Mixed cultures, a sustainable way to accelerate phytomining of rare earth elements, is there a future here?

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Background

- Mixed culture cropping systems play an important role in improving nutrient supply by mobilizing elements in at least one species' rhizosphere, making these elements accessible to the neighbouring species.
- *Lupinus angustifolius* (narrow leaf lupin) is also one of the species known for releasing high carboxylates, which can also then be accessed by other elements
- Even though the addition of P-fertilizer may increase P in the soil, it is not readily available for plant uptake, lupines release carboxylates which mobilize P into the rhizosphere to increase bioavailability.

Aims

- Investigation of the influence of fertilizer (Phosphate as a treatment) on the accumulation of REE
- To investigate effect of mixed cultures on the effect of the availability of REE in barley
- To investigate the distribution of REE within plant compartments (Stems and Leaves)

Methods

Monoculture: Barley (L0)
Mixed Culture: Barley + 11% narrow leaf lupine (Lan11)
Barley + 33% L.angustifolius (Lan33)

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Treatment:
3 g N m^{-2} as NH_4NO_3,
1 g P m^{-2} as KH_2PO4,
5.6 g K m^{-2} as KH_2PO_4 and K_2SO_4

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Analysis of REE by ICP-MS from stems and leaves

Results and Discussion

Effect of Mixed Cultures on LREE and HREE enrichment in stems and leaves of Barley

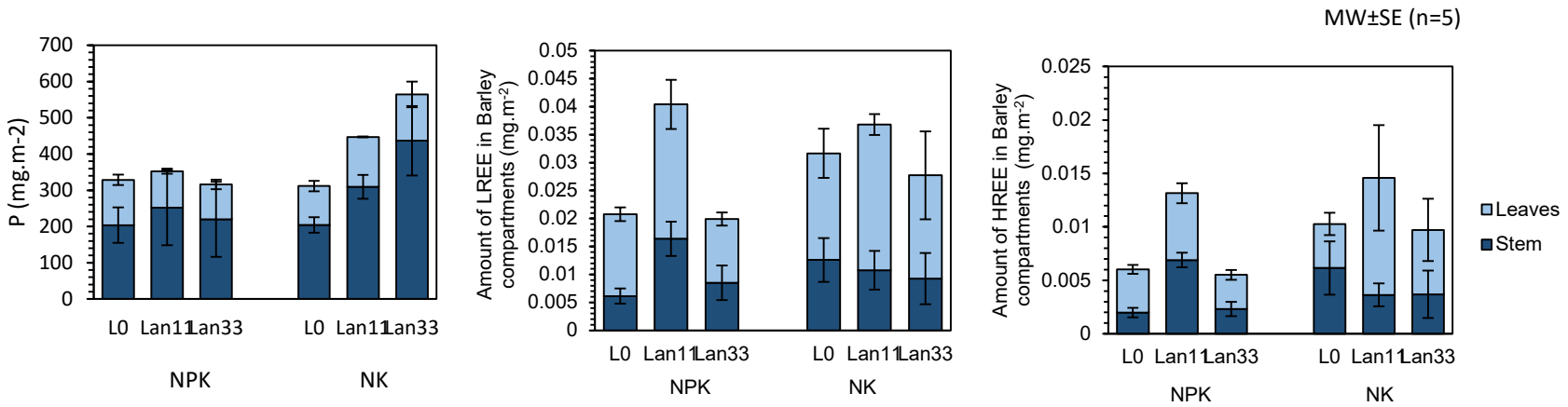

Table 1: Fertilizer and Mixed Cropping Effects on carboxylates in Lupine

Species	P +/- [-]	DW root [g]	DW shoot [g]	Citrate	Tartrate	Malate	Fumerate
				[nmol · (g · h)$^{-1}$]			
L. angustifolius	P+	0.16	0.76	19578.4	308.03	5756.03	120.33
	P-	0.175	0.59	7843.7	184.82	2069.95	0
F-value		0.92	0.22	0.87	2.29	0.67	0.6
p-value		0.92	0.67	0.42	0.23	0.47	0.0001

Conclusion

- Intercropping with 11% narrow leaf lupin enhances the availability of REE to barley
- P-acquisition strategies of *L.angustifolius* increases P availability to neighbouring species that are less P-efficient.
- P-fertilizer increased the overall accumulation of both LREE and HREE
- Higher amounts of REE mostly in leaves
- Although carboxylates increase at the addition of inorganic P, there is no consistent relationship between the P in barley shoots and the exudates patterns observed in L. angustifolius.

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