EIP-AGRI Focus Group
Reducing livestock emissions from Cattle farming

Mini-paper - Looking for synergies for a sustainable livestock production

Authors

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Introduction

In recent years, regulation pressure and efficiency needs have encouraged researchers and farmers to develop, test and apply different strategies to reduce emissions. Other mini-papers developed by this focus group deal with the most relevant of these strategies, including breeding, nutrition, housing systems and precision livestock farming. The mini-paper on measurement of emissions evidences the difficulty of assessing these techniques independently. Therefore, the knowledge on how several of these different techniques can be applied on real farm conditions is limited, and the aggregate potential of emissions reduction is difficult to assess.

The mini-paper on modelling discusses how models can represent the farm system in different degrees of complexity. Interactions among mitigation strategies can be modelled, but there is still a very important gap for improvement, particularly regarding the synergy among animal, feeding and the environment (the last one in a broadest sense) (Figure 1). Therefore, the question to be solved is how to integrate the different strategies to abate emissions in an effective and practical way, under farm conditions, at farm or regional scale.

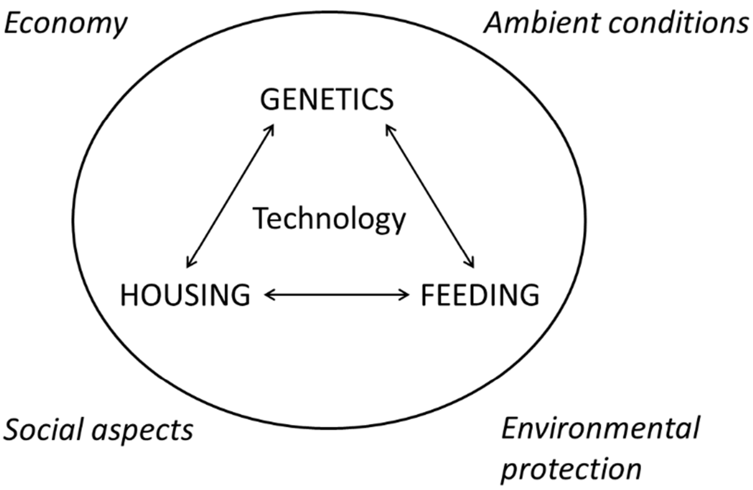

Figure 1: Synergy aspects within the livestock production system and external constraints.

Assessing interactions in practice

A better understanding of interactions in the animal production system, including the whole life cycle, would probably not result in direct and dramatic reductions of gas emissions, but it would most probably allow to reduce the emissions because of the animal production system as a whole may be optimised. Therefore, the understanding of interactions in the animal production system is essential to achieve minimum emissions and avoid unwanted pollution swapping.

At regional level, marginal abatement cost (MAC) curves have been used to model the combined use of different strategies (McLeod et al., 2010; Beach et al., 2015). Combining reduction techniques is essential to achieve further reductions, but effects are not additive, as demonstrated in the literature (Del Prado et al., 2010). For this reason, a deep understanding of the biological, chemical and physical processes leading to emissions is required. This knowledge is essential for modelling and MAC curves to provide an accurate representation of the relationship between abatement potential and costs. This approach has been also used at farm level (e.g. Jones et al., 2015), and it allows prioritizing the techniques to be used in terms of cost-effectiveness.

The interpretation of MAC curves is that when abatement strategies are progressively introduced, it may be expected that abatement become more expensive and less effective, but validating these interactions is extremely complicate in farm conditions. However, the continuous development of monitoring and control systems in practice and further analysis of information may be a real option to assess these interactions and provide a better framework for decision taking.

Potential synergies to be studied

Evidences show that in intensive animal production systems the environmental conditions provided to the animals is not adequate for them to express their potential to use efficiently their resources, and this produces a loss of productivity which can be estimated roughly between 10% and 30%. For example, research on heat stress effects in dairy cows reveals significant losses of productivity in warm and temperate conditions, suggesting the need for including this trait in selection programs (Bernabucci et al., 2014).

Ambient-animal interactions*:* As mentioned before, the inability to provide the animals with the proper ambient conditions (particularly protection against warm conditions) causes relevant losses of efficiency. In most cattle production systems, however, the means available for climate control are still limited. Breeding programs must be aware that in most cases the genetic potential of animals can not be obtained in practice because of this fact, and therefore consider it whenever it is economically feasible. For that reason, research to enhance 'robustness' of animals may be required to obtain resilient production systems to stressful conditions such as heat waves, despite being overall less productive. This trade-off will tilt in favour of one or other direction depending on the length and assiduity of heat stress waves. This could be further studied and modelled for decision-making.

Adaptation to suboptimal ambient conditions: Cattle production is held in very variable conditions, many of them leading to reduced productivity (lower fertility and milk production) due to heat stress. Heat stress is reducing the efficiency of cattle production even in temperate areas of Europe. Furthermore, predictions of climate change indicate that environmental conditions will change in the future (Hayes et al., 2013). Breeding should therefore consider the genetic component of adaptation to the environment. It must be considered that the indoor environment is also a very determining factor for emission processes, particularly those related to manure. Therefore, controlling the indoor conditions may at the same time improve productivity and reduce emissions.

Adaptation to suboptimal feeding: Competition with human consumption and climate change effects may threaten the use of high quality feedstuffs in animal nutrition. For this reason, selection for animals that perform well at different nutrition levels would be necessary to ensure the sustainability of livestock production in

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a probable future with increasing prices of raw materials (Hayes et al., 2013). Local breeds constitute a valuable source of genetic resources for adaptation traits, and therefore their preservation will also be essential to ensure a long term sustainability of cattle production (Biscarini et al., 2015). It must be considered that suboptimal feeding of ruminants may lead to higher methane emissions because of lower digestibility of feeds. However, if forage replacing high quality feeds comes from grasslands, soil C storage compared with feed coming from arable systems can offset CH_4 increases.

Integrating crop and livestock systems (Lemaire et al., 2014). Livestock and agriculture production affects nutrient cycling. Promoting the local integration of livestock and cropping systems promotes coupling nutrient cycling in the environment, which enhances livestock production and reduces N related emissions such ammonia and nitrous oxide. For cattle and for ruminants in general, grassland-based systems may in addition offer a production that has a smaller impact on the human food chain by feeding animals with pastures that cannot be used for crop production, and at the same time, this can help maintaining soil carbon (long-term grasslands) (Vellinga et al., 2004). Although a relevant question is whether potential larger enteric CH_4 emissions of grassland-based systems can offset other production systems based on crops (Soussana and Lemaire, 2014), it must be considered that regional differences (mainly in soil properties and climate) may be a critical production factor. This is however no guarantee of reducing CH_4 emissions, which must be particularly taken into account.

Examples

In intensive livestock production systems these synergies among strategies are established when interest of stakeholders is evident (particularly the economic viability). Some relevant examples already exist, for example the "feed a gene" project (**http://www.feed-a-gene.eu/**) or the Cost Action "Methagene" (**http://www.methagene.eu/**), which combine nutrition and genetic aspects, and includes precision farming. Combining different feeding and housing techniques is being studied as regulatory options in the Netherlands and Flanders to reduce ammonia emissions. Establishing common efforts between nutrition and genetics may result in outstanding advances, particularly in cattle production. In addition, for ruminant systems, recent studies focus on how the microbiome of the rumen can be modified, with very promising results to mitigate of enteric emissions (Duin et al., 2016).

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