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Improving productivity of perennial ryegrass pastures in dairy systems in New Zealand and Ireland: Rate of genetic gain, pasture persistency, and genotype x environment interactions



Key external stakeholders:

Dairy farmers, milk processing companies, farm advisory services

Practical implications for stakeholders:

The results from this work indicate that greatest DM yield advantage from grass-white clover swards will be obtained when chemical N fertiliser inputs are maintained at low levels and grazing rotation is close to 30 days.

Main results:

Dry matter (DM) of varieties under evaluation in the Northern Ireland plant testing program showed an average annual DM yield increase of 0.44% under conservation and 0.33% under simulated grazing, with similar levels of gain within maturity groups and ploidy from 1973 - 2013.

White clover proportion had a significant impact on nitrogen (N) fixation. The greatest DM yield advantage from grass-white clover swards was obtained when chemical N fertiliser inputs were maintained at low levels. A reduced contribution to total DM yield by white clover was associated with reduced sward white clover content which occurred at high N fertiliser rates.

Opportunity / Benefit:

The genetic gain of perennial ryegrass was investigated and quantified over a 40 year time period. The associated interactions of nitrogen level and grazing management were investigated when managing WC pastures, this work highlighted the need to investigate WC systems at lowering N levels.

Collaborating Institutions:

Queens University Belfast
AFBI
INRA

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1. Project background:

Perennial ryegrass (*Lolium perenne* L.) is the most widely sown forage species for ruminant production systems in cool-temperate agricultural regions like Ireland and the UK. Consistent use of perennial ryegrass varieties in ruminant grazing production systems can be attributed to their high DM productivity potential, high forage digestibility throughout the grazing season and the large varietal diversity adapted to a range of growing conditions and farming practices. Limitations to land availability coupled with increasing environmental requirements to reduce greenhouse gas emissions and N losses to ground water are placing increased pressure on grass based animal production systems to provide additional quantities of high quality forage. The ability of farmers to increase forage yield, through increased fertiliser inputs is limited. Thus, increased performance must be achieved by other means and one of the most important avenues is grass breeding. Incorporating white clover (*Trifolium repens* L.) in to grass clover swards can have benefits in terms of herbage production and herbage quality. The appropriate N application rate and management to maximise the benefits for farmers must be investigated.

2. Questions addressed by the project:

Experiment 1: The objective of this study was to produce an accurate estimation of the genetic progress achieved in perennial ryegrass breeding. This was achieved by using the annual performance data compiled from applicant varieties that were subsequently listed on the Northern Ireland Recommended List of Grass and Clover varieties between 1973 and 2013. Three performance parameters were assessed (DM yield, sward density and digestibility) under conservation and simulated grazing and differences between ploidy and maturity groupings were also examined.

Experiment 2: Understanding the performance differences of perennial ryegrass-white clover (WC) swards versus grass only swards over multiple years when grazing and N management are altered provides a direct measure of sward performance potential for on farm use. Identifying key management x WC interactions for DM yield performance and management effects on WC sward contribution and persistence under animal grazing will be critical in this understanding and in developing practical guidelines for farmers. The objective of the study was to examine the effect of differing grazing rotational lengths and level of N application on the DM yield performance of perennial ryegrass-WC and grass only swards as well as on WC productivity and persistence under animal grazing.

3. The experimental studies:

Experiment 1: The annual DM yield and sward density (1973 – 2013) and the digestibility (1980 – 2013) was compiled from applicant varieties that were subsequently listed on the Northern Ireland Recommended List of Grass and Clover varieties. Genetic gain in perennial ryegrass varieties was analysed and identified. A variety by year's matrix was compiled for each parameter and comparable means between varieties never in side by side performance trials were produced.

Experiment 2: The DM yield of perennial ryegrass varieties sown with or without white clover under different N application rates under intensive animal grazing was examined over a three year period (2013-2016).

4. Main results:

Experiment 1: Dry matter yields showed an overall significant ($P < 0.001$) average annual increase of 0.44% under conservation and 0.33% under simulated grazing, with similar gain levels within maturity groups and ploidies. These rates were not constant over time, and periods of negative gain occurred in various variety groupings. Sward density of the examined varieties did not change significantly. Herbage digestibility showed no improvement over the timeframe but had the largest differences between concurrent varieties, indicating that improvements were possible in the future. The study indicated that plant breeding gains were primarily DM yield focused with sward density remaining stagnant over the 40 year period, while the lack of grass digestibility improvement appeared to only require more time to overcome.

Experiment 2: Including WC in perennial ryegrass swards significantly increased annual, mid-season and autumn herbage production in comparison to grass only swards over the three years of the study. Spring growth on the perennial ryegrass-WC swards varied between years making it more unpredictable than grass-only swards for spring herbage supply. Significant contribution of WC to DM yield in the mid-season and autumn were obtained from the sward mixtures which are in line with the seasonal growth pattern of WC but such contributions are generally when grass growth rates are sufficient to support livestock capacity when fertilised adequately.

A significant management x WC interaction occurred for annual DM yield and this interaction was maintained for each season. The interactions were due to the reduced contribution of WC to sward productivity under a higher N input management regime. Applying a low rate of N fertiliser and increasing rotation length resulted in a greater contribution of white clover to DM yield compared to higher N and a short rotation. White clover proportion has been shown to have a significant impact on N fixation with lower N swards benefiting greatest in additional DM yield. A reduced contribution to total DM yield by WC was associated with reduced WC proportion at high N rates. The findings of this experiment and previous research indicate that WC proportion in the sward has a significant impact on the contribution of WC to DM yield in perennial ryegrass-WC swards.

5. Opportunity/Benefit:

This study has shown that perennial ryegrass breeders have achieved modest increases in DM yield production over time and at creditable annual rates in comparison to grain crops, given the greater challenge of increasing the total shoot biomass in an allogamous species. These increases were evident in all ploidy and maturity sub-groups under both conservation and simulated grazing managements. There was no evidence of sward density improving despite large gains in DM yield. This indicates that breeders have improved yield capacity of perennial ryegrass plants without sacrificing sward persistence significantly. There was almost no evidence of any improvements in digestibility under either management regime but the very wide variation in grass quality between contemporary varieties indicated that improvements are possible. Given that the recognition of digestibility improvement was only relatively recently introduced to the testing system, further advances can be expected. This conclusion recognizes that the variety testing system is an important catalyst driving the pace and influencing the direction of advances made by plant breeders. For this reason great care is required when deciding how different performance parameters are used in the listing decisions of new varieties as this can promote important improvements such as better grass quality in the future but equally cause significant effects such as the potential impact on sward density and persistence.

Considerations for the benefits of WC inclusion in grass in swards must take N use and grazing rotation into account to maximise production benefits associated with WC. Results from this study indicate greatest DM yield performance will be obtained from WC over 3 years when chemical N fertiliser inputs are maintained at low levels and grazing rotation is close to 30 days. This offers a lot of potential to low input sustainable production systems. When selecting a management strategy for lifetime productivity of such swards it remains unclear of how WC will perform and persist in a mixed sward for a period greater than 3 years under low N fertiliser inputs at longer grazing intervals.

6. Dissemination:

The primary stakeholders for this research are Irish dairy farmers, advisors, Wholesale grass seed companies, Co-ops and consultants. The results are also useful for grass breeders and evaluators. The results of this project have been disseminated through the popular press and at Teagasc Moorepark Open Days, as well as at scientific conferences and in scientific peer-reviewed publications.

Main publications:

Justin McDonagh PHD Thesis 2017

McDonagh J, Gilliland TJ, McEvoy M, Delaby L, O'Donovan M (2017). Nitrogen and white clover impacts on the management of perennial ryegrass-clover swards for grazing cattle. *The Journal of Agricultural Science* 2017;155(9):1381-1393; doi Doi: 10.1017/s002185961700051x.

McDonagh, J. O'Donovan, M, McEvoy, M and Gilliland, T.J. (2016) Genetic gain in perennial ryegrass (*Lolium perenne*) varieiteis 1973 to 2013. *Euphytica* DOI 10.1007/s10681-016-1754-7

McDonagh, J. Gilliland, T. McEvoy, M. Delaby, L and O' Donovan, M. (2016). The effect of perennial ryegrass cultivars and allowance on utilisation, grazing efficiency and milk production In: *The multiple roles of grassland in the European bioeconomy. Grassland Science in Europe*, 21: 89-91.

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