Macro Mineral Concentrations of Five Contrasting Temperate Grassland Species Grown in Pure Stands or Mixtures

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Introduction

Mixtures of grassland species often results in over-yielding (Finn *et al*., 2013). This may be due to complementarity in traits above- and below-ground. Here I report the concentrations of macro minerals in five grassland species grown as pure stands or in mixtures in a field fertilized with moderate amounts of nitrogen (N).

Materials and Methods

A field experiment was established at Svalöv, Sweden (55° 55’N, 13° 07’E, 55 m a.s.l.), in June 2007. The climate is cool–temperate with an annual mean temperature of 7.7 °C and annual mean precipitation of 700 mm. The soil at the site was a sandy loam with a pH of 5.8 containing 2.0% organic matter, 99 mg available phosphorus (P) kg^{-1}, 87 mg potassium (K) kg^{-1}, 40 mg magnesium (Mg) kg^{-1} and 1760 mg calcium (Ca) kg^{-1}. The experimental plot received 42 kg phosphorus and 150 kg K ha^{-1} at sowing (2007), and 45 kg K and 6 kg sulphur (S) ha^{-1} each harvest year. In the harvest years, 100 kg N ha^{-1} yr^{-1} was applied in split dressings to each harvest. The plots were mowed three times in 2008 and four times in 2009. The species used were selected based on their contrasting functional traits and were combined in two different four-species mixtures. All mixtures contained two grasses differing in competitive ability, namely, *Lolium perenne* L. (cv. Birger, competitive) and *Phleum pratense* L. (cv. Ragnar, non-competitive), and one legume, namely, *Trifolium pratense* L. (cv. Vivi), all having a shallow root system. The fourth component was a deep-rooted forb, either *Cichorium intybus* L. (cv. Grasslands Puna) or another legume, namely, *Medicago sativa* L. (cv. Pondus). The experimental setup consisted of 48 communities. Thirty communities followed a simplex design (Cornell, 2002) with four pure stands of *P. pratense*, *L. perenne*, *T. pratense* and *C. intybus*, and 11 mixtures of these four species all sown at two densities. In addition, 18 communities followed a simplex design using *M. sativa* instead of *C. intybus* (*i.e*. four pure stands of *P. pratense*, *L. perenne*, *T. pratense* and *M. sativa*, and five mixtures of these four species all sown at two densities). In total, 48 plots were arranged in a completely randomized design, with an individual plot size of 17 m^2. Whole plots were cut to a stubble height of approx. 7 cm with a Haldrup plot harvester. Samples for the analysis of dry matter (DM) yield and botanical composition were taken from the accumulated biomass on each mowing occasion. The botanical samples were sorted to species, dried and weighed. The sown fractions from all harvests were ground per species to pass through a 1 mm screen, sub-sampled by riffle splitting, ball milled, and finally analyzed for Ca, K, Mg, P and S. The data were evaluated for each species as completely randomized repeated-measures ANOVAs according to the model: Y = monomix + type + dens + year + ε augmented with terms for interactions. Y was, in turn, the concentration of each macro mineral, MONOMIX was a variable set to 0 for pure stands and to 1 for mixtures, type denotes mixture type, DENS denotes the sowing density and YEAR denotes the harvest year. TYPE, DENS and YEAR were all included as fixed factors. There was no need for transformations of any of the data. All repeated-measures analyses were carried out using the mixed procedure in SAS/STAT software, version 9.1 (SAS Institute Inc., Cary, NC). Based on the Akaike information criterion, the most appropriate covariance structure (*i.e*. unstructured, compound symmetry, autoregressive, or Toeplitz) for each response variable was used to describe the time dependence among harvests. The significance of each variable was evaluated using type III F-tests.

Results and Discussion

There were no significant effects of sowing density or mixture type on the concentrations in any of the species. In some species the concentrations differed significantly between years, which probably were a response to the difference in mowing frequency between the two years, and thus differences in maturity at harvest. With the exception of S concentrations of *T. pratense* and *P. pratense*, the concentrations of all macro minerals were in the normal range for all species (Whitehead, 2000). *L. perenne* had significantly higher concentrations of K, Mg and P in mixtures compared to pure stands, while the concentrations of *P. pratense* did not differ with stand type (Tab. 1). The two deep-rooted forbs had significantly higher concentrations of Ca and Mg when grown in mixtures compared to pure stands. The two legume species had significantly lower concentrations of S when grown in mixtures compared to pure stands, while *T. pratense* also had significantly lower concentrations of Ca, Mg and P when grown in mixtures compared to pure stands.

Table 1: Concentrations (% of dry matter) of Ca, K, Mg, P and S in five temperate grassland species grown in pure stands or mixtures. Mean values over all harvests and over the two mixture types. Data for P. pratense are from 2009 only. Figures with different superscript are significantly different, will all comparisons made between mixtures and pure stands for each species.

Species	Ca		K		Mg		P		S	
	Pure	Mix	Pure	Mix	Pure	Mix	Pure	Mix	Pure	Mix
L. perenne	0.42^a	0.45^a	2.6^a	3.0^b	0.12^a	0.13^b	0.29^a	0.35^b	0.20^a	0.21^a
P. pratense	0.32^a	0.33^a	2.4^a	2.4^a	0.09^a	0.10^a	0.29^a	0.31^a	0.16^a	0.17^a
T. pratense	1.79^a	1.69^b	2.2^a	2.4^a	0.27^a	0.26^b	0.32^a	0.29^b	0.18^a	0.17^b
M. sativa	1.48^a	1.64^b	2.7^a	2.3^a	0.19^a	0.20^b	0.29^a	0.27^a	0.21^a	0.20^b
C. intybus	1.42^a	1.76^b	3.5^a	3.6^a	0.20^a	0.26^b	0.40^a	0.40^a	0.28^a	0.34^b

The results suggest that root morphology is important for the uptake of macro minerals, and that there may be differences in species' root traits within functional groups. Thus *L. perenne* generally had higher concentrations of macro minerals in mixtures, but the grass species P. pratense did not. Further, the two deep-rooted species' took up more of the minerals Ca and Mg in mixtures than in pure stands. However, this appears to have taken place at the expense of the shallow-rooted legume *T. pratense*. Moreover, both legumes had lower S concentrations in mixtures than in pure stands, while the opposite was true for *C. intybus*. This suggests that interactions among species nutrient uptake was most important in the surface horizon of the soil. Similar results have been reported by von Felten and Schmid (2008).

Conclusion

It is concluded that both synergy and competition for macro minerals may take place in grassland crops grown in fertile soils.

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