Grassland diversity enhances productivity at low and high levels of nitrogen addition

T. Carnus [1,3], J.A. Finn[1], L. Kirwan [1,2] A. Cuddihy [1] and J. Connolly [3]
[1] Teagasc Environment Research Centre, Co. Wexford, [2] Eugene Lawler Graduate School of Computing, WIT, Co. Waterford, [3] Environmental and Ecological Modelling Group, School of Mathematical Science, UCD, Dublin 4. E-mail: tim.carnus@teagasc.ie

Key words: Biodiversity, Grassland productivity, Nitrogen fertilisation

Introduction A central theory of ecology postulates that ecosystem processes in more diverse ecosystems are more stable than in less diverse ones, especially when environmental changes occur. Thus, diversity can provide insurance for some ecosystem function responses, such as biomass production (Yachi & Loreau, 1999). This study quantifies the contribution of species identity and evenness to biomass production in mixed grassland systems under different N addition regimes.

Material and methods A split-plot field experiment was established in autumn 2006. The main plot treatment varied plant diversity and the split-plot treatment varied nitrogen (N) application (+ 155 kgN/ha/yr). All plots received a total of 45 kg/ha/yr N in two applications and were harvested 3 times in 2007. Plant community composition consisted of two grasses (G1: *Lolium perenne* and G2: *Phleum pratense*) and two legumes (L1: *Trifolium pratense* and L2: *Trifolium repens*) sown at proportions defined within a simplex design. Thus, evenness (E), a measure of the distribution of the relative abundance of species in a community, was varied (Kirwan *et al.*, 2007). The basic design consisted of 4 monocultures (E=0), 6 two sp.-mixtures (E=0.67) and 18 four sp.-mixtures dominated in turn by each species (88:4:4:4, E=0.29 and 70:10:10:10, E=0.64), by pairs of species (40:40:10:10, E=0.88) and equally represented at the centroid (25:25:25:25, E=1). The design was repeated at two levels of overall initial abundance (low being 60% of high). Total yield was analysed as a function of species identity and evenness (Kirwan *et al.* 2007) using linear mixed models to account for the split plot random effects. Likelihood Ratio Tests (LRT) were used to identify significant terms in the model. Analyses were performed in R (version 6.0).

Results and discussion Both evenness (LRT $\chi^2_1=7.81$; $P=0.005$) and N addition (LRT $\chi^2_1=47.68$; $P<0.001$) had significant and positive effects on total yield (Figures 1 and 2). There was a linear relationship between yield and evenness, which was maximum at the centroid where estimated yield was 1.63 t/ha more than expected from monoculture yields. The interaction between N treatment and evenness (N*E) was not significant (LRT $\chi^2_1=0.91$; $P=0.341$). The positive overall effect of N addition depended on the increase in yield of the two grass species (average increase of 1.14±0.14 t/ha in monocultures at high N level; Figure 2).

Unlike other similar studies (Kirwan *et al.*, 2007) transgressive overyielding did not occur; mixtures (E>0) did not consistently yield higher biomass than the best-performing monoculture (Figures 1 and 2). The centroid yield at the low level of N addition was comparable to the yield of the best-performing monoculture at the high N level.

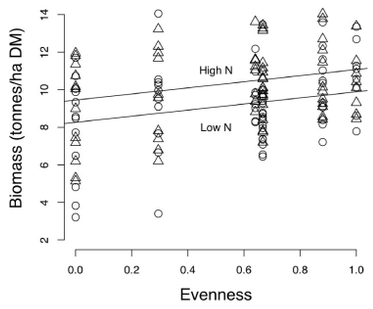

Figure 1 *Total yield at different levels of sown evenness. Lines represent high (triangles) and low (circles) levels of N addition.*

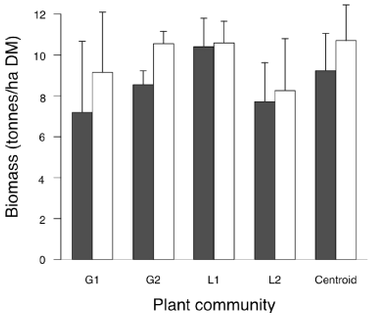

Figure 2 *Mean (+sed) yield of species in monoculture and at the centroid (dark grey: low N; light grey: high N).*

Conclusions These results indicate benefits of using agronomic mixtures in managed grasslands under high and low levels of N addition. The positive effect of evenness at both high and low levels suggests that the diversity effect was not solely due to symbiotic N fixation. Other benefits of grassland mixtures will be investigated, and include stability of yield over time and resistance to weed invasion.

References

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