Nitrate leaching from silage maize

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A maize experiment on coarse sandy soil demonstrates that it is no easy matter to establish an effective catch crop of perennial ryegrass in high-yielding maize.

The catch crop did not reduce nitrate leaching from the soil but tended to reduce maize yields, while the application of slurry increased both yield and nitrate leaching.

During the last 20 years the area with maize in Denmark has increased dramatically and reached 163,000 ha in 2008. Silage maize is easy to grow, is a suitable fodder for cows and goes well with grass-clover in the diet. This means that silage maize is often found in crop rotations with grass-clover on sandy soils in western Denmark.

The ploughing in of grass-clover fields poses a serious risk of increased nitrate leaching on a coarse sandy soil, even when carried out in spring. With increased maize cropping, there is therefore a need for strategies to reduce nitrate leaching after ploughing of grass-clover.

In the ICROFS project, OrgGrass, we examined the effect of catch crop and slurry application on nitrate leaching from maize after a spring-ploughed grass-clover.

The experiment

The maize experiment was initiated in spring 2008 after ploughing a 6-year-old grass-clover field on a commercial organic farm on a coarse sandy soil in the southern part of Denmark.

Four maize treatments were established (Table 1). The fertilized treatments received 135 kg per ha total N including 78 kg per ha ammonium-N in cattle slurry. As a reference to the maize treatments there was an unfertilized green barley treatment where spring barley and Italian ryegrass were grown for silage (Table 1).

The grass-clover field was ploughed on 14 May 2008 and maize was sown the following day. Spring barley was sown on 16 May, which was relatively late under the prevailing weather conditions.

An overview of the experiment on 24 June, spring barley in front and maize to the right. Photo: Henning Thomsen.

Cattle slurry was placed on both sides of the rows of maize in the fertilized treatments. The Italian ryegrass catch crop was sown late (8 June) in the green barley plots due to very dry soil condition. Due to continuous drought the Italian ryegrass was re-sown on 17 June where also perennial ryegrass was sown in maize. On 19 June the field was irrigated with 25 mm.

Before the maize experiment was started, the grass-clover field had been part of an experiment with three different grazing strategies from spring 2006 to autumn 2007. As there were no significant effects of grazing strategy or interaction between previous grazing strategies and maize treatment, the presented values are therefore averaged across the previous grazing strategies.

Yields

Maize benefited from the warm weather in spring 2008. A dry matter production of 16.0 t per ha in

Treatment	Leaching N kg/ha		Yield dm kg/ha		N uptake kg/ha	
Unfertilized maize	86	b	13,157	b	141	b
Unfertilized maize with a catch crop[1]	74	b	12,888	b	136	bc
Fertilized maize	136	a	15,976	a	181	a
Fertilized maize with a catch crop1	115	a	15,379	a	173	a
Unfertilized green barley with a catch crop[2]	27	c	5,884	c	127	c
LSD.95	-		741		11	

Table 1. Leaching from 1 April 2008 to 30 March 2009, yields and N uptake. Percolation 562 mm. [1] Perennial ryegrass (12 kg ha-1 seeds). [2] Italian ryegrass (25 kg ha-1 seeds). Yield and N-uptake including grass cuts (specified in Table 2).

Perennial ryegrass (variety: Mikado) was sown in maize on 17 June. Photo: 16 July, Henning Thomsen.

The maize variety Rosalie gave a better soil cover than several other maize varieties (Danish Agricultural Advisory Service, 2008), which is an important factor in relation to competition against weed, but it probably also affects the growth of the catch crop. Photo: 26 July, Henning Thomsen.

The warm weather seemed to benefit maize more than barley and Italian ryegrass in green barley plots (in front and to the right). On 26 July the height of maize was approximately 180 cm. The green barley plots were harvested on 16 July. Photo: Henning Thomsen.

fertilized maize was on level with conventionally grown Rosalie maize in 2008 (Danish Agricultural Advisory Service, 2008).

Maize responded positively to fertilization. With an application of 78 kg per ha ammonium-N it yielded 2.8 t per ha more than unfertilized maize.

In both fertilized and unfertilized maize, yields were not significantly different whether perennial ryegrass was grown as a catch crop or not. However, the trend was that yields were lower with a catch crop than without.

This was not expected since the ryegrass showed a poor development during autumn, maybe due to the competition from maize. In spring 2009 the perennial ryegrass had almost disappeared from the plots, showing that it is no easy matter to establish perennial ryegrass as an effective catch crop in vigorously growing maize.

	Date	Yield kg/ha	N uptake kg/ha
Green barley	15 July	3,375	65
1st cut of Ital. ryegrass	25 August	1,402	37
2nd cut of Ital. ryegrass	28 October	1,107	25

Table 2. Yield and N in green barley and Italian ryegrass.

The yield of the green barley plus two Italian ryegrass cuts was less than half of the maize yields. This yield was low compared with a green barley harvest in a previous DARCOF experiment in 2003. The green barley itself only yielded 3.4 t per ha (Table 1) compared with 6.1 t ha-1 after a 5-year-old grass-clover fertilized with 60 kg ammonium-N in the 2003 experiment.

The late sowing of the barley and the Italian ryegrass in 2008 probably contributed to the yield reduction, but the two Italian ryegrass cuts did not come up to expectations either. The yield for the two cuts was 2.5 t per ha (Table 2) compared with 6.2 t ha-1 in the previous experiment. It was noticed that during the summer period Italian ryegrass grew less vigorously than in the previous experiment, probably due to the warmer and drier weather in 2008. This might have influenced the autumn growth of the ryegrass.

An overview of the experiment on 30 October. Plots with a catch crop in the foreground. Plots without a catch crop were treated with a rotary cultivator just before the photo was taken. Plots with Italian ryegrass in green barley plots in the background. Photo: Henning Thomsen

Nitrate leaching

Leaching in all the maize treatments was significantly higher than the reference treatment level in green barley of 27 kg N ha per ha (Table 1). The lowest leaching level in maize was in unfertilized maize with a catch crop (74 kg N/ha), and the highest level was found in fertilized maize without a catch crop (136 kg N/ha).

Slurry application to maize increased leaching significantly in comparison to unfertilized maize. The application of 78 kg N per ha in slurry increased leaching by 50 kg N ha-1 and in the same treatment the N uptake in maize was increased by 40 kg N ha-1. This indicates that even though maize increased dry matter yield and N uptake after slurry application, it could not increase the N uptake by an amount corresponding to the ammonium-N in slurry. From an environmental point of view the results suggest that maize grown after a long-established grass-clover field should receive less fertilizer.

Catch crops are often suggested as a measure to reduce nitrate leaching. In the maize experiment leaching tended to be less (12 kg N/ha) in unfertilized maize when a perennial ryegrass catch crop was included rather than leaving the soil bare after harvest (Table 1). In fertilized maize, leaching also tended to be less (21 kg N/ha) with a catch crop, but the difference between the two fertilized treatments with or without a catch crop was not significant.

The result demonstrates the challenge of establishing a catch crop in maize, where the catch crop is able to reduce nitrate leaching satisfactorily in autumn while not reducing the yield of maize.

Read more

You can find more information about the DARCOF III research project OrgGrass on grass-clover in organic dairy farming on the following webpage: www.icrofs.org/Pages/Research/darcofIII_orggrass.html