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The effect of ploidy, white clover and cow breed on the productivity of spring milk production

Key external stakeholders:
Dairy farmers, milk processing companies, farm advisory services

Practical implications for stakeholders:
Grass-based production systems are the key driver of Ireland's competitive advantage in milk production. Increasing productivity within these systems without increasing the levels of bought in supplementation and production costs would be of major benefit to both farmers and the dairy industry. Dairy cow breed can also have significant impact on the productivity of grass-based milk production systems. This project investigated the potential of using different combinations of perennial ryegrass ploidies, white clover inclusion in a sward and cow breed to increase the productivity of spring milk production systems.

- Perennial ryegrass ploidy did not affect total annual grass dry matter production or milk production per cow in this study but did affect sward nutritive value throughout the grazing season.
- White clover inclusion in the sward significantly increased total annual grass dry matter production, sward nutritive value and milk production per cow.
- Cow breed did affect milk production and reproductive performance however the differences were biologically small and the performance of all breeds used in this study were above recognised industry targets.

Main results:
- Perennial ryegrass ploidy (Diploid or Tetraploid) did not affect grass dry matter (DM) production (16.1 vs.16.2 t DM/ha, respectively) or milk solids production per cow (458 vs. 463 kg milk solids/cow, respectively)
- Including white clover in the sward significantly increased grass DM production (15.6 vs. 16.8 t DM/ha for grass-only swards compared with grass-white clover swards) and milk solids production per cow (437 vs. 485 kg milk solids/cow, for cows on grass-only swards vs. grass-white clover swards, respectively)
- Cow breed had an effect on milk solids production as Holstein-Friesian x Jersey produced the highest milk solids (466 kg/cow), the Holstein-Friesian was similar (455 kg/cow) but the Norwegian Red x Holstein-Friesian x Jersey produced less milk solids (448 kg/cow) than the Holstein-Friesian x Jersey.

Opportunity / Benefit:
The results from this study highlight the potential of including white clover into perennial ryegrass swards to increase both grass DM production and animal performance in grazing systems without increasing bought in supplementation or fertiliser inputs thereby increasing the overall efficiency of the system.

Collaborating Institutions:
Queens University Belfast, AFBI, INRA

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1. Project background:

With the fast-growing worldwide demand for dairy products, particularly in developing countries, there is a need for not only efficient but also sustainable farming practices. Ireland's suitable climate for forage production has given it a competitive advantage to produce high quality milk from low cost grazed grass. Grazed perennial ryegrass is considered the cheapest feed available for dairy cows, therefore to maximise profits, dairy farmers should utilise this high quality feed where possible. The aim of grass-based systems is to maximise milk production from grazed grass and to achieve this, good grazing management is necessary to improve feed nutritive value and mitigate some of the seasonal effects on herbage nutritional value. Increasing milk production within grass-based production systems may be achieved through the use of improved grass cultivars or through the use of forage legumes. Recent research has reported a significant effect of perennial ryegrass cultivar on milk production per cow and that perennial ryegrass ploidy may also have an effect on milk production per cow. However, there is contrasting evidence in the literature as to the effect of perennial ryegrass ploidy on milk production as short-term studies have shown increased milk yield for cows grazing tetraploid swards compared to diploid swards (Wims et al., 2013) whereas longer term full lactation studies have shown no effect of ploidy on milk production (O'Donovan and Delaby, 2005). White clover is the main forage legume that is used in temperate grazing systems due to its complimentary growth habit with perennial ryegrass, its high nutritive value and its ability to biologically fix nitrogen from the atmosphere. Recent research has shown that perennial ryegrass-white clover swards can have higher annual grass DM production compared with perennial ryegrass-only swards in plots (Enriquez-Hidalgo et al., 2016). Milk production per cow can also be increased when cows graze perennial ryegrass-white clover swards compared to perennial ryegrass-only swards through increased DM intake. A 1.5 kg d^{-1}increase in dry matter intake has been observed for cows grazing perennial ryegrass-white clover swards compared to perennial ryegrass-only swards (Ribeiro-Filho et al. 2005). However, similar to the effect of ploidy, these studies were short term experiments and there is a requirement to investigate the effect of perennial ryegrass ploidy and white clover inclusion over a full grazing season and multiple years. Dairy cow breed can also significantly affect the productivity of spring milk production systems. There has been increased interest in the use of crossbreeding in grass-based production systems in recent years (Buckley et al., 2014).

2. Questions addressed by the project:

- Can Tetraploid perennial ryegrass swards support higher levels of grass DM production and milk production per cow than Diploid perennial ryegrass swards?
- Can we include white clover into an intensive grass-based dairy production system at high levels of nitrogen (250 kg N/ha) and relatively high stocking rates (2.75 cows/ha)?
- Can perennial ryegrass-white clover swards support higher levels of grass DM production and milk production per cow than perennial ryegrass-only swards?
- Is there an interaction between perennial ryegrass ploidy and white inclusion on sward white clover content, sward nutritive value or sward dynamics?
- Which cow type (Holstein-Friesian, Holstein-Friesian x Jersey or Norwegian Red x Holstein-Friesian x Jersey) performs best in low input grass-based dairy production systems?

3. The experimental studies:

This study was a farm systems experiment that used a randomised design with a factorial arrangement of treatments, i.e. there were two grass ploidies (Tetraploid and Diploid) x two white clover treatments (perennial ryegrass-only and perennial ryegrass-white clover) which were studied over four years (2014 to 2017). A dairy grazing platform of 44 ha was used with 75% of the experimental area reseeded in 2012 and 25% reseeded in 2013 by full cultivation (ploughing and tilling). Four separate grazing treatments were sown, a tetraploid perennial ryegrass-only sward (TGO), a diploid perennial ryegrass -only sward (DGO), a tetraploid perennial ryegrass sward with white clover (TWC) and a diploid perennial ryegrass sward with

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white clover (DWC). The four tetraploid cultivars (Astonenergy, Dunluce, Kintyre and Twymax, sown at 37.5 kg/ha) and four diploid cultivars (Aberchoice, Glenveagh, Tyrella and Drumbo, sown at 30 kg/ha) were sown as monocultures, with each cultivar sown 10 times across the grazing platform. In the white clover paddocks a 50:50 mix of the medium-leaved white clover cultivars Chieftain and Crusader were sown at 5 kg/ha. This resulted in four farmlets being created with 20 paddocks per grazing treatment for the 4 years. Paddock's for each treatment were balanced for location block, soil type and soil fertility throughout the farm. Each farmlet was 10.9 ha and stocked at 2.75 cows/ha. Thirty spring calving dairy cows were assigned to each grazing treatment based on breed, parity, calving date and Economic Breeding Index (EBI). Three cow breeds were used for this experiment; Holstein Friesian, Jersey x Holstein Friesian and Norwegian Red x Jersey x Holstein Friesian, with 10 cows of each breed allocated to each grazing treatment. Individual animal error was used to test for differences between treatments. The effects of ploidy, white clover inclusion, breed and their interactions on milk production per cow and per ha, bodyweight and body condition score and grass DM production and nutritive value were analysed.

4. Main results:

- Perennial ryegrass ploidy (Diploid or Tetraploid) did not affect grass dry matter (DM) production (16.1 vs.16.2 t DM/ha, respectively) or milk solids production per cow (458 vs. 463 kg milk solids/cow, respectively)
- Sward nutritive value was great for tetraploids than diploids with greater organic matter digestibility (+ 10 g/kg) and lower neutral detergent fibre (- 19 g/kg) and acid detergent fibre (- 16 g/kg) observed for tetraploid compared to diploid swards.
- Sward white clover content was on average 23% for tetraploid with white clover swards and 25% for diploid with white clover swards, with no significant difference between the two. However, there were significant seasonal and annual changes in sward white clover content as sward white clover content declined over time.
- Including white clover in the sward increased grass DM production by 1.2 t DM/ha on average over the four years, 15.6 vs. 16.8 t DM/ha for grass-only swards compared with grass-white clover swards.
- Milk yield per cow increased by 596 kg/cow (5,818 vs. 5,221 kg milk/cow) and milk solids yield per cow increased by 48 kg/cow (485 vs. 437 kg milk solids/cow) when cows grazed perennial ryegrass-white clover compared to perennial ryegrass-only swards.
- Sward nutritive value increased when white clover was included in perennial ryegrass swards as crude protein content and organic matter digestibility were greater (+ 35 and + 21 g/kg) and neutral detergent fibre and acid detergent fibre were lower (- 40 and - 14 g/kg) for perennial ryegrass-white clover compared to perennial ryegrass-only swards.
- Although grass DM production was increased when white clover was included in the sward, growth rate over the winter period (December and January) was reduced which led to a reduction in grass availability in spring that required extra supplementation for cows on perennial ryegrass-white clover swards in the spring period.
- Biological nitrogen fixation was measured in 2015 and was estimated at 151 kg nitrogen/ha when sward white clover content was 25% and 250 kg nitrogen fertiliser/ha was applied.
- Gazing treatment did not affect reproductive performance as all four treatments had similar reproductive performance (24 day submission rate of 96%, a six week calving rate of 86% and an overall pregnancy rate of 94% (12 week breeding period).
- Cow breed had an effect on milk solids production as Jersey x Holstein-Friesian produced the highest milk solids (466 kg/cow), the Holstein-Friesian was similar (455 kg/cow) but the Norwegian Red x Jersey x Holstein-Friesian produced less milk solids (448 kg/cow) than the Jersey x Holstein-Friesian.
- Cow breed had an effect on some reproductive variables as Jersey x Holstein-Friesian had a greater conception rate to first service (78.2%) than Holstein-Friesian (64.4%) and Norwegian Red x Jersey x Holstein-Friesian (61.5%) Six week pregnancy rate was higher for Jersey x Holstein-Friesian and Holstein-Friesian (89.9% and 88.1%) compared to the Norwegian Red x Jersey x Holstein-Friesian (83.8%) although overall pregnancy rate was similar for all breeds (94.7%).

5. Opportunity/Benefit:

The results from this study highlight the potential to include white clover into perennial ryegrass swards to increase both grass DM production and animal performance in terms of milk production per cow particularly, in grazing systems. This should be of interest to dairy farmers and the industry as a whole, as further

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increases in milk production could be achieved in a more sustainable manner by including white clover into perennial ryegrass swards.

6. Dissemination:

The primary stakeholders for this research are Irish dairy farmers, animal nutrition companies and consultants. The results of this project have been disseminated through the popular press and at the Teagasc Moorepark Open Days, as well as at scientific conferences and in scientific peer-reviewed publications.

Main publications:

Dineen M., Delaby, L., Gilliland, T.J. and McCarthy, B. (2018) 'Meta-analysis of the effect of white clover inclusion in perennial ryegrass swards on milk production' *Journal of Dairy Science* 101: 1804 – 1816.
Guy C., Hennessey, D., Gilliland, T.J., Coughlan, F. and McCarthy, B. (2018) 'Growth, morphology and biological nitrogen fixation potential of perennial ryegrass-white clover swards throughout the grazing season' *Journal of Agricultural Science* 156: 188 – 199.
Guy C., Hennessey, D., Gilliland, T.J., Coughlan, F., McClearn, B., Dineen, M. and McCarthy, B. (2018) 'Comparison of perennial ryegrass, Lolium perenne L., ploidy and white clover, Trifolium repens L., inclusion for herbage production, utilization and nutritive value' *Grass and Forage Science* 73: 865 – 877.

Popular publications:

Hennessy, D., Egan, M. and McCarthy, B. (2015). Role of white clover. Tresearch 10 (2): 20-21
McCarthy B., Dineen, M., Guy, C. and Coughlan, F. (2016) 'Clonakilty Update: The effect of tetraploid and diploid swards sown with and without white clover on the productivity of spring milk production systems' *Moorepark Dairy Levy Research Update Clonakilty Agricultural College* 31: 9 – 13.

Conference Proceedings:

McCarthy, B., Dineen, M., Guy, C., and Coughlan, F. (2016). Incorporating white clover into spring calving pasture-based production systems to increase performance – the Clonakilty experience. In: Proceedings The Positive Farmers Conference Cork, 13-14 Jan-2016
McClearn B., Gilliland, T.J., Guy, C., Dineen, M., Coughlan, F. and McCarthy, B. (2018) 'The effect of grass ploidy and and white clover inclusion on milk production of dairy cows' *Sustainable meat and milk production from grasslands: Grassland Science in Europe* 23: 298 – 300.
Guy C., Hennessey, D., Gilliland, T.J., Coughlan, F. and McCarthy, B. (2018) 'Sward structure and biological nitrogen fixation potential of perennial rye-grass-white clover swards' *Sustainable meat and milk production from grasslands: Grassland Science in Europe* 23: 212 – 214.

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