcing.

The challenge is to combine the largest field grown vegetable commodity in horticulture with the new PAS 2050-1 for horticulture. The only two carbon footprint studies on asparagus were in the UK (Audsley et al., 2009) and Switzerland (Stoessel, 2012) before the PAS 2050-1 hort standard (BSI, 2012) became available. For a number of reasons, neither biogenic carbon nor the relevant use phase was included in these previous studies. For the first time, the new PAS 2050-1 (hort) is used as methodology including the new approach to biogenic carbon and Land Use Change (LUC) emissions for the shorter time period of only 20 years (old 100 years) and different crop rotation systems. This study was part of the pilot projects towards the development of the PAS 2050-1 hort (BSI, 2012).

Hence, the objective of this study is to assess the carbon emissions of different asparagus field production systems using a number of supposedly improvements such as waste energy for forcing asparagus to satisfy consumer demands for all year around vegetable supply. Since regional asparagus is not available all year round, the airfreight import of fresh asparagus from other parts of the world is used to fill in the marketing gap. Asparagus is employed here as a model crop for the comparison of heated and un-heated early (forcing) local production. Import of asparagus from Peru by ship and airfreight is included as a different way of sourcing for the European market.

2. Methods

2.1. Primary data assessment

Primary data from two farms in Germany with different supply chains include the unproductive first years after planting within the overall 11 years of an asparagus plantation. Biogenic carbon was also accounted for following the special requirements of the new PAS 2050-1 for horticulture (BSI, 2012). A heated cultivation was compared with an unheated standard cultivation system and marketing via two different ways (retail and farm shop).

2.2. Calculation of carbon footprint

The carbon footprint was calculated for the supply of asparagus based on the new PAS 2050-1 "Assessment of life cycle greenhouse gas emissions from horticultural products - Supplementary requirements for the cradle to gate stages of GHG assessments of horticultural products undertaken in accordance with PAS 2050" (BSI, March 2012), which includes the GHG emissions CO_2 (1x), CH_4 (25x) and N_2O (298x) and results in CO_2 equivalents (CO_2e). The new horticultural PAS 2050-1 (BSI, March 2012) includes specific requirements for different cultivation systems like perennial crops such as asparagus or orchards over their complete lifetime from plantlet supply to grubbing. Additionally, there is the opportunity to include the biogenic carbon in the harvested product, if used for food and feed, which is not considered in previous studies.

2.3. Functional unit and system boundary

Two functional units were employed for carbon footprint assessment:

- Acreage [ha] for asparagus cultivation (PAS 2050-1)
- Weight [kg] of saleable product at farm gate (PAS 2050-1) and for further marketing, use phase and disposal (PAS 2050)

The results for the assessed greenhouse gas emissions (GHG) are shown for the cultivation phase up to the harvest with the specific Farm Carbon Footprint (FCF), including the post-harvest activities up to the farm gate (B2B) and with transportation, marketing, consumer use phase and disposal (B2C, PCF).

2.4. Cultivation and marketing systems for asparagus

Three cultivation systems on two farms were selected on the grounds of representativeness, different primary energy use and marketing strategies. The large farm used one cultivation system with an underground soil heating system and another one without heating system. On the second farm the overall asparagus acreage was smaller and not heated. The marketing strategies differed in that the large enterprise (farm one) with its large volume of asparagus markets exclusively via nationwide wholesale and retailers. By contrast, farm two sales the smaller volumes of asparagus through farm shops and regional street markets direct to the consumer. Consumer shopping tours with private vehicle differ in distance and size of the shopping basket (20 kg with 1 kg asparagus for retail and various scenarios depending on specific marketing system combined for farm two). Home storage and cooking as well as composting were modeled.

3. Results

3.1. Carbon Footprint of Asparagus

The carbon footprint of asparagus was calculated over the entire life-span including the productive and unproductive phases, i.e. 11 years. In this case study for the new PAS 2050-1 only one farm with one cultivation system was analysed to study the ease of implementation of the new rules. LUC was calculated with an Excel tool that was developed in the pilot project. The result of the LUC for asparagus following annual crop land was negative for our specific growing and environmental conditions. To avoid any criticism of offset it was assumed zero in our calculation. The biogenic carbon was calculated from its 6 % dry matter with 47 % carbon content based on average (11 year) yield (7t/ha) including the unproductive phase of the cultivation. The result for the Farm Carbon Footprint (FCF) was 2.307 t CO_2-eq/ha asparagus, after the biogenic carbon was subtracted.

Including the cooling, grading and packaging the business to business carbon footprint according to the new PAS 2050-1 was 414 g CO_2-eq/ kg asparagus (Table).

The transportation to retail and the use phase (shopping tour, fridge and cooking) at the consumer amounted to 401 g $CO_{2\text{-eq}}$/ kg asparagus using the guideline of the PAS 2050:2011. The overall business to consumer (B 2 C) carbon footprint of 815 g $CO_{2\text{-eq}}$/ kg asparagus shows the result over the all life-cycle stages of asparagus.

Since waste energy was employed from a separate enterprise, viz a soot factory, this energy was excluded from the asparagus carbon footprint. However, the carbon footprint of heated asparagus doubled to 1.75 kg CO_2e/kg relative to unheated asparagus due to the plastic tubing to distribute the hot water to the plants and due to the energy consumption to pump the hot water

Table 1: Carbon footprint of asparagus cultivated in an integrated production system (asparagus regional)

	Integrated Production (IP) of Asparagus
Farm carbon footprint per acreage [t/ha]	
Average asparagus yield per ha and per year (over 11 years)	7.02 t/ ha
Yearly cultivation, tillage and planting (per ha) without bio-genic carbon	2.503 t CO_2-eq/ ha/a
LUC (asparagus after annual cropland)	0.0 kg CO_2-eq/ ha/a*
Biogenic carbon per ha (6 % dry matter of asparagus)	-0.198 t CO_2-eq/ ha/a
From planting to harvest (over 11 years) (ha)	2.307 t CO_2-eq/ ha/a
Farm carbon footprint [g per kg]	
From planting to harvest (over 11 years) (kg)	328 g CO_2-eq/ kg asparagus
Cooling, grading and packaging (5 kg cardboard carton)	086 g CO_2-eq/ kg asparagus
Carbon footprint from seedling to harvest according to PAS 2050 -1 (B 2 B)	**414 g CO_2-eq/ kg asparagus**
Product carbon footprint [g per kg]	
Overall transportation farm to retail	096 g CO_2-eq/ kg asparagus
Use phase (shopping tour, fridge and cooking)	305 g CO_2-eq/ kg asparagus
Product Carbon Footprint from harvest via use phase to disposal	**401 g CO_2-eq/ kg asparagus**
Product Carbon Footprint (PCF) CO_2 eq /kg asparagus **(B 2 C)**	**815 g CO_2-eq/ kg asparagus**
Product Carbon Footprint (PCF) CO_2 eq /kg asparagus **(B 2 C) excl. offset of biogenic carbon**	**843 g CO_2-eq/ kg asparagus**

*LUC result was negative but assumed as zero.

Alternatives to heated regional asparagus in spring for the consumer are imports by truck from Greece (2,100 km by ship or plane from Peru, resulting in 6- 12 kg CO_2e/kg asparagus in comparison with forced regional asparagus 1-2 kg CO_2e/kg asparagus.

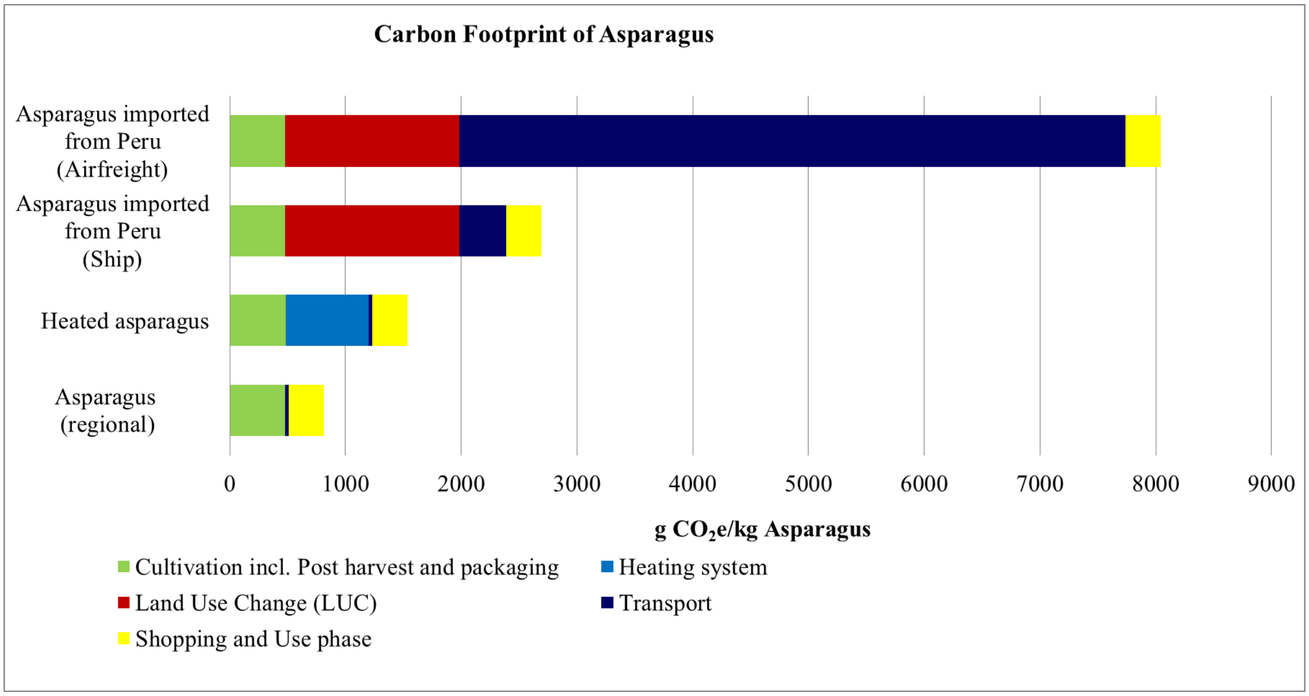

Figure 1: Product Carbon Footprint of different sources of Asparagus

3.2. Biogenic carbon

Biogenic carbon, i.e. the carbon contained in the harvested product exported outside the system boundary (out of the farm gate), is offset in the PAS 2050-1 against the carbon emissions during horticultural production, if used for food or feed. Similarly, bio-genic carbon not used for food or feed, e.g. tree trunks for the timber or furniture industry, can be offset against horticultural production (BSI, 2012) (Table).

Capital goods in horticulture such as greenhouse support structures for poly-tunnels, buildings, grading facilities and cold stores are defined and excluded from the Carbon Footprint calculations in PAS 2050-1.

Consumables, which are replaced on a regular basis, such as plastic foils for plant covering and growing substrates, are included. Similarly, fertilisers and plant protection compounds are included in the product carbon footprint.

4. Discussion

The larger carbon footprint of 1.9-2.4 kg CO_2e/kg asparagus by Audsley et al (2009) for asparagus cultivated in England may be due to the calculation from basic root vegetables and adjustments made for yield deviations from the average root vegetable crop. Our value of 8 kg CO_2e/kg airfreighted asparagus from Peru compares favorably with 12.2 kg CO_2 e/ kg asparagus by Stoessel et al. (2012), who used a stopover on the flight to Switzerland compare with a direct flight to Frankfurt in the present study.

5. Conclusion

The present study is, to our knowledge, the first approach based on the new dedicated PAS 2015-1 (2012) and utilizes comprehensive primary data assessed on carefully selected farms. Different marketing scenarios are presented, which include farm sale (regional asparagus) and supermarket shopping (Peruvian asparagus), in which the consumer played a relevant role with his shopping trip (2 x 5 km) with a standard 20 kg shopping basket with 1 kg asparagus (Schaefer, 2012).

6. References

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