Catch-up in response to elevated CO_2 – a study of genotypes of 12 grassland species

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Introduction Differential growth enhancements for species or genotypes under elevated CO_2 can lead to changes in the composition of plant communities. Under a Rich-get-richer hypothesis, species that constitute a large proportion of a community (the dominants) will increase their dominance at elevated CO_2 (Bazzaz and Garbutt, 1988). Under the alternative Catch-up hypothesis the smaller components of communities will benefit proportionately more than dominants from elevated CO_2 conditions (tested at the level of individual plants in a monoculture in Wayne and Bazzaz, 1997). A recent review (Poorter & Navas, 2003) provided no evidence for differential growth enhancements by dominant or subordinate species. We examine this question at the genotype level for genotypes of 12 grassland species.

Materials and methods The data are from a study on the effects of CO_2 enrichment on genotypes within plant species (for details see Luescher *et al*., 1998). Twelve native perennial species from 3 functional groups Grass (*Lolium perenne, Lolium multiflorum, Arrhenathecult elatius, Dactylis glomerata, Festuca pratensis, Holcus lanatus, Trisetum flavescens*), Non-Legume Dicotyledon (*Rumex obtusifolius, Rumex acetosa, Ranunculus friesianus*) and Legume (*Trifolium repens, Trifolium pratense*)) were grown in a FACE system. A maximum of 14 genotypes were selected for each species. Three replicates of each genotype were grown at both ambient (350 p.p.m.) and elevated (600 p.p.m.) CO_2 levels. The genotypes were grown in competition with a background matrix of the grass species *Lolium Perenne*. Harvests were taken 3 times a year for 3 years with yields for the first harvest not included in the analysis. A Structural Relationship model (Kendall & Stuart, 1979), fitted by Maximum Likelihood, was used to discriminate between the hypotheses. The model for each species was $E(z_{aij}) = \mu_{ai}$ and $E(z_{eij}) = \mu_{ei} = \alpha + \beta\mu_{ai}$, where z_{aij} and z_{eij} are the logarithm of the yield of the jth replicate of the i^{th} genotype at ambient (a) and elevated (e) CO_2 level respectively and β is the slope of the structural relationship. A value of $\beta < 1$ supports the Catch-up hypothesis and a value > 1 supports the Rich-get-richer hypothesis.

Results The majority of species-harvest combinations support the Catch-up hypothesis ($\beta < 1$), in most cases significantly so (Table 1). Nine species have a majority of species-harvest combinations supporting this hypothesis with 3 species showing complete support. Two species (*Festuca pratensis* and *Rumex obtusifolius*) have a majority of species-harvest combinations supporting the Rich-get-richer hypothesis. There was a general decrease in the average slope (β) over the 3-year period.

Table 1 Number of species-harvest combinations supporting the two hypotheses

Supporting	Significant	Non-Significant	Total*
Catch-up ($\beta < 1$)	48	17	65
Rich-get-richer ($\beta > 1$)	2	25	27

*Four combinations were excluded due to missing values

Conclusions For several species there is support for the Catch-up hypothesis. If this occurred within a community consisting solely of genotypes of a species, the composition would shift in favour of the subordinate genotypes under elevated CO_2 conditions.

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