



Multi-species mixtures: more from less N

*John Finn, Shona Baker
Teagasc, Johnstown Castle, Ireland*

AgroEcology, Nov 2024



Acknowledgements



 <https://multi4more.ie/>



Funded by



An Roinn Talmhaíochta,
Bia agus Mara
Department of Agriculture,
Food and the Marine



Department of
**Agriculture, Environment
and Rural Affairs**

Sustainability at the heart of a living, working,
active landscape valued by everyone

Supported by



Germinal.
Sowing future seeds



DLF

Project partners



AGRICULTURE AND FOOD DEVELOPMENT AUTHORITY

afbi AGRI-FOOD
& BIOSCIENCES
INSTITUTE



Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin



AGRICULTURE AND FOOD DEVELOPMENT AUTHORITY

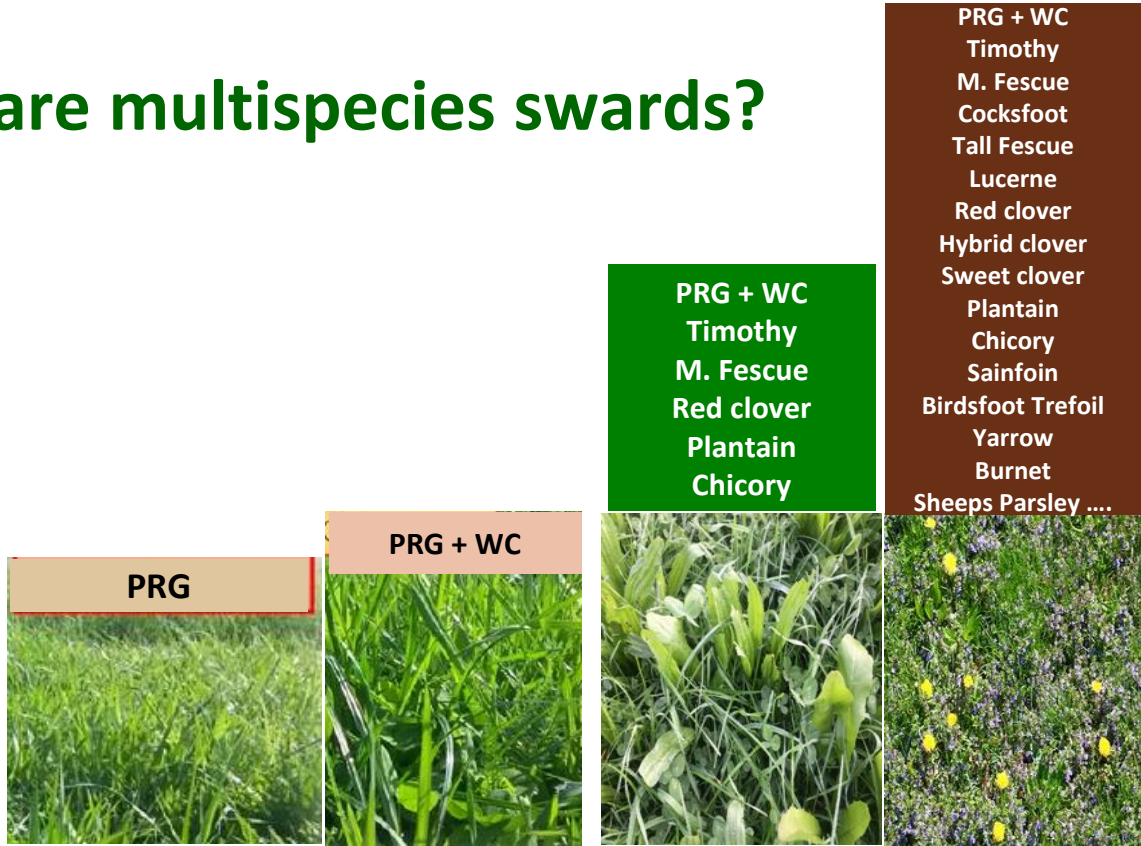
Overview

- Multispecies grassland and forage systems, nitrogen and forage quality
- Ecosystem services and services
- Drought resilience
- Stock performance

Pressure to reduce fertiliser use



What are multispecies swards?



Productivity/+Nutrient availability/ +Climate stress/ +Pollinators/ +Pest resistance





Within the same level of nitrogen fertiliser,
multispecies grassland mixtures in plot
expts:

i) typically outyield the
component
monocultures, and

ii) typically yield the highest-yielding
monoculture, and

iii) have lower weed biomass

(see Finn et al. 2013, Lüscher et al. 2022, Finn et al. 2024)

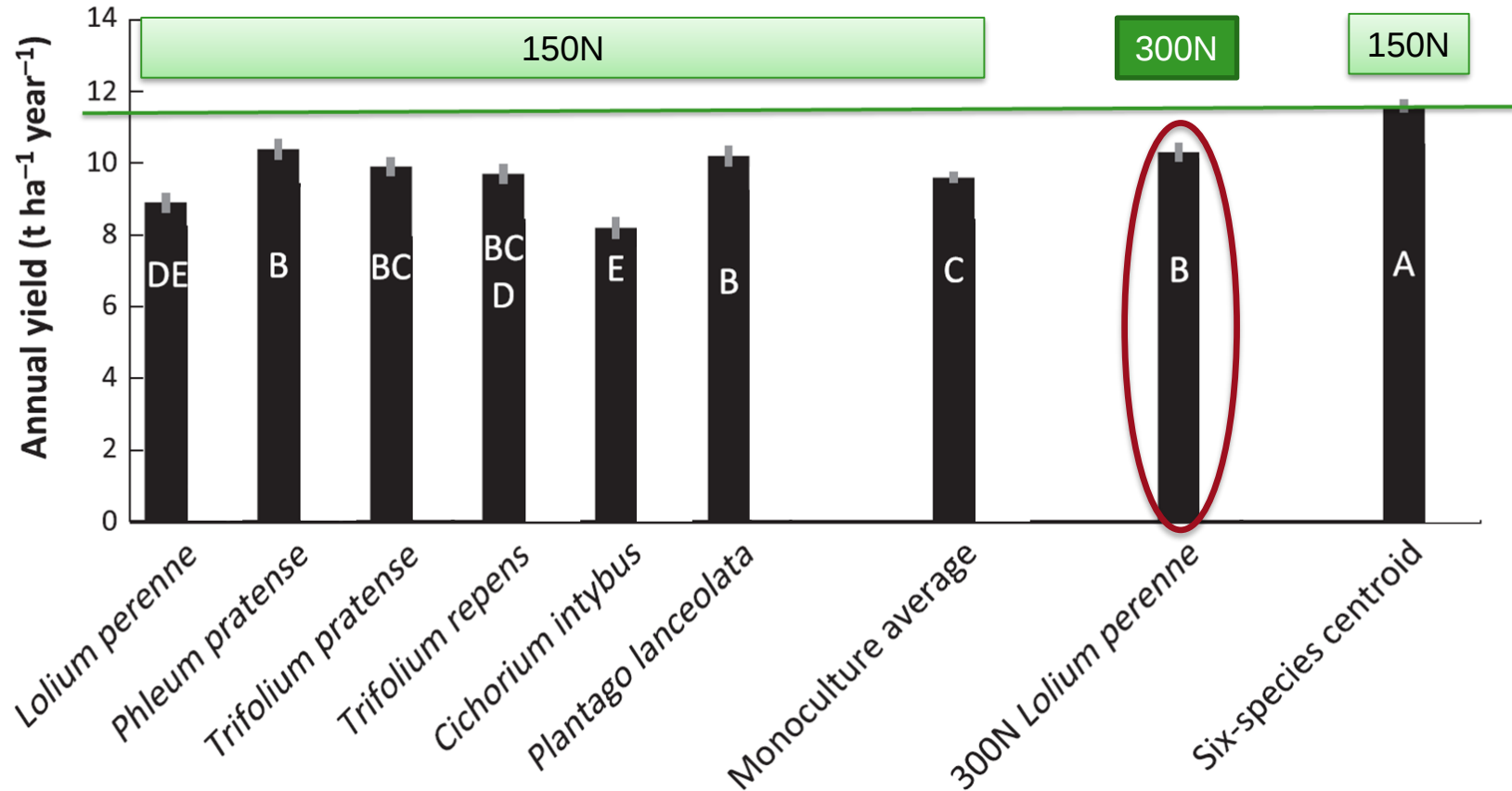
But what about different nitrogen levels?

High N vs low N-> forage yield

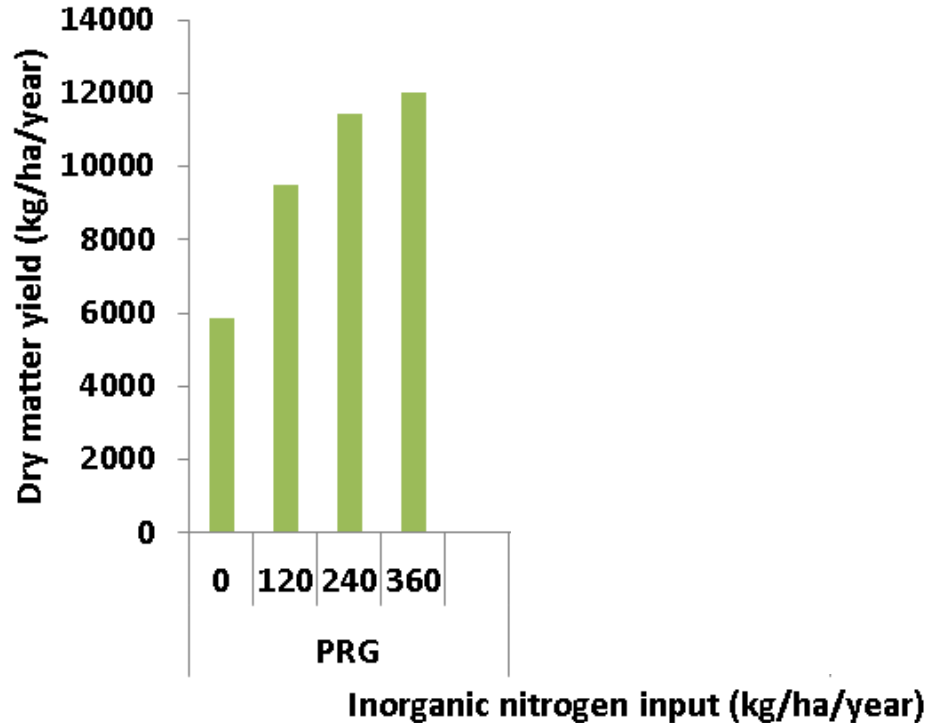


Lower N mixtures outyield higher-nitrogen PRG

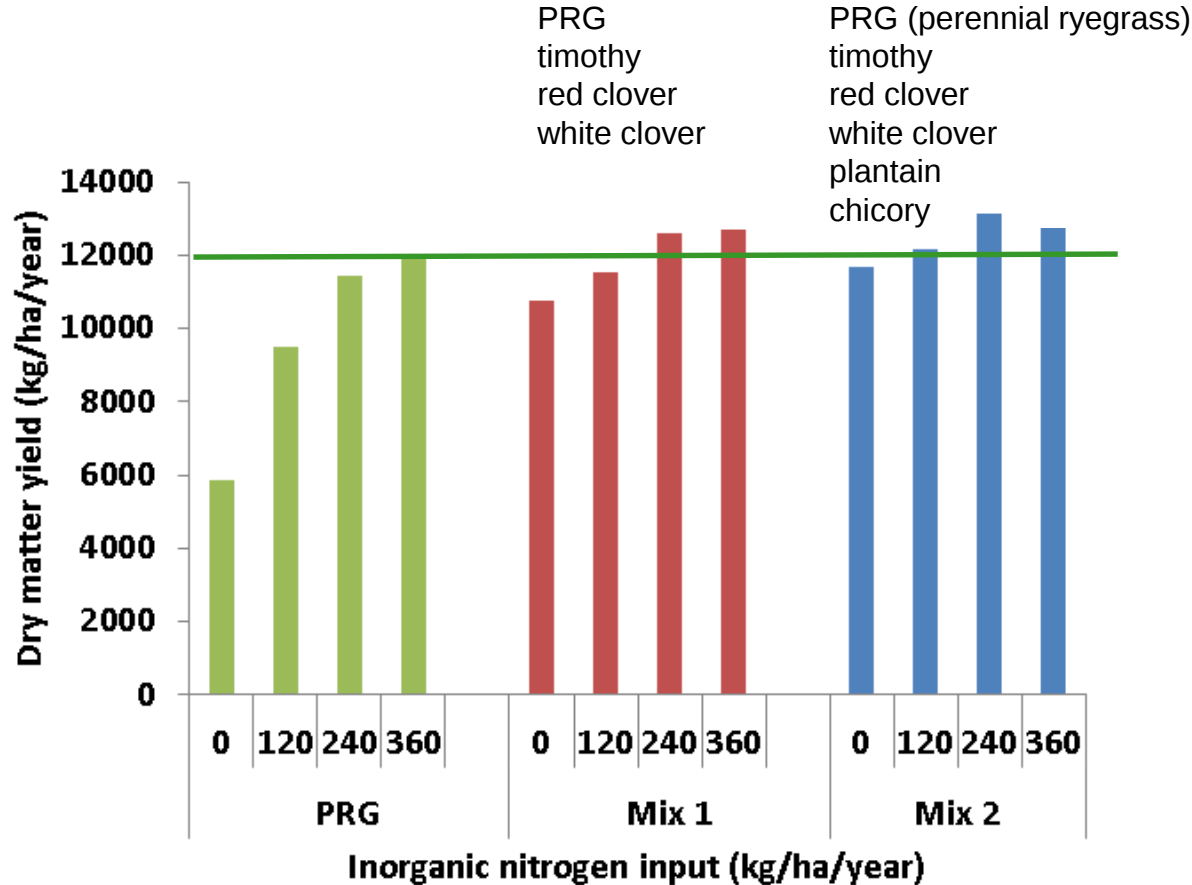
Grange et al. 2021, J Appl. Ecol.



Lower-nitrogen mixtures outyielded 360N PRG



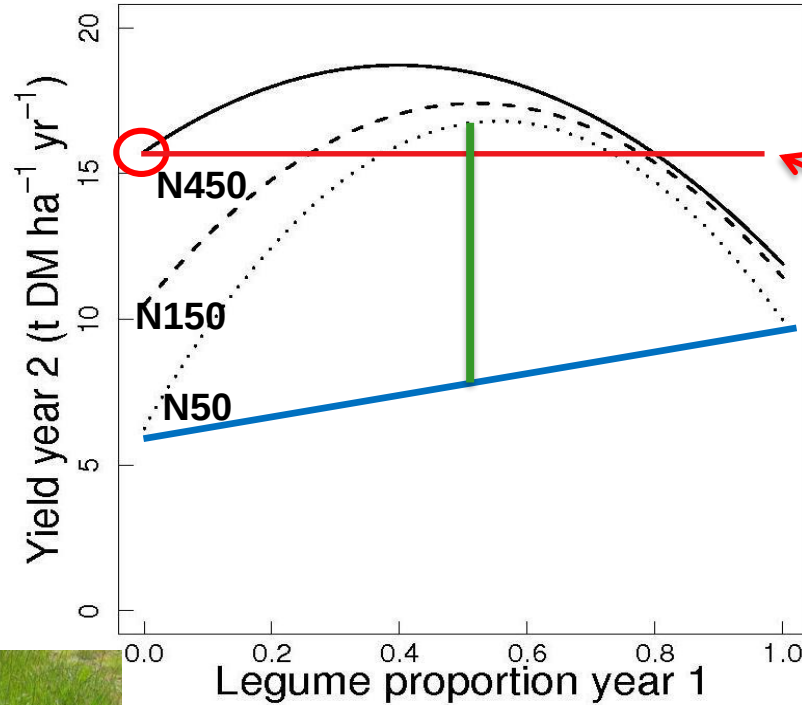
Lower N mixtures outyielded 360N PRG (silage)



Annual yield achieved by
PRG + 360 kg N/ha/yr
= Mix 2 + no inorganic N
= Mix 1 and Mix 2
receiving 120 kg N/ha/yr

Moloney et al. (2020)

Balanced grass/legume mixtures at N50 can be as productive as grass-only at N450



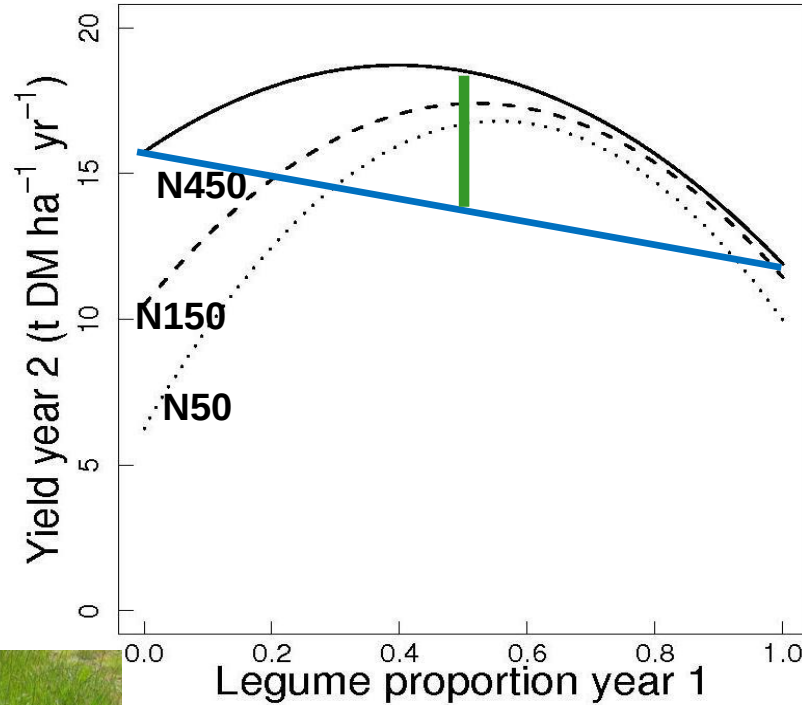
Grass only
450 kg/ha N



Nyfeler *et al.* 2009. J. Appl. Ecology

Balanced grass/legume mixtures at N50 can be as productive as grass-only at N450

Higher nitrogen
fertiliser reduced
legume % in
swards over year
2 and 3



Nyfeler *et al.* 2009. J. Appl. Ecology

Can mixtures provide 'insurance' against drought?



Can mixtures better resist and recover from environmental stresses than monocultures (EU AnimalChange)?



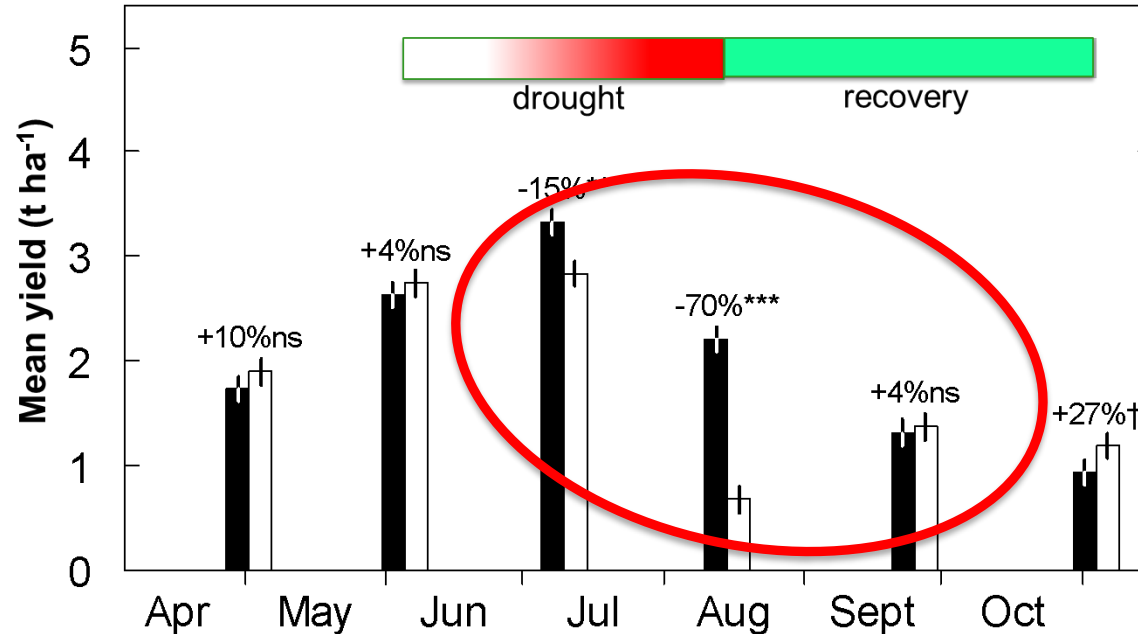
4 species

	Shallow-rooting (SR)	Deep-rooting (DR)
Non-fixing	 <i>L. perenne</i>	 <i>C. intybus</i>
N ₂ fixing	 <i>T. repens</i>	 <i>T. pratense</i>

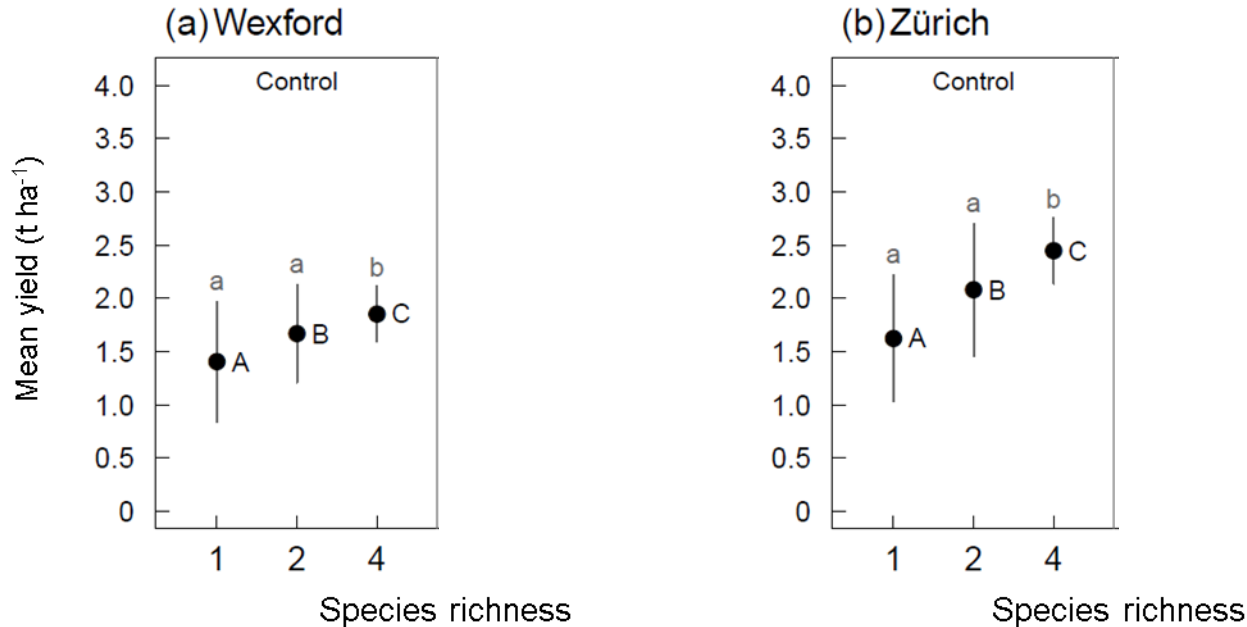
- Ireland (Teagasc) + Switzerland (Agroscope)
- Species: functional traits
- 1, 2, 4 species
- 36 main plots, rain shelter for **9 weeks** on 3m x 5m sub-plot
- 150 (IE), 200 (CH) kg N ha⁻¹
- mowing

What is the effect of experimental drought on yield ?

Examined yields across three harvests (mid-drought, end-of-drought and recovery) and two years, Ireland and Switzerland.

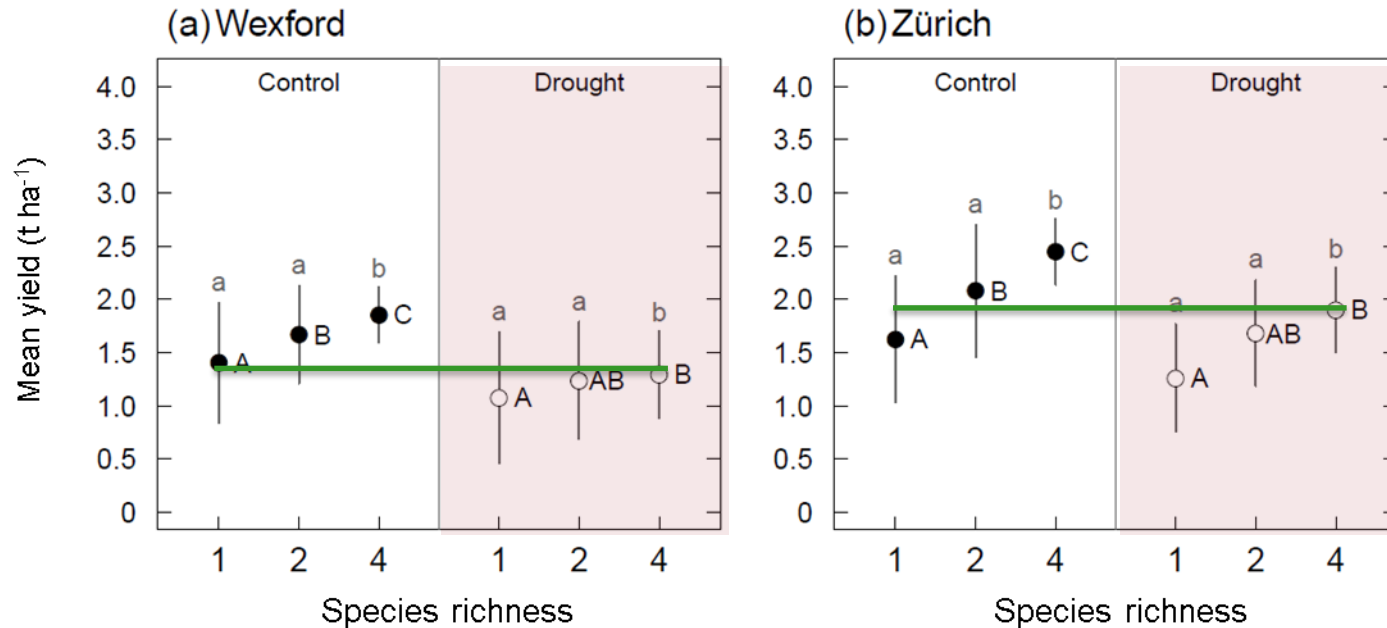


Species diversity increased mean yield & reduced yield variation = yield stability



Effects of drought and species richness on average harvest yield and yield variance under rainfed control and drought conditions. Means across six harvests: three harvests X two years. (Haughey et al. 2018, *Nature Scientific Reports*)

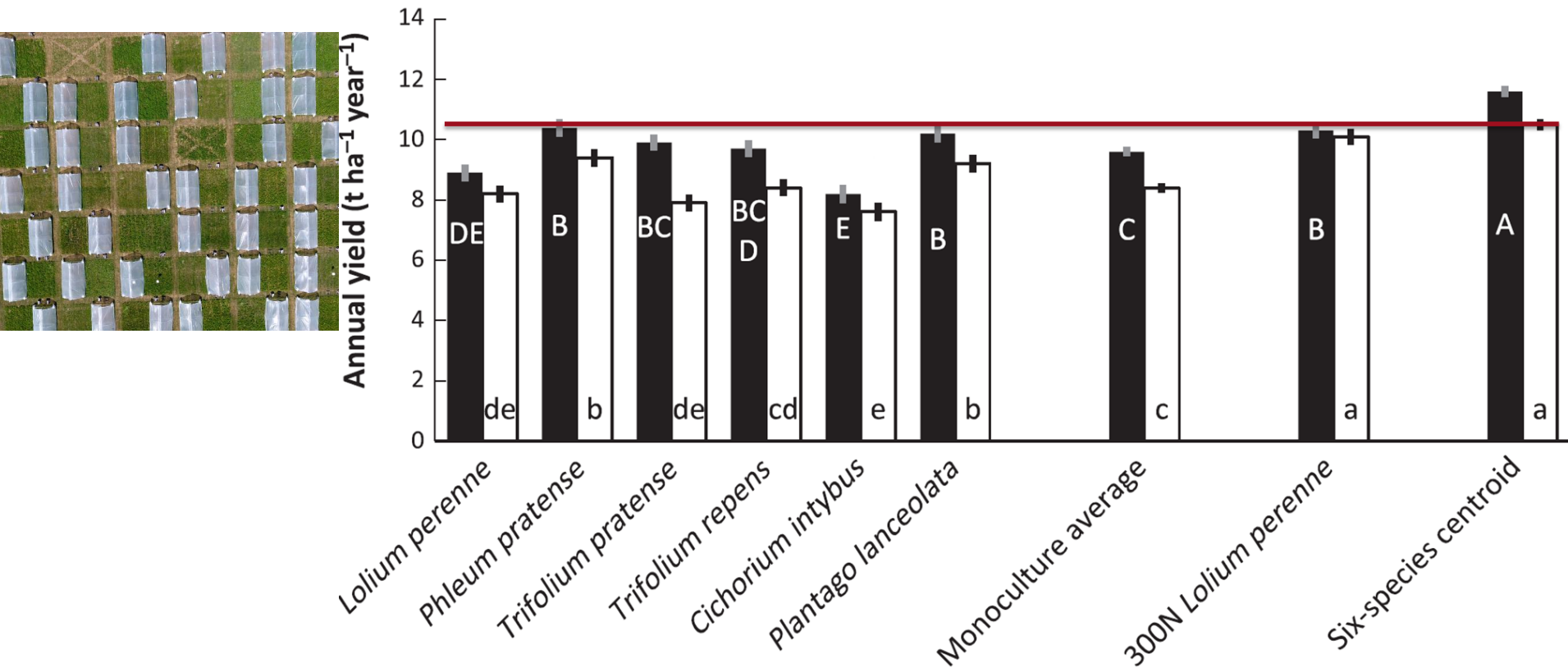
Species diversity increased mean yield & reduced yield variation = yield stability ...even under drought



Effects of drought and species richness on average harvest yield and yield variance under rainfed control and drought conditions. Means across six harvests: three harvests X two years. (Haughey et al. 2018, *Nature Scientific Reports*)

Diversity mitigated drought effects on total annual yield

Grange et al. J. Appl. Ecology 2020



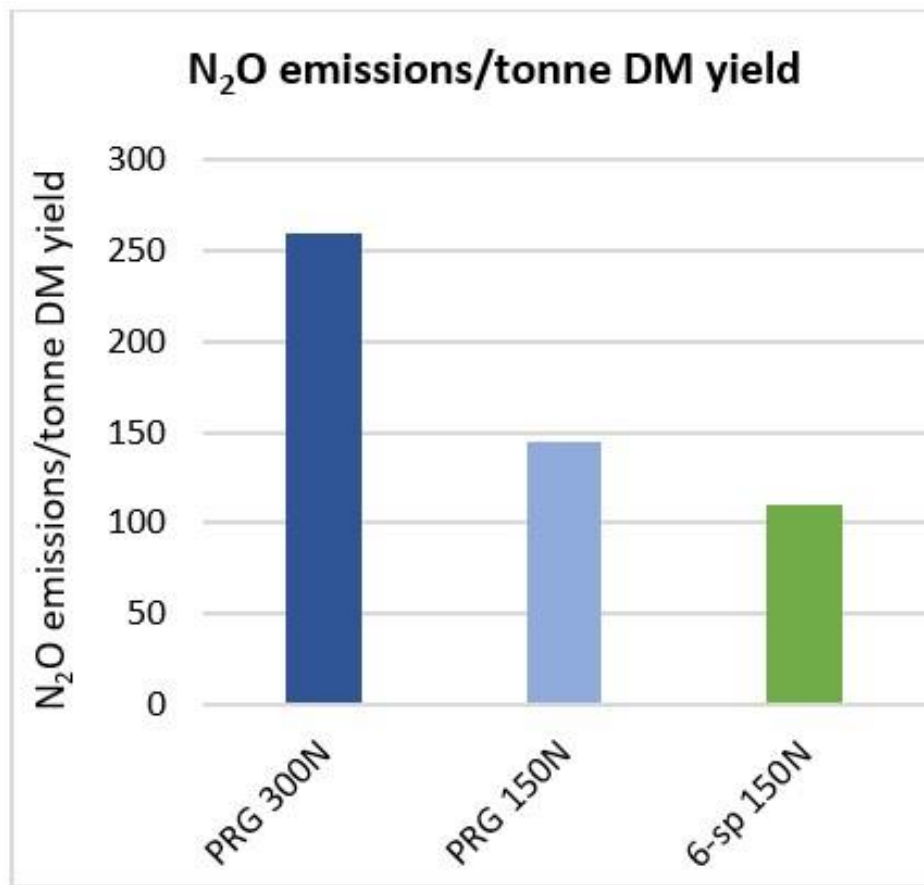
Lower nitrous oxide emissions intensity from mixtures

Cummins et al (2021)



Lower nitrous oxide emissions intensity from mixtures

Cummins et al (2021)



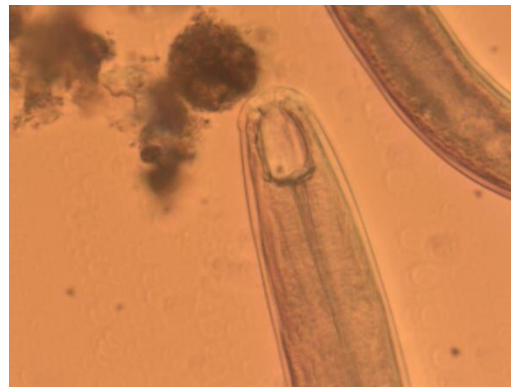
Plant diversity in multi-species mixtures increased nematode types that indicate improved soil health



Bacterial feeder



omnivorous
nematodes

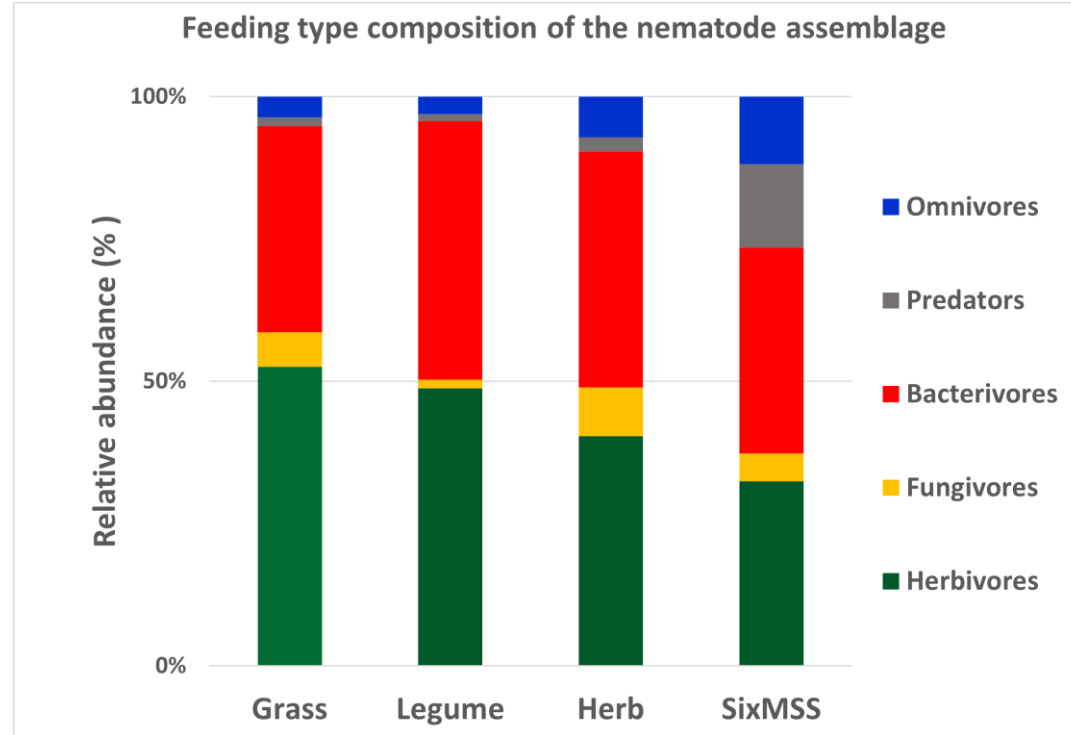


predatory
nematode



parasitic
nematode

Plant diversity in multi-species mixtures increased nematode types that indicate improved soil health

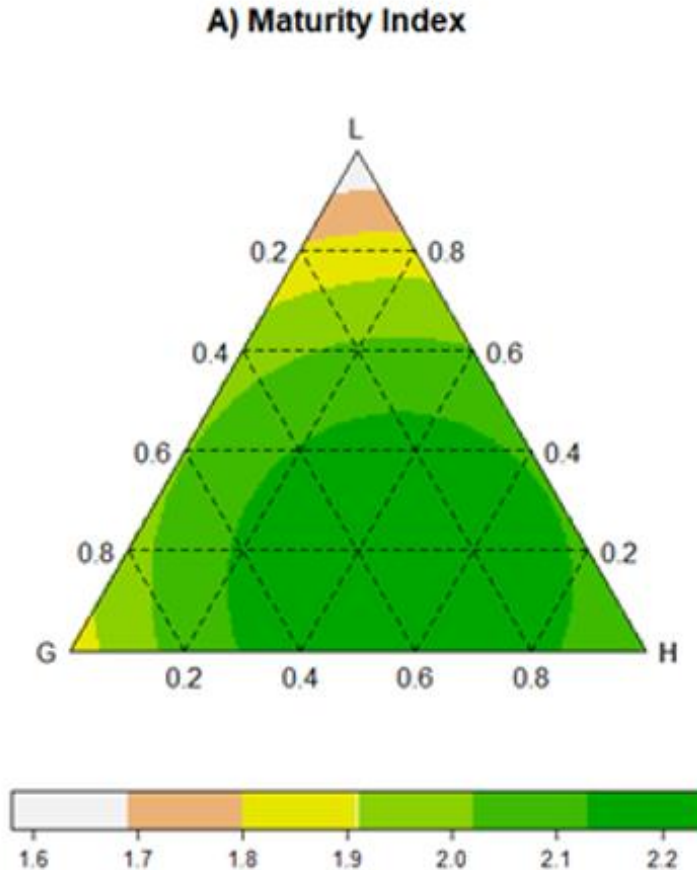


Nematode occurrences in soil under grass, legume and herb species, and under the six-species mixture (SixMSS). (Ikoyi et al., 2023 European Journal of Soil Biology)

Plant diversity has synergistic benefits on nematode-based index that reflects soil health

Nematode 'maturity index' in grass, legume and herb monocultures, and in the six species mix sward (SixMSS).

(Ikoyi et al., 2023. European Journal of Soil Biology)



Multi-species mixtures: key messages

- Use of legumes as a cost-effective displacement of fertiliser nitrogen
- Lower-nitrogen legume-based mixtures as productive, if not more productive, than higher-N grass-only
- Benefits to N use efficiency, drought resilience, yield stability, soil health and N₂O emissions



Multispecies Swards Forage quality and Animal Performance

From plots to paddocks!



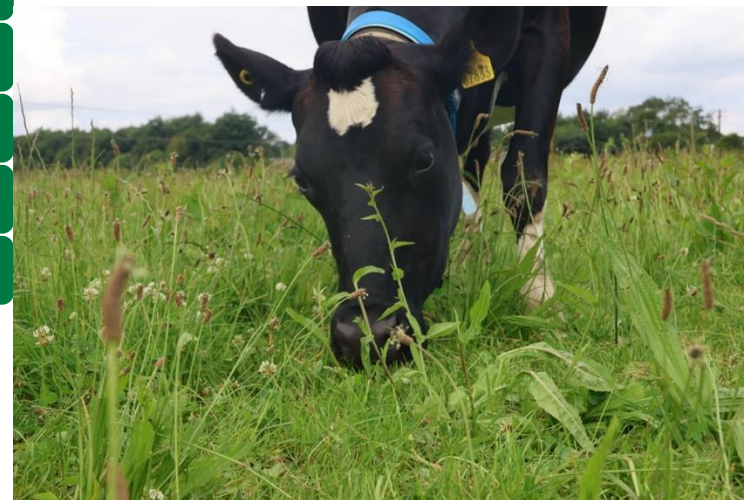
France: Dairy Grazing Study

Two year grazing study

INRA Le Rheu, France

8.7 ha platform, 75 kg N, 4.1 cows/ha

Four treatments:



(Roca-Fernández et al., 2016)

1 spp

- Perennial ryegrass (PRG)

Mixed 3 spp

- PRG + red clover & white clover

Multi 4 spp

- PRG-RCWC + chicory

Multi 5 spp

- PRG-RCWC-C + Festuca

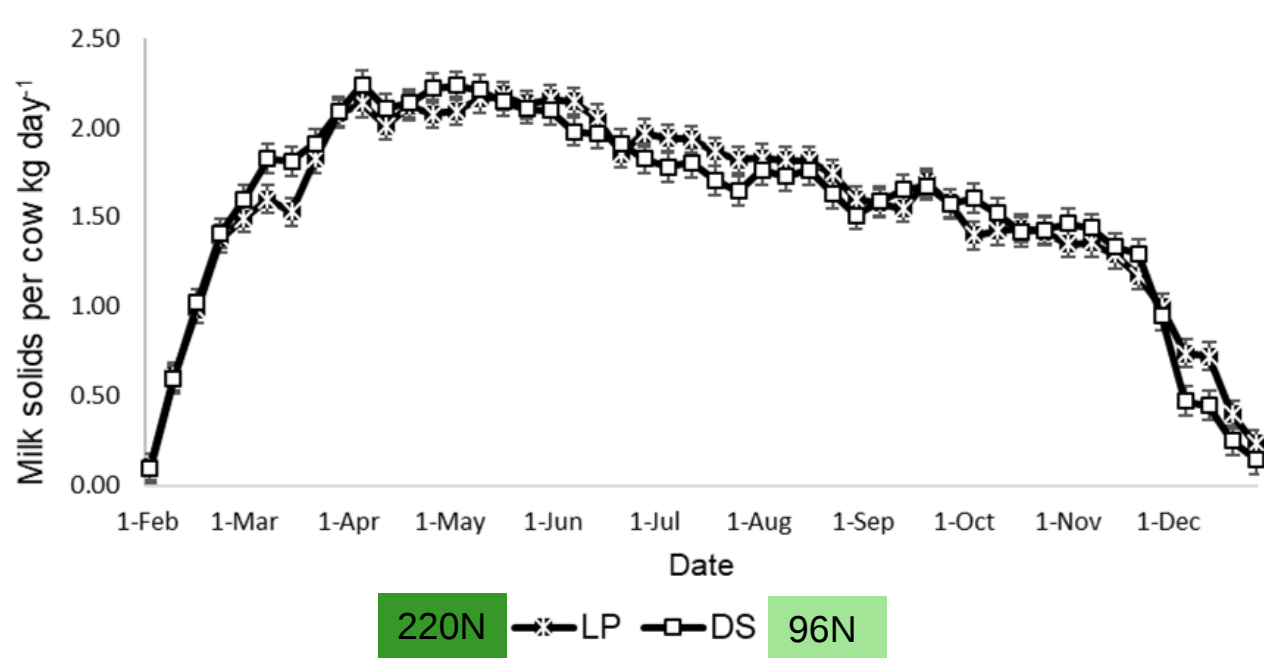
} **higher milk production**

Meta-analysis of grazing studies: similar quality, greater intakes, more milk produced

- ↓ Fibre (Clover and MSS)
- ↑ Ash (MSS)
- ↑ Greater intake (Clover and MSS)
- ↑ More milk (MSS)
- ↑ Milk solids (MSS → Protein and Lactose)

(McCarthy et al., 2023)

Similar milk production from high-N PRG vs. low-N mixture



Daily milk solids (fat plus protein) for cows grazing ryegrass (LP) or diverse species (DS) swards across lactation

(Patton et al., 2022)

Similar milk production from high-N PRG vs. low-N mixtures



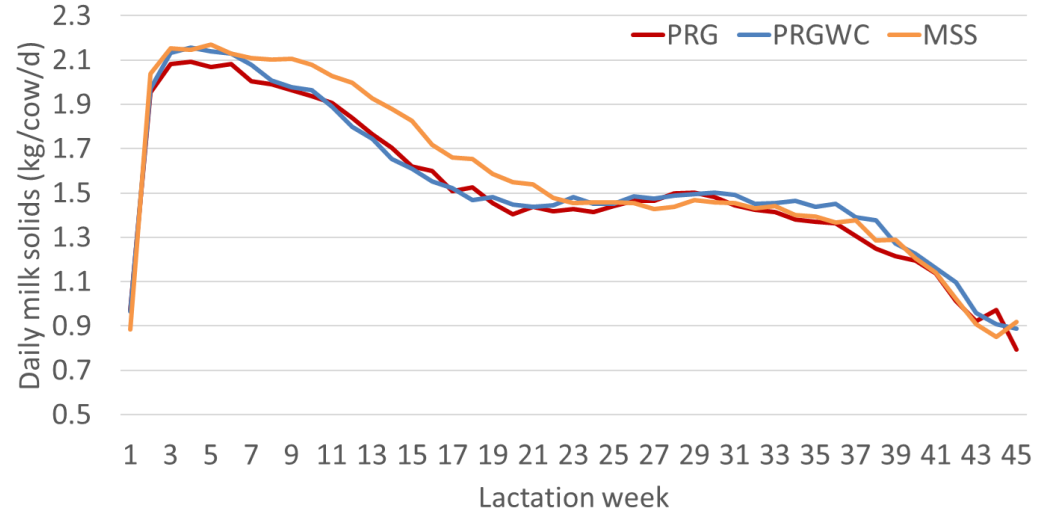
PRG 250N



PRGWC 125N



MSS 125N



↑ Milk yield (MSS)

↑ Milk solids (Clover and MSS)

≡ Forage quality

Summary

- Multispecies grassland mixtures, nitrogen and forage yield
- Ecosystem goods and services
- Drought and resilience
- Livestock performance



Looking to the future...

- Just starting!
- Grass-clover vs multi-species?
- Multiple ecosystem functions
- Soil health, carbon and microbiology
- Grazing + feeding experiments
- Farmers' experiences (LLs?)
- Many new projects and new evidence:
 - LegacyNet <https://legacynet.scss.tcd.ie/>, EU LegumeLegacy



More at: <https://farmecol.blogspot.com/>



Multi4More Project

Enhance agricultural practices: sustainability and efficiency

- Forage production and quality
- Nitrogen replacement
- Biodiversity and soil health
- Animal performance
- Gaseous emissions
- Soil fertility
- Knowledge Transfer



<https://multi4more.ie/>