

Introduction

In Baden-Württemberg, Germany, the national monitoring (2009) according to the water framework directive identified 23 water bodies as vulnerable zones for which 14 zones will not reach the "good quantitative status and good chemical status of the groundwater" until 2015. Agricultural and horticulture land use was designated for being the main contributor exceeding the threshold of 50 mg nitrate L⁻¹. Besides existing national and state specific action plans (DüV, MEKA, SchALVO)¹ this enforces additional requirements to reduce nitrate input to fulfil the requirements of the water framework directive. Therefore the state horticultural college Heidelberg successfully established a three-year-project to improve nitrogen efficiency of vegetable crops in three of the vulnerable zones (Rhein-Neckar, Hockenheim-Walldorf and Bruchsal).

¹ action programmes of Baden-Württemberg: DüV = German action programme according to nitrate directive on national level. MEKA = Reduction in market pressures and protection of cultivated landscape on state level. SchALVO = Protection area – and compensation regulation for water protection areas on state level

Materials and Methods

Representative data of one of three pilot farms are presented (table 1). Fertilizer recommendations followed N-Expert and were compared with farmer's practice. Side by side to N-recommendation system crop rotation varied (table 2 and table 3). Soil sampling took place in depths of 0-30, 30-60 and 60-90 cm (according Nmin method).

table 1: data of pilot farm

farm size [ha]	450	WB at risk accord. WFD	✓
vegetable cropping system	sowing	agricultural crops	✓
crops per field & year	2	advisory service	✓
soil type	IS	soil sampling DüV ¹	✓
humus [%]	0,9	marketing	food retailing Gemüsering Stuttgart

table 2: treatments

Variation	N-fertilization	crop rotation (table 3)
1	farmers practice	a
2	N-Expert ²	a
3	farmers practice	b
4	N-Expert ²	b

table 3: crop rotation: (a) bunch onions during winter 2011/2012 and (b) fodder rye as greening in winter 2011/2012

	2011												2012												2013											
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
a	fallow	b. carrots	b. radish	bunch onions									carrots			rye						N.N.														
b	fallow	b. carrots	b. radish	fodder rye									carrots			rye						N.N.														

² N-Expert = software application (IGZ Grossbeeren) to improve fertilizer management by better matching N supply to crops needs

Results

- Calculated N requirement by N-Expert reduced N supply up to 20 kg N ha⁻¹ and 50 kg N ha⁻¹ only with carrots (2012) and bunch carrots (2011) without yield reduction, respectively (table 4).
- In all other crops N-Expert and farmer's practice resulted in similar recommendations for N supply (table 4).
- On this sandy soil a large amount of nitrogen was shifted to deeper soil layers not available for shallow rooting crops (figure 1).
- Replacing the vegetable crop during winter 2011/2012 by fodder rye significantly reduced N-content in 0-90 cm. This reduction was also found with the succeeding carrot crop (2012) (figure 1).
- The increase of soil mineral N (0-90 cm) in autumn 2011 is due to rising temperature (figure 1).
- Comparing the years N content in 60-90 cm continuously decreased (figure 1).

table 4: Yield and N-supply

Year	Crop	fertilizer recommendation	N supply ³ kg N ha ⁻¹	fm yield dt ha ⁻¹	statistics
2011	bunch carrots	practice	172	603	n.s.
		N-Expert	116	600	
	bunch radish	practice	138	434	n.s.
		N-Expert	132	478	
2011-2012	bunch onion	practice	177	386	n.s.
		N-Expert	172	423	
2012	onion → carrots	practice	147	655	b
		N-Expert	116	740	a
	rye → carrots	practice	128	695	ab
		N-Expert	110	668	b
2013	onion → carrots → rye	practice	138	56	n.s.
		N-Expert	137	55	
	rye → carrots → rye	practice	135	51	n.s.
		N-Expert	132	55	

³ N supply= N fertilizer + soil mineral N at sowing in maximum rooting depth

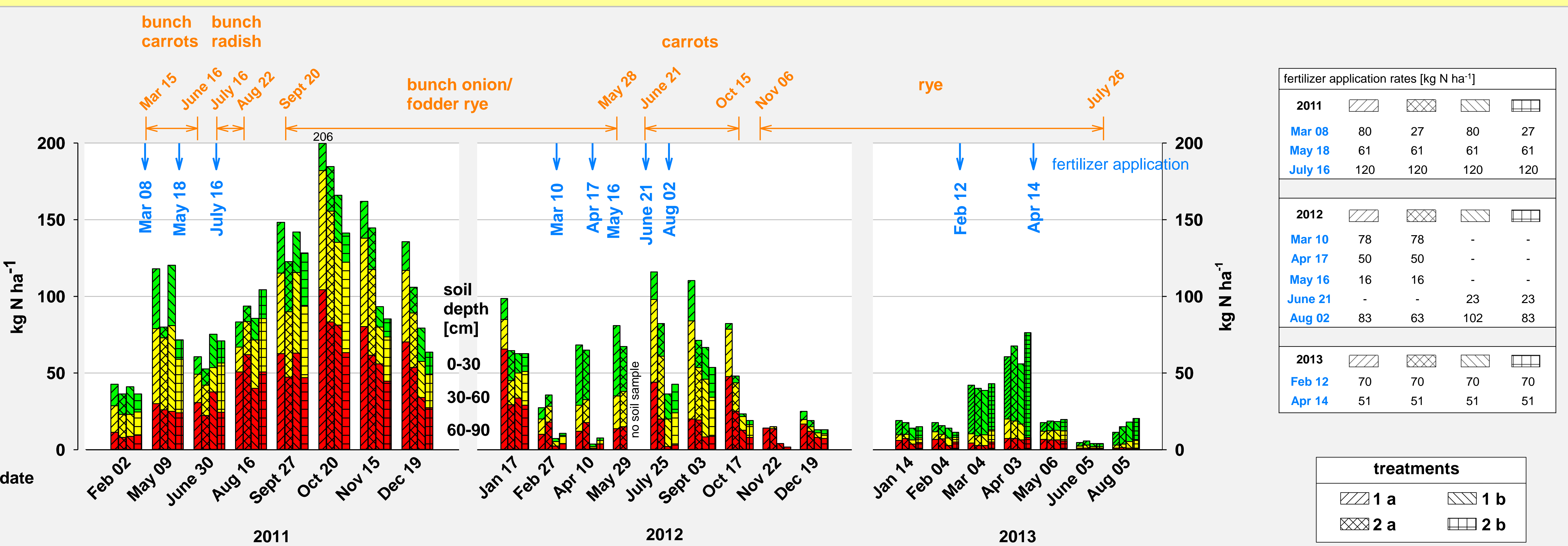


figure 1: mineral N-content in soil (0-90 cm) from 2011 to 2013

Conclusions

- N-Expert improved fertilizer management by better matching N supply to N-demand for all carrot crops.
- Replacing the vegetable crop during winter by fodder rye significantly reduced N-content in 0-90 cm.
- Soil mineral N could mostly be reduced by N-Expert. Combining 'N-Expert and change in crop rotation' resulted in a further decrease of N-losses.
- Intensive consulting of the farmer led to success of the project which could be shown by:
 - The current results have already convinced the farmer to reorganize his fertilization with sowing crops on farm level.
 - The farmer spends his saved money due to fertilization reduction (20.000 €) in taking more soil samples for a better matching supply and demand of the crops.

Project Partners:

- Regional Council Karlsruhe, Department 33
- Official extension services for water protection and vegetable crops of the District Offices Karlsruhe and Rhein-Neckar-Kreis
- Nitratlabor Heidelberg
- Vegetable growers in the groundwater bodies at risk Rhein-Neckar, Hockenheim-Walldorf and Bruchsal

