PhD School on Agriculture, Environment and Bioenergy

(http://sites.unimi.it/dottorato_aab/)

(XXXIV cycle, 2018-20)

Project draft

1.Field of interest

*Indicare **il/i** settore/i scientifico disciplinari: Agr/18*

2.Project title

Improving feed efficiency through forage strategies for increasing dairy profitability and sustainability.

3.Tutor (membro del Collegio dei Docenti) Dott. Colombini Stefania

- Eventually: co-tutor/s Prof. Luca Rapetti

4.Relevance of the topic and state of the art:

Sustainable food security is the ultimate goal of agricultural production systems. To reduce competition for limited resources, dairy systems will require more productive and environmentally beneficial forage and grain cropping systems (Martin et al. 2017). For example, over the long-term, Little et al. (2017) showed that lucerne had greater potential to store soil carbon than corn silage, although not enough to offset green house gases emissions from dairy production. Similarly, as reported by Zucali et al. (2018), among the most common fodder crops grown in Northern Italy, lucerne (silage) and the double cropping system "Italian ryegrass hay/silage - whole plant maize silage" showed the best environmental performances, when expressed per unit milk. The same authors suggest that the high variability of forage quality implies opportunities for improvement in terms of mitigation potentials.

In this context, strategic ration formulation becomes a priority also for the environmental sustainability of the dairy sector. Indeed, the production of green house gases, especially methane, from dairy ruminants is a main concern for the present livestock industry.

Forages represent an important proportion of the total mixed ration (TMR) which affects dry matter intake and hence productive performance and CH_4 emission. A study on commercial TMR fed to lactating cows in the Po' plain (Viganò, 2017) showed that maize silage is frequently used in TMR rations, although other alternative forage systems are emerging (such as systems based on winter cereals) and the amount of maize silage used in the TMR is slightly decreasing in favour of other ingredients.

Strategies for reducing enteric CH_4 include offering diets high in starch content, improving forage quality, and changing forage type (e.g., maize silage and legume forages). For example, legumes tend to decrease CH_4 synthesis compared with grasses because of their shorter residence time in the rumen which may also affects diet digestibility, a lower fibre content (associated to methane production) and a higher protein content. In addition, the source of forage and its quality in the diet can increase animal productivity, thereby lowering enteric CH_4 emissions per unit of product (Little et al., 2017). It has also to be underlined that a change in forage feeding affects the feed production system as well as milk production and composition due to differences in intake and nutrient availability (i.e., digestibility) and all this factors should be considered (Colombini et al., 2012, 2015). Moreover, while the forage source can affect

CH_4 emissions and milk production from the dairy system, these effects must be considered in liaise with effects on emissions from associated changes in the agronomic system.

5.Layout of the project (draft)

5.1. Materials & Methods:

Commercial dairy farms (approximately 20) characterized by a different forage basis of lactating cow diets (hays vs corn silage vs winter cereal silages vs grass/lucerne silages) will be visited twice during the project. In each visit, samples of feed, TMR and faeces will be collected. Lactating cows and heifer TMR compositions and data of milk yield will be registered.

The collected samples will be analysed to determine chemical composition (AOAC methods), indigestible NDF (in vitro incubation at 288 h), *in vitro* gas and methane production (by gas chromatography).

Total tract digestibility of NDF of cows fed the different diets will be estimated using iNDF as marker (Huhtanen et al. 1994). Methane production of the different TMR (lactating cows and heifers) will be determined by *in vitro* incubation and the effects of the diets based on the different experimental forage systems will be compared on milk production, dairy efficiency, methane production and diet digestibility. Mitigation dietary strategies (such as using forages of different quality, lipid supplementation, additives, etc.) will be tested in some of the selected commercial farm and or/in the lab and the effects will be evaluated on milk yield and diet digestibility (commercial farms) and on methane emission,gas production and digestibility (in the lab).

The collected faecal samples will be analysed for microbial community (NGS Illumina MiSeq) and the effects of diet on faecal microbial community will be evaluated. Moreover, using a dataset of samples obtained in a previous trial, the relationship between faecal and rumen communities and methane emissions from lactating cows will be evaluated.

5.2 Schedule and major steps (3 years):

The major steps that should be achieved during the project are:

1) Visits to the demonstrative farms and samples collecting (1st visit during the 1st year of the project; 2nd visit during the 2nd year). In the first 2 years, all the farms will be visited twice and all the samples will be collected and processed;
2) Sampling for chemical and in vitro analyses (1-2-3 years). The collected samples will be chemically and *in vitro* analyzed during the 3 years of the project.
3) Dietary strategies to mitigate methane emissions (1-2 year). This experimental activity will be conducted mainly in the lab to study *in vitro* the most promising dietary strategies which can affect methane production: quality of the forage, type and dose of lipid and additives (such as essential oils) supplementation.
4) Determination of faecal microbial community (2-3 years). The analysis of microbial faecal community will be conducted on a smaller dataset of samples staring from the 2nd year of the project.

Detailed plan of the experimental activities

Activity	1 year		2 year		3 year	
	1-6 months	7-12 months	1-6 months	7-12 months	1-6 months	7-12 months
Visiting of the farms and sample collection						
Samples chemical and in vitro analysis						
Dietary strategies to decrease methane emissions in the lab						
Fecal microbial community						
Thesis preparation						

6. Available funds (source and amount)

Life forage 4Climate: 326.712 €
Feedinnova: 190.989 €
Fitorumin: 6490 €

6. Literature:

Colombini S, Galassi G, Crovetto GM, Rapetti L. 2012. Milk production, nitrogen balance, and fiber digestibility prediction of corn, whole plant grain sorghum, and forage sorghum silages in the dairy cow. J. Dairy Sci. 95:4457-4467.

Colombini S, Zucali M, Rapetti L, Crovetto GM, Sandrucci A, Bava L. 2015. Substitution of corn silage with sorghum silages in lactating cow diets: In vivo methane emission and global warming potential of milk production. Agric. Syst. 136:106-113.

Huhtanen P, Kaustell K, Jaakkola S. 1994. The use of internal markers to predict total digestibility and duodenal flow of nutrients in catttle given six different diets. Anim. Feed Sci. Technol. 48:211–227.

Little SM, Benchaar C, Janzen HH, Krobel RR, McGeough EJ, Beauchemin K.A. 2017. Demonstrating the effect of forage source on the carbon footprint of a Canadian dairy farm using whole-systems analysis and the Holos model: alfalfa silage vs. corn silage. 2017. Climate 5:87.

Martin NP, Russelle MP, Powell JM, Sniffen CJ, Smith SI, Tricarico JM, Grant RJ. 2017. Sustainable forage and grain crop production for the US dairy industry. J. Dairy Sci. 100:9479-9494.

Viganò S. 2017. Diete per vacche in lattazione e relativi sistemi foraggeri di 137 allevamenti lombardi. Università degli studi di Milano, tesi di laurea magistrale.

Zucali M, Bacenetti J, Tamburini A, Nonini L, Sandrucci A, Bava L. 2018. Environmental impact assessment of different cropping systems of home-grown feed for milk production. J. Clean. Prod. 172:3734-3746.