

Grass/clover for phosphate mining on abandoned arable land

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Abstract

Abandoned arable land that is in conversion to nature conservation areas, often has an imbalance in regard to chemical, physical and biological soil fertility. A major problem on sandy soils is the high soil phosphate level, which inhibits the development of nature target types. The current management on abandoned arable land, aiming to impoverish the soil, leads to a depression in dry matter production and consequently inhibits the removal of phosphate. This is probably due to limited availability of nitrogen and potassium. To solve these problems, a grass/clover management is proposed including supplementary potassium fertilisation. In an experiment in both a one year old as well as a five years old sward, four levels of potassium were applied. Productivity and phosphate removal were measured. Results suggest that grass/clover management may indeed support phosphate mining.

Keywords: phosphate mining, abandoned arable land, grass/clover, potassium fertilisation

Introduction

In the Netherlands each year on average 6500 hectare of agricultural land is converted into nature conservation area. The national Nature Policy Plan is aiming at a total conversion area of 151.500 hectare in 2018 (Natuurcompendium, 2003). On abandoned arable land the chemical, physical and biological soil fertility is often unbalanced due to former intensive agricultural practices. In the short term, this coincides with dominant occurrence of ruderal species, like Broad-leaved dock (*Rumex obtusifolius*) and Creeping thistle (*Cirsium arvense*). In the long term the imbalance in chemical, physical and biological soil fertility is supposed to interfere with the development of target vegetation (Critchley *et al.*, 2002). In a survey Sival and Chardon (2002) collected evidence that the high levels of phosphate, occurring in almost all arable sandy soils in the South and the East of the Netherlands, inhibit this kind of development. Furthermore high phosphate levels may damage the environment because of leaching to the ground and surface water. The current management on abandoned sandy arable lands, aiming to impoverish the soil, includes sowing and cutting of a perennial grass sward. This management may however, not remove the high phosphate levels on these sandy soils. After some years the dry matter (DM) production of the vegetation will probably decrease due to a restricted availability of nutrients like nitrogen and potassium. The depressed DM production subsequently inhibits the phosphate mining. The current practice on sandy soil also seems to enhance noxious weeds like Ragwort (*Senecio jacobaea*) and also limits soil organisms that are important food items for birds and mammals (e.g. Blacktailed godwit, Curlew and Badger). Therefore specific management techniques might be necessary to remove phosphate from abandoned arable land and meanwhile safeguard the development of nature target types. Possibly the adoption of a grass/clover management may offer a solution in regard to both objectives. The grass/clover was planted with a seed mixture of grasses (*Lolium perenne*, *Pheum pratense*, *Festuca pratensis* and *Poa pratensis*) and clovers (*Trifolium repens* and *T. pratense*). The sward was cut rather intensively and received supplementary fertilisation in regard to nutrient (i.e. potassium) deficiencies. The objective of this research was to test the hypothesis that a grass/clover sward by means of nitrogen fixation and potassium fertilisation increases the phosphate removal ('mining') in nature reserves.

Material and methods

Experiments took place in 2001-2002 on two different locations in the National Park the 'Loonse and Drunense Duinen'. The soil consisted of coversands of pliocenic origin. The fields were formerly cropped with maize that was manured excessively by slurry. Location 1 was a grass/clover sown in 1997 ('old') and location 2 a recently established grass/clover ('young') (Table 1). Seed rate for both locations 30 kg ha⁻¹ grass mixture, 5 kg ha⁻¹ Red clover (*Trifolium pratense*) and 3 kg ha⁻¹ White clover (*Trifolium repens*).

Table 1: Soil characteristics of the two experiments in march 2002 (0-10 cm).

Location	Year Establishment Grass/clover	P-Al (mg P ₂ O ₅ 100 g ⁻¹ soil)	P-total (mg P ₂ O ₅ 100 g ⁻¹ soil)	K-HCl (mg K ₂ O 100 g ⁻¹ soil)	pH-KCl	Org.matter (%)
1 'old'	1997	135	186	3	5,5	2,4
2 'young'	2001	57	116	4	5,3	3,3

Both locations had the same randomised experimental design including four different levels of potassium fertilisation (0 %, 50 %, 100 % and 150 % of 480 kg K₂O per year) in four repetitions. The potassium treatments were performed on plots of 4 x 10 m. Plots were harvested simultaneously with the surrounding parcel; at location 1 this meant four times and at location 2 five times in 2002. Preceding each harvest plots were sampled in subplots of 6 x 1 m. Measurements of samples included: DM yield, Clover-yield and N-, P- and K-content. Statistical analyses were conducted using GENSTAT. Differences between potassium levels and locations were tested with ANOVA ($P < 0.01$).

Results

In old grass/clover the potassium levels of 50 %-150 % as compared to 0 % fertilisation, had significant ($P = 0.005$) positive effects on the clover fraction. No significant differences were observed between 50 %, 100 % and 150 % potassium level in regard to clover fraction over the year (Figure 1).

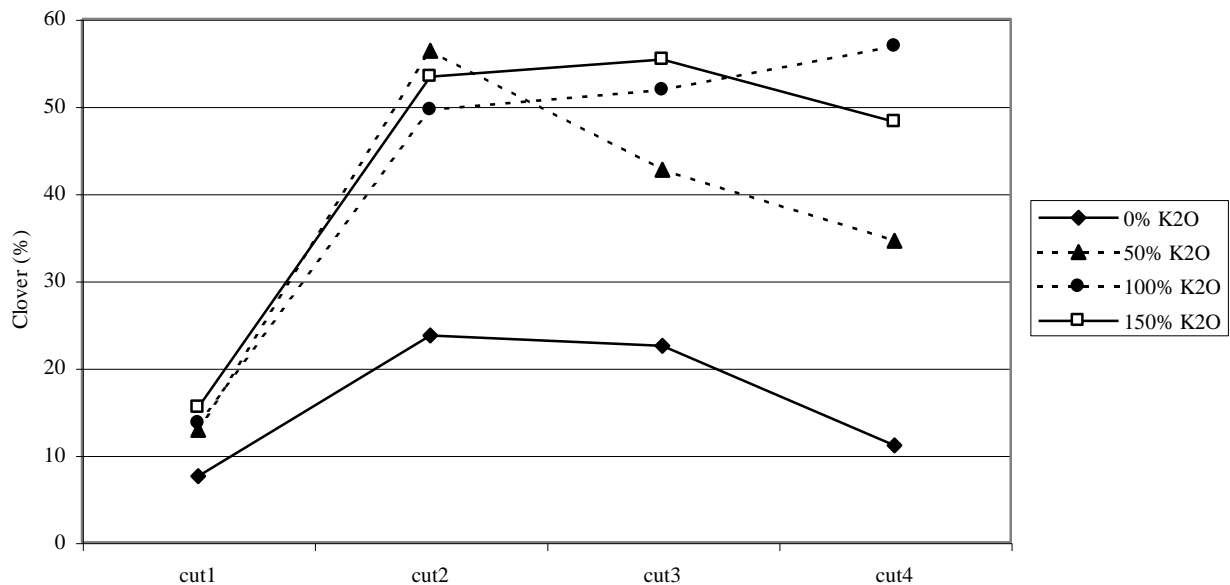


Figure 1: Effect of potassium fertilisation on clover fraction in 'old' grass/clover in 2002.

In the 'young' grass/clover no reaction was observed, despite the equally low level of potassium (Table 1). Without potassium supply the total DM yield on the 'old' grass/clover sward was 4.06 t ha⁻¹ (Table 2). As a result of potassium fertilisation the DM yield significantly increased with 66 percent to 6.76 t ha⁻¹. This related to an increase of phosphate removal of 48 %. In the 'young' grass/clover, however, the phosphates mining was much faster related to a higher total DM yield.

Table 2. Comparison of the results at a 'old' grass/clover and a 'young' grass/clover in 2002.

Potassium fertilisation ¹	'Old' grass/clover			'Young' grass/clover		
	0 %	100 %	s.e.d	0 %	100 %	s.e.d
Total DM yield (t ha ⁻¹)	4.06	6.76	0.47*	11.94	12.20	0.81 ^{n.s.}
Total clover yield (t ha ⁻¹)	0.57	2.62	0.27*	2.61	2.17	0.61 ^{n.s.}
Clover fraction (%)	14	39		22	18	
Nitrogen yield (kg N ha ⁻¹)	89	196	13.98*	345	347	20.1 ^{n.s.}
Phosphor yield (kg P ha ⁻¹)	21	31	2.59**	48	49	3.84 ^{n.s.}
Potassium yield (kg K ha ⁻¹)	60	192	13.66*	393	485	32.0***

¹ 0 % = 0 kg K₂O ha⁻¹, 100 % = 480 K₂O ha⁻¹

* $P < 0.001$, ** $P < 0.05$, *** $P < 0.1$, n.s. not significant

Discussion and conclusion

The results show that the concept of phosphate mining by grass/clover cultivation and potassium fertilisation can work. However on a 'young' grass/clover, the potassium fertilisation seems not to be necessary in the first year even when the potassium status of the soil is low. A possible explanation was found in the fact that the roots of a young grass/clover were better developed. The 'young' sward with less nitrogen deficiency was possibly also part of the reason for the difference in production between the 'old' and 'young' grass/clover. Besides that an 'old' grass/clover sward with an existing potassium deficiency in the plants, probably takes some time for the clover and the grass to recover and to produce on full strength. In the coming years the focus of this research will be on the degree of phosphate mining in the different soil layers, how this affects the botanical composition and the density of earth worms.

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