Higher yield and fewer weeds in four-species grass/legume mixtures than in monocultures: results from the first year at 20 sites of COST action 852

L. Kirwan (Ireland)[1], G. Bélanger (Canada), J. Finn (Ireland), M. Fothergill (UK), B. Frankow-Lindberg (Sweden), R. Garcia-Sarrion (Spain), A. Ghesquiere (Belgium), P. Golinski (Poland), A. Helgadóttir (Iceland), M. Jørgensen (Norway), Z. Kadžiuliene (Lithuania), D. Nyfeler (Switzerland), P. Nykänen-Kurki (Finland), G. Parente (Italy), V. Vasileva (Bulgaria), R. Collins (UK), J. Connolly (Ireland), A. Lüscher (Switzerland), C. Porqueddu (Italy) and M.T. Sebastià (Spain)

See the authors' affiliations at http://www.COST852.com [1]*Email: Laura.Kirwan@ucd.ie*

Keywords: grass / legume mixtures, forage yield, invasion, simplex design

Introduction Utilisation of grass/legume mixtures instead of grass monocultures is a sensible alternative for low input, efficient agricultural systems that reduce production costs, promote environmental policy and maintain a living countryside. Consequently, widely adapted forage legumes will become increasingly important. Instability of simple grass / legume mixtures with only one grass and one legume species is a major problem (Wachendorf *et al*., 2001). An experiment was established in 39 sites in Europe, Australia and Canada within COST Action 852 to: (1) assess the benefits of grass / legume mixtures in terms of forage production, (2) test whether the combination of fast and slow-growing species improves the stability of the mixtures and (3) assess response patterns over a large environmental gradient.

Materials and methods The experiment consisted of 30 plots, each sown with a mixture of varying proportions of 2 grass and 2 legume species, or a monoculture of one of the 4 species after a simplex design (Cornell, 1990). The design was duplicated at 2 sowing densities (100 and 60 %). One species of each functional group was fast- and the other was slow-growing. Results from year 1 were analysed from 20 sites covering a North-South gradient from Iceland to Spain. Data were available only for the first harvest in 5 of the sites. Three mixture types were tested: North European (NE), Central European (CE) and Mediterranean (Med). The swards were managed according to local farming practices.

Results and Discussion The mean yield of mixed plots was compared with the mean for monoculture plots for the total yield for year 1 in 20 sites (Table 1). The averaged monocultures never performed better than the averaged mixtures and the average yield of the mixed plots was significantly greater than the average yield of the monoculture plots in 12/20 sites. The average percentage unsown species for year 1 in mixed plots was lower than in monoculture plots for 19/20 sites, significantly so in 15 sites. This suggests the existence of synergistic yield effects among the sown species and greater resistance to invasion by unsown species in the mixtures.

Conclusions: The results of year 1 suggest that mixing forage species from different functional types, grasses and legumes, enhances productivity and decreases the proportion of unsown species. The observed advantages of the mixtures were consistent for most sites, and the results are assumed to be reliable due to the broad gradient considered in this study.

Table 1 Ratio of Mixed / Mono for total yield and % unsown at 20 sites for the first year after establishment

Country	Total		% Unsown			
	Mix/Mon	Sig	Monoculture	Mix/Mon	Sig	
CE	1.4	<0.001	8.8	0.26	<0.001	
CE	1.4	<0.001	10.4	0.28	<0.001	
CE	1.3	0.011	15.9	0.12	<0.001	
CE	1.4	<0.001	33.1	0.50	<0.001	
CE	1.3	0.002	33.7	0.59	0.004	
CE	1.65	0.002	38.7	0.07	<0.001	*
CE	1.0	NS	45.2	0.72	0.006	
CE	1.1	NS	67.1	0.72	0.076	
CE	1.2	<0.001	2.5	0.50	NS	*
CE	1.0	NS	64.5	1.05	NS	
CE	1.0	NS	80.5	0.85	NS	
Med	1.72	<0.001	33	0.92	NS	
Med	1.97	<0.001	29.6	0.03	<0.001	
Med	1.0	NS	71.3	0.66	0.023	
Med	1.4	NS	68.4	0.58	0.008	
Med	1.2	NS	54.9	0.54	0.007	*
NE	1.3	<0.001	40.6	0.15	0.001	
NE	1.3	<0.001	38.5	0.15	<0.001	
NE	1.45	<0.001	30.4	0.33	0.001	*
NE	1.08	0.065	93.1	0.91	0.004	*

Results for sites marked * were for the first harvest

References

Cornell, J. A. (1990). Experiments with Mixtures: designs, models, and the analysis of mixture data, 2nd ed. John Wiley & Sons, New York, 632 pp.

Wachendorf, M., R. P. Collins, A. Elgersma, M. Fothergill, B. E. Frankow-lindberg, A. Ghesquiere, A. Guckert, M. P. Guinchard, A. Helgadottir, A. Lüscher, T. Nolan, P. Nykänen-kurki, J. Nösberger, G. Parente, S. Puzio, I. Rhodes, C. Robin, A. Ryan, B. Stäheli, S. Stoffel, F. Taube & J. Connolly (2001). Overwintering and growing season dynamics of *Trifolium repens* L. in mixture with *Lolium perenne* L.: A Model Approach to Plant-Environment Interactions. *Annals of Botany,* 88: 683-702