

Project number: 5782
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Productivity of clover-based grassland under organic management and nitrate losses to ground water



Key external stakeholders:

Organic dairy farmers, grassland farmers, advisors, organic milk processors

Practical implications for stakeholders:

It is possible to substantially lower the cost of producing organic milk during the winter by grazing cows throughout the winter on grass/white clover swards. This practice had no impact on milk yields per cow, the processing characteristics of the milk or on N losses to ground water.

Main results:

- Producing milk by grazing cows over the winter at low stocking density (1.2 cows/ha) had no effect on milk output per cow, milk composition and the processing characteristics of the milk but substantially lowered the cost offering Irish dairy producers a viable option to produce organic milk during the winter months when a premium price is paid for the milk.
- Trampling in winter resulted in less of a reduction in pre-grazing herbage yield than trampling in spring due to lower soil surface deformation and longer recovery periods. Grazing during the winter resulted in significant increases in clover content, herbage production and N-fixation estimates. The results show that grazing during the winter can increase clover content, BNF and herbage production and is therefore a useful management tool for maintaining or increasing clover contents of swards.
- A 42-day rotation with a low defoliation height (2.7 to 3.5 cm) during the autumn and early winter gave the most desirable results in terms of herbage yield and white clover stolon mass in the following spring/summer.
- Grazing over the winter period on this site had no effect on N losses to groundwater due to high natural buffering capacity of the soils associated with heavy texture, high SOC, high soil pH, anaerobic conditions and presence of shallow groundwater. Mean concentrations of DON, NH₄-N, NO₂-N and NO₃-N were 2.16, 0.35, 0.01 and 0.37 mg L⁻¹ respectively.

Opportunity / Benefit:

- It is possible to substantially lower the cost of producing organic milk during the winter by grazing cows throughout the winter on grass/white clover swards. This practice had no impact on milk yields per cow, the processing characteristics of the milk or on N losses to ground water.

Collaborating Institutions:

Waterford Institute of Technology (WIT).

Teagasc project team: Dr. James Humphreys (PL)
Mr. Paul Phelan

External collaborators: Ms Magdalena Necpalova, WIT
Dr. Bill Keogh, WIT
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1. Project background:

- Ireland is a net importer of organic dairy products at processing and retail levels. This contrasts sharply with conventional dairy production where approximately 80% of Irish products are exported. In Ireland, a premium price is paid for milk produced on organic dairy farms if 50% of the milk is supplied during the autumn and winter (September to March). Grazing cows on clover-based grassland is a key component of profitable organic milk production. Ireland's climate is conducive to production from clover swards over a long growing season. Organic systems of production operate at low stocking densities compared with conventional systems. Low stocking rates offer the potential to extend the grazing season throughout the autumn, winter and early spring with the potential to substantially lower the cost of feed for organic winter milk production. This project aimed at substantially lowering the cost of feed for organic winter milk production by supplying a large proportion (>50%) of the diet from grazed grass-clover during autumn and winter.

2. Questions addressed by the project:

- The objective of task 1 was to investigate the productivity of white clover-based grassland under different management regimes for dairy production including a system where a large proportion (>50%) of the diet during the autumn and winter was grazed grass-clover swards.
- The objective of task 2 was to investigate the effects of grazing interval and post-grazing height during the autumn on herbage accumulation during the autumn, winter and following spring and to investigate trampling by dairy cows on soil properties and herbage production within this winter-grazing system on a soil with impeded drainage.
- Grazing during the winter, albeit at low stocking rates, carries the risk of losses of nitrate to groundwater. The objective of task 3 was to measure the impacts of this dairy production system involving grazing over the winter on nitrate losses to groundwater compared with more conventional systems on a poorly drained clay-loam soil with a high natural attenuation capacity.

3. The experimental studies:

- Fifty four primi- and multi-parous Holstein-Friesian dairy cows were used in a one factor experiment with 3 systems and repeated over two lactations (2008/09 and 2009/10). The three systems compared had: (i) a mean calving date of 17 February, stocking density of 2.15 dairy cows ha⁻¹, receiving 90 kg ha⁻¹ of annual fertilizer N input; (ii) a mean calving date of 17 February, stocking density of 1.6 dairy cows ha⁻¹, receiving no fertilizer N input and (iii) a mean calving date of 16 April, stocking density of 1.6 dairy cows ha⁻¹ between calving and 1 September and stocking density of 1.2 dairy cows ha⁻¹ between 1 September until dry-off in early February, receiving no fertilizer N input.
- The effects of defoliation interval (INT: 21, 42, 56 or 84-days), defoliation height (DH: 2.7, 3.6, 5.3 or 6.0 cm) and final defoliation (closing) date (FIN: 23 September, 4 November or 16 December) on herbage production in a grass-clover sward were studied. Treatments were only imposed between July and December 2008, with all plots under a common management in the following March to June 2009.
- A dense network of shallow groundwater piezometers was installed to determine groundwater flow direction and N spatial and temporal variation. Estimated vertical travel times through the unsaturated zone allowed the correlation of management with groundwater N within a short space of time.

4. Main results:

- Producing milk by grazing cows over the winter at low stocking density (1.2 cows/ha) had no effect

on milk output per cow, milk composition and the processing characteristics of the milk but substantially lowered the cost offering Irish dairy producers a viable option to produce organic milk during the winter months when a premium price is paid for the milk.

- Trampling in winter resulted in less of a reduction in pre-grazing herbage yield than trampling in spring due to lower soil surface deformation and longer recovery periods. Grazing during the winter resulted in significant increases in clover content, herbage production and N-fixation estimates. The results show that grazing during the winter can increase clover content, BNF and herbage production and is therefore a useful management tool for maintaining or increasing clover contents of swards.
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5. Opportunity/Benefit:

It is possible to substantially lower the cost of producing organic milk during the winter by grazing cows throughout the winter on grass/white clover swards. This practice had no impact on milk yields per cow, the processing characteristics of the milk or on N losses to ground water.

6. Dissemination:

Main publications:

- Necpalova M., Fenton O., Casey I.A. and Humphreys J. (2012) N leaching to groundwater from dairy production involving grazing over the winter on a clay-loam soil. *Science of the Total Environment* **432**, 159-172.
- Phelan P., Keogh B., Casey I.A., Necpalova M. and Humphreys J. (2012) The effects of treading by dairy cows on soil properties and herbage production in white clover based grazing systems on a clay loam soil. *Grass and Forage Science*, (in press)
- Phelan P., Casey I.A. and Humphreys, J. (2012) The effects of simulated autumn and winter grazing management on herbage production and white clover persistence in a grass-clover sward. *Grass and Forage Science*, (accepted subject to changes)
- Phelan P., Casey I.A. and Humphreys J. (2012) The effect of target post-grazing height treatment on herbage yields and dairy production from grass-white clover swards. *Journal of Dairy Science*, (accepted subject to changes)
- Necpalova M., Li D., Lanigan G., Casey I.A., Burchill W. and Humphreys, J. (2012) Changes in soil organic carbon in clay-loam soil following ploughing and reseeding of permanent grassland under temperate moist climatic conditions. *Grass and Forage Science*, (submitted and under review).
- Necpalova M., Casey I.A. and Humphreys J. (2012) Effect of ploughing and reseeding of permanent grassland on soil N, N leaching and nitrous oxide emissions from a clay-loam soil. *Nutrient Cycling in Agroecosystems*, (submitted and under review).
- Keogh B., O'Brien B., Phelan P., Casey I.A. and Humphreys J. (2012/3) The effect of organic management strategies on milk production and milk processability characteristics within an Irish clover-based grassland system. *Journal of Dairy Science*. (Submitted)
- Necpalova M., Phelan P., Casey I.A. and Humphreys, J. (2012/3) Soil N balances and soil N dynamics in a clay-loam soil under Irish dairy production systems. *Soil Use and Management*. (Submitted).
- Necpalova M., Phelan P., Casey I.A., Humphreys J. (2012) Effect of non-fertilized winter grazing dairy production on soil N balances and soil N dynamics. In: Proceedings of the 63rd annual meeting of European Federation of Animal Science, Bratislava, 27-31 August 2012, p. 150.
- Phelan P., Casey I. and Humphreys J. (2012). Predicting N-fixation in a grass-clover sward. *Grassland Science in Europe*, **17**, 154-156.
- Necpalova M., Li D., Lanigan G., Casey I.A., Fitzgerald E., Burchill W., Humphreys J. (2012) Changes in soil organic carbon in clay-loam soil under permanent and cultivated grassland under temperate moist climatic conditions *Grassland Science in Europe*, **17**, 583-585.
- Necpalova M., Phelan P., Casey I.A., Humphreys J. (2012) Effect of non-fertilized winter grazing dairy production on soil N balances and soil N dynamics in a clay-loam soil. In: *Proceedings from 17th international Nitrogen Workshop*, 26-29 June 2012, 309-310.
- Necpalova M., Fenton O., Casey I.A., Humphreys J. (2012) Effect of non-fertilized winter grazing dairy production system based on clay-loam soil on N leaching to groundwater. In: *Proceedings from 17th*

international Nitrogen Workshop, 26-29 June 2012, 311-312.

Necpalova M., Casey I.A., Humphreys J. (2012) Effect of ploughing and reseeding of permanent grassland on N leaching to groundwater and nitrous oxide emissions from a clay-loam soil. In: *Proceedings from 17th international Nitrogen Workshop*, 26-29 June 2012, 313-314.

Necpalova M., Li, D., Lanigan, G., Casey, I.A., Fitzgerald, E., Burchill, W. and Humphreys, J. (2011) Changes in soil organic carbon in clay loam soil under permanent and cultivated grassland in temperate moist climatic conditions. *Proceedings of the 10th research conference of the British Grassland Society*, 20th-21st September 2011, Belfast, 73-74.

Phelan P., Keogh B., Fitzgerald E., Casey I.A. and Humphreys J. (2011). The effect of trampling by dairy cows on a rotationally grazed grass-clover sward. *Proceedings of the 10th research conference of the British Grassland Society*, 20th-21st September 2011. Belfast. p7.

Humphreys, J. Keogh, B., Phelan, P., Necpalova, M., Fitzgerald, E. and Casey, I. A. (2010) Dairy production from clover-based grassland under different management strategies. Nordic Association of Agricultural Scientists Seminar 432, Hvanneyri, Iceland, 20- 22 June, 117 – 120.

Phelan, P. Keogh, B. Casey I.A. Fitzgerald E. and Humphreys J. (2010) Cutting height and interval in autumn and annual herbage production in a white clover-grass sward. Nordic Association of Agricultural Scientists Seminar 432, Hvanneyri, Iceland, 20- 22 June, 125 – 128.

Phelan P., Keogh B., Casey I.A. and Fitzgerald E. (2010). Impacts of autumn cutting height and interval on annual productivity of white clover-grass sward. *Grassland Science in Europe*, 15, 985-987.

Keogh, B., Humphreys, J., Phelan, P., Necpalova, M., Casey, I.A. and Fitzgerald, E. (2010). The effect of organic management strategies on dairy production in clover-based grassland. *Grassland Science in Europe*, 15, 907–909.

Necpalova, M., Keogh, B., Fitzgerald, E. and Humphreys, J. (2010) Effect of cultivation of clover based grassland on N losses to groundwater on a clay-loam soil. *Advances in Animal Biosciences*, 1, p. 90.

Keogh, B., Humphreys, J., Phelan, P., Necpalova, M., Casey, I. and Fitzgerald, E. (2010) Organic management strategies and its effect on clover-based grassland production. *Advances in Animal Biosciences*, 1, p. 147

Phelan, P., Keogh, B., Casey, I.A., Fitzgerald, E. and Humphreys, J. (2010). The effects of autumn rotation length and cutting height on a perennial ryegrass-white clover sward. *Advances in Animal Biosciences*, 1, p. 320.

7. Compiled by: Dr James Humphreys
