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Plantain as a GHG mitigation option: N_2O, C and GHG balances from an intensively grazed New Zealand dairy pasture

Aaron Wall[1], Jordan Goodrich[1], Anne Wecking[1], Jack Pronger[2], David Campbell[1], and Louis Schipper[1]

[1]University of Waikato, Hamilton, New Zealand (aaron.wall@waikato.ac.nz)
[2]Manaaki Whenua – Landcare Research, Hamilton, New Zealand

Agricultural greenhouse gas (GHG) emissions account for almost half of New Zealand's total emissions, and therefore considerable attention has been given to identifying and testing mitigation options. At plot scale, plantain (Plantago lanceolate L.) in the pasture sward has been demonstrated to reduce nitrous oxide (N_2O) emissions but has not been tested at paddock scale on an operating farm. Our aim was to test the efficacy of a pasture sward containing >30% plantain as a GHG mitigation option at paddock scale (2.5-3 ha) on a year-round rotationally grazed commercial dairy farm in the Waikato region of New Zealand. Utilising eddy covariance measurements of CO_2, N_2O and CH_4 coupled to farm management records, N_2O, carbon (C) and GHG balances (sign convention: positive value = emission to the atmosphere) were calculated for two adjacent paddocks – a control paddock containing an existing ryegrass/clover sward (RC), and a paddock that underwent renovation with the establishment of a ryegrass/clover/plantain sward (RCP). Establishment of RCP was via spraying and direct drilling and occurred in March 2018 (autumn). For the establishment period between initial herbicide application and the first grazing of the new RCP sward 66 days later, N_2O emissions were 2.58 kg N ha^{-1} compared with 1.69 kg N ha^{-1} for the RC paddock. During the same period, C losses from the RCP paddock were greater than from the RC paddock (2.40 t C ha^{-1} for RCP and 1.29 t C ha^{-1} for RC) primarily due to reduced photosynthetic inputs associated with the herbicide application. The GHG budget (including enteric methane emissions from feed grown and eaten in the paddock) during the 66 day establishment period was an emission of 6.56 t CO_2-eq ha^{-1} for RC and 9.85 t CO_2-eq ha^{-1} for RCP. Unfortunately, the RCP sward establishment was poor, and after one year, total pasture production was unexpectedly lower than RC. Additionally, plantain accounted for <7% of the total RCP dry matter production. N_2O, C and GHG balances for RCP in the first year following (and including) establishment were 6.61 kg N ha^{-1} y^{-1}, 3.25 t C ha^{-1} y^{-1} and 21.40 t CO_2-eq ha^{-1} y^{-1} respectively, while for RC they were 7.21 kg N ha^{-1} y^{-1}, 0.95 t C ha^{-1} y^{-1} and 13.29 t CO_2-eq ha^{-1} y^{-1}. Due to the poor establishment of plantain, any N_2O and GHG benefits of this species were unable to be initially concluded, but additional plantain was sown and measurements are ongoing. However, we did identify several relevant findings: any N_2O/GHG benefits of plantain must firstly offset emissions (including C losses) associated with the establishment of the sward (>3 t CO_2-eq ha^{-1} in this study), and furthermore, there is a risk that should the establishment be poor, GHG emissions can be considerably greater (and pasture production lower) than an existing pasture.