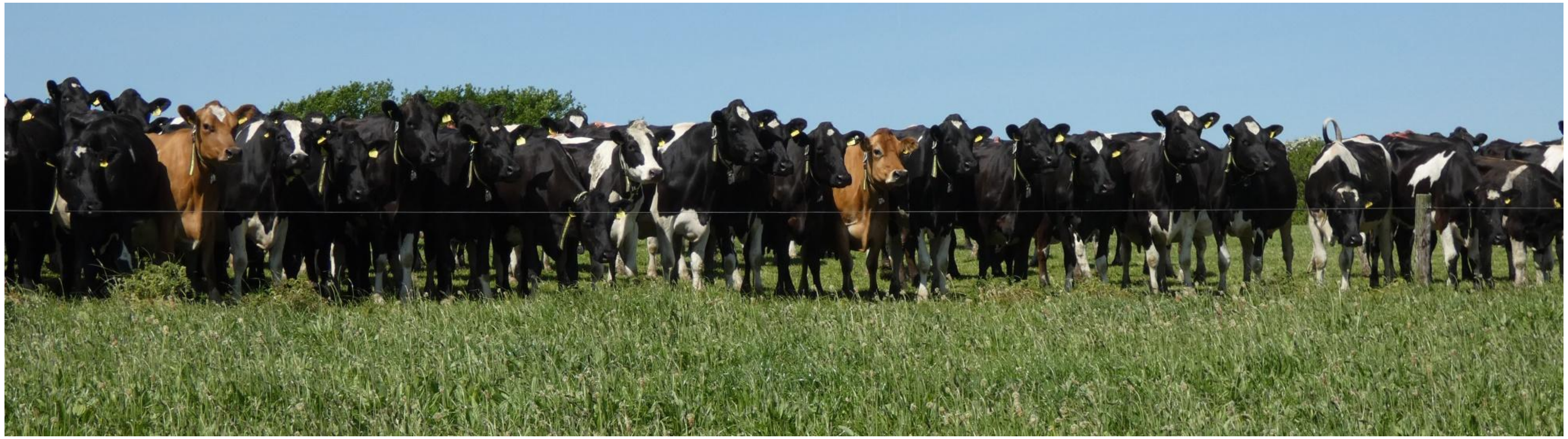


The impact of sward species diversity on pasture and animal performance and milk characteristics within grazing dairy systems (2021 – 2027)

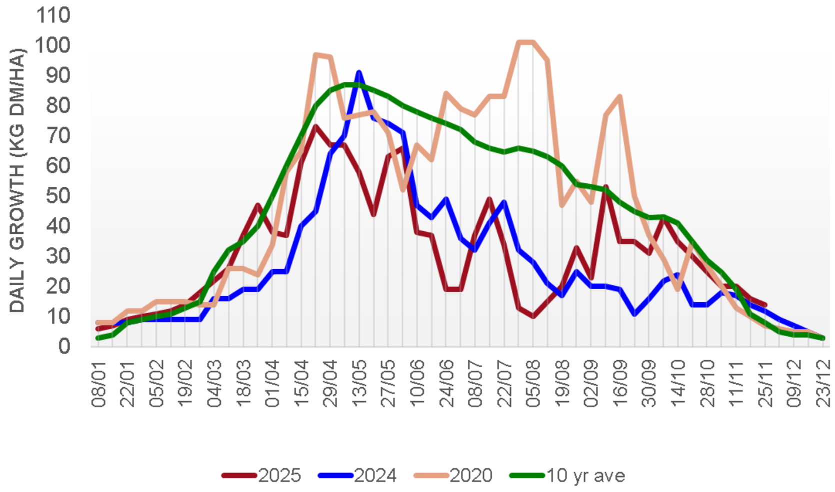
A. Jezequel[1,3], C. Dwan[1,4], R. Page[1,4], R. Kostovska[1,4], A. Floyd[1, 4], L. Delaby[2], C. O’Sullivan[1], J. Finn[1], E. Ruelle[1], B. Lahart[1], L. G. Gómez-Mascaraque[1], P. Lamichhane[1], J. Tobin[1], Z. McKay[3], W. Burchill[4], A.L. Kelly[4], S. O'Mahony[4], T. O'Callaghan[4] and **B. Horan**[1]

(1) Teagasc [Moorepark, Cork & Johnstown Castle, Wexford] - (2) INRAE Saint Gilles - (3) UCD Dublin - (4) UCC Cork

Multi4More Workshop 26th February 2026

Building grazing system resilience for tomorrow

- **4 challenges to futureproof grazing systems**
  - Improve pasture productivity – DM yield & quality – adapt to climate change
  - Reduce inputs and costs – fertiliser & feed, herbicides, etc
  - Reduce impacts – nutrient losses, GHG & Ammonia
  - Increase biodiversity & ecosystem services (C storage)



Well implemented pasture-based production systems have many advantages and can deliver these required outcomes

Growing evidence of sward diversity benefits

SWARD

- ↑ DM yield
- ↑ Yield stability

ENVIRONMENT

- ↓ N requirement
- ↓ N leaching
- ↓ N_2O emissions
- ↑ C sequestration
- ↑ Soil biodiversity

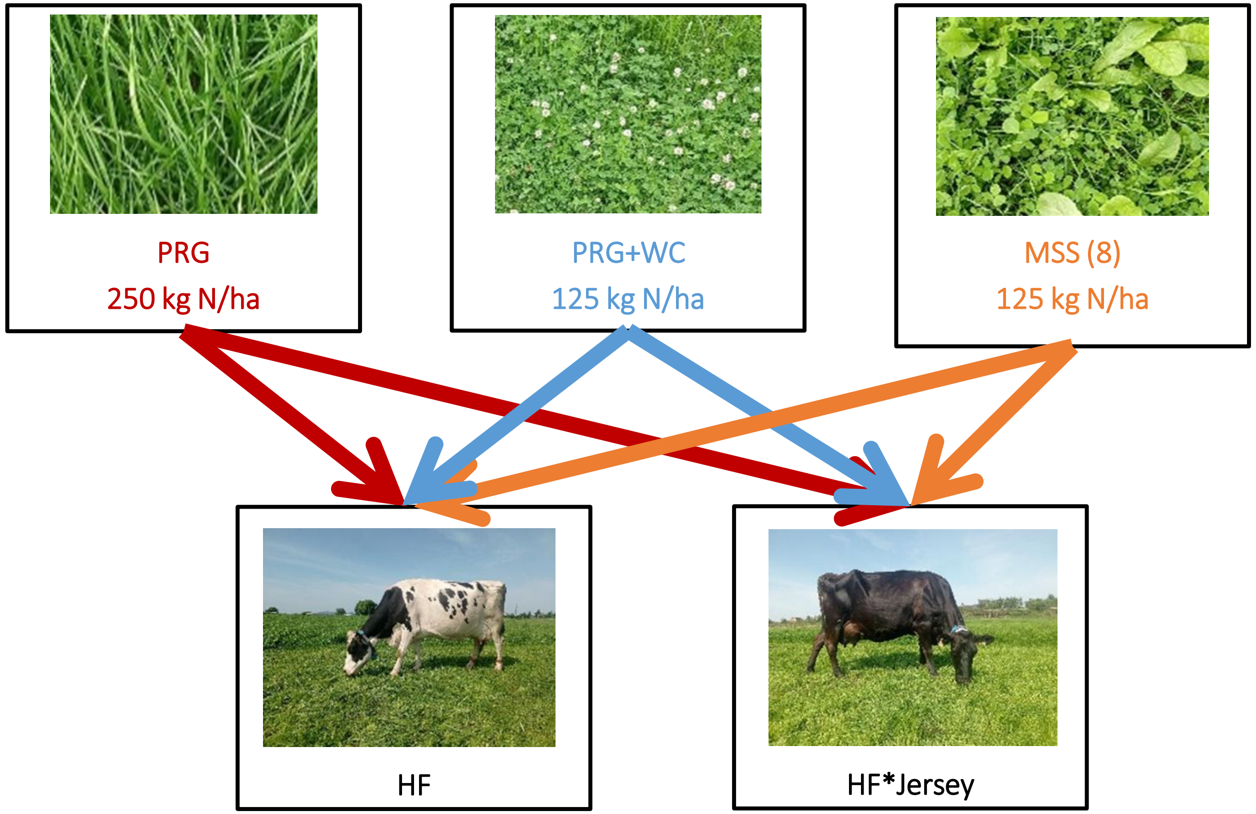
ANIMAL

- ↑ Intake
- ↑ Performance

⇨ Most of the **data** available on diverse swards comes from **plot** or **short term** studies - need for a multi-year farm systems framework

(Baker et al., 2023); (Boland et al., 2022); (Buzhdygan et al., 2020); (Dineen et al., 2018); (Finn et al., 2018); (Grange et al., 2021); (Lüscher et al., 2014); (McCarthy et al., 2020); (McNally et al., 2015); (Navarrete et al., 2016)

Experimental design



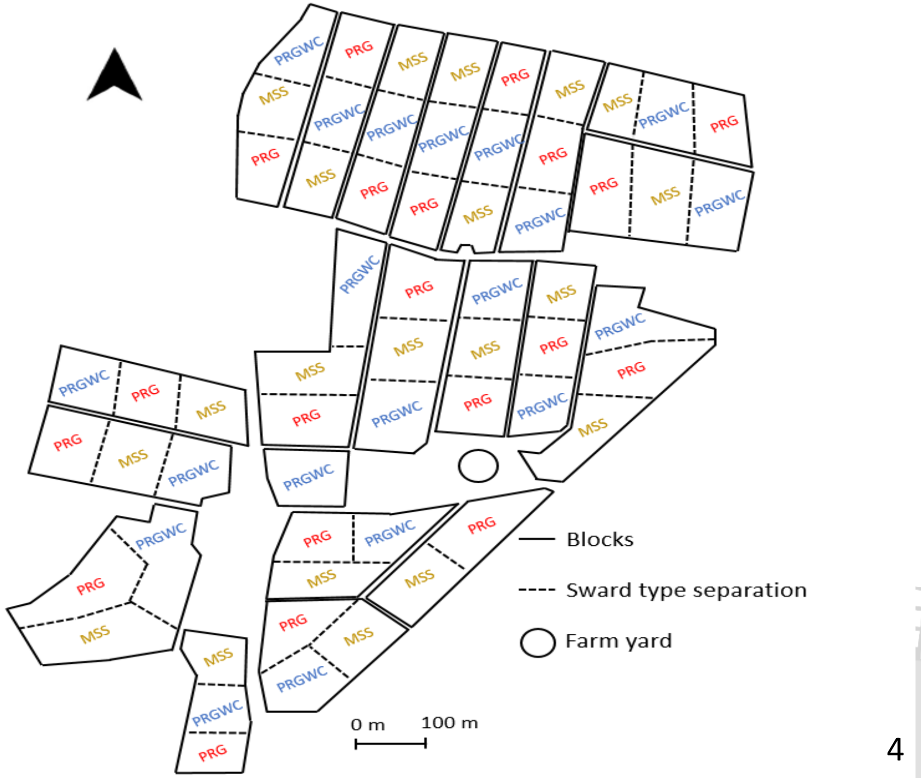
Experimental farm of **56 ha**

Divided into **20 blocks**

Each block equally divided into **3 sward types**

SWARDS SOWN (kg/ha)

Species	PRG	PRG + WC	MSS
PRG	35	26.3	11
Timothy			2
Meadow fescue			4
White clover		3.8	3
Red clover			0.6
Alsike clover			3
Chicory			0.4
Plantain			1



PRG: Perennial ryegrass, WC: white clover, MSS: multispecies, HF: Holstein-Friesian

Management

SAME MANAGEMENT FOR ALL TREATMENTS

- Rotation length: **21-23 days**
- Post-grazing sward height: **4 cm**
- Stocking rate: **2.5 LU/ha**
- Feed supplementation: **300-400 kg/cow** (concentrate)

N FERTILISER

- **PRG 250N** → 30 kg N/ha after each grazing
- **PRGWC 125N** → 100 kg N/ha in spring + 25 kg N/ha in September
- **MSS 125N** → 100 kg N/ha in spring + 25 kg N/ha in September



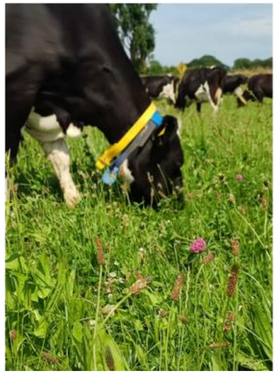
Measurements

SWARD MEASURMENTS BEFORE EACH GRAZING EVENT

- Pre-grazing herbage mass
- Botanical composition
- Nutritive value (Ash, CP, NDF, ADF, OMD)
- Post-grazing sward height

ANIMAL MEASUREMENTS

- Milk yield → daily
- Milk composition → weekly
- Body weight and BCS→ biweekly
- Animal intake → two times a year

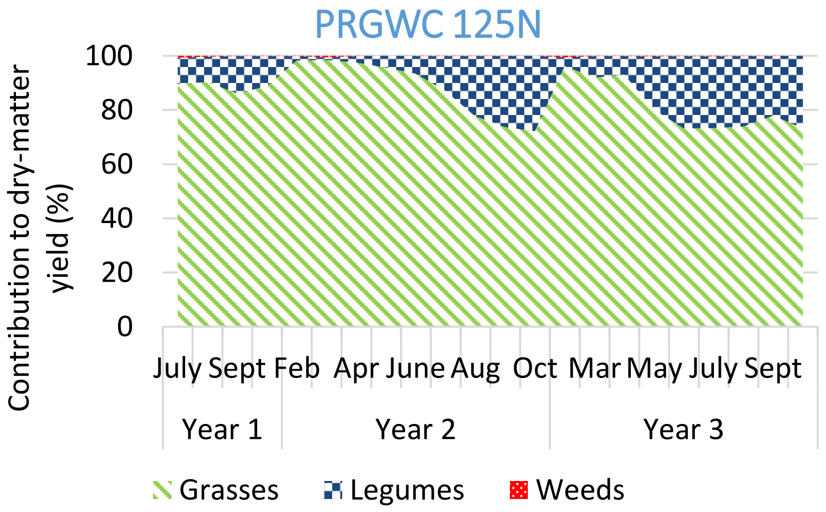
BCS= Body Condition Score

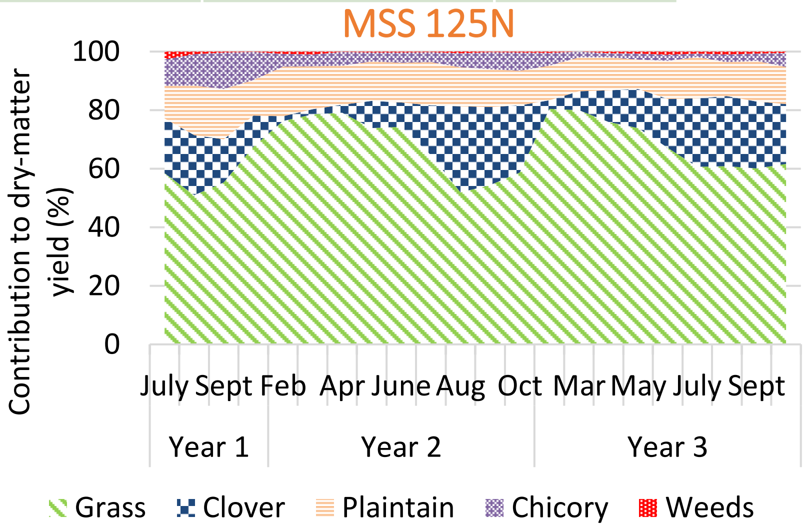
Impacts on sward yield & botanical composition

- No reduction in pasture productivity despite N application reduction
- Large variation in species persistency between paddocks, seasons & years

Jezequel et al. 2024, Grass and Forage Science.
https://doi.org/10.1111/gfs.12700

	PRG / 250 N	PRG-WC /125 N	MSS/ 125 N	Pr <
Total yield (t DM/ha)	13.3	12.5	13.2	0.01
WC (%)		15	16	
Between paddock WC variability (%)		3 - 38	7 - 32	
Plantain (%)			13	
Chicory (%)			4	





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Minor effect of sward diversity on nutritive value

The effect of sward type on sward nutritive value, as a three years average (2021-2023)

	PRG 250N	PRGWC 125N	MSS 125N	SEM	Significance[1]
Ash (g/kg DM)	91^{a}	95^{b}	104^{c}	1.5	***
CP (g/kg DM)	205	206	212	4.3	N.S.
NDF (g/kg DM)	429^{b}	412^{a}	416^{a}	3.5	***
ADF (g/kg DM)	208	207	211	1.7	N.S.
OMD (g/kg DM)	801^{b}	799^{b}	788^{a}	3.3	**

PRG 250N: perennial ryegrass sward with 250 kg N ha^{-1} yr^{-1}, PRGWC 125N: perennial ryegrass and white clover sward with 125 kg N ha^{-1} yr^{-1}, MSS 125N: multispecies sward with 125 kg N ha^{-1} yr^{-1}

*[1]Significance: *= P<0.05, ** <0.01, *** <0.001, **** <0.0001. $^{a-b}$: within rows, means with differing superscripts with a tendency to differ (P < 0.05).*

PRG 250N

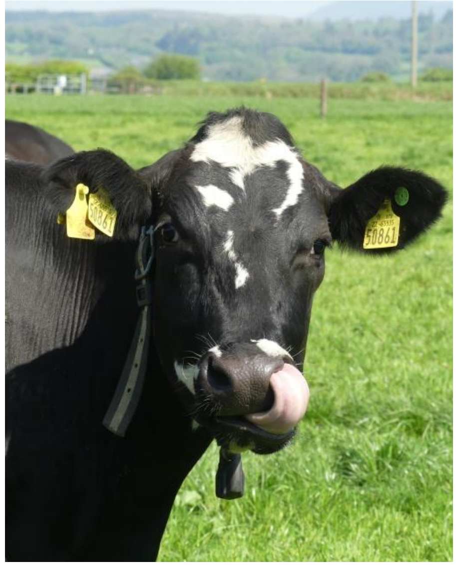
PRGWC 125N

MSS 125N

Jezequel et al. 2024, Grass and Forage Science. https://doi.org/10.1111/gfs.12700

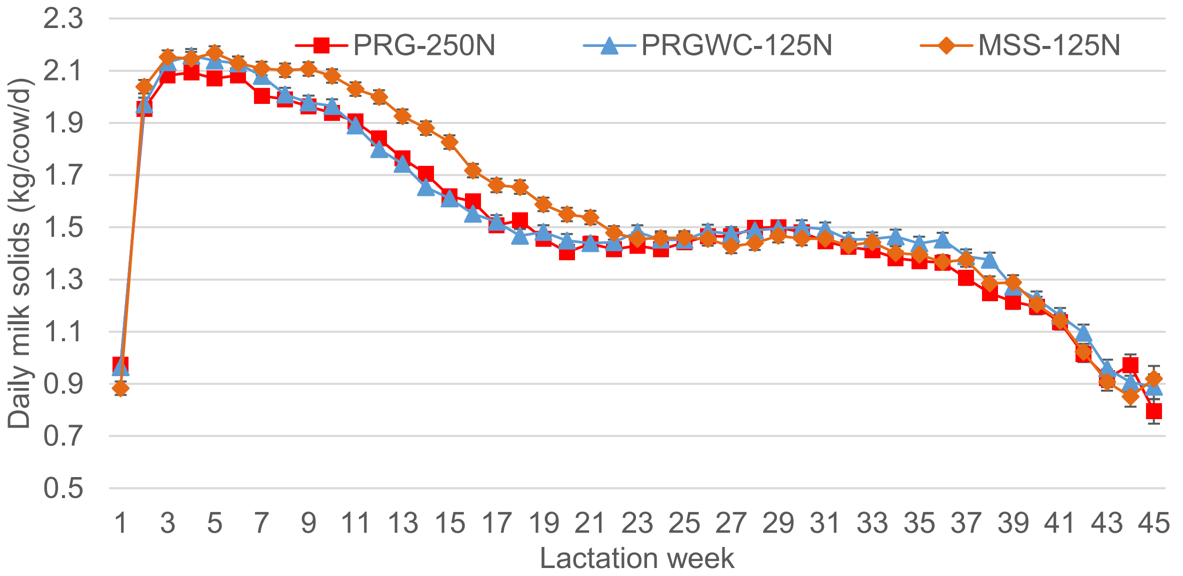
Animal performance

	PRG / 250 N	PRG - WC / 125 N	MSS / 125 N	Pr <
Concentrate	632	624	627	
Total MY (kg)	5,000	5,150	5,300	0.001
Fat (g/kg)	52.4	52.6	51.7	0.05
Protein (g/kg)	38.0	37.9	38.2	NS
Fat + protein (kg)	452	463	475	0.001

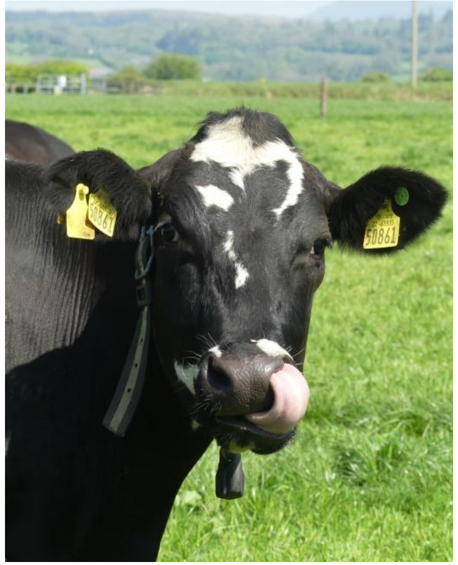


Higher MY (+300 kg) and F+P (+25kg) on MSS

Jezequel et al. 2024, Journal of Dairy Science.
https://doi.org/10.3168/jds.2024-25177



DM intake & feed efficiency



- Traditional alkane method is imprecise with diverse pastures due to variation in C33 concentrations between species (low levels in clover & chicory)
- Ytterbium is a rare earth element _ measuring the dilution of the marker according to total faecal output (Delagarde et al., 2010)

- **Increasing sward diversity increases animal intake**

	PRG / 250 N	PRG - WC / 125 N	MSS / 125 N	Pr <
Total DM intake (kg/cow/d)	14.7	15.8	17.1	*<0.001*
Net energy intake (UFL/d)	15.7	16.4	17.0	*<0.001*
Milk solids/UFL (g MS/UFL)	83	91	87	*<0.001*

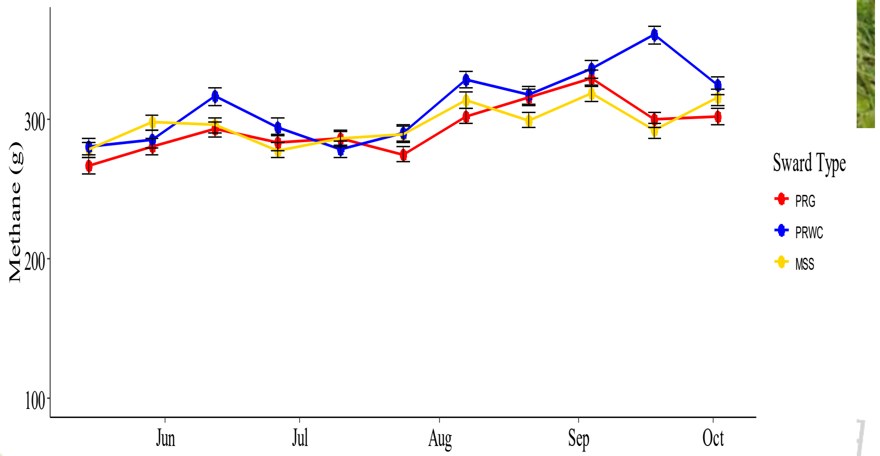
Jezequel et al. 2025, J. Dairy Sci. 108:5027–5038.
https://doi.org/10.3168/jds.2024-25837

Methane emissions

- Methane measurements using Greenfeed from early-May to early-October 2023 - 11 x 2-week periods
- Feed intake measured in late July and early October
- MSS increased animal intake & milk yield, resulted in similar methane yield to PRG, and reduced methane intensity (/kg MS and /kg DMI)

	PRG	PRWC	MSS	SE	*P-value*
Milk yield (kg/d)	15.3[a]	15.9[ab]	16.6[b]	0.31	<0.01
Milk solids (kg)	1.40[a]	1.44[ab]	1.49[b]	0.022	<0.01
DMI (kg)	17.3[ax]	18.1[ay]	20.2[bz]	0.43	<0.001

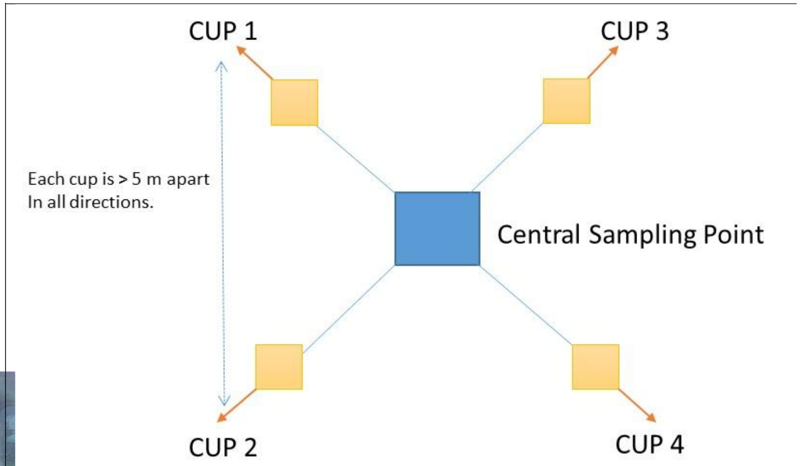
	PRG	PRWC	MSS	SE	*P-value*
CH_4 (g/d)	294[a]	310[b]	297[a]	3.8	<0.01
CH_4/milk solids (g/kg)	217[a]	219[a]	208[b]	2.9	<0.01
CH_4 yield (g/kg DMI)	17.2[a]	17.4[a]	15.7[b]	0.39	<0.001

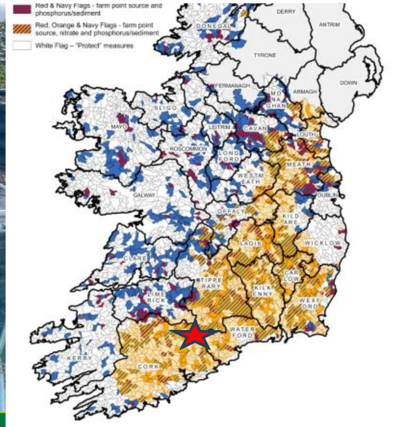


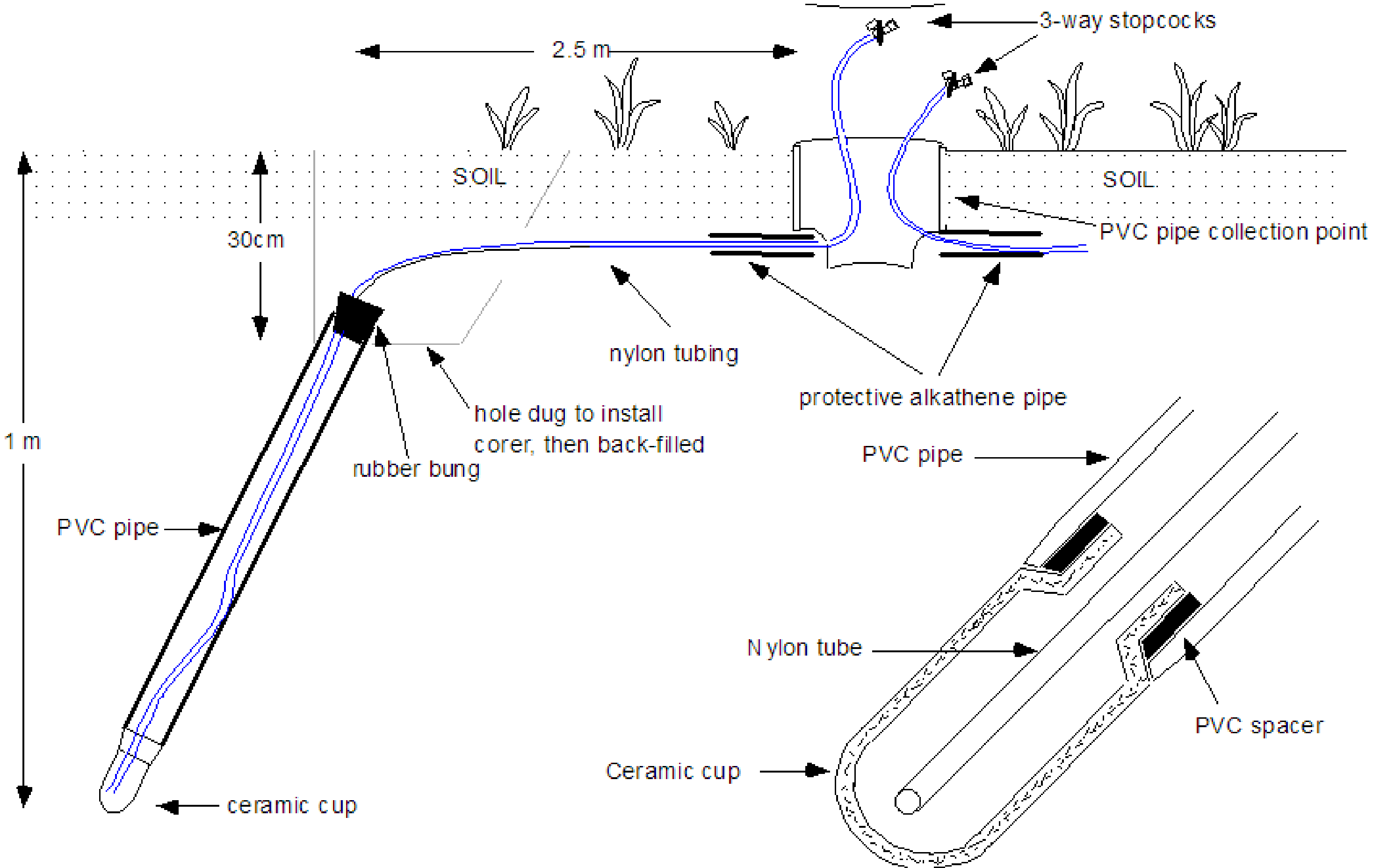
Dwan et al., 2026, J. Dairy Sci., https://doi.org/10.3168/jds.2025-27375

Nitrate leaching

- Since 2023, porous ceramic cups have been installed to analyse nitrate-N (NO3-N) concentrations at 0.9 m depth based on a common protocol (Fenton et al. 2024) - nest design with a central sampling point
- 18% of each farmlet area - 144 cups installed in total – 36 per treatment
- Sampled every 14 days during the drainage season (October – May)





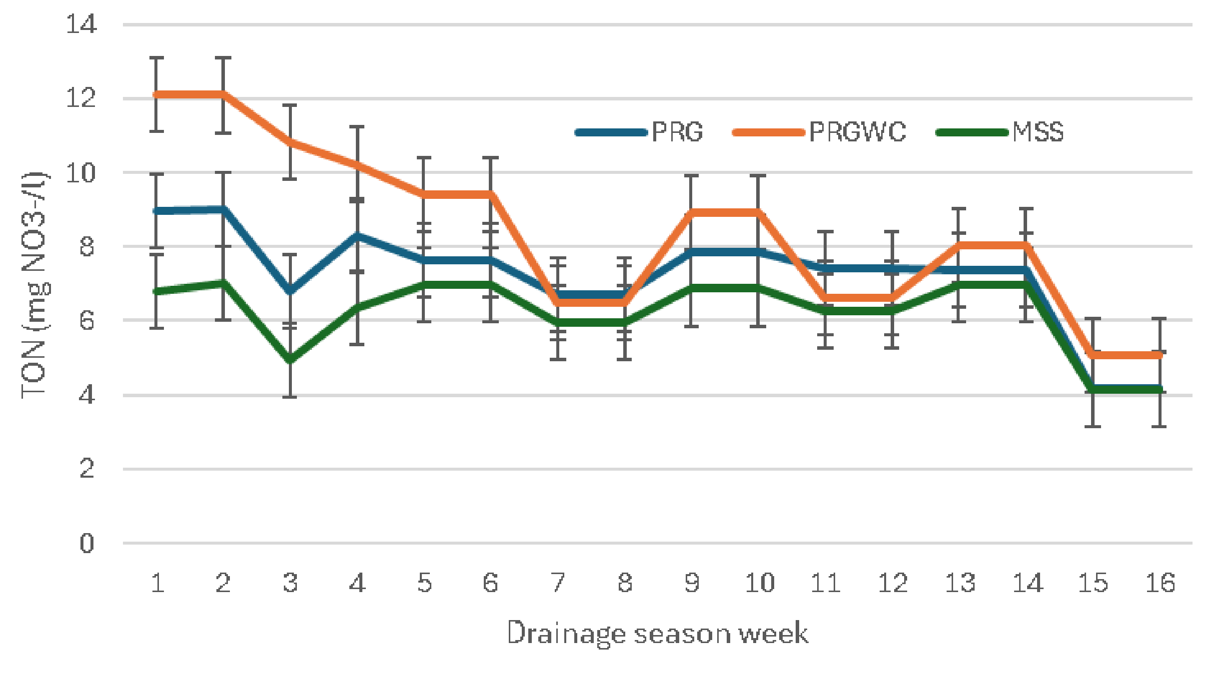


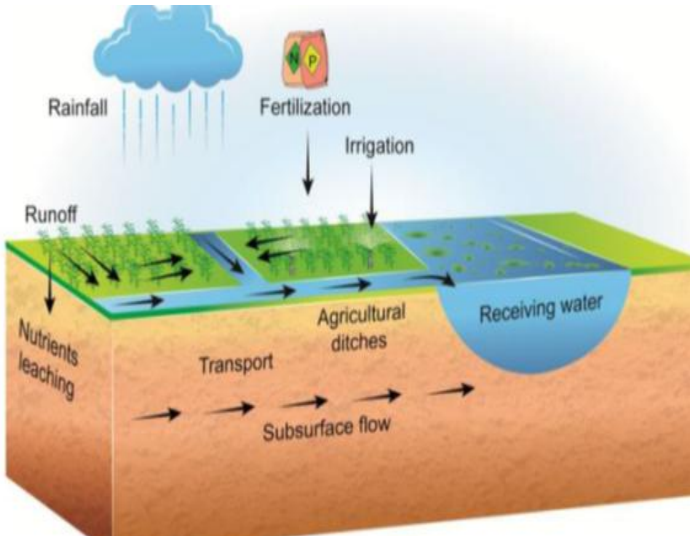
Nitrate leaching

- Early indications of reduced nitrate losses from ceramic cups on MSS < PRG < PRGWC

2022-2025	PRG	PRGWC	MSS	SEM	Treatment	Year	Week
NO_3-N (mg/l)	7.1[a]	9.0[b]	5.7[c]	1.38	<0.001	0.01	0.05

- Each 2 mg/l reduction in NO3-N corresponds to a 10 kg/ha reduction in N leached/ drainage season
- Early autumn/ winter losses significantly impactful with minimal differences by late spring

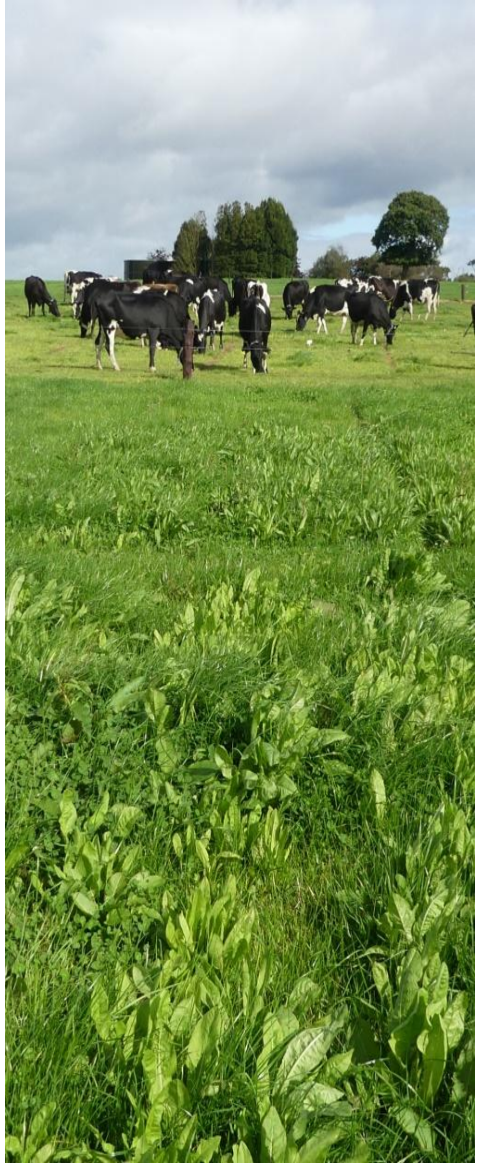




Economic performance

Simulated by the Moorepark Dairy Systems Model for a 40 ha farm @
2.5 LU/ha based on current costs and prices and incorporating various reseeding frequencies

Euros	PRG / 250 N	PRG - WC / 125 N	MSS / 125 N
Receipts	271,800	274,100	279,500
Costs	177,200	178,700	178,200
Fertilisers	13,000	7,600	7,600
Silage import	3,600	8,100	6,900
Net profit /ha	2,365	2,385	2,535



Increased profits with MSS mainly due to increased receipts (MY) & fertiliser cost savings

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Jezequel et al., 2026, J. Dairy Sci., https://doi.org/10.3168/jds.2025-26889

Impact on the milk and milk products characteristics?

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Fatty acid profile of cheesemilks

Mean total-fatty-acid profile of cheesemilks obtained from the MSS and PRG diet, and stage of lactation, treatments (± standard deviation)

	Diet		Stage of lactation (SOL)		Statistical interpretation		
	Perennial	Multispecies	Mid	Late	Diet	SOL	SOL x Diet
C4:0	5.04 ± 0.74	4.19 ± 0.68	4.19 ± 0.88	5.04 ± 0.48	*	*	NS
C6:0	2.57 ± 0.2	2.31 ± 0.14	2.37 ± 0.23	2.51 ± 0.19	*	NS	NS
C8:0	1.43 ± 0.08	1.4 ± 0.09	1.45 ± 0.08	1.39 ± 0.07	NS	NS	NS
C10:0	3.19 ± 0.19	3.24 ± 0.39	3.41 ± 0.25	3.03 ± 0.21	NS	*	NS
C11:0	0.07 ± 0.02	0.07 ± 0.02	0.08 ± 0.02	0.06 ± 0.02	NS	NS	NS
C12:0	3.58 ± 0.27	3.71 ± 0.52	3.89 ± 0.35	3.39 ± 0.28	NS	*	NS
C13:0	0.1 ± 0.02	0.1 ± 0.02	0.1 ± 0.02	0.09 ± 0.02	NS	NS	NS
C14:0	10.87 ± 0.67	11.08 ± 0.98	11.56 ± 0.54	10.39 ± 0.57	NS	**	NS
C14:1	0.95 ± 0.07	1 ± 0.11	0.97 ± 0.05	0.98 ± 0.13	NS	NS	NS
C15:0	1.17 ± 0.14	1.22 ± 0.1	1.16 ± 0.12	1.23 ± 0.12	NS	NS	NS
C16:0	30.94 ± 2.5	29.93 ± 2.15	31.45 ± 2.55	29.42 ± 1.59	NS	NS	NS
C16:1	1.66 ± 0.1	1.77 ± 0.11	1.7 ± 0.04	1.73 ± 0.17	*	NS	*
C17:0	0.61 ± 0.04	0.62 ± 0.04	0.63 ± 0.05	0.59 ± 0.02	NS	NS	NS
C17:1	0.05 ± 0.01	0.06 ± 0.01	0.06 ± 0.01	0.04 ± 0	*	***	*
C18:0	9.36 ± 0.84	9.04 ± 0.52	9.14 ± 0.85	9.26 ± 0.55	NS	NS	NS
C18:1 TFA	2.87 ± 0.51	3.02 ± 0.57	2.65 ± 0.47	3.24 ± 0.4	NS	NS	NS
C18:1n9c	17.1 ± 1.74	17.73 ± 1.19	17.35 ± 1.75	17.48 ± 1.27	NS	NS	NS
C18:1n9t	0.15 ± 0.03	0.15 ± 0.04	0.13 ± 0.04	0.17 ± 0.01	NS	*	NS
C18:2 TFA	1.43 ± 0.56	1.92 ± 0.78	1.21 ± 0.43	2.14 ± 0.59	NS	*	NS
C18:2n6c	0.94 ± 0.07	0.98 ± 0.2	0.99 ± 0.2	0.93 ± 0.07	NS	NS	NS
C18:2n6t	0.09 ± 0.04	0.1 ± 0.03	0.09 ± 0.04	0.1 ± 0.02	NS	NS	NS
CLA c9t11	0.86 ± 0.16	0.86 ± 0.18	0.79 ± 0.16	0.93 ± 0.14	NS	NS	NS
C18:3 TFA	0.29 ± 0.13	0.42 ± 0.22	0.23 ± 0.08	0.48 ± 0.18	NS	*	NS
C18:3n3	0.8 ± 0.07	0.79 ± 0.09	0.78 ± 0.08	0.8 ± 0.08	NS	NS	NS
C20:0	0.13 ± 0.01	0.12 ± 0.02	0.13 ± 0.01	0.12 ± 0.02	NS	NS	NS
C20:1	0.04 ± 0.01	0.03 ± 0.02	0.03 ± 0.02	0.03 ± 0.01	NS	NS	NS
C20:3n6	0.03 ± 0.01	0.03 ± 0.02	0.02 ± 0.02	0.04 ± 0	NS	NS	NS
C20:4n6	0.05 ± 0	0.03 ± 0.02	0.04 ± 0.02	0.05 ± 0.01	NS	NS	NS
C20:5	0.1 ± 0	0.09 ± 0.01	0.1 ± 0.01	0.1 ± 0.01	NS	NS	NS

Impact of pasture diet, breed & SOL on fat fractions

Perennial Ryegrass **(PRG)**	Multispecies Swards **(MSS)**

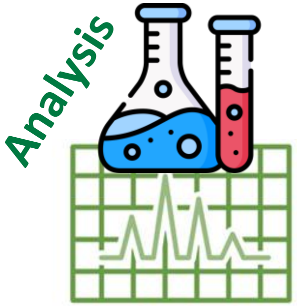
Typical pasture diet	New, more sustainable pasture diet

2021

a.m. + p.m.
Weekly, 36 weeks; n = 144

March → November

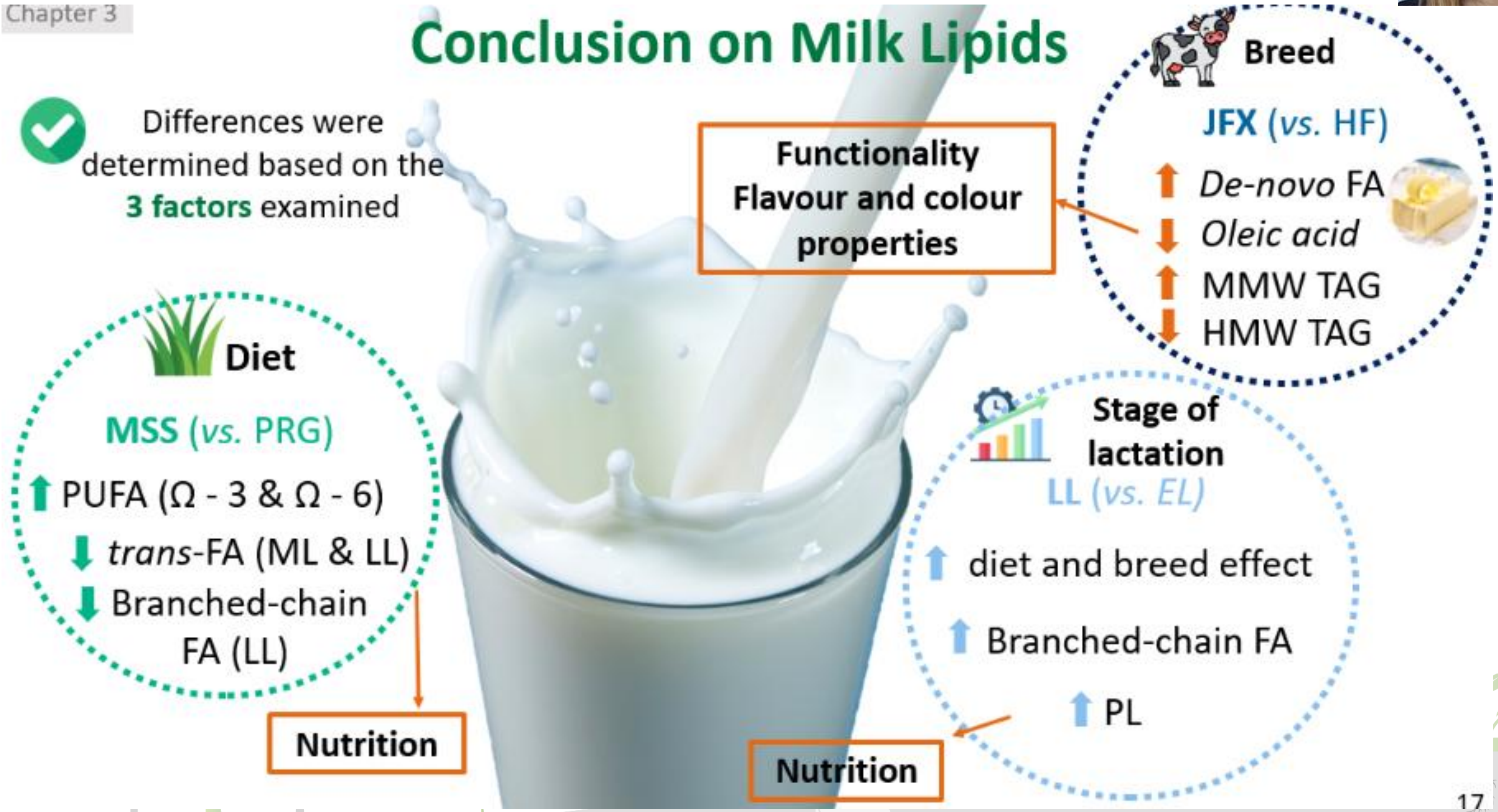
Early Lactation (EL) — **Middle Lactation (ML)** — **Late Lactation (LL)**



- ❖ Yield and gross composition
- ❖ Physio-chemical properties
- ❖ Fatty Acid Profile (GC-FID)
- ❖ Triglycerides Carbon Chain Number (HT-GC-FID)
- ❖ Polar Lipids (HPLC-ELS-MS)
- ❖ Raman micro-spectroscopy

Kostovska et al. 2025, J Dairy Sci. 108:1261–1284 https://doi.org/10.3168/jds.2024-25462

Impact on milk lipid profile



Kostovska et al. 2025, J Dairy Sci. 108:1261–1284 https://doi.org/10.3168/jds.2024-25462

Impact of pasture diet & SOL on cheese production

- 25 cows in each group (Multi-species sward vs Perennial ryegrass monoculture)
- Cheeses were made in three different occasions in June 2022 (mid-lactation) and October 2022 (late-lactation)
- Various analyses were performed on milk and full-fat Cheddar cheese samples

Page et al. 2025, Int. Journal of Dairy Tech - https://doi.org/10.1016/j.idairyj.2025.106342

Impact on milk and cheesemilk and full-fat Cheddar cheese

Raw milk

Milk standardisation:
Protein-to-fat ratio of 0.95

Raw milk derived from multispecies sward treatment had:

- Slightly higher total protein content
- Slightly lower somatic cell count

Cheesemilk

Cheese manufacture

Diet treatment had no impact on the rennet gelation behaviour

Rennet gelation is one of the important steps of cheesemaking.

Cheesemilk derived from multispecies sward treatment had:

- Slightly higher total protein content
- Slightly higher fat content (higher fat content is due to standardisation process rather than diet itself)
- Increased P content

Full-fat Cheddar cheese

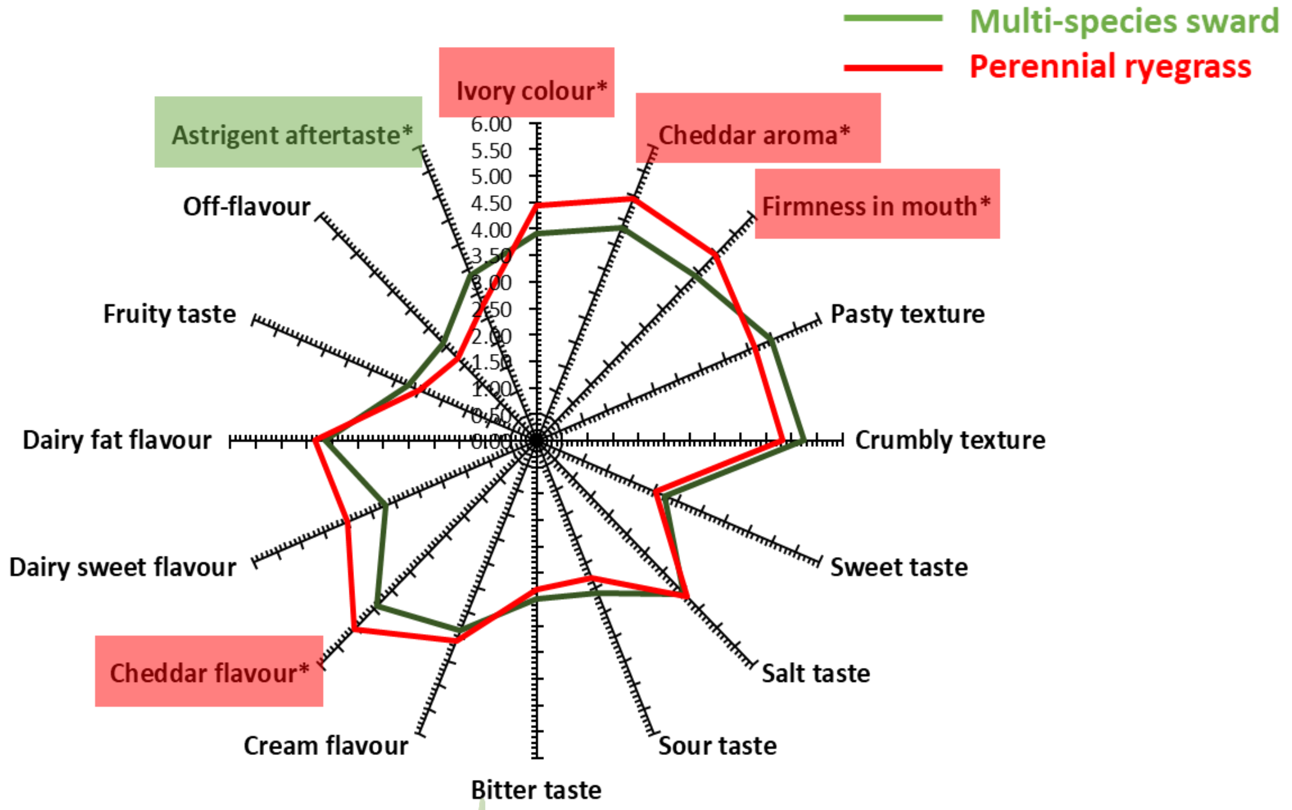
Cheese derived from multispecies sward treatment had:

- Slightly higher total protein content
- No impact on moisture & fat content
- Higher cheese yield
- No meaningful impact on the cheese-maturation related parameters, such as pH, proteolysis, aroma compounds, and lipolysis.
- Pasture-type was associated with some total fatty-acid-profile differences, but greater differences resulted from seasonality.

Page et al. 2025, Int. Journal of Dairy Tech - https://doi.org/10.1016/j.idairyj.2025.106342

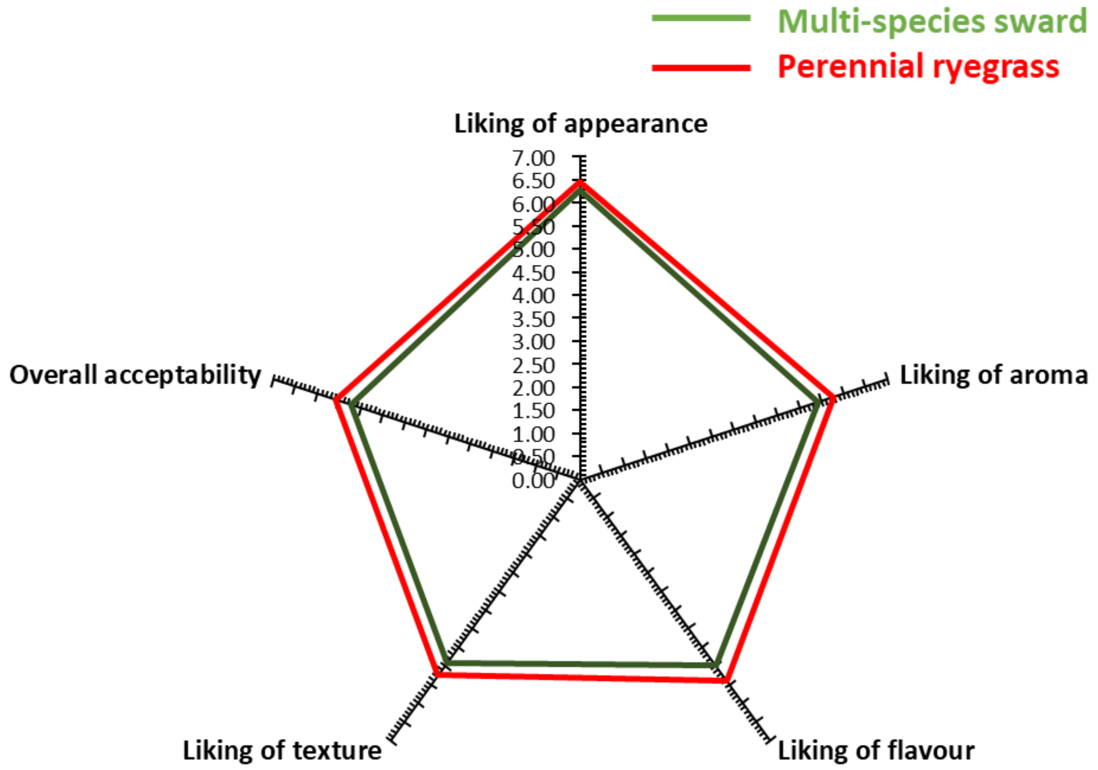
Sensory panel analysis

Optimized descriptive profiling (ODP), method for obtaining sensory descriptions utilising semi-trained sensory panellists, mean data of 25 assessors in triplicate.



Out of the 16 sensory attributes evaluated, semi-trained sensory panellists detected differences in five attributes. However, the magnitude of these differences was small.

Sensory Affective Hedonic Evaluation of Cheddar cheese; mean data of 25 untrained assessors.



Untrained assessors, representing general consumers, did not detect any significant effect of diet on the sensory attributes of Cheddar cheese.

Page et al. 2025, Int. Dairy Journal - https://doi.org/10.1016/j.idairyj.2025.106522

Multimilk preliminary conclusions

Grazing systems must be adapted to improve productivity with reduced N fertiliser use and deliver reduced GHG emissions & nutrient losses & improved biodiversity in the future – we need to be brave & more ambitious

Do we recommend MSS swards to farmers? Yes, legume based MSS have demonstrated the capability

- to maintain grass production & quality with less chemical N
- to increase DM intake and milk and fat + protein yield and further improve milk character
- to reduce methane intensity & nitrate leaching
- improve farm financial performance

Some challenges remain…

- to reduce high variability in WC and MSS contents between paddocks/seasons/years…?
- to maintain diversity and improve persistency longer term (>5 years)?
- to define the best combination of species according to local climate & soil types?

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Thank you for your attention