Multifunctional land use and its impact on the nitrate concentration in groundwater under grassland

Korevaar, H.*, Geerts, R.H.E.M. & Visser, W. de

Plant Research International, P.O. Box 16, 6700 AA Wageningen, the Netherlands

** E-mail: hein.korevaar@wur.nl*

Abstract

During three years data of six grassland types were collected on 14 farms. Grass production, number of plant species, N fertilization, Nmin in autumn and nitrate leaching in following spring showed a large variation. There was no relation between N-fertilization level and Nmin, neither between Nmin in autumn and nitrate concentration in the following spring.
Multifunctional land use, including diversification and extensification of grassland, can help to meet the target of 50 mg nitrate per l in groundwater.

Keywords: DM production, fertilizer, grassland, leaching, nitrate, nitrogen

Background and objectives

The objective of multifunctional land use is to combine different functions (e.g. food production, nature conservation, environmental protection and recreation) within one area. Multifunctional land use is considered as an option to enlarge the economical and environmental sustainability of an area. In 1998 a large program on sustainable land use started in the Winterswijk area. The area consists of a small-scale landscape with a dominant role for agriculture. Substantial parts of the area are covered by nature, forests, recreation areas and campsites. The focus of the program is:

- to create more variation in grasslands and arable crops, than only perennial ryegrass swards and silage maize
- to enlarge the ecological values of farmland
- to make the area more attractive for recreation and tourism
- to reduce environmental losses like nitrate leaching.

Material and methods

From 2002 till 2004 an intensive monitoring programme was carried out on 14 farms covering a broad range in farming types. Relations between fertilization, production, farm income, biodiversity and environmental issues were analysed thoroughly.
In this paper we present results of different grassland management types on dry matter production, number of plant species, N-fertilization (fertilizer N and effective N from slurry), N harvested in the crop, residual Nmin in autumn and nitrate in upper groundwater in the following spring.

Results and conclusions

The grasslands were grouped into the six types (Table 1). Total N-fertilization (mainly cattle slurry) on grass-clover swards was less than half the amount of fertilized ryegrass swards (which were regarded as a kind of control for the ordinary farming system in that region), but the average dry matter production, N-uptake and nitrate concentration on grass-clover swards were similar. The average clover content (expressed as ground cover by clover leaves) on the grass-clover fields was 33%.

Fertilization levels on the fertilized grass mixtures (of native grasses) and species-rich grasslands (grassland with wild flowers) were low. Nitrate concentration in groundwater under grass mixtures and species-rich grasslands (fertilized and unfertilized fields) was far below the EU-limit.

Table 1. *Number of plant species, dry matter yield, N-fertilization, N-uptake, N-min in autumn and NO_3-concentration in groundwater in following spring on different multifunction grassland types in 2002 to 2004.*

Grassland type	n	Number of plant species on 100 m^2	DM production t ha^{-1}	N-fertilization kg ha^{-1}	N-uptake by the grass kg ha^{-1}	N-min autumn (layer 0-60 cm) kg ha^{-1}	NO_3 in upper ground-water mg l^{-1}	NO_3 % of fields <50 mg l^{-1}
Ryegrass; fertilized	9	11	12.1	191	370	59	92	33
Grass-clover	7	8	11.9	84	384	36	95	43
Grass-mixtures; fertilized	5	18	9.3	57	239	29	18	80
Grass-mixtures; unfertilized	6	17	8.1	0	153	25	18	100
Species-rich; fertilized	8	29	9.8	62	235	17	25	75
Species-rich; unfertilized	9	21	5.2	0	83	8	5	100

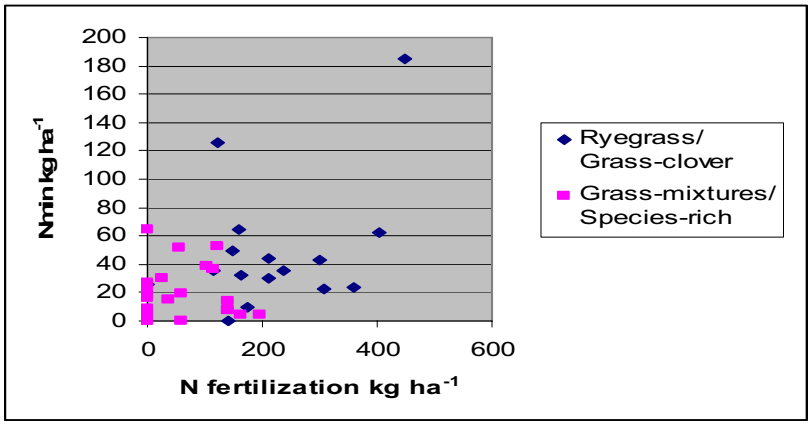

Figure 1. *Relation of N fertilization and mineral N in autumn.*

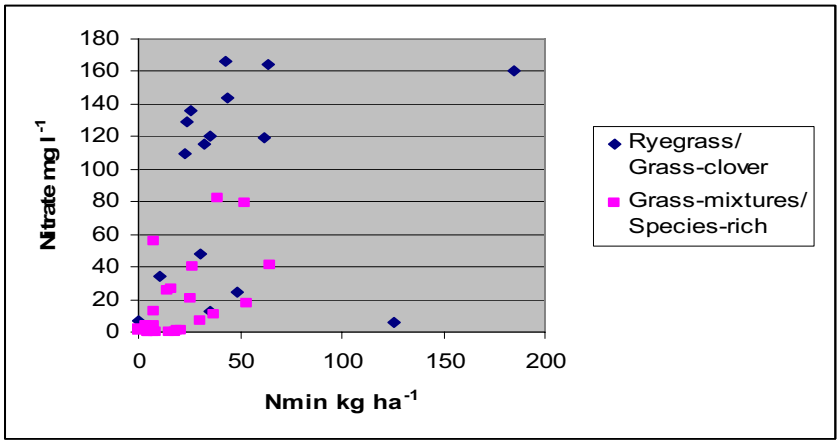

Figure 2. *Relation of mineral N in autumn and nitrate in upper groundwater in the following spring.*

There was no relation between N-fertilization level and Nmin (Figure 1), neither between Nmin in autumn and nitrate concentration in the following spring (Figure 2).

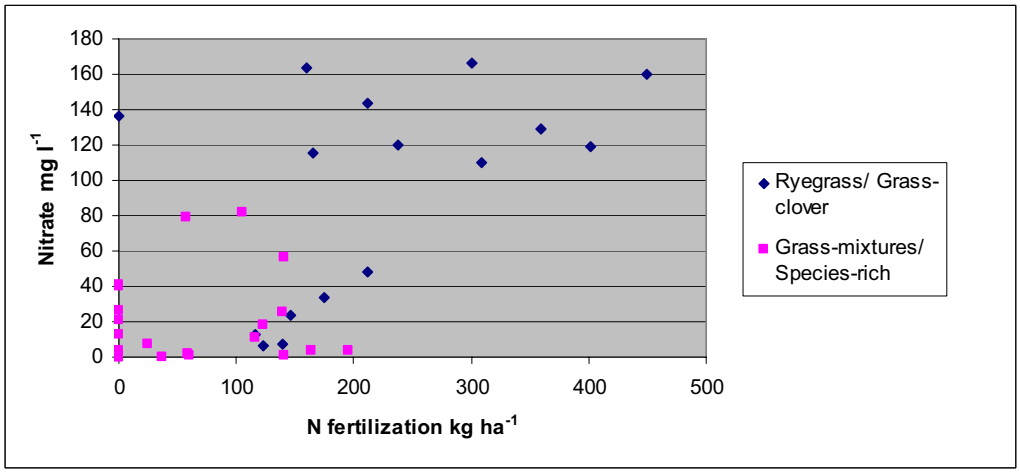

Figure 3. *Relation of N fertilization and nitrate in upper groundwater in the following spring.*

The relation between N fertilization and nitrate is a complicated one (Figure 3). There were two subgroups in the data. The ryegrass and grass-clover swards had a high N input by fertilization, fixation by clover and excretion by cattle and most of them (10 of the 16) were located on soils with a good water management (low groundwater table). The 28 grass-mixtures and species-rich grasslands had a much lower N input (all < 200 kg N ha^{-1}) and almost all these fields (15 of the 28) were situated on wet soils. These fields were not of only a part of the season grazed and cut once or twice a year for hay or silage. On wet soils more denitrification may be expected. So the lower nitrate concentration under grass-mixtures and species-rich grasslands is explained as a combination of a lower N input, less grazing and more denitrification.

Grass-mixtures and species-rich grasslands are more common on soils with a high groundwater table, for instance along brooklets, than grass-clover and fertilized ryegrass fields. A low fertilization with a maximum of 100 kg N ha^{-1} stimulates grass production to a level that still a high biodiversity is achievable and the nitrate leaching stays at an acceptable level.

Conclusions

Multifunctional land use, more precisely diversification and extensification of grassland, in most cases brings by less grass production, but more plant species and more often meeting the target of 50 mg nitrate per l in groundwater. A low total N-fertilisation level (on grass-clover swards) however is no guarantee to meet the NO_3 target.

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