Is Early Sowing of winter cereals as effective as Catch Crops in Increasing Nitrogen Use Efficiency in Cropping Systems?

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Abstract

To evaluate the effects of early seeding of a winter cereal and the use of catch crops on nitrate leaching and grain yield a long-term experiment was set up in 2015 in two different climates in Denmark. The main crops were either continuous winter cereals or spring barley where the soil over winter was either sown with a catch crop, left with weeds and volunteers, or held bare by herbicide. Different levels of N fertilisation rates ranging from 0 to 300 kg/ha were applied, and nitrogen uptake by the main crops and the catch crops, as well as nitrate leaching were measured.

Keywords: catch crops, N leaching, sowing time, yield, N uptake, economic optimum fertilisation rate

1. Introduction

The use of catch crops in the autumn/winter period for reducing nitrogen (N) leaching from cropping systems has been studied in many regions worldwide, and is mandatory in Denmark (Thomsen and Hansen 2014). An alternative to catch crops is early sowing of winter cereals (Munkholm et al. 2017). Both catch crops and early sowing increase N uptake in autumn, reduce the mineral N content in the soil after the harvest of the main crop, and consequently N leaching (Myrbeck and Stenberg 2014). Despite the fact that Danish farmers have recently been allowed to replace catch crops in a one-to-four ratio by early-sown winter cereals the use of early sowing on reducing N leaching and increasing N use efficiency is debated.

2. Methods and Materials

The field experiments were carried out from 2016 to 2019 on two experimental sites in Denmark, with different climatic conditions. One of the farms was located in Foulum (FU) and the other at Flakkebjerg (FB) The soil at FU and FB are both sandy loam soils. Five different rotation types were set up: 1. continuous winter rye (WR) at FU and winter wheat (WW) in FB sown according to common practice; 2. continuous WR (FU) or WW (FB) sown in early September; 3. spring barely (SB) and catch crop of undersown perennial ryegrass in FU, and fodder raddish broadspread before harvest in FB; 4. continuous SB with bare soil over the autumn/winter period; 5. continuous SB with volunteers over the autumn/winter period. For SB N fertilisation rates ranging from 0 to 200 kg N/ha were applied, for WR these were 0-250, and for WW 0-300 kg N/ha. Measurements included grain yield, N uptake by the main and catch crops, and N leaching based on suction cups.

3. Results

3.1 Grain yield, grain N content, and autumn N uptake

The grain yield of the WR and SB in Foulum increased in all years, as expected with increased N fertilisation rate. Early seeding of WR had little effect on the grain yield, with a small decrease in two of the years. Yields for WR in 2017 and 2018 were lower compared with those in 2016, likely due to the draught period in September 2017 and a dry summer in 2018. In Flakkebjerg the grain yield of the WW

was significantly different in all three years, with highest yields across fertilisation rates in 2016, and lowest in 2018. The timing of the seeding had not significant effect on the yield. In 2017 yields of WW and SB were very similar, whereas in the other two years SB had lower yields compared with WW. The use of CC or V had no significant effect on the SB yield.

The grain N content shows a similar trend as the grain yield, with no significant difference between normal and early sown WR at both sites. The use of a CC or V had no significant effect on the N content of the SB grain.

The efficiency of the autumn/winter vegetation on reducing N leaching depends on the N uptake in the autumn period, which was in Foulum in all three years significantly higher by early sown compared to normal sown WR. Overall, the N uptake of early sown WR was similar to those of the catch crops. In Flakkebjerg N uptake in the autumn period was quite similar for WW and catch crops in 2016 and 2017, but in 2018 uptake by catch crops far exceeded those of WW. Again, early sowing had a significant higher uptake compared with normal sowing in 2016 and 2018.

3.2 N leaching

Nitrate leaching in Foulum was relatively low in 2016/17 with no significant effect of the fertilisation rate. Early seeding reduced N leaching significantly compared to normal seeding in all three years, and the use of a catch crop also decreased N leaching compared to the bare soil treatment over autumn, which had the highest leaching. In 2017/18 leaching was higher and increased with increasing fertilisation rate, likely due to the lower yield and N uptake in this year. In 2018/19 leaching increased further, likely due to low yields, and a carry-over effect from the previous years.

In Flakkebjerg N leaching was also very low in 2016/17, and not significantly different across fertilisation rates. Leaching under SB was slightly higher compared with WW, and the use of a catch crop decreased N leaching significantly. Leaching in 2017/18 and 2018/19 were again higher, with early sowing and catch crops reducing leaching.

The average nitrate leaching over the three years studied shows that, as expected, the use of a catch crop in a SB rotation decreased N leaching compared with a bare soil in autumn/winter. Early seeding of a winter cereal also decreased leaching at common and higher N fertilisation rates (Figure 1). Early sown winter cereals had lower leaching than the SB rotations.

4. Conclusions

This three year study allowed us to simultaneously evaluate the effect of early sowing of a winter cereal and the use of a catch crop in a spring barley rotation on yield, and N leaching in two contrasting environments in Denmark. In general, both, the use of catch crops, as well as early seeding of winter cereals reduced N leaching. Differences observed between the three years, however means that further long term studies are required to determine the ratio by which catch crops can be replaced by early-sown winter cereals to reduce N leaching.

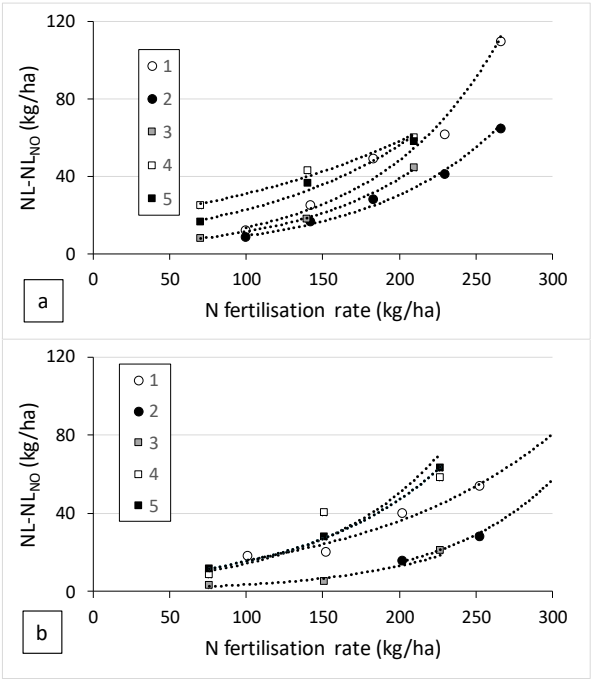

Fig. 1: Nitrate leaching (3 year average) from different cropping systems in a) FU and b) FB. The rotation treatments are: 1= continuous WR (FU) and WW (FB), 2 = continuous WR or WW sown early; 3 = continuous SB with ryegrass as catch crop; 4 = continuous SB with bare soil in autumn; 5 = continuous SB with volunteers in autumn.

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