Agronomically improved grass-legume mixtures: higher dry matter yields and more persistent legume proportions

Daniel Suter, Olivier Huguenin, Daniel Nyfeler, Andreas Lüscher
“Have you ever eaten a good grass-legume mixture?”
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Switzerland: long tradition for mixtures

- Backbone of forage production in the lowlands of Switzerland (Swiss Plateau)
- Since 1955 recipes for “best” seed mixtures are published as “Swiss Standard Mixtures” (SSMIX)
- Based on extensive research
- Revised every 4 years
- Mixtures for intensive production: 4 to 10 species
- SSMIX account for about 90% of forage plant seed sales

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Mixtures: growing interest in Europe

- Many research programs
  - Maintain or increase productivity with lower fertiliser input
  - Make use of the biological nitrogen fixation of legumes to reduce energy consumption

- COST852 “Agrodiversity Experiment”
  - 33 experimental sites
  - Intensive management
  - Productive system
  - Mixtures of 4 species (2 legumes and 2 grasses)

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COST 852: Swiss site at ART in Zurich

- Mid-European set of species
  - *Lolium perenne*
  - *Dactylis glomerata*
  - *Trifolium pratense*
  - *Trifolium repens*

- Fertiliser: 150 kg N ha\(^{-1}\) yr\(^{-1}\)
- 5 cuts per year

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  - *Lolium perenne*
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- Fertiliser: 150 kg N ha⁻¹ yr⁻¹

- 5 cuts per year

- High yield
- Optimal legume proportion

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Dependence of yield on legume proportion

Nutrients: 150 kg N ha$^{-1}$ yr$^{-1}$

Yield [Mg DM ha$^{-1}$ yr$^{-1}$]

Legume proportion

Lüscher et al. 2008b
Nyfeler et al. 2009

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Dependence of yield on legume proportion

- Legume proportion matters: maximal yield at 40-60% legumes

![Graph showing the dependence of yield on legume proportion with data from Lüscher et al. 2008b and Nyfeler et al. 2009. The graph includes a line for the best monoculture, an area for the average monoculture, and a shaded region for the significance range. Nutrients: 150 kg N ha\(^{-1}\) yr\(^{-1}\).]
Dependence of yield on legume proportion

- Legume proportion matters: maximal yield at 40-60% legumes
- Advantage is significant over a wide range

Nutrients: 150 kg N ha\(^{-1}\) yr\(^{-1}\)

Yield [Mg DM ha\(^{-1}\) yr\(^{-1}\)]

Legume proportion

Lüscher et al. 2008b
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Dependence of yield on legume proportion

- Legume proportion matters: maximal yield at 40-60% legumes
- Advantage is significant over a wide range

![Graph showing the dependence of yield on legume proportion.](image)

**Nutrients:** 150 kg N ha$^{-1}$ yr$^{-1}$

**Significance range**

**Lüscher et al. 2008b**

**Nyfeler et al. 2009**
PROBLEMS
COST852: legume proportion

- Strong decrease from 2nd year to the 3rd year
Species richness and yield

- Studies from low-input systems:
  - Yield depends on the number of species (graph)
- COST852 under fertile, agricultural conditions:
  - Higher yield with 4-species mixtures, than with the best monoculture
  - The effect of increased complexity is not known

Tilman 1999 *Ecology*
QUESTIONS
Yield and legume proportion

- Are the COST852 mixtures the end of the story?
- Do mixtures in practice - e.g. SSMIX - show the same strong performance as COST852 mixtures?
- Do more complex mixtures outperform COST852 mixtures?

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Yield and legume proportion

**SSMIX**
- Multi-species mixtures with 6 to 7 species
- Total: 7 to 8 varieties

**COST 852**
- 4-species mixtures
- 4 varieties
  - (1 variety per species)
- Legume proportion in the optimal range (40 to 60 %)
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SSMIX vs. COST852

- SSMIX: clearly higher yielding (15.9 vs. 14.5 Mg DM ha\(^{-1}\) yr\(^{-1}\))
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SSMIX vs. COST852

- SSMIX: more stable legume proportion
SSMIX vs. COST852

- SSMIX: more stable legume proportion

![Graph showing legume proportion over years for SSMIX and COST852]

Legume Proportion

SSMIX = 0.30
COST852 = 0.13

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Swiss Standard Mixtures (SSMIX)

- The SSMIX tested differ from COST852-Mixtures in:
  - species richness
  - species identities
  - cultivar identities
  - number of cultivars

- More than 50 years of extensive research
- More than 50 years of experience under practical conditions

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CONCLUSIONS
Yield and legume proportion

- COST852 mixtures are **NOT** the end of the story!
- As shown with the “SSMIX”, higher yields and more stable legume proportions are quite possible!
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