The Addition and Cessation of Inorganic Fertiliser Amendments in Long-Term Managed Grasslands: Impacts on Above and Below-Ground Communities

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The addition and cessation of inorganic fertiliser amendments in long-term managed grasslands: impacts on above and below-ground communities

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Introduction In recent times, land use in the United Kingdom has undergone considerable changes because of social and economic pressures, leading to a fine balance between the demands of highly productive intensive systems and practices which are perceived to be more environmentally acceptable. Plant productivity is governed by the supply of nutrients from the soil, which in turn is dependent on the dynamics of organic matter decomposition driven by soil micro-, meso- and macro fauna. Considerable information is available concerning the impact of inorganic fertiliser additions on communities of macro-fauna and flora, but the effects on specific microbial communities in soils are less clear. The effects of withholding inorganic nitrogen (N) are much less studied. The present study investigated the impact on plant and soil communities of either adding or with-holding N from long-term managed plots.

Materials and methods Soils (poorly drained silty clay loam of the Hallsworth series) were sampled from the Rowden long-term experimental site at the Institute of Grassland and Environmental Research, North Wyke Research Station, Devon in S.W. England. These were grazed swards that had been under long-term pasture for the previous 50 years and under experimental management for 15 years. Nitrogen fertiliser applications of 0 to 200 kg N/ha had been applied during this period and in the last two years additional treatments were introduced so that some previously unfertilised plots were treated with 200 kg N/ha and vice-versa. Botanical composition of the treatments was assessed visually and scored on a percentage scale. Soil samples were taken from each plot and analysed for the following characteristics. Soil microbial communities were determined through both phospholipid fatty acid (PLFA) and DNA-molecular profiling. Total direct bacterial counts and fungal hyphal lengths were determined microscopically. Soil nematode communities were described by trophic composition and by ecological indices based on proportions of five groups on the coloniser-persister scale. To represent soil mesofauna, soil collembola and mite communities were assessed by extracting the animals from the soil using a Tullgren funnel apparatus, individuals were assigned to morphotypes. Microbial PLFA, nematodes, mesofauna and plant data were statistically analysed using PCA and microbial DNA-molecular profiles by PCO. To establish the weight of impact of either adding or withholding N fertiliser to respective plots numerical distances were determined on all groups using canonical variance analysis.

Results and discussion Plant community composition was significantly different between the long-term fertilised and unfertilised plots. The addition of N to previously unfertilised plots had a significant impact on botanical composition whereas withholding N from the long-term fertilised plots had no significant effect. Total bacterial counts (typically about 10^8/g soil) and bacterial PLFAs were generally higher in those plots which were unfertilised, and bacterial molecular profiles were different between all treatments. Fungal hyphal lengths were highly variable between treatments, typically ranging from about 7–17 m/g soil, and were not significantly different. However, the amount of fungal PLFA 18:2ω6 was highest in the long-term unfertilised and lowest in the long-term fertilised treatments. For total microbial PLFAs, withholding N had a slightly larger effect than adding N. Faunal community composition was significantly different between the two long-term treatments. Numbers and diversity indices of mites and nematodes showed little change in response to a shift in fertiliser regime, however, greater numbers of collembola were supported in those soils that currently received N in both long-term background treatments.

Conclusions Whilst confirming the findings of previous studies reporting the impact of N addition on plant, micro- and mesofauna community compositions, a significant finding in this study was the impact of withholding N fertiliser on the composition of soil communities. It is not clear whether the effects seen were a result of the direct impact of inorganic N management on specific communities or the consequences of a series of trophic interactions. This may have implications for organic conversion, sustainability and restoration of previously managed grasslands.

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