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Short communication

The environmental burdens of maize silage production: Influence of different ensiling techniques

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A B S T R A C T

Livestock production has a major impact on the environment. Feed production is one of the major environmental hotspots of livestock production and its eco-assessment becomes a key issue of the whole cattle chain. Yearly about 150,000 tons of silage are produced worldwide and they are mainly used as animal feeding and for biogas production.

The aim of this study is to evaluate, using the LCA methodology, the environmental impact of maize silage production using different ensiling techniques: bunkers silos and bag silos. The results highlight that the production of the chopped maize is responsible for the main part of the environmental burdens of maize silage (more than 88% for all the evaluated impact categories) while ensiling is responsible for a small share of the overall impact. However, maize silage stored in silobag, compared to the one stored in bunker silo, shows lower environmental impact for all the evaluated impact categories (from −5% to −9%). Such difference is mainly explained by lower dry matter losses occurring through the use of silobag. A sensitivity test has been performed in order to gauge the influence of the value of dry matter losses on the systems analyzed. Results of the sensitivity analysis highlight the pivotal role played by such parameter on the overall eco-profile of maize silage: the decrease of the impact of maize silage is in fact directly proportional to dry matter losses reduction.

1. Introduction

Over the last years, the interest in the environmental impacts associated with food systems has strongly grown. Several works have confirmed the relative importance of "food and beverages consumption" in contributing to environmental impacts (IPCC, 2011),. According the 5th Assessment report of the IPCC (Smith et al., 2014) the annual Greenhouse Gases (GHG) emissions from the agricultural production in 2000–2010 were estimated at 5.0–5.8 GT CO_2 eq/year; among this several studies highlighted that livestock activity plays a key role (de Vries and de Boer, 2010; De Boer et al., 2011). Estimates of global GHG emission attributable to livestock range from 8% to 51% (FAO, 2006; Goodland and Anhang, 2010). Although this big variability, the estimates of international scientific organization are in close agreement with variation mainly arising

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on how GHG emissions are allocated to and use and land use change (Herrero et al., 2011). The United Nations Food and Agriculture Organisation (Steinfeld et al., 2006; FAO, 2013) assess that livestock accounts for 18% of the global GHG emissions. Livestock production has a major impact on the environment; meat and dairy products are the foods carrying the greatest environmental impact, accounting for approximately 50% of food generated GHG emissions (Garnett, 2009). The impacts associated with feed production, raising the livestock and manure handling are the greatest contributor to the overall impact resulting from meat production (FAO, 2006; Roy et al., 2009; Herrero et al., 2011; Hünerberg et al., 2014). Being feed production one of the major environmental hotspots of livestock production, its eco-assessment becomes a key issue of the whole cattle chain. Such evaluation should include both the agricultural phase of cereals cropping and the ensiling stage. De Boer et al. (2011) evaluated the main options available to mitigate GHGs in animal production from a life cycle perspective. Among these mitigation solutions, with regard to feed production, the solutions addressed are the yield increase and the improvement of nutrient use efficiency but the improvement of feed storage techniques was not considered. Considering that, yearly about 150,000 tons of silage are produced worldwide (Weinberg and Ashbell, 2003), it can be easily figured the benefits arising from the reduction of silage environmental load.

Several Authors addressed the environmental impact of cereal silages production considering their different utilizations: animal feed (Bacenetti et al., 2015) and biogas production (González-García et al., 2013; Bacenetti et al., 2014). Nevertheless, in these studies, the impact of ensiling within the silage production system has not been highlighted; Bacenetti et al. (2014), as regard to biomethane production from silages, pointed out that the environmental impact of ensiling ranges from 2% to 5% for maize and wheat silage.

In Northern Italy (45°60′–44°77′ lat. N, 7°65′–12°22′ long. E) two different cropping systems are the most common for cereal silage production: single crop, in which only a summer crop (usually, maize hybrids FAO classes 600–700) is grown, and double crop in which the summer crop (e.g. maize hybrids FAO classes 300–400 and 500) follows a winter cereals (mainly triticale, wheat and barley). Cereal silages are used for animal feeding, in particular cattle and pigs, but can also be used for starch production as well as for as human food or for biogas production (Bacenetti et al., 2013; Lijó et al., 2014a,b). In 2013 growing seasons, about 10% of the overall Italian maize area (approximately 10.000 km^2) (Negri et al., 2014a, Fusi et al., 2014) was earmarked to biogas production.

However, regardless its utilization and the cropping system carried out to produce it; the storage of harvested biomass is a key issue, both from an economical and environmental point of view. Both in case of energy production and animal feeding, the quality of silage and the reduction of dry matter losses are relevant aspects that must be carefully evaluated (Borreani and Tabacco, 2010a,b).

Different ensiling techniques can be carried out; among them, in Europe, the two most widespread solutions are: bunker silos (normally made of concrete) and plastic bag silos. Although the bunker silos represents so far the most utilized solution, the plastic bag silos are a cheaper alternative to traditional silage storage systems considering that, according to some authors (Wallentine, 1993; Ashbell et al., 2001; Muck and Holmes, 2006) they allow to reduce the dry matter losses.

The main advantages of silobags are:

(1) To be an effective way for preserving feed with minimum nutrient loss (The anaerobic environment that is created eliminates spoilage from the growth of yeasts, moulds and adverse bacteria while maintaining essential proteins and nutrients).
(2) To allow the silage store anywhere the farmers need it. A well graded and well drained ground surface is all that is necessary.
(3) To seal completely the silage in the bag. This means that all the acid is retained in the silage, unlike that in bunker silos when it seeps out through the bottom of the pit as effluent. This compensates for the longer pieces of forage and lower compaction than that found with silage machinery, so that the quality of the silage is just as good.

Over the years, the Life Cycle Assessment (LCA) method has become more and more employed to evaluate the environmental performances of agricultural processes. LCA is a methodology that aims to analyse (and compare) products, processes, or services from an environmental perspective [ISO 14040, 2006] (Guinée, 2002; ISO, 2006), providing a useful and valuable tool for agricultural system evaluation.

The aim of this study is to evaluate, using the LCA methodology, the environmental impact of silage production using different ensiling techniques: bunkers silos and bag silos. Considering that the environmental impact of cereal crops has been already evaluated (González-García et al., 2013; Bacenetti et al., 2014, 2015), in this study the environmental impact of maize silage is assessed paying particular attention on the comparison between the above mentioned ensiling techniques.

2. Materials and methods

2.1. Goal and scope definition

The goal of this study is to compare the environmental burdens of the two most widespread ensiling techniques for cereal silage production in Northern Italy aiming to detect the solution having the lower impact on the environment. Particular attention has been focused on ensilage because, in Po Valley, especially in areas with irrigation, the cereal cultivation practice is characterized by a quite standardized sequence of field operations. Therefore, from one year to another, the main