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Conventional and organic rice production in Northern Italy: What is the (environmentally) best?

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Abstract

In this study, using the Life Cycle Assessment (LCA) approach, the environmental performances of rice production in Italy considering both conventional rice production (CRP) than organic rice production (ORP) was evaluated. Inventory data were collected by means of surveys in 69 farms located in Northern Italy, 20 for ORP and 49 for CRP.

The best cultivation practice depends on the evaluated impact category and by the specific cultivation practices. On average the impact for ORP are higher than for CRP but, above all for ORP, there is a wide variability of the environmental performances.

Keywords: Life cycle assessment, Agricultural systems, Cereals, Environmental impact

1. Introduction

In Europe, conventional rice production (CRP) is by far the most common agricultural system for rice. However, the organic one (ORP) is becoming more and more important. In 2015, in Italy, the organic rice area was 12,425 ha (5.4% of the rice area), with remarkable increase in respect of 2015 (+13.9%) (SINAP, 2015).

Unless than conventional rice, where a quite standardised cultivation practice is carried out, in organic rice farming several different cultivation practices are performed, leading to a wide variability of productive performances. The ORP can vary as regard to: fertilisation, sowing, soil tillage, water and weed management. However, compared to conventional rice production, the organic system is usually characterized by lower yields and, above all, by a huge yield variation over the years (Bacenetti et al., 2016). The aim of this study is compared, using the Life Cycle Assessment (LCA) approach, the environmental performances of rice production in Italy considering both CRP than ORP.

2. Materials and Methods

The selected functional unit is 1 ton of paddy rice at the commercial moisture (14%). The study was carried out with a "cradle to farm gate" approach therefore all the processes from raw material extraction to grain drying were included in the system boundary while rice processing, packaging and distribution were excluded.

The inventory data were primarily collected by means of surveys in the rice farm located in Northern Italy. The survey included 69 farms, 20 for ORP and 49 for CRP. The organic farms were identified taking into account the compliance with the organic cultivation guidelines and the absence of sprayers in the farm machinery fleet. Mixed farms (organic and conventional) were not considered. After the surveys, 4 different cultivation practices were identified for ORP and 9 for CRP. The paddy rice yield ranges from 3 to 4.6 t/ha for organic production and from 6 to 9 t/ha for the conventional one. Twelve impact categories were evaluated using the ILCD method: Climate Change (CC), Ozone Depletion (OD), Human toxicity, non-cancer effects (HTnoc), Human toxicity, cancer effects (HTc), Particulate matter (PM), Photochemical ozone formation (POF), Acidification (TA), Terrestrial (TE). Freshwater (FE), Marine (ME) eutrophication, Freshwater ecotoxicity (FEx) and Mineral, fossil & ren resource depletion (MFRD).

3. Results

The table reports the results for the different cultivation practices. In particular, the ORP4 where compost (22.5 t/ha) is spreaded for fertilization shows by far the worst environmental performance considerably higher also compared to the other ORP systems. More in details, for ORP4, the CC is 3 times higher than the other ORPs and 4 times higher than CRPs. ORP shows worst environmental performances for 9 of the 12 evaluated impact categories and respect to CRP presents higher variability (Figure 1). Both for ORP and CRP: i) CH_4 emissions are the main hotspot for CC (from 40 to 65% of the total impact), ii) the emissions due to fertilizers application for TA, PM, FE, TE and ME, iii) the mechanization of field operations is a hotspot for MFRD, OD and HTc mainly due to emission from fuel combustions; for CRP the MFRD is almost completely due to (> 90%) to mineral fertilizer production. For FEx, the main hotspot is seed production for ORC and the emission of pesticides into the soil for CRP. For ORP 4, the consumption of compost as organic fertilizer and its transport (60 km) are the most important contributor to CC, OD, HTc and POF.

	CC kg CO_2 eq	**OD** mg CFC-11 eq	**Htnoc** CTUh x 10^{-4}	**HTc** CTUh x 10^{-5}	**PM** kg PM2.5 eq	**POF** kg NMVOC eq	**TA** molc H+ eq	**TE** molc N eq	**FE** kg P eq	**ME** kg N eq	**FEx** CTUe	**MFRD** mg Sb eq
ORP 1	1069	39.57	7.83	1.32	0.159	2.545	3.75	16.3	0.012	2.41	747	7.21
ORP 2	1192	32.47	5.53	1.13	0.639	2.048	25.89	115.2	0.022	11.81	573	5.48
ORP 3	1251	43.41	4.84	1.85	0.378	2.645	9.75	40.9	0.079	4.48	1667	80.02
ORP 4	3498	73.41	5.50	2.50	1.312	7.207	52.44	235.4	0.141	9.97	864	7.61
CRP 1	942	50.90	2.22	1.63	0.643	2.613	21.59	94.2	0.115	11.25	2661	80.28
CRP 2	935	40.85	1.83	1.42	0.583	2.277	20.14	88.1	0.093	11.80	1603	67.62
CRP 3	807	43.04	1.84	1.57	0.547	2.399	17.62	76.5	0.102	10.08	1900	79.42
CRP 4	898	33.66	1.63	1.16	0.616	2.032	21.64	94.8	0.092	11.70	1706	52.18
CRP 5	893	37.85	1.90	1.30	0.697	2.309	24.37	106.9	0.108	13.11	1952	58.25
CRP 6	1276	42.02	2.04	1.60	0.453	2.691	14.29	61.9	0.111	13.21	11105	110.0
CRP 7	825	42.76	1.51	1.21	0.515	1.909	17.61	76.7	0.080	9.01	7022	59.66
CRP 8	1027	29.39	1.38	1.02	0.485	1.862	16.86	74.0	0.074	8.65	7913	55.96
CRP 9	829	40.06	1.86	1.44	0.478	2.190	14.90	64.5	0.109	7.29	1914	95.58

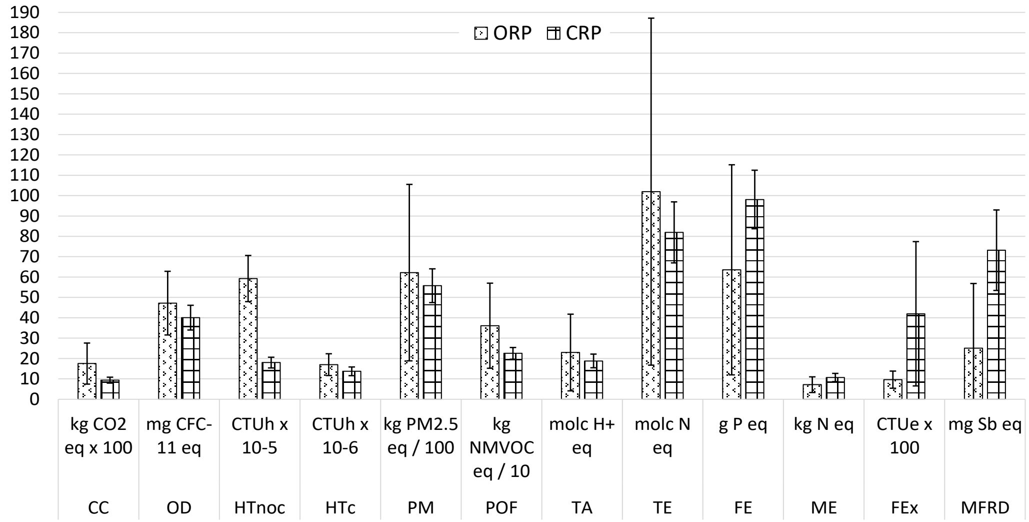

Figure 1. Environmental Impacts for ORP and CRP (The error bars represent the average value ± the standard deviation

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