Combination of undersown catch crops and row-hoeing for optimizing nitrogen supply and weed control in organic spring barley

Thi Thuy Hong Phan *±1, Kristian Thorup-Kristensen

[1] Department of Plant and Environmental Sciences, Crop Science Section, Faculty of Science, Copenhagen University

* Speaker

± Corresponding author: phan@plen.ku.dk

1 Introduction

Current organic cereal production faces two main problems: nitrogen (N) deficiency and high weed pressure. The use of catch crops, including legumes is an important approach to improve soil fertility and also to reduce the environmental impact of agricultural activities. In Europe, catch crops are usually grown to take up N remaining in the soil after main crop harvest. However, in practice farmers prefer an early termination of catch crops or not establish them to allow intensive autumn soil tillage for weed control, especially perennial weeds, strongly reducing or withdrawing their desired effects. Therefore, an innovative weed control strategy is tested, which should reduce the need for tillage and allow the efficient use of catch crops as green manure and weed suppressor. In the current study, we aim to develop a row crop system for organic cereal production with an increased row-distance of 24 cm, the use of undersown winter hardy catch crops and inter row-hoeing. We test different catch crop mixtures, different sowing times and study the integrated effect of a combined undersown catch crop-row hoeing-row crop system on crop yield, crop and soil N dynamics, N effect (Neff) of catch crops for the succeeding crop and on weed control.

2 Materials and Methods

Two-year field experiments (2014 - 2015 and 2015 - 2016) are established in organic spring barley. The experimental factors include (1) row cropping system or conventional system (with 24 or 12 cm row-distances); (2) with or without catch crops; (3) different catch crop species mixtures and (4) three different catch crop sowing times.

Catch crops were sown at the same time as spring barley in April or delayed 3 and 6 weeks. Depending on the three sowing dates, row hoeing was made either 0, 1 or 2 times between the spring barley rows prior to sowing catch crops. We used different legume-nonlegume mixtures to take advance the biological N fixation of legumes (i.e. white clover, red clover, Lucerne,…) and a more sufficient soil N depletion of non-legumes (i.e. rye grass, chicory, Dyer's woad,…). All of them are winter-hardy species. After the spring barley harvest in August, the catch crops remain on the field during autumn and winter and are incorporated into the soil in March next year. Moreover, to mimic the common intensive soil tillage activities of farmers, the two fallow treatments of both two cropping systems were harrowed three times during September-October. Then, a pure-stand spring barley will be established in April of the second years.

We measure aboveground plant biomass of each plot at four dates: Early August before the barley harvest, November at the end of the growing season, early March before catch crop incorporation and early August before the new spring barley harvest. They are sorted into 4 groups of plant species: 1) legume, 2) non-legume, 3) thistle (*Cirsium arvense*) and 4) other weeds. Then we record their dry biomass and analyze the C:N ratio. We also measure the soil inorganic N content - N_{inorg} (ammonium-N and nitrate-N) of three different soil layers (i.e. 0-50 cm, 50-100 cm and 100-150 cm) at two dates: Mid November and early May after the new spring barley establishment.

We also employ other assessment strategies for studying the effect of row hoeing and catch crops on the thistles: 1) direct counting the thistle population in the entire plots, according to their height categories and analyze their N content; 2) injecting ^{15}N in October, measuring the soil ^{15}N content up to a 100 cm depth in May and measuring the ^{15}N recovery in aboveground biomass of the new spring barley and thistles of the second year.

3 Results - Discussion

Plant growth, yield effect and expected Neff

All of catch crop species had a limited growth as undersown, but a fast development after the barley harvest. Therefore, they did not affect the barley yield in the first year (data not shown). The same or higher total dry matter of white clover/rye grass mixture was obtained in the 24 cm row cropping system than in the 12 cm row system, even at later sowing times (Treatment 4 & 5 compared to Treatment 3, Fig. 1). This indicates that we can delay the sowing date of catch crops, allowing us to employ one or two times of the inter row-hoeing for weed control without reducing catch crop growths. Amongst the sowing dates, a short delay where catch crops are sown three weeks later than the main crop after one row hoeing, the clover species produced twice as much biomass as if sown after six weeks and two row-hoeings. However, they suppressed the growth of their companion grass species. In contrast, the non-leguminous species expressed greater tolerance to later sowing. They obtained a similar dry biomass to in the first sowing date and much higher than if sown at the second sowing date. In terms of weed control, weed biomass were reduced more than 50% in all catch crop treatments compared to the fallow treatments. While two row hoeings and later sowing reduced legume growth, its effect on weeds was not clear. The effects of row cropping, hoeing and catch crops on total N content in the succeeding barley crop and the Neff of different catch crops will be measured. The Neff is expected to vary between catch crop mixtures and different sowing times, being high where a high catch crop N content was achieved.

Table 1. List of treatments presented in Figure 1

Treatments	Catch crops	Row distance (cm)	Sowing times	Number of hoeing
1	No catch crop	12	-	0
2	No catch crop	24	-	0
3	White clover/rye grass	12	1	0
4	White clover/rye grass	24	2	1
5	White clover/rye grass	24	3	2
6	Red clover/orchard grass	24	2	1
7	Red clover/orchard grass	24	3	2

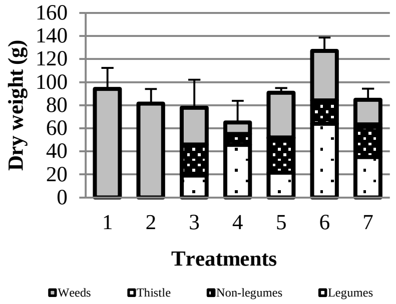

Fig. 1. The mean of total aboveground dry matter of legume, non-legume, thistles and other weeds of different treatments in Novermber 2014 of the 2014-2015 experiment, 3 replicates. Bars show standard errors.

Soil inorganic N and thistle effects

We expect the catch crops will effectively deplete the soil N in the autumn, and their mineralized N_{inorg} will redistributed into the surface layer after their incorporation, leading to increased topsoil N_{inorg} compared to un-covered treatments. Treatments with deeper-rooted species such as chicory, Dyer's woad and winter radish were included in the study, to evaluate their ability to transport N upwards from deep soil layers, thereby reducing N leaching losses (Thorup-Kristensen, 2001). In summary, the reduction of N in subsoil layers and the increase of N_{inorg} in the topsoil in the next season by the catch crop treatments will produce an optimal condition for the N uptake of the shallow rooted crops like spring barley, compared to thistles with a high root density in the deeper soil layers. Therefore, in combination with row-hoeing, this continuous N competition from first the catch crops and then the succeeding barley crop is expected to weaken the thistles, leading to the decline of their growth and regeneration. To consolidate this hypothesis, we expect that the ^{15}N study will show a lower ^{15}N recovery in thistles after the catch crop treatments than after the treatments without catch crops.

4 Conclusions

We aim to contribute to the development of a row crop system which is more optimal for the development of catch crops than the conventional system while at the same time allowing the necessary control of thistles. The optimized row crop system with the employment of proper catch crop species, sowing time and row hoeing will be a promising system for developing higher yielding organic cereal crops and for more environmental friendly weed control.

Acknowledgements. We thank the Danish AgriFish Agency for sponsoring this research within the row crop project.

References

Thorup-Kristensen, K. (2001). Are differences in root growth of nitrogen catch crops important for their ability to reduce soil nitrate-N content, and how can this be measured? *Plant and Soil*, **230**, 185-195.