MM31: High Starch Diet

Category
Livestock management: Increased NUE and improved feeding practices

Overview
Increasing the digestible energy (DE%) content of the diet by increasing the amount of starchy concentrates in the ration, while small decrease in the total crude protein content of the diet, animal performance unchanged apart from a reduction inenteric methane excretion.

Mitigation summary

Effect on GHG categories*	Rating	Notes
Enteric CH_4	-	
Manure CH_4	-	
Manure N_2O	-	
Soil N_2O: applied N		
Soil N_2O: grazing	-	If ration protein content is reduced
Energy CO_2: fieldwork		
Energy CO_2: other		
CO_2 liming and urea		
CO_2 sequestration below ground		
CO_2 sequestration above ground		
Pre-farm emissions		
Post-farm emissions		
Substitution of higher C products		
Production increases by more than the emissions		
Confidence in mitigation effect	moderate	In vivo measurements of CH4 yield are lacking (Dewhurst 2013)
Cost-effectiveness**	low	
Confidence in cost-effectiveness	high	

* ”-“ GHG reduction, “+”: GHG increase, “ ”: no significant effect
** low: =< £0/tCO_2e, moderate: £0/tCO_2e< >SCC, high: >SCC

Related measures and potential synergies

Measure	**Impact on other measures**
21 Higher sugar content grasses	
36 Diverse swards	
32 Precision feeding (+ feed analysis)	
35 3NOP	
34 Plant extracts	
26 Breeding for rumen microflora with lower rates of methanogenesis	
28 Genetic selection for reduced methanogenesis	

Inclusion in other marginal abatement cost curves

UK 2008	UK 2010	UK 2015	Ireland 2012	France 2013	France 2019
Y – maize silage, concentrates	Y - maize silage	n	n	n	?

What does the measure entail?

Replacing conserved grass with maize silage, to increase the digestibility of the ration. This will reduce enteric methane emissions and manure CH_4 (as less volatile solids will be excreted). The starch content could also be increased by replacing grass silage with high starch concentrate, however Moran et al (2008) found this to be a more expensive way of achieving mitigation.

Abatement rate

According to Hristov et al. (2013, p37) "it is generally believed that higher inclusion of grain (or feeding forages with higher starch content, such as whole-crop cereal silages) in ruminant diets lowers enteric CH_4 production."

Moran et al. (2008) assumed (based on IGER 2001) that replacing grass silage with maize silage in the rations of dairy cattle (the proportion of grass: maize silage in the diet was changed from 3:1 to 1:3) would lead to a 7% increase in milk yield and a 2% increase in CH_4 production. They estimated that this would lead to a maximum reduction in UK emissions of 213ktCO_2e/year at a cost of -263£/tCO_2e. These assumptions were also used in MacLeod et al (2010).

IBERS (2010, p3) concluded that "feeding more maize silage and less grass silage reduced methane production relative to feed intake and milk yield (a 13 and 6% reduction per unit of dry matter intake and per litre of milk output respectively when shifting from a 75:25 grass silage: maize silage ration to a 25:75 ration). Feeding less protein reduced nitrogen excretion in manure and increased the efficiency of dietary nitrogen utilization."

They assumed that this measure could be implemented year round in 50% of the dairy UK dairy sector and would lead to a 5% reduction in enteric CH_4 emissions and a 20% reduction in N excretion. They assumed no impact on livestock performance. (IBERS 2010, p17).Based on these assumptions they estimated that across the UK the emissions from dairy cattle would reduce by 520ktCO_2e (163 ktCO_2e reduction in enteric methane and 358 ktCO_2e reduction in N_2O – primarily from reduced N excretion on pasture) (IBERS 2010, p27). Doreau et al., (2012) reported similar results to IBERS (2010), i.e. a reduction in methane yield and N excretion. Dewhurst (2013): "Reducing N intake by inclusion of maize silage in mixtures with legume silages leads to a marked reduction in urine N without loss of production potential. It is predicted, on the basis of their chemical composition and rumen kinetics, that legume silages and maize silages would reduce methane production relative to grass silage, though in vivo measurements are lacking."

Wilkinson and Garnsworthy (2017) found that a maize silage diet could lead to higher methane emissions than a grass silage diet (though the overall effect on the carbon footprint of milk was modest, when other emission sources were included).

Cost-effectiveness

“Adapting dairy cow diet by increasing forage maize content and reducing crude protein has economic and GHG emission benefits. The size of the benefit is dependent on farm geographic location and relative grass and forage maize yield.” IBERS (2010, p30).

Based on IBERS (2010) and Moran et al. (2008), the cost-effectiveness is categorised as being low.

Applicability, current uptake and potential additional maximum uptake
Maize needs to be grown in warm areas on medium soils (Morgan and Frater 2015), it will not be readily cultivated on a significant % of the grassland under grass on dairy farms in England.

Assumptions used in the MACC
Assume low/no cost

Given the following constraints: lack on in vivo evidence on the effect on enteric methane, agronomic conditions not suitable on many dairy farms, risks of soil erosion, risk of soil carbon loss from conversion of grass to arable, likely uptake of measure since previous (IBERS 2010, Moran et al 2008, MacLeod et al 2010), we assume a lower uptake rate of 30% of the dairy farms in England and a 5% reduction in enteric methane. Maize production in particular can be detrimental for soil carbon sequestration unless cover cropping is employed.

Ancillary effects

Table 1. Ancillary effects of the operation

Positive effects		**Source**
Off-farm GHG		
Production	Potential increase in milk yield.	
Adaptation		
Environment		
Negative effects		
Off-farm GHG		
Production		
Adaptation		
Environment	Impact on soil health, soil erosion, loss of nutrients to water bodies	

Identified implementation challenges and barriers
“Growing maize is a high-risk activity with regard to the environment and requires more measures for cross compliance than other crops. These may include land drainage, use of early-maturing varieties, cultivating across a slope, using low ground pressure tyres, introducing a cover crop or undersowing.” Morgan and Frater (2015)

“Maize is a high-risk crop for soil erosion. This is because the soil is left exposed for weeks before the crop establishes and the crop is harvested in autumn with heavy machinery, which can damage soil structure. Selecting appropriate fields is crucial to manage this risk.” Morgan and Frater (2015)

Risk of loss of soil carbon if grassland is converted to maize cultivation (Vellinga and Hoving 2011), but “assuming that maize is planted in a rotational forage system with temporary grass and other crops any soil carbon impacts should be minimal” Spadavecchia (2015).

Table 2 Potential barriers to uptake and key risks/uncertainties

Barrier to uptake	**Source**
Lack of evidence on effect on enteric CH4	
Unsuitable agronomic conditions on many dairy farms	
Other key risks/uncertainties	

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