Performance of red clover mixtures in high output dairy systems: an agro-economical comparison

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Abstract

Inclusion of red clover (Trifolium pratense) in grasslands offers important economic and environmental advantages as nitrogen (N) fertilizer is replaced with N from N₂ fixation. These advantages seemed to be reduced under high fertilization rates. In a field experiment we compared perennial ryegrass swards (Lolium perenne) with grass-clover mixtures in which the artificial N fertilizer was omitted. The experiment was conducted at two locations (sandy and clay soil) at high fertilization levels (254 and 306 kg total-N ha⁻¹ on grass-clover and 389 and 489 kg total-N ha⁻¹ on the pure grass swards). Grass-clover mixtures produced more dry matter (+18%), digestible energy (+12%), crude protein (+45%) and digestible protein (+27%). Economic evaluation at farm level shows that grass-clover mixtures had a surplus of €510 ha⁻¹ year⁻¹ over pure grass swards. This surplus would be reduced (to €282 ha⁻¹) if the higher crude protein content of grass-clover cannot be balanced in the feed ration, resulting in extra N excretion of the animals and subsequent higher costs for manure disposal if maximum allowable manure application rates per ha are exceeded. These results show that inclusion of red clover in grasslands has agro-economic benefits, also under high fertilization rates.

Keywords: Trifolium pratense, ecological intensification, protein production, economic advantages

Introduction

Inclusion of red clover in grassland offers important economic and environmental advantages as nitrogen (N) fertilizer is replaced with N from N₂-fixation. The economic benefits of grass-red clover mixtures for organic dairy farms have been described by Doyle and Topp (2002). However, the yield advantages seem to be reduced under high levels of N fertilization (Nyfeler, 2009). Nevertheless, for conventional dairy farmers, the relevant question is: What are the differences between grass-red clover (fertilized with animal manure) and grass (fertilized with animal manure and artificial fertilizer) in terms of yield, fodder quality and economic cost and benefits? A field experiment was conducted to make such an agro-economic comparison.

Materials and methods

Experimental fields were established on two intensive dairy farms early September 2011 on sandy soil (52°19’ N, 6°28’ E) and clay soil (51°62’ N, 4°62’ E). Red clover (Trifolium pratense, 7 kg ha⁻¹) and white clover (Trifolium repens, 3 kg ha⁻¹) were sown with five different grass mixtures specifically selected for cutting regimes at commercially advised seeding rates, and compared with perennial ryegrass (Lolium perenne). Mixtures were sown in two replicates and pure grass was sown in four replicates per location.

Measurements were conducted in the second and third production year (2013 and 2014). In each year, grass-clover mixtures received on average 254 (sand) and 306 (clay) kg N ha⁻¹ from slurry, whereas pure grass received on average 135 (sand) and 183 (clay) kg N ha⁻¹ from artificial fertilizer in addition. Plots were harvested four (2013) or five (2014) times per year. Dry matter yield was determined by cutting a strip of 0.81x5 m with a two-wheel-drive tractor. After weighing the fresh biomass, sub-samples were analysed for nutritive value by NIR at a commercial lab. (By mid-2012 red clover had almost disappeared from one of the mixtures on clay; therefore this treatment was not included in the analyses.) Results
were tested by analysis of variance (unbalanced design) using GenStat 13.3. Experimental results were combined with actual historical prices and literature data for economic comparison.

**Results and discussion**

Dry matter yield was 18% higher in grass-clover plots than in plots with only grass (Table 1), and had a 22% higher crude protein content and a 8% higher intestinally digestible protein content (Table 2). Subsequently, crude protein yield was 43% higher and intestinally digestible protein was 27% higher in grass-clover (Table 1). Net energy lactation content of grass-clover was slightly lower than that of grass (Table 2), but due to the higher dry matter yield the net energy lactation yield of grass-clover surpassed that of grass (Table 1). Yields differed between years (+3 Mg dry matter for grass and grass-clover in 2014) and somewhat between locations, but differences between grass and grass-clover were constant.

The average economic value of these differences is given in Table 3. Average annual costs for grass-clover were comparable to those for grass only. Higher costs for seed and sowing and the higher renewal rate of grass-clover compared with grass resulted in higher annual establishment costs, but costs for artificial fertilizer and weed control were absent. Higher crude protein production may result in extra N-excretion of the cattle, and the total amount of N in animal manure may exceed the maximum application level for the farm. If all additional N produced needs to be disposed elsewhere, the costs for manure disposal increase to €228 ha⁻¹ (or higher, if the manure needs to be transported long distances), resulting in an economic benefit of grass-clover, compared to grass, of €282 ha⁻¹. However, if either the N-surplus can be applied on own land or the additional protein production is used to replace the use of off-farm protein-rich fodder, the economic benefit of grass-clover compared with grass can rise to €510 ha⁻¹. On most farms the costs for manure disposal are likely to be around €114 ha⁻¹, as part of the extra crude protein from the grass-clover can be balanced by using more maize silage or concentrate with a lower protein level. In that case the net annual result is €396 ha⁻¹.

**Conclusions**

Successful inclusion of red clover in grasslands has major agro-economic advantages, and these also apply under high fertilization rates. Dry matter production, total energy production and protein production

### Table 1. Mean yields of pure grass (n=8) and grass-clover mixtures (n=18) of two years.

<table>
<thead>
<tr>
<th></th>
<th>Dry matter Mg ha⁻¹</th>
<th>Net energy lactation MJ ha⁻¹</th>
<th>Crude protein kg ha⁻¹</th>
<th>Intestinally digestible protein kg DVE ha⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass only</td>
<td>11.0</td>
<td>6.97×10⁴</td>
<td>1.88×10³</td>
<td>8.20×10²</td>
</tr>
<tr>
<td>Grass-clover</td>
<td>13.0</td>
<td>7.76×10⁴</td>
<td>2.69×10³</td>
<td>10.4×10²</td>
</tr>
<tr>
<td>Difference</td>
<td>18%</td>
<td>11%</td>
<td>43%</td>
<td>27%</td>
</tr>
<tr>
<td>Significance</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

### Table 2. Mean energy and protein content of pure grass (n=8) and grass-clover mixtures (n=18) of two years.

<table>
<thead>
<tr>
<th></th>
<th>Net energy lactation MJ kg⁻¹</th>
<th>Crude protein g kg⁻¹</th>
<th>Intestinally digestible protein g DVE kg⁻¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass only</td>
<td>6.32</td>
<td>169</td>
<td>74.0</td>
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<tr>
<td>Grass-clover</td>
<td>5.98</td>
<td>207</td>
<td>80.1</td>
</tr>
<tr>
<td>Difference</td>
<td>-5%</td>
<td>22%</td>
<td>8%</td>
</tr>
<tr>
<td>Significance</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
<td>&lt;0.001</td>
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</tbody>
</table>

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are increased in grass-clover compared with grass. Grass-clover fodder has a higher protein content and slightly lower energy content than grass. The economic benefits mainly result from the higher production in combination with avoiding the costs of artificial fertilizer. The financial benefits of grass-clover depend on the farming system into which it is integrated, as well as on the extent to which a farmer is able to adapt his fodder regime.

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