Irish grassland: feedstock for a green biorefinery application

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Introduction 'Green Biorefinery' (GRB) is a novel alternative use of grass biomass. It is an integrated refinery concept using green biomass (pasture) as raw material, splitting it into **press cake** (solid fibre fraction) and **press juice** (liquid fraction). For GRB, there needs to be a thorough understanding of the relationship between the quality (desired fraction content) of the end product and grass biomass and composition (Grass, 2004). The aim of this paper is to assess the effects of botanical composition, nitrogen application and phenological growth stage on the presscake fraction yields (NDF, ADF), for a GRB application.

Material and methods Field trials were established on six commercial farms around the country, Wexford (52º N, 6º W), Cork (52º N, 8º W), Offaly (53º N, 7º W), Roscommon (53º N, 8º W), Monaghan (53º N, 6º W), and Fermanagh (52º N, 8º W). Sites were cleared off each year in March. At each of the six sites, three annual nitrogen treatments (225, 90, 45 kg ha^{-1} yr^{-1}) as CAN were applied to plots (2.5 × 2.0 m) in four replications; a blanket dressing of phosphorus (30 kg ha^{-1} yr^{-1}) and potassium (120 kg ha^{-1} yr^{-1}) was applied as 0:7:30. A two cut silage system was implemented (May /June, July/Aug.). A strip cut from each plot using an Agria (Haag, Germany) was used to determine plot yield. Grass cores were taken from each plot and were sub sampled for determination of DM concentration (dried at 100 °C overnight). Chemical analysis was conducted on the sub samples dried at 40 ºC for 48 h and ground through a 1-mm screen using a hammer mill. Samples were analysed for neutral detergent fiber (NDF) and acid detergent fiber (ADF) (Van Soest, 1963). The yields of the presscake fractions (NDF, ADF) were determined as the product of the mass fractions and the dry matter yields, summed over the two harvests to give annual fraction yields. Another sub sample of the harvested grass was taken from each plot, sorted into individual grass species, and analysed for relative abundance within the harvested sward. The growth stage was also assessed for the individual species (Moore *et al.*, 1991). Species found included *Lolium perenne* (Lp), *Poa spp*. (Poa), *Agrostis stolonifera (*As), *Holcus lanatus* (Hl), *Trifolium repens* (Tr), *Rumex obtusifolius* (Rumex) and *Ranunculus repens* (Rr).

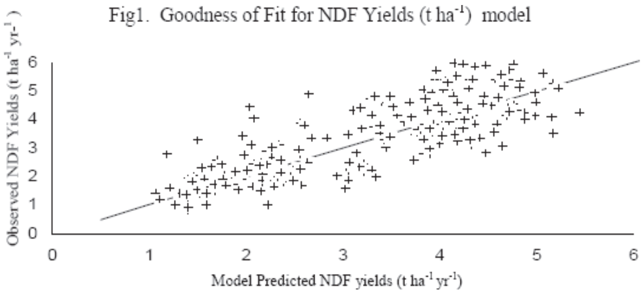
Statistical analysis The diversity-interaction modelling approach (Kirwan *et al*., 2009) was used to estimate the effects of species interactions on the herbage chemical composition. The fixed effects included botanical composition (the proportions P_i of the i^{th} species), species interactions (specified as P_iP_j among the i^{th} and j^{th} species), nitrogen application (*N*), soil and climatic variables (*C*) and growth stage at cutting (*GS*). The form of the fixed effects model for each fraction yield (*FY*) was:

$$FY = \sum_{i=1}^{s} \beta_i P_i + \sum_{\substack{i,j=1 \\ i<j}}^{s} \delta_{ij} P_i P_j + \alpha N + \lambda_k C_K + \phi\, GS$$

Where species within a functional group [grass (Lp, Poa spp., As. Hl) and forbs (Tr, Rumex, Rr)] were found to perform in a similar manner, the species coefficients were combined to give a composite functional group coefficient. A linear mixed model (LMM) was fitted to account for repeated measures. Model fitting was conducted for both the fixed and random effects, and the model of best fit was determined for each chemical component using Akaike's Information Criterion (AIC). The compound symmetric random structure was the best fit for the random model of the fibre fractions. The final models presented are those that gave the lowest AIC value. All models were fitted using MIXED procedure in SAS (v. 9.1).

Results Figure 1 shows the goodness of fit for the fiber yield (NDF) model. The individual species contributed significantly to presscake yields (NDF/ADF). The grass functional group interaction with N (grass × N) rate was highly significant (*P<0.0001*) for increasing the fibre yields, indicating that fibre yield from grasses responded more rapidly to N fertilisation than fibre yield from forbs. The grass functional groups interaction with average daily rainfall reduced the fibre yields (NDF: *P* = 0.0121; ADF: *P* = 0.0312). The effect of the As interactions within the sward (*P* = 0.0233) was significant for increased fibre (NDF) yields. The growth stage of Lp at time of harvest also increased the ADF yields (*P* = 0.0325).

Fig1. Goodness of Fit for NDF Yields (t ha^{-1}) model



Conclusions The results of the field trials suggest the interaction effect of *A. stolonifera* with the other species in the sward, the phenological growth stage of *L. perenne* and nitrogen are favourable for producing higher fibre yields. These are important sward management factors for GRBs' interested in increasing the harvestable fibre in the biomass for applications such as insulation material.

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