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Phytoextraction of phosphorous to enhance nature restauration in a brook valley

Results from an 8-year experiment in Roeghoorn Drenthe (NL)

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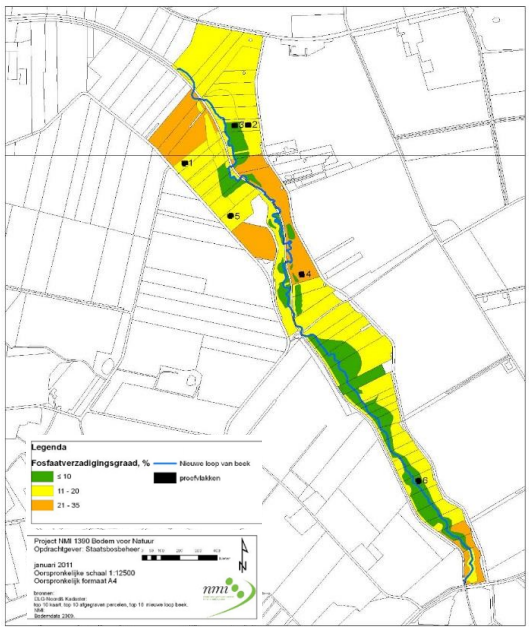
Experimental setup

Plot	Soiltype	topsoil removed	Fertilisation (kg/ha/yr)	# mowing/yr	Actual soil P level
1a	Poor sand	No	None	3x	High
1b		No	300 N and 380 K2O	3x	High
2a	Loamy fine sand	No	None	3x	Average
2b		No	300 N and 380 K2O	3x	Average
3a	Poor sand	Yes	None	3x	Average
3b		Yes	300 N and 380 K2O	3x	Low
4a	Peat on sand	No	None	2x	Low
4b		No	220 N and 280 K2O	2x	Low
5a	Sand on peat on	No	None	2x	Low
5b	loam	No	220 N and 280 K2O	2x	High
6a	Sand on	Yes	None	2x	Low
6b	peat/peaty clay	Yes	220 N and 280 K2O	2x	Low

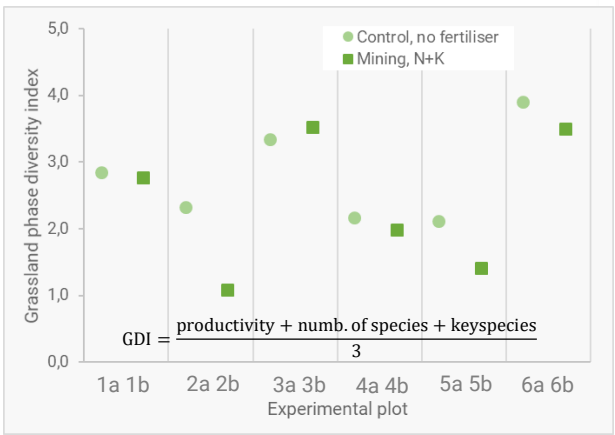


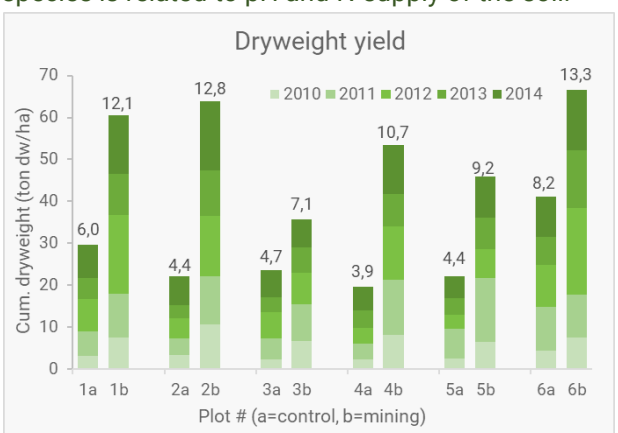
Measurements in each experimental plot (N=12):

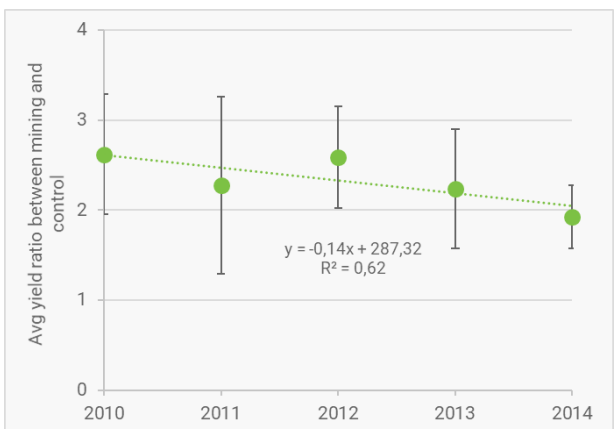
- Crop yield and N, P, K removal: 2010 - 2014 (N=5)
- Soil 0-10 cm: 2010 - 2014 and 2017 (N=6)
- Soil 0-10, 10-30, 30-50: 2011, 2014, 2017 (N=3)
- Watertable: each month 2010 – 2014
- Vegetation 2010 and 2014

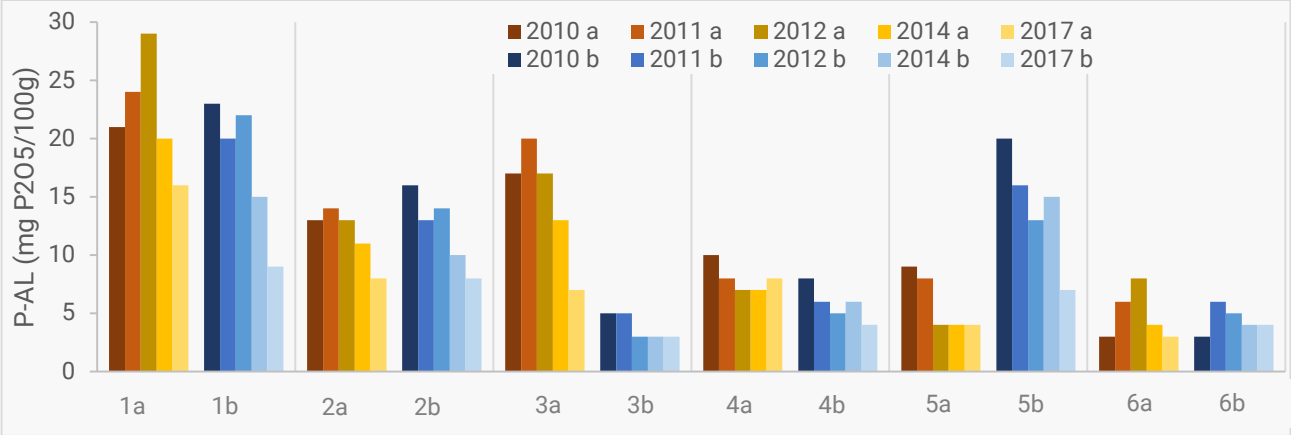
Results crop response

Dryweight yield increases on average a factor 2 – 2,5 between fertilisation with N and K and no fertilisation. The effect depends per plot. In plot 3 the difference is smallest due to P-limitation after topsoil removal. In 2011 yield is lower due to cold weather conditions. Dryweight production is highest on the most moist conditions of plot 6, especially clear for the control. Over time effectiveness phytoextraction decreases slightly. The grassland diversity index shows the highest diversity at location 3 and 6. Mining treatments only have a slightly lower GDI. Number of species is related to pH and N-supply of the soil.







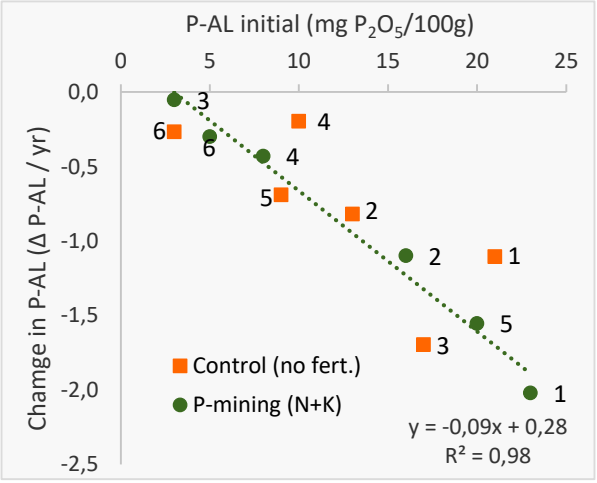


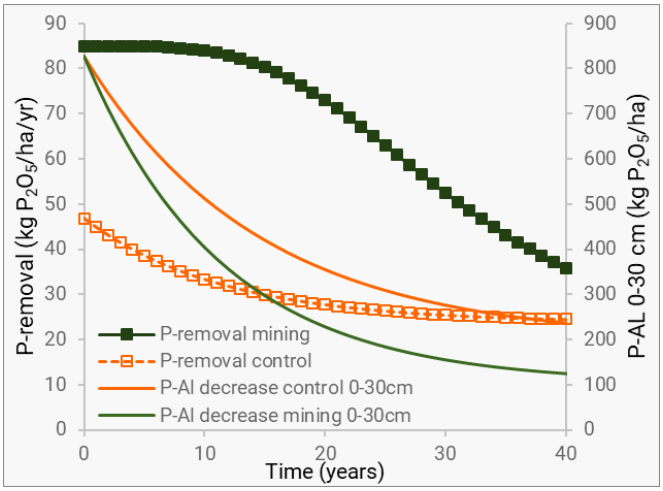
Soil phosphorus dynamics

Soil P removal rate is on average 2,7 (2010) to 1,6 (2014) times higher with N+K fertilisation than without. Exception is plot 3 where the initial soil P-level is so low it limits P-uptake in the mining treatment with N+K. The effect of N+K on P-removal decreases over time and this decrease is faster than for yield.
Removal rate is not only related to P in topsoil. In the dry locations (plot 1, 2) available P decreases with soil depth (0-50cm). For plot 3 and 4 P-AL is low over the whole 50 cm depth. For the wet locations P-AL increases with soil depth to values ranging from 20 to 30 mg P_2O_5/100g. Additional P is mobilised due to wet conditions (plot 5 and 6).
In all the plots, except plot 4, the total P reserves are relatively low (P-ox is 2 - 21 mmol P/kg) due to a low P-sorption capacity of the soil. In plot 4 the peat soil has a large sorption capacity and large P-reserves (+/- 45 mmol P/kg). Due to a relatively P-saturation the available P (P-AL) is low.
The change in available P (P-AL) over 8 years is linearly related to the initial P-AL. With N+K fertilisation the relationship is strongly linear (r^2=0,98). Without fertilisation available P also decreases but there is more variation depending on soil P-reserves (higher on plot 1 and 4). Change in plot 3 in the control is high because both P-reserves and P in soil profile are low.

Conclusions

- Phytoextraction of P leads to higher drymatter yield (2 - 2,5x), higher P-removal rates (1,6 – 2,7x), a faster decrease in available soil P levels and a lower final soil P level.
- Effectiveness of phytoextraction compared to no fertilisation depends on soil P reserves (P-ox) that can buffer the available soil P levels, the soil P adsorption capacity and the soil P levels in deeper soil layers that become available when hydrological setting is changed to wetter conditions.





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